Chapter 13

Douglas-fir Tussock Moth, *Orgyia pseudotsugata*

I.S. Otvos, J.C. Cunningham, and R.F. Shepherd

Introduction

The Douglas-fir tussock moth, *Orgyia pseudotsugata*, (Lepidoptera: Lymantriidae) is an important defoliator in the interior dry-belt forests of southern British Columbia and the western United States. The primary host tree in British Columbia is Douglas-fir, *Pseudotsuga menziesii*. However, in other areas, heavy feeding can also occur on grand fir, *Abies grandis*, white fir, *A. concolor*, ponderosa pine, *Pinus ponderosa*, and several species of spruce, *Picea* spp.

Outbreaks of the Douglas-fir tussock moth occur periodically at intervals of about 8 to 14 years in British Columbia, Washington, Idaho, Oregon, California, Arizona and New Mexico. Eight outbreaks have been reported since 1916 in susceptible forest stands in British Columbia (Harris et al. 1985; Shepherd and Otvos 1986) (Fig. 1).

Douglas-fir tussock moth population increases are usually first noted in valley bottoms and on open-grown trees near settlements. Infestations usually last for 1 to 4 years in any particular stand and cause growth loss, top kill and tree mortality (Fig. 2) (Wickman 1978; Alfaro et al. 1987). Defoliation occurs in distinct patches in the first year, spreading and coalescing in later years of the outbreak. All age classes and sizes of the host trees may be attacked, and the most severely attacked trees generally die. Large, but less severely defoliated trees are weakened and these may be subsequently attacked and killed by the Douglas-fir bark beetle, *Dendroctonus pseudotsugae*. Outbreaks with noticeable defoliation usually last from 2 to 5 years and are generally terminated by epizootics of a naturally occurring nuclear polyhedrosis virus (NPV) but usually not before severe damage occurs to the infested stands (Dahlsten and Thomas 1969; Mason and Luck 1978; Shepherd and Otvos 1986).

Two morphotypes of NPV virus have been isolated from Douglas-fir tussock moth larvae. In the first type the virus particles are embedded singly (unicapsid) in the protein inclusion-body matrix and in the second type they are embedded in bundles (multicapsid) (Hughes and Addison 1970).

Biology

The Douglas-fir tussock moth has one generation per year. The winged males search out the flightless females and after mating the female lays all her eggs, about 150 to 200 in one mass, on her cocoon in August or September (Wickman

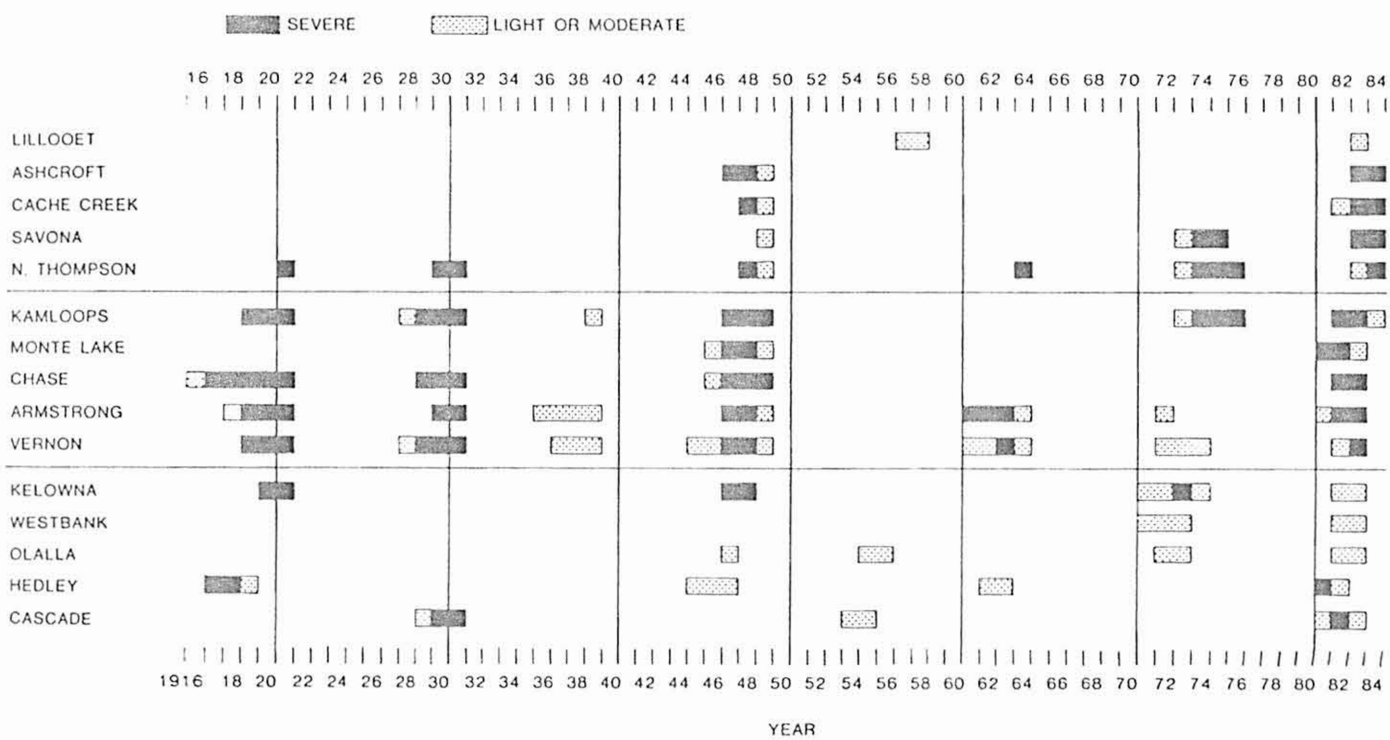

Figure 1. Histogram of Douglas-fir tussock moth, *Orgyia pseudotsugata*, outbreak periods from 1916 to 1984 by geographic locations in British Columbia.

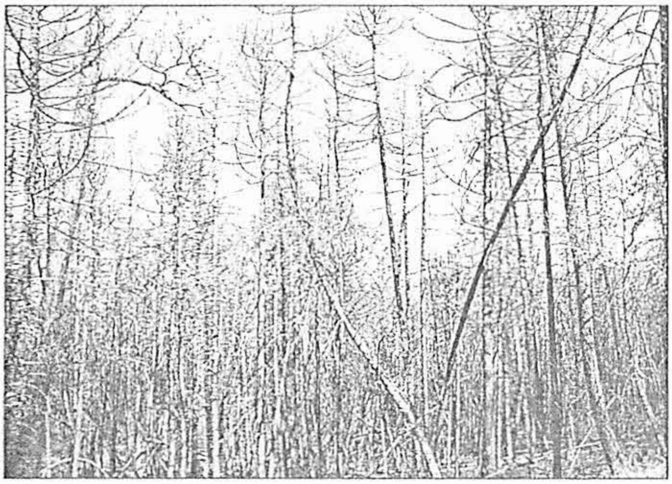

Figure 2. Douglas-fir stands killed by Douglas-fir tussock moth, *O. pseudotsugata*.

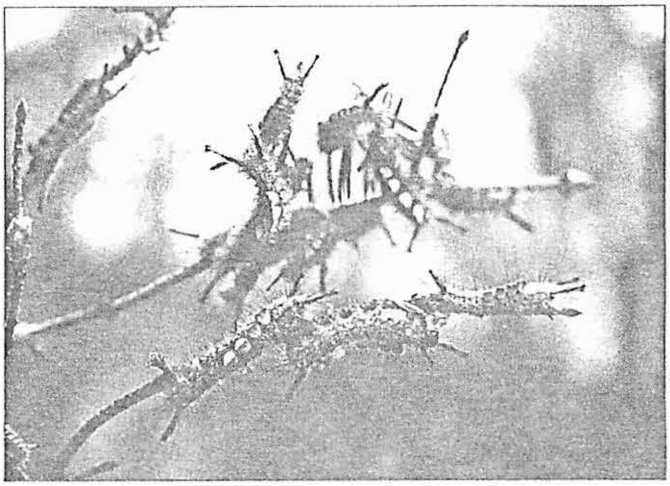

Figure 3. Mature Douglas-fir tussock moth, *O. pseudotsugata*, larvae.

and Beckwith 1978; Shepherd et al. 1984a). The egg is the overwintering stage. Eggs hatch just after bud flush from about late May to early June depending on temperature. The young larvae can feed only on new needles of the elongating shoots and can be dispersed by drifting on silken threads carried by wind. Older larvae (Fig. 3) will feed on old foliage if the current year's foliage is depleted. Partly consumed needles dry out and change color, giving a reddish brown appearance to infested trees. Males have five larval instars and females have six. Mature larvae pupate within cocoons in late July or August, usually on the underside of needles and branches; the pupal stage lasts about 2 weeks. At high population densities, cocoons may also be found at many other sites including tree trunks and fence posts.

Early Treatments

During infestations in the 1940s, 1950s, and 1960s, DDT was used operationally from the air to control the tussock moth in Idaho, Oregon, and California (Wickman et al. 1975). Later, Zectran® (carbaryl), Dursban® (organophosphate chloropyplim), and pyrethrin were tested as alternatives to DDT (Wickman et al. 1975; Lejeune 1975). In the early 1970s, a nuclear polyhedrosis virus and *Bacillus thuringiensis* (Bt) were successfully tested in small field plots in Oregon (Stelzer et al. 1975).

These early operational and experimental United States spray treatments were tested in Canada under experimental conditions and the results summarized by Lejeune (1975). Reduced dosages of DDT (0.57 kg/ha, 0.5 lb/acre) and malathion (1.12 kg/ha, 1.0 lb/acre) were tested from the air, each in 9.4 L/ha (1 U.S. gal/acre) of spray formulation, to minimize the undesirable side effects of DDT at the higher dosage (Lejeune 1975). A nuclear polyhedrosis virus was also successfully field-tested by hand spraying on individual trees (Morris 1963).

Operational Field Trials Against the Douglas-fir Tussock Moth in British Columbia, 1975 to 1982

The efficacy of five materials was tested for the control of Douglas-fir tussock moth during 1975 and 1976: acephate, Dimilin®, Bt, and two strains of the naturally occurring nuclear polyhedrosis virus (NPV). The multicapsid strain of NPV was tested in a water and molasses formulation in aerial and ground applications in 1981. In 1982, an oil and water formulation was compared with the molasses and water formulation and reduced dosages of the virus were also tested in oil formulation.

Chemical Insecticides

Acephate (Orthene®) (registered for control of other insect pests) and Dimilin® (not registered for any insects in Canada in 1975) were tested at various dosages of active ingredient in 1975 on 180 ha and acephate was used in operational trials on 8 490 ha in 1976. Acephate was applied at 1.12 kg in a volume of 9.4 L/ha experimentally in 1975 and in operational trials in 1976. Reduced rates of 0.56 and 0.84 kg in 9.4 L/ha were tested in 1976. Dimilin® was applied at 0.28 kg and 0.14 kg/ha. The insecticides were mixed in a 10% aqueous ethylene glycol formulation. The treatment was applied when 90% of the monitored egg masses had hatched and the larvae had moved out to feed on the new shoots. Nine plots, ca. 180 ha in size, were treated in 1975.

Acephate was effective in the operational trials at 1.12 kg/ha and experimentally at both 1.12 and 0.84 kg/ha, but did not provide adequate control at 0.56 kg/ha (Fig. 4). Its effect on tussock moth larvae was rapid and appeared to be complete by 7 days, with little mortality occurring after that time (Shepherd 1980). An experiment on the timing of acephate applications was also conducted on three plots with a total area of 60.7 ha. This application was made when 70% of the egg masses had hatched but the larvae had not necessarily left the egg masses to feed. Effectiveness of this early treatment was reduced because acephate has a short active life and larvae that hatched late because of cool weather escaped exposure.

Dimilin® acted more slowly than acephate but retained its effectiveness for a longer time. Dosages of 0.28 and 0.14 kg/ha gave almost complete mortality, but 0.07 and 0.035 kg/ha did not give acceptable results (Hard et al. 1978). Because of the faster action of acephate, tree defoliation was less (3.4%) than with Dimilin®, (11.9%), although the latter was still acceptable compared with two nontreated areas which suffered 73.7% and 90.8% defoliation. As a result of these trials, Orthene® (acephate) was registered for control of Douglas-fir tussock moth at 1.12 kg active ingredient in 3.8 L water/ha.

The results of the tests with carbaryl (Sevin®) are discussed in Chapter 56.

Bt Applications

A total of about 15 260 ha were treated operationally with two Bt products in 1975; Dipel®-SC and Thuricide®-HPC were applied in the Kamloops Forest District in British Columbia using a Cessna AgTruck aircraft equipped with Micronair® AU3000 atomizers. About 8 620 ha were treated with 17.0 billion international units (BIU)/ha of 60% Dipel-SC® mixed with 30% sorbitol and 10% water by volume and applied at 3.6 L/ha. A single application was made over 6 694 ha and double applications were made on 5 245 ha. The remaining 3 320 ha were treated with 17.0 BIU/ha of 80% Thuricide®-HPC mixed with 20% water by volume and applied at 4.7 L/ha. A separate test was made with two applications of Thuricide® for comparison and double and single applications of Thuricide® were also compared. A single application of Thuricide® was made on 3 035 ha and a double application on 283 ha. In 1976, Thuricide® was used operationally along streams and acephate was utilized on the upland sites.

The results of the 1975–76 Bt trials were disappointing; foliage protection and early larval mortality were inconsistent and unacceptably low. Larval mortality in the operational trial spray blocks 21 days after the spray averaged 34% (range: 13% to 57%) (Fig. 5). Larval mortality was determined by counting the number of larvae per unit of branch area on two midcrown branches from 15 to 25 sample trees per plot. Mortality attributed to treatment was calculated from the difference in survival between treated and untreated plots (Shepherd 1980). A double application of both materials and the higher volume of Thuricide® gave 20% better control than a single application of 4.7 L/ha (Shepherd 1980). Satisfactory levels of control in the operational program were not achieved until 35 days after spraying and then only in plots that received double applications. Experiments on increased volumes, concentrations, formulations, and different products indicated that Thuricide® was superior to Dipel®, and molasses was a better additive than sorbitol, but none of the trials resulted in satisfactory foliage protection of the trees.

Virus Applications

The use of virus for control of Douglas-fir tussock moth was considered as early as 1962 in British Columbia (Morris 1963), but it was not until 1975 that a large-scale aerial spray

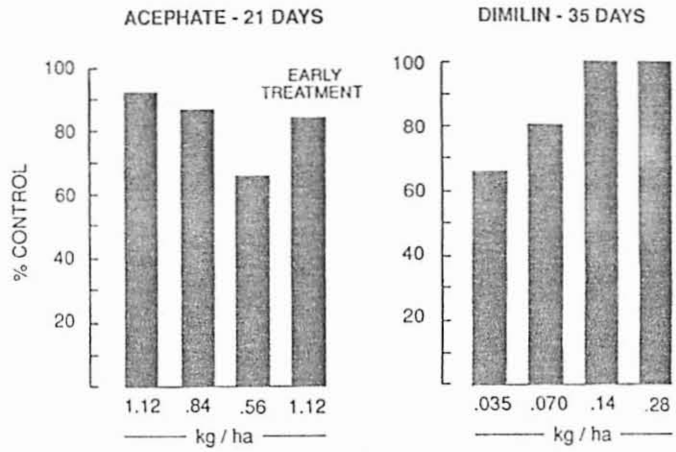

Figure 4. Effectiveness of different concentrations of acephate and Dimilin® and an early treatment using acephate.

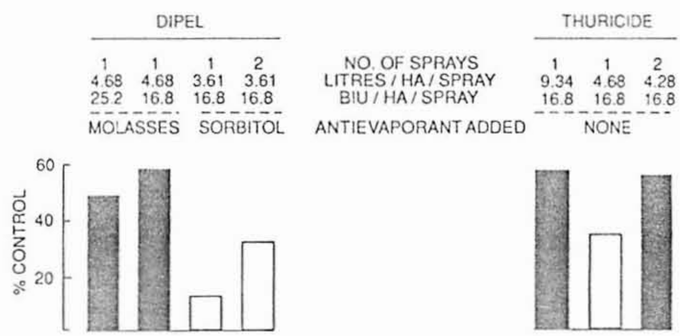

Figure 5. Effectiveness of aerial application of different formulations of Bt against the Douglas-fir tussock moth, *O. pseudotsugata*.

trial was conducted jointly by the British Columbia Forest Service, Forestry Canada, and the United States Forest Service in British Columbia (Stelzer et al, 1977; Shepherd 1980; Cunningham and Shepherd 1984). Three virus stocks were applied aerially to 13 plots with a total area of about 1 062 ha. Two of the stocks were propagated from the multicapsid strain of virus isolated from the Douglas-fir tussock moth in Oregon; one was propagated in the original host and the second in larvae of whitemarked tussock moth, *Orgyia leucostigma*. The third stock was the unicapsid strain of the virus isolated from and propagated in the whitemarked tussock moth from Nova Scotia. All three stocks were tested experimentally on a total of 72 ha at 18.7 L/ha, and in an operational trial on 990 ha at 9.4 L/ha. All three stocks of virus were applied at 2.5×10^{11} polyhedral inclusion bodies (PIB)/ha in an aqueous suspension containing 25% molasses or 50% Sandoz adjuvant V (v/v, concentration is expressed as percent volume over volume). Treatments were applied by Cessna AgTrucks and AgWagons equipped with booms fitted with Tee-jet® 8010 flat fan nozzle tips. Larvae were in the occurred sooner, about 2 weeks earlier, in the plots with higher larval densities, and the initial level of virus infection was higher in plots with higher larval densities. By the end of the larval development 100% mortality was recorded. The incidence of viral infection increased slowly over the first 4 weeks and an epizootic developed 5 weeks after treatment in the aerially treated plots. It was surprising to find naturally occurring virus in our check plots because this is not usually prevalent in new outbreaks. However, it could have been introduced by monitoring staff. These experiments showed that the virus can be introduced into a Douglas-fir tussock moth population at an early phase of the outbreak and a viral epizootic can be initiated both by aerial and ground treatment.

In a study of horizontal virus transmission, a line of 15 scattered trees was treated by ground spray and both the treated and the intermediate trees were monitored. Parallel lines of trees at 50 m on either side and one at 100 m on one side were also sampled to investigate spread of the virus. No spray drift was detected on Kromekote® cards placed between the treated line of trees and lines of trees used to detect spread. A line of check trees was located 200 m from the treated trees. Except for the post-spray on the intermediate trees at week 7, the incidence of virus infection in the larvae, collected from the sample trees, followed the expected pattern of spread from an infection source (Shepherd et al. 1984b). Infection appeared to decrease with distance from the treated trees. Thus, treatment of Douglas-fir tussock moth infestations with widely spaced swaths, every 100 to 200 m, may be sufficient to initiate epizootics and protect infested trees.

Virus-killed larvae were not observed in the ground-sprayed plots in the field until 5 to 8 weeks after spraying. Thus, feeding damage continued for most of the larval period and little foliage protection due to treatment could be detected either in ground-treated plots or the aerially treated plots. This indicates that a virus application is most useful when applied early in the outbreak cycle, preferably in the year before significant defoliation takes place, so that infested stands can tolerate defoliation until the treatment takes effects.

In 1981, aqueous tank mixes with 25% molasses (v/v) were used. This mix was widely used in previous tests both in Canada and the United States, but with the low relative humidity in the interior of British Columbia, spray deposits have often been poor. In 1982, the second year of the tussock moth outbreak, Virtuss® was applied in two different tank mixes at another location (Veasy Lake). In an aqueous mix the recommended (label) dosage (2.5×10^{11} PIB/ha) of virus was applied, while in oil mixes (25% Dipel blank carrier vehicle and 75% water) the virus was applied at the recommended dosage as well as at one-third and one-sixteenth of that recommended dosage. Each of these treatments was applied to a 10-ha plot with a fixed-wing aircraft when most larvae were in the first instar. The aircraft was equipped with a boom and Tee-jet® 8005 nozzles calibrated to deliver 9.4 L/ha (Otvos et al. 1987a).

Applications of Virtuss® in the oil mix resulted in population reductions at 6 weeks post-spray which increased with dosage. The full dosage (2.5×10^{11} PIB/ha) resulted in a 95% population reduction; one-third of this gave 91% and one-sixteenth resulted in a 65% reduction. The full dosage of the aqueous mix with molasses reduced the population by 87% (Table 1).

Surveys conducted in the fall of 1982 showed that egg-mass densities in all treated plots were reduced from their spring outbreak values to endemic values or below, while in two of the check plots egg-mass densities remained about the same and doubled in the third. The Virtuss® treatments prevented significant tree mortality in the treated plots. One year after application, less than 1% of sample trees died in the treated plots and 38% died in the check plots. In 1984, two years after the virus application, no tussock moth larvae were

Table 1. Population densities of Douglas-fir tussock moth (*O. pseudotsugata*) larvae and proportion of dead sample trees in plots treated in 1982 with Virtuss® and in matching check plots at Veasy Lake, British Columbia.

Plot no.	Treatment[a] PIB/ha	1982 Pre-spray larval/m^2	% Larval population reduction[b] 1982	% Sample trees killed by Douglas-fir tussock moth 1983	1984
T1	1.6×10^{10}-O	182.8	64.7	0	0
T2	8.3×10^{10}-O	145.8	90.6	2	7
T3	2.5×10^{11}-O	302.0	95.1	0	4
T4	2.5×10^{11}-M	41.8	86.6	0	0
				$\bar{x}^c$ 0.6	2.8
C1	Check	197.5		53	60
C2	Check	136.9		cut for powerline	
C3	Check	360.6		60	62
C4	Check	81.2		0	0
				$\bar{x}$ 37.8	40.7

[a]Treatment: PIB/ha = polyhedral inclusion bodies/hectare; O = oil formulation; M = molasses formulation.
[b]% Reduction was calculated by a modified Abbott's formula (Fleming and Retnakaran 1985).
[c]$\bar{x}$ = Average for the four plots.

second and third instar at the time of application, and most of the current year's foliage had already been destroyed.

All of the virus treatments resulted in high infection and high larval mortality; no significant differences could be detected between strains or formulations. Larval population reductions in the treated plots ranged from 71% to 93%, 68% to 95%, and 84% to 99% at 21, 28, and 35 days post-spray, respectively. The corresponding larval mortality in the check plots averaged 68%, 76%, and 84%. These population reductions were associated with high levels of naturally occurring virus infection enhanced by the spray application in the treated plots. The high mortality in the check plots was caused by naturally occurring virus; over 50% of the larvae in the check plots were naturally infected 35 days after the date of spraying. This was expected as the outbreak was in its declining phase in that area. Only light defoliation, 11% to 14% of the older foliage, occurred on all but one of the treated plots where spray deposit, measured on Kromekote® cards placed 30 cm above ground level, was poor due to adverse weather during treatment. In contrast, defoliation of the older foliage in the check plots averaged 60%. No egg masses were found in the treated plots, while egg masses were common in the check plots and adjacent untreated areas.

Figure 6. Helicopter spraying against Douglas-fir tussock moth, *O. pseudotsugata*, 1981.

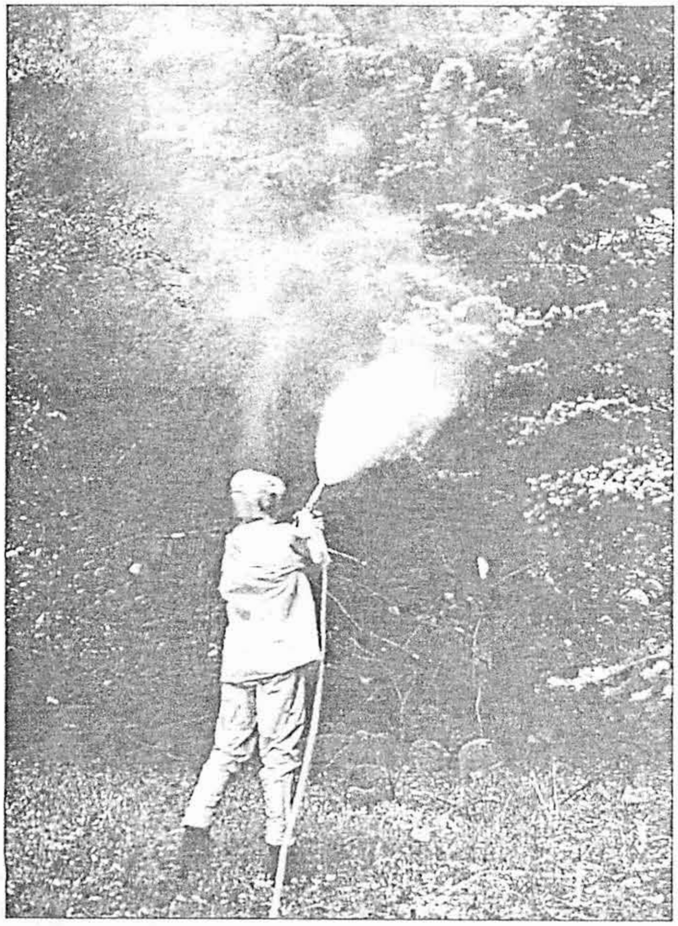

Figure 7. Ground spraying against Douglas-fir tussock moth, *O. pseudotsugata*, 1981.

The results of the 1975 virus trials were promising, but because the treatments were applied in the declining phase of the outbreak the effect of the application on the course of the outbreak could not be evaluated. Following these tests, the multicapsid virus isolated from and produced in Douglas-fir tussock moth larvae was registered by the Environmental Protection Agency in the United States in 1976 under the name TM BioControl-1. The same virus produced in whitemarked tussock moth received temporary registration in Canada in 1983 and full registration in 1987 under the name Virtuss®. TM BioControl-1 was also granted Canadian registration in 1987.

Another Douglas-fir tussock moth population buildup started in 1980 in the Hedley area in southern British Columbia where a previous outbreak had collapsed in 1963. This provided an opportunity to test whether a virus epizootic could be initiated artificially at an early phase of an outbreak before a natural epizootic might occur and before significant tree damage occurred. In 1981, four plots, totalling 20 ha, with moderate to light Douglas-fir tussock moth population densities were aerially sprayed with NPV (Virtuss®) using a helicopter equipped with an 11-m-long boom and nine flat fan nozzles (Tee-jet® 8010); a dosage of 2.2×10^{11} PIB/ha when 60% of the larvae were in the first instar and 40% in the second (Fig. 6) was applied. The aqueous virus suspension, containing 25% molasses, was applied at 11.3 L/ha. Spray deposit, measured on Kromekote® cards, in the four aerially treated plots was poor with 8.4, 8.1, 5.1, and 2.1 droplets/cm^2 (Shepherd et al. 1984b). In addition to the aerial spray trials, trees in two additional plots were sprayed from the ground with a modified orchard-type hydraulic sprayer applying 4.5 L of aqueous suspension/tree (containing 2.4×10^{10} PIB/ha with 25% molasses, v/v) (Fig. 7). An assessment of virus spread was made in one of the ground-treated plots.

An epizootic occurred both in the aerially and ground-treated plots, even at population densities as low as about 40 larvae/m^2 of foliage. Douglas-fir tussock moth populations were reduced and no egg masses were found in any of the treated plots. The occurrence of an epizootic appeared to be inversely related to initial population density; the epizootic found in any of the treated or check plots. Tree recovery, in terms of new foliage production, was good in the treated plots. The number of trees killed increased slightly from the previous year, both in the treated and the check plots (Table 1). Tree recovery continued in 1985 and no additional tree mortality occurred that could be attributed to Douglas-fir tussock moth (Otvos et al. 1987b). It is now considered feasible, as a result of these trials, to reduce the recommended dosage of NPV from 2.5×10^{11} to 8.3×10^{10} PIB/ha and to use either the aqueous or emulsifiable oil formulation for virus applications.

The results of the experiments with NPV over the past few years indicate that the development of Douglas-fir tussock moth outbreaks may be prevented by the application of virus at the beginning of the outbreak. Foliage protection may be poor in the year of application, but will be substantial in the following years. Virus application at reduced dosages makes it economically more acceptable and gives forest managers a viable alternative to the use of chemical insecticides. The cost of virus application may be further reduced by spraying widely spaced swaths, giving only partial coverage of the infested stands. Both the reduced virus dosage and widely spaced swaths will be tested during the next Douglas-fir tussock moth outbreak in British Columbia.

References

Alfaro, R.I.; Taylor, S.P.; Wegwitz, E.; Brown, R.G. 1987. Douglas-fir tussock moth damage in British Columbia. For. Chron. 63: 351-355.

Cunningham, J.C.; Shepherd, R.F. 1984. *Orgyia pseudotsugata* (McDunnough), Douglas-fir tussock moth (Lepidoptera: Lymantriidae). Pages 363-367 *in* J.S. Kelleher and M.A. Hulme (Eds.), Biological Control Programmes against Insects and Weeds in Canada, 1969-1980. Commonw. Agric. Bureaux, Slough, U.K.

Dahlsten, D.L.; Thomas, G.M. 1969. A nucleopolyhedrosis virus in populations of the Douglas-fir tussock moth, *Hemerocampa pseudotsugata*, in California. J. Invertebr. Pathol. 13: 264-271.

Fleming, R.; Retnakaran A. 1985. Evaluating single treatment data using Abbott's formula with reference to insecticides. J. Econ. Entomol. 78: 1179-1181.

Hard, J.S.; Ward, J.D.; Ilnytzky, S.I. 1978. Control of Douglas-fir tussock moth by aerially applied Dimilin (TH6040). USDA For. Serv., Pac. Southw. For. Range Exp. Stn., Res. Paper PSW-130, 6 pp.

Harris, J.W.E.; Dawson, A.F.; Brown, R.G. 1985. The Douglas-fir tussock moth in British Columbia, 1916-1984. Can. For. Serv., Pac. For. Cent., Inf. Rep. BC-X-268, 16 pp.

Hughes, K.M.; Addison, R.B. 1970. Two nuclear polyhedrosis viruses of the Douglas-fir tussock moth. J. Invert. Pathol. 16: 196-204.

Lejeune, R.R. 1975. Douglas-fir tussock moth. Pages 206-207 *in* M.L. Prebble (Ed.), Aerial control of forest insects in Canada. Environ. Can. Cat. No. F023/19/1975.

Mason, R.R.; Luck, R.L. 1978. Population growth and regulation. Pages 41-47 *in* M.H. Brookes, R.W. Stark, and R.W. Campbell (Eds.), The Douglas-fir Tussock Moth: A Synthesis. U.S.D.A. For. Serv. Tech. Bull. 1585.

Morris, O.N. 1963. The natural and artificial control of the Douglas-fir tussock moth. *Orgyia pseudotsugata* (McDunnough), by a nuclear polyhedrosis virus. J. Insect Pathol. 5: 401-414.

Otvos, I.S.; Cunningham J.C.; Friskie, L.M. 1987a. Aerial application of nuclear polyhedrosis virus against Douglas-fir tussock moth, *Orgyia pseudotsugata* (McDunnough) (Lepidoptera: Lymantriidae): I. Impact in the year of application. Can. Entomol. 119: 697-706.

Otvos, I.S.; Cunningham, J.C.; Alfaro, R.I. 1987b. Aerial application of nuclear polyhedrosis virus against Douglas-fir tussock moth, *Orgyia pseudotsugata* (McDunnough) (Lepidoptera: Lymantriidae): II. Impact 1 and 2 years after application. Can. Entomol. 119: 707-715.

Shepherd, R.F. (Ed.). 1980. Operational field trials against the Douglas-fir tussock moth with chemical and biological insecticides. Can. For. Serv., Pac. For. Res. Cent. Inf. Rep. BC-X-201. 19 pp.

Shepherd, R.F.; Otvos, I.S. 1986. Pest management of Douglas-fir tussock moth: procedures for insect monitoring problem evaluation and control actions. Can. For. Serv., Pac. For. Cent., Inf. Rep. BC-X-270, 14 pp.

Shepherd, R.F.; Otvos, I.S.; Chorney, R.J. 1984a. Pest management of Douglas-fir tussock moth (Lepidopetera: Lymantriidae): sampling method to determine egg-mass density. Can. Entomol. 116: 1041-1049.

Shepherd, R.F.; Otvos, I.S.; Chorney, R.J.; Cunningham, J.C. 1984b. Pest management of Douglas-fir tussock moth (Lepidoptera: Lymantriidae): prevention of a Douglas-fir tussock moth outbreak through early treatment with a nuclear polyhedrosis virus by ground and aerial applications. Can. Entomol. 116: 1533-1542.

Stelzer, M.J.; Neisess, J.; Thompson, C.G. 1975. Aerial application of a nuclear polyhedrosis virus and *Bacillus thuringiensis* against the Douglas-fir tussock moth. J. Econ. Entomol. 68: 269-272.

Stelzer, M.J.; Neisess J., Cunningham, J.C.; McPhee, J.R. 1977. Field evaluation of baculovirus stocks against Douglas-fir tussock moth in British Columbia. J. Econ. Entomol. 70: 243-246.

Wickman, B.E. 1978. Tree mortality and top kill related to defoliation by the Douglas-fir tussock moth in the Blue Mountains outbreak. U.S.D.A. For. Serv. Res. Pap. PNW-206. 13 pp.

Wickman, B.E.; Beckwith, R.C. 1978. Life history and habits. Pages 30-37 *in* M.H. Brookes, R.W. Stark and R.W. Campbell (Eds.), The Douglas-fir Tussock Moth: A Synthesis. U.S.D.A. For. Serv. Tech. Bull. 1585.

Wickman, B.E.; Mason, R.R.; Thompson, C.G. 1975. Major outbreaks of the Douglas-fir tussock moth in Oregon and California. USDA For. Serv. Gen. Tech. Rep. PNW-5. 18 p.

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