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Douglas-fir Tussock Moth

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Introduction

The Douglas-fir tussock moth (DFTM), *Orgyia pseudotsugata McDunnough,* (*Lepidoptera: Erebidae, Lymantriinae)* (Fig. 1 & 2) is an economically and ecologically important native defoliator of Douglas-fir (*Psuedotsuga menziesii*) and true firs in western North America. Outbreaks of DFTM can cause substantial damage to Douglas-fir and true fir forests. It is sometimes a pest of concern with Colorado blue spruce (*Picea pungens*) and Engelmann spruce (*Picea engelmannii*) in urban settings.

Figure 1. Adult male DFTM.

Figure 2. Mature DFTM larva.

In the Pacific Northwest, outbreaks occur approximately every seven to ten years, while in other regions of western North America, outbreaks may follow other cyclic patterns. Dense, multistoried stands of mature and overmature hosts competing for moisture and nutrients on upper slopes, ridgetops, and sites with poor productivity are generally associated with DFTM outbreaks. Although outbreaks typically end after one to four years, several in New Mexico have persisted for up to seven years in the same general area.

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Figure 3. DFTM-caused stand mortality.

Severe outbreaks have occurred throughout forests of the western U.S. and Canada, with defoliation resulting in growth loss, top-kill, mortality (Fig. 3), or weakened trees that become prone to bark beetle attack. A DFTM infestation in the Blue Mountains of Oregon and Washington in 1972-73 killed 39 percent of all trees in heavily defoliated areas. Within these areas were patches where nearly all trees died. Top-kill in the heavily defoliated areas amounted to 10 percent of the grand fir and 33 percent of the Douglas-fir.

Additional impacts from DFTM infestations can include increased wildfire risk and adverse impacts on fish and wildlife habitats. People and domestic animals often have allergic reactions to the hairs of larvae during outbreaks. Referred to as "urticating hairs", they can become embedded in skin and mucous membranes, causing an irritation known as lepidopterism or tussockosis. Symptoms of this condition may include itchy skin, watery eyes, rashes and sneezing.

Distribution and Hosts

Despite its common name, DFTM has three preferred host tree species depending upon location in western North America (Fig. 4). In British Columbia and northern Washington, Douglas-fir is its primary host. Douglas-fir and grand fir (*Abies grandis*) tend to be favored in Central and Southern Washington, while Oregon and Idaho experience widespread defoliation in Douglas fir, grand fir, and white fir (*Abies concolor*). In the southwestern states of California, Arizona, and New Mexico, DFTM prefers white fir. Recently, DFTM has been collected from white fir in Sierra San Pedro Martir National Park, Baja California Norte, Mexico.

Other species such as red fir (*Abies magnifica*) and subalpine fir (*Abies lasiocarpa*) can be damaged when

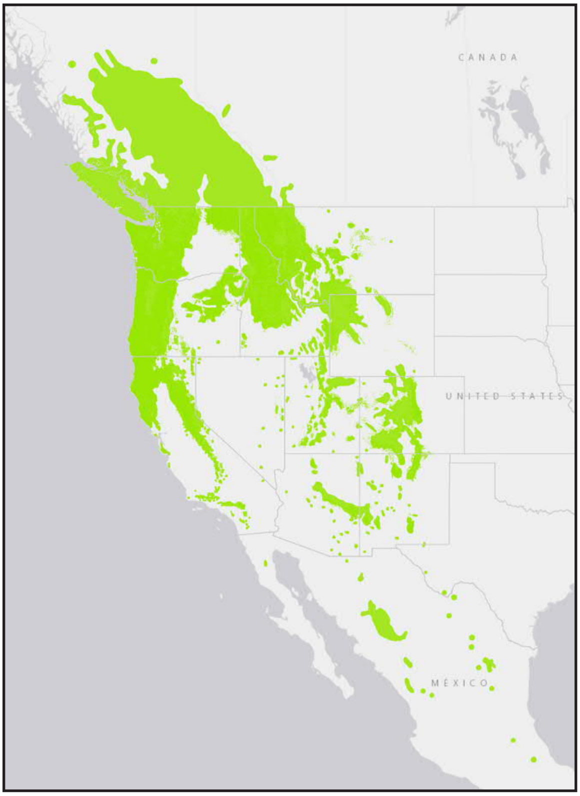

Figure 4. Distribution of combined host types where DFTM can be found.

preferred hosts have been nearly or completely defoliated. Douglas-fir tussock moth larvae have also been observed feeding on Jeffrey, lodgepole, ponderosa and sugar pines (*Pinus jeffreyi, P. contorta, P. ponderosa*, and *P. lambertiana*), western hemlock (*Tsuga heterophylla*), western larch (*Larix occidentalis*), and Engelmann and Colorado blue spruce, as well as understory shrubs and host reproduction.

Description

Adult males (Fig. 1) have feathery (plumose) antennae, gray-brown bodies, and a wingspread of about 1¼ inches (3.2 cm). The forewings have two small whitish spots close to the outer edges, and two muted black wavy bands against a gray-brown mottled background. The hindwings are a contrasting brown color.

Adult females (Fig. 6) are flightless, with tiny rudimentary wings, small threadlike antennae, and large abdomens. The body is typically ¾ inch (1.9 cm) in length, hairy, and primarily gray-brown near the head, and darker toward the posterior where hairs are denser and longer. Females have limited mobility and remain on the

Figure 5. First instar larvae.

Figure 6. Adult DFTM female on pupal cocoon.

pupal cocoons from which they emerge.

Eggs are laid directly on the cocoon in a single mass (about ½ inch or 1.3 cm in diameter). The round, white eggs are covered with a gelatinous substance mixed with body hairs from the female's abdomen. This substance soon dries into a tough, leathery, gray colored material that provides protection for the eggs (Fig. 7). Masses may contain up to 350 eggs depending on location. Egg masses from DFTM's northern range often contain fewer eggs than from its southern range.

Figure 7. DFTM egg mass on cocoon.

Young larvae range in length from ⅛ to ¼ inch (3-6 mm), are light tan to dark gray, and are covered with long hairs (Fig. 5). As larvae mature, hairs on the dorsal side become thicker and later develop into four dense tufts or "tussocks", usually with reddish or brown tips. Mature larvae are the most noticeable and colorful of DFTM life stages (Fig. 2). Two black forward-projecting "horns" of hair are located just behind the head, with a single longer horn found at the posterior end. The rest of the body is covered with long and short black hairs that originate from small, red tubercles. Larvae can grow to 1¼ inches (3.2 cm) in length.

The pupa is light to dark brown and covered with a straw-colored pubescence. It is encased in a greyish, spindle-shaped cocoon that includes some of the larval hairs (fig 6).

Life Cycle

Douglas-fir tussock moth produces one generation per year. Overwintering eggs hatch from late May to late June, coinciding with bud burst and shoot elongation of host trees. Newly hatched larvae usually remain on the egg mass for several days before dispersing. Because the adult female is flightless, the primary mode of DFTM dispersal is by windblown first instar larvae. Larvae that hatch on defoliated trees spin down on long silken threads. They are caught on the wind and may be blown considerable distances; a process referred to as "ballooning". However, the distance most caterpillars travel rarely exceeds ¼ mile (400 m). Longer range dispersal by a few individuals will not produce new outbreaks.

Larvae grow slowly at first, then progressively faster as they typically undergo five molts. Up to seven instars may occur under stressful conditions. During early development, first and second instars must feed on new foliage, which is higher in nutritional and moisture content than older foliage. As larvae mature and new foliage is depleted, they shift and complete their development consuming older foliage.

Pupation typically lasts 10 to 18 days, from mid-July to the end of August or longer, depending on site conditions, temperature and elevation. Females that pupate under nutritional stresses are smaller, make thin and transparent cocoons, and produce fewer eggs.

Adults emerge from late July into November, with peak activity typically occurring in September. Male flight is stimulated by light and temperature. Flight begins about midday, peaks in late afternoon, and rapidly diminishes at dusk. At any particular location, male flight generally continues for eight to ten weeks.

Females emit an attractant pheromone which enables males to locate them. Females mate soon after emerging from their pupal cocoon and die within a few days after oviposition. Overwintering egg hatch success depends on surviving parasitism, predation, and effects from other environmental influences.

Evidence of Infestation/Damage

Douglas-fir tussock moth outbreaks follow a pattern of four phases:

Phase 1: Population begins to build. Larvae are evident, but little or no defoliation is visible.

Phase 2: Population is high. Larvae are readily seen and defoliation is evident.

Phase 3: Population is extremely high and there is widespread defoliation.

Phase 4: Population collapses from combined effects of disease, parasitism, predation and starvation.

During an outbreak, damage is first evident in late spring. Newly-hatched, inconspicuous larvae gather and feed primarily on the underside of new foliage at the tops and outer branches of host trees, causing needles to shrivel and turn brown (Fig. 8). Tops of trees may be completely stripped of needles, possibly resulting in top-kill only after one season. It may take only two to three weeks for all new foliage to be completely stripped if

Figure 8. Damage to tops and outer branches by DFTM larvae.

larval density is high, and mortality can occur in one year if defoliation is over 90%. During high populations, silken threads emitted by larvae

Figure 9. "Silken caps" in upper crowns due to high larval populations.

for descending to fresh foliage can form residual "silken caps" in upper crowns. They are easily observed from the ground (Fig. 9).

By mid-July, larvae are larger and more visible. They can be seen feeding on both current and older foliage in lower crowns and inner branches. This feeding pattern produces a characteristic reddish-brown cast from dead needles across stands and landscapes (Fig. 10).

As they prepare to pupate, light to moderate DFTM populations typically spin cocoons on the underside of old foliage and branches. When populations are high, cocoons may also be found on tree trunks or on any nearby supportable surface (Fig. 11).

In urban settings, upper crown defoliation of ornamental spruce and fir trees is quite common. This often occurs one or two years prior to a major outbreak in surrounding rural forests. Prolonged defoliation of these urban ornamentals can cause top-kill or whole tree mortality.

Management Options

Options to mitigate undesirable impacts from DFTM outbreaks depend on management objectives. Early detection, monitoring, suppression and prevention must be well integrated into management plans to ensure adequate resource protection.

Defoliation by DFTM is readily detected by aerial detection surveys

Figure 10. Extensive landscape defoliation caused by DFTM outbreak.

Figure 11. DFTM cocoons on doorway and ceiling during high populations.

and ground observations, but these methods only identify outbreaks that are in progress. Since DFTM populations tend to aggregate, attempting to track increasing numbers by using traditional ground-based sampling techniques involves rigorous field work. The DFTM Early Warning System (EWS) has been developed to provide land managers a practical way to annually monitor population trends. This system involves deploying traps lined with a sticky material and baited with an attractant pheromone that draws in male moths (Fig. 12). These "sticky traps" (Fig. 13) are deployed before moth flight. Once inspections show counts of trapped male moths exceeding an average trap catch of 25 or more, surveys for egg masses and larvae can support outbreak predictions. Some State and Federal land management agencies have set up annual EWS "trap lines" in areas identified as being prone to cyclic DFTM outbreaks.

The DFTM EWS can help predict an outbreak two to three years in advance, providing an early indication of increasing populations. However, EWS cannot identify specific areas of severe impacts, nor can it predict if increased trap catches will ultimately result in damage-causing outbreak levels. Additional egg mass and larval sampling help delimit the potential outbreak areas and allow managers time to consider management options.

Figure 12. DFTM male adult caught in sticky trap.

Figure 13. Douglas-fir tussock moth sticky trap.

The decision to suppress a DFTM outbreak depends on its projected impacts, the value of the threatened resources, and management objectives for the affected stand or landscape. Suppression strategies are designed to reduce larval populations and protect foliage. Short-term suppression treatment strategies include chemical and microbial insecticides and mating disruption pheromones. State or Federal Forest Health Specialists should be consulted for assistance with details of these treatment strategies and updates on current registered insecticides.

Management can reduce impacts from DFTM

outbreaks. Long-term strategies include silvicultural treatments to make stands more resilient to DFTM. Multi-storied stands of host species are especially vulnerable to DFTM damage. Thinning overstocked stands with a high percentage of true fir and Douglas-fir will reduce the number of susceptible hosts and can improve residual tree health. However, if root disease is present, stumps from management can increase inoculum of root pathogens. Increased inoculum and root and bole wounds can increase infection and mortality of residual root disease susceptible trees, especially Douglas-fir and true firs.

Figure 14. Ants attacking DFTM larva.

Natural Control

Douglas-fir tussock moth populations are generally regulated by a combination of predators, parasites, pathogenic microbes, late spring frosts, or food that is either scarce or of poor quality. In low populations, over 90% of the larvae and at least 75% of the pupae and eggs are killed in each generation by natural causes. If this mortality rate does not occur, populations will rapidly increase.

A portion of newly hatched larvae will fail to find new foliage after dispersal and starve, while others may be eaten by birds, spiders, or predaceous insects. Birds, such as the dark-eyed junco *(Junco hyemalis)* and red-breasted nuthatch *(Sitta canadensis)*, feed on tussock moth eggs, destroying a considerable number of overwintering egg masses when DFTM densities are low. Overwintering eggs and pupae are usually heavily parasitized by small wasps and flies. Early larval instars may be parasitized by several wasp species in the genus Phobocampe or Hyposotor. The parasitic fly *Carcelia yalensis* (Sellers) will attack all larval instars. Ants (Fig. 14) and spiders can have a substantial impact on larval mortality of first and second instars.

When natural controls prove inadequate, DFTM can rapidly increase and cause considerable amounts of defoliation. However, these outbreaks usually collapse abruptly after a couple of years due in large part to a nuclear polyhedrosis virus contagion that kills both larvae and pupae. The internal organs of infected, dead larvae will liquefy (Fig. 15) and eventually rupture. The virus-laden contents end up either on the ground or smeared across

Figure 15. Larva killed by naturally occurring virus.

foliage, infecting and dispersing through the remaining population. Virus particles may persist in the environment for many years.

In the absence of viral disease and parasitoids, outbreak populations of DFTM 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. Competition with western spruce budworm will also lower the amount of available new foliage. These factors will result in starvation and lowered egg production and survival, reducing population numbers to where they are once again regulated by natural enemies.

Additional Information

Private landowners can get more information from county extension agents, state forestry departments, or state agriculture departments. Federal resource managers should contact Forest Health Protection, USDA Forest Service (www.fs.usda.gov/goto/foresthealth/).

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