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SOILS

Influence of Lime Incorporated in Soil Mix on Growth of Douglas-fir.—Production of containerized seedlings for experimental field planting began at the Pacific Forest Research Centre in 1967 and has expanded to the present British Columbia Forest Service (BCFS) operational production of 25 million seedlings a year. Since the inception of this program, dolomite lime has been incorporated in the soil mix to adjust the pH to about 5, the optimal value for Douglas-fir (Van den Driessche, B.C. Forest Serv. Res. Notes 48, 1969), and to provide an available source of calcium and magnesium. The soil mix, a 3 peat:1 vermiculite V/V (Matthews, Can. For. Serv. Inf. Rep. BC-X-58, 1971) mixture, initially contained 5 kg dolomite lime (12 mesh and finer) (Matthews 1971) per cubic meter of mix. This quantity of dolomite lime was later reduced to 3 kg per cubic meter of mix.

In the normal production of seedlings, chlorosis occasionally develops. To overcome this, biweekly applications of ferrous sulfate, to supplement iron supplied by hi-sol fertilizers, have become part of the normal production schedule. Because this apparent iron chlorosis is speculated to be lime-induced and because some other agencies are not using lime to adjust the pH of the soil mix, there has been some discussion as to the need for continuing the lime incorporation.

The study described here was undertaken to evaluate the need for continuing lime incorporation in the soil mix. In the spring of 1973, we compared the growth of Douglas-fir, using three different levels of dolomite lime (0, 3, and 5 kg/m^3) in the standard 3 peat:1 vermiculite soil mix and associated with the two different fertilizer schedules shown in Table 1.

For this experiment, the peat was shredded sphagnum (Sunshine^R) and the vermiculite was horticultural grade. Seedlings were watered between fertilizer applications as required. The water had a pH of 7.0 and a conductivity of 25 micromhos. All treatment combinations were replicated four times. An individual replicate was one-quarter (48 cavities) of the "Styroblock 2" container (Matthews 1971). Containers were seeded April 15, 1975, with stratified Douglas-fir seed (BCFS seedlot #315, 460 m elevation) and kept in the greenhouse at 20° C for 1 week before being moved to the shadehouse for the remainder of the experiment. Final sampling began in early November 1975. To reduce the edge effect in each "quarter block," only the 20 central cavities were extracted and measured. Measurements on these 20 plants from each replicate included stem diameter (at cotyledon), height (from cotyledons to tip plus 2.5 cm), and top, root, and total dry weight (48 h at 70° C).

TABLE 1

Seedling fertilization schedule

FERTILIZER 1	Week 1 - 3	- Water as required
	Week 4	- 28:14:14* at a concentration of 78 mg/l twice weekly (21.7, 4.7, 9)
	Week 5 - 29	- 28:14:14* at a concentration of 156 mg/l twice weekly (43.5, 9.5, 18)
FERTILIZER 2	Week 1 - 3	- Water as required
	Week 4	- 10:52:10** at a concentration of 625 mg/l twice weekly (62, 141, 52)
	Week 5 - 13	- 20:20:20** at a concentration of 500 mg/l twice weekly (100, 44, 82)
	Week 7	- $FeSO_4$ (anhydrous) at a concentration of 13.6 mg/l was applied at 2-week intervals to experiment termination
	Week 14 - 29	- 10:52:10** at a concentration of 625 mg/l twice weekly (62, 141, 52)

*Plant Products Ltd., Port Credit, Ont.
**Green Valley Fertilizer and Chemical Co., Surrey, B.C.

The figures in brackets are Nitrogen (N), Phosphorus (P) and Potassium (K), respectively, in parts per million.

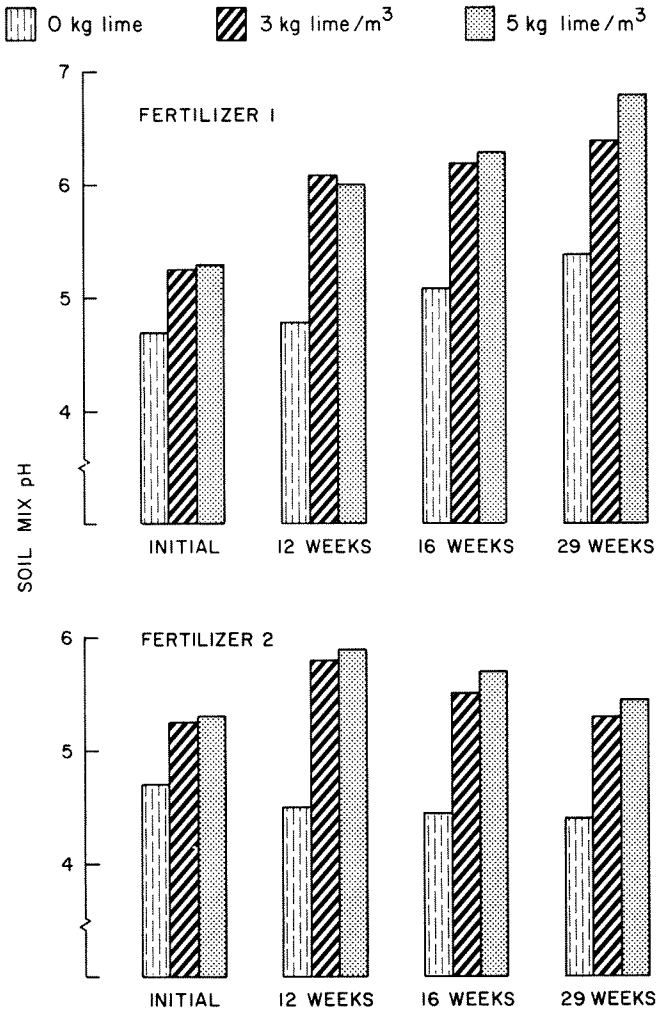

Figure 1. Soil mix pH fluctuations over 29-week production cycle.

The two fertilizers had different effects on the soil mix pH (Fig. 1). Fertilizer 1 and no lime resulted in a gradual increase in pH throughout the season, while fertilizer 2 and no lime produced a slight decline in soil pH in the first 12 weeks, with little or no change observed for the remainder of the experimental period. The differences observed in soil mix pH are probably due to differences in the fertilizer composition. Fertilizer 1 supplies 70% of the nitrogen as urea which, on hydrolysis, yields alkaline products (NH_3 and CO_2). In contrast, with fertilizer 2, 30% of the nitrogen is supplied as urea in the first 13 weeks and none in this form for the remaining 16 weeks. In both instances, however, the no-lime soil mix remained within the desired pH range (4-6) for Douglas-fir growth. As expected, the 5 kg lime incorporation produced a soil mix with the highest pH and, combined with fertilizer 1, it reached pH 6.8 before the end of the growing season, while fertilizer 2 and 5 kg lime increased the pH to 5.9 after 12 weeks and then declined throughout the remainder of the experiment.

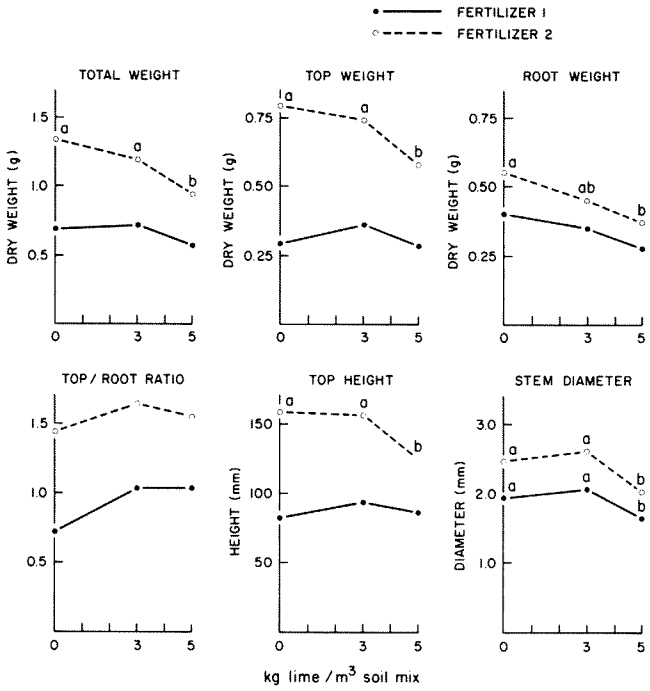

Figure 2. Growth of Douglas-fir seedlings after 29 weeks on three different soil mixes. (Values followed by different letters are significantly different [P=0.05].)

Chlorosis was noted by the end of May (in about 6 weeks) in all treatments receiving lime. The most severe cases were associated with the 5 kg lime application, while the 3 kg lime treatment appeared to have a reduced effect. The final effect of the lime additions on seedling growth for these fertilizers is presented in Fig. 2. With no lime additions to the soil mix, the seedlings produced with fertilizer 2 (present BCFS operational schedule) were nearly twice (1.9 times) as large as those produced with fertilizer 1. With increasing lime additions to the soil mix and fertilizer 2, there was a decrease in total, top, and root dry weights. This growth reduction was statistically significant (P=0.05) only for the 5 kg lime treatment. A similar effect was recorded for height and stem diameter measurements. With the exception of stem diameter, where there was a significant (P=0.05) reduction in size, the differences noted with fertilizer 1 were not significant, although the same general trend as for fertilizer 2 was observed. No significant effects were detected for top-root ratios, although the no-lime treatment produced the smallest ratio.

These observations and those reported by Smilde (Plant Soil 39:131-138, 1973) of a negative response of Douglas-fir shoot dry weight to added lime suggest that the practice of incorporating dolomite lime in the container nursery soil mix should be discontinued. These results further suggest that additional, more detailed experimentation on lime addition and nutrient uptake interactions is required.—J.A. Dangerfield, Pacific Forest Research Centre, Victoria, B.C.

SILVICULTURE

Performance in a Progeny Test of White Spruce Seedlings Produced by Accelerated Growth.—This report describes the height growth of 17 white spruce progenies from a superior seed source (Beachburg, Ont.) in which 1-year-old seedlings produced by accelerated growth were used. Details of the technique and height growth 18 weeks and 25 weeks after sowing were previously reported (Pollard and Teich, Bi-mon. Res. Notes 28:19-20, 1972). In brief, seedlings were grown under 16-h daylength at 22 ± 2° C and fed 3X daily with nutrient solution. Seedlings suitable for field planting can be produced by this method within a year.

TABLE 1

Seed weight and juvenile growth of white spruce progenies from Beachburg, Ont., arranged in descending order according to total height

Progeny seedlot no.	1,000-seed weight (g)	25-week ht (cm)	Height increment (cm) 1975	1976	Survival (%)	Total ht (cm) 1976
70061	2.46	26.6	22	20	95	107.1
70059	3.12	26.8	22	20	100	98.7
70066	3.37	25.3	21	19	70	98.1
70073	3.14	20.9	25	21	97	97.8
70071	2.53	19.0	23	21	86	94.5
70069	2.43	24.3	21	19	83	93.6
70060	2.83	21.3	22	19	83	93.2
70056	2.40	22.7	21	16	93	91.5
70072	2.36	24.5	19	16	81	90.0
70067	2.50	21.1	20	18	82	88.9
70057	2.90	22.7	21	19	83	88.3
70063	2.63	16.9	20	15	100	87.5
70068	2.38	21.4	20	19	90	87.4
70062	2.36	19.9	20	18	88	86.3
70070	2.00	19.2	19	16	90	84.9
70058	2.42	21.6	15	15	83	75.8
70055	2.35	19.5	15	18	87	73.4
Mean	2.60	22.0	20	18	87	90.4
LSD (0.05)		3.8	4.9	4.4		15.5

TABLE 2

Correlation coefficients among seed weight and juvenile growth of white spruce progenies (r = 0.48 required for significance at P = 0.05)

	Height 1975	Height Increment 1976	25-week ht	1,000-seed wt
Total height, 1976	0.87	0.76	0.59	0.49
Height increment, 1975		0.85	0.29	0.54
Height increment, 1976			0.42	0.49
25-week height				0.37

A field test was established in the spring of 1972. The experimental design was a randomized complete block with six replications of five-tree plots spaced 1.8 x 1.8 m. Seedlings of a few progenies were insufficient to fill all replications; 2 + 2 Norway spruce were used as filling plants. Total height and height increment during the 1975 and 1976 growing seasons were recorded in 1976.

There were considerable differences in total height among progenies (Table 1). The fact that the tallest was 47% taller than the smallest indicated potential for within-provenance selection. Correlation between 25-week height and final total height was significant (Table 2). The three tallest progenies at week 25 were still the tallest in 1976 (Table 1). However, considerable rank changes occurred among others: progenies 71 and 73 jumped from the 17th and 12th to the 5th and 4th rank respectively. These two progenies also had the greatest height increment during the 1975 and 1976 growing seasons and may eventually outgrow the others.

The correlation between seed weight and height growth was significant except at week 25 (Table 2). The three progenies with heaviest seed ranked 2, 3, and 4 in height in 1976, but the tallest progeny had below-average seed weight (Table 1). The extent of seed weight influence on juvenile growth needs to be further investigated.

Comparison between seedlings produced by accelerated growth and conventional methods cannot be made because the latter were not included in the test. However, there was no evidence of negative effect of accelerated growth on either survival or height growth. This growth-acceleration technique has potential for more efficient production of experimental stock.—C.C. Ying and D.F.W. Pollard, Petawawa Forest Experiment Station, Chalk River, Ont.

PATHOLOGY

Phomopsis Blight of Eastern White Cedar in Newfoundland.—Eastern or northern white cedar, *Thuja occidentalis* L., is a native tree of central and eastern Canada. The species does not grow naturally in Newfoundland, but was introduced and is now a common ornamental tree on the Island.

Phomopsis blight, caused by *Phomopsis juniperovora* Hahn, has been a devastating disease of juvenile junipers for more than 70 years in nurseries in the United States (Peterson and Hodges, USDA Forest Serv. Forest Pest Leafl. 154, 6 pp., 1975). In Canada the disease has been reported from Ontario (Peterson, *in* Important Forest Insects and Diseases of Mutual Concern to Canada, the United States and Mexico, Can. Dep. For. Rural Dev. Publ. 1180:55-56, 1967) and British Columbia (Funk, Can. Plant Dis. Surv. 54(4):166-168, 1974). In the summer of 1976, blight and dieback symptoms were observed on 12-year-old ornamental trees of eastern white cedar in the Newfoundland Forest Research Centre Tree Nursery at Pasadena in western Newfoundland and in some home gardens in St. John's in eastern Newfoundland and Grand Falls in central Newfoundland. This article reports the distribution and severity of the disease on the Island. It also records the occurrence of other microfungi on some blighted shoots, and results of some investigations on the storage of diseased material and survival of the fungus.

Ornamental junipers (eastern white cedar; Sarawa false cypress, *Chamaecyparis pisifera* [Sieb. and Zucc.] Engl.; and an unidentified juniper, *Juniperus* species) growing in the Newfoundland Forest Research Centre Tree Nursery at Pasadena and in several home gardens at Grand Falls and St. John's were examined for the presence of the disease. Information on the symptoms and data on the incidence and intensity of the disease were obtained only at the Tree Nursery at Pasadena because of the low incidence of the disease and patchy distribution of the host tree at St. John's and Grand Falls. Juniper trees totalling 107 were examined and data were recorded on the number of infected live and infected dead trees; the number of trees with main stem, branches, or both infected; the number of trees with infected stem less than or more than 2 cm in diameter; and the proportion of the tree crown damaged (with dead, browned, or leafless branches). Percent infected trees, stems, and branches and percent crown damaged were calculated. Small yellowish spots on needles, the reddish brown to ashen gray of infected branches, lesions and cankers on branches, whitish tendrils of spores, and two types of spores were the diagnostic features. The identity of *P. juniperovora* was confirmed by the characteristic yellow coloration, bright orange-red crystals, and two types (A and B) of spores produced by the fungus on potato dextrose agar and on 2% malt agar.

The Phomopsis blight was found only on eastern white cedar and appears to be scattered across the Island. The data showed that 37% of the trees were infected and that average crown damage was 20% (range from less than 1% to 45%). No tree mortality was observed. In most cases the infection was restricted to branches. Stem infections were few (stem infection alone 6%, stem and branch infection 24%, and branch infection alone 70%) and affected only stems less than 2 cm in diameter.

Other microfungi isolated from the blighted twigs of the host species included *Alternaria tenuis* Nees (saprophyte), *Colletotrichum* species (unknown status), *Cytospora abietis* Sacc. (probably saprophyte or facultative parasite on weakened trees), *Fusarium* spp. (unknown status), *Micropera* species (unknown status), *Pestalotia thujae* Swada (probably saprophyte), *Rhizopus nigricans* Ehrenberg (saprophyte). Funk (1974) also isolated a *Micropera* species from the dead twigs of eastern white cedar infected with *P. juniperovora* and *Cytospora abietis* Sacc., and *Pestalotia thujae* Swada from the dead twigs (induced by dieback) of yellow cedar, *Chamaecyparis nootkatensis* (D. Don) Spach.

Investigations on the storage of the diseased material and the survival of Phomopsis have revealed that infected dead branches, stored for 10 months at a laboratory temperature of 22°C, contained and produced viable mycelium and spores. About 77% of these spores germinated after an incubation of 24 h at 20°C (Scheld and Kelman, Plant Dis. Rep. 47 [10]:932-935, 1963). However, the spores obtained from a material stored in a freezer chamber (-20°C) and in a refrigerator (4° - 5°C) showed an average percent germination of 15 and 70, respectively. Although no data were collected, it was observed that the germ tubes produced from the material stored at 22°C and 4° to 5°C were conspicuously longer than those produced from the spores obtained from the material stored at -20°C. Peterson and Hodges (1975) reported that mycelium of *P. juniperovora* can persist for a period of 2 years in dead parts of infected plants and produce spores, but they did not indicate the temperature which the fungus can survive.

In the present investigations cankers and girdling were found only on a few stems and those of less than 2 cm in diameter. Peterson and Smith (USDA Forest Serv. Agric. Handb. 470, 125 pp., 1975) also reported that stems of 1- and 2-year-old seedlings and those less than 1.3 cm in diameter are frequently girdled, perhaps because the causal fungus does not spread far below the girdling cankers in the older stocks. This may explain why there was no tree mortality in the Pasadena nursery although extensive infections were observed on some tree crowns: the trees were 12 years old and their main stems in most cases were more than 2 cm in diameter.

This is the first record of the disease in Newfoundland and it has been observed only at three widely separated locations on the Island. It would appear that there was more than one source of infection. Funk (1974) remarked that sporadic occurrence of such diseases of forest and ornamental trees are completely unpredictable and that sometimes they do have a serious impact on the development and growth of trees. At present this disease does not cause any tree mortality, but the infected trees do appear unsightly because of numerous dead twigs and discolored foliage. Since the pathogen is known to persist for periods of up to 24 months as mycelium and conidia in the infected tissues, and since it can also spread from shoot to shoot and seedling to seedling through watering of bundled seedlings during transit, I suggest that special care must be taken in introducing seedlings of this and the other host species susceptible to the fungus.—Pritam Singh, Newfoundland Forest Research Centre, St. John's, Nfld.

ENTOMOLOGY

Predation by *Formica lugubris* (Hymenoptera: Formicidae) on *Choristoneura fumiferana* (Lepidoptera: Tortricidae).—*Formica lugubris* Zett. is a predacious red wood ant successfully introduced to Quebec from central Europe as a desirable control agent of forest pests in 1971 (Finnegan, Can. Entomol. 107:1271-1274, 1975). Since its release in a forested area at Valcartier, about 25 km north of Quebec City, the ant colony has steadily increased in size. In 1975, the colony consisted of six nests, two of which measured more than 125 cm in height and the smallest about 50 cm in height, contained within an area of about 2 ha. The stand in which the ants are located is of mixed composition, containing about 53% red pine (*Pinus resinosa* Ait.), 27% white pine (*P. strobus* L.), 12% balsam fir (*Abies balsamea* [L.] Mill.), 7% white spruce (*Picea glauca* [Moench] Voss), and 1% larch (*Larix laricina* [Du Roi] K. Koch).

The spruce budworm (*Choristoneura fumiferana* [Clem.]), which has been increasing in Quebec since 1966, now occurs epidemically over much of the province. In the Valcartier area, the first trace was noticed only in 1973, but during the following years there was heavy defoliation of fir and spruce in the area. Since this was the first occasion for *F. lugubris* to prey actively on populations of the budworm, the results were followed closely during the months of June and July of 1974 and 1975.

Preliminary tests carried out in the laboratory in 1972 indicated that *F. lugubris* was highly aggressive in searching for and attacking fourth-, fifth-, and sixth-instar larvae, as well as pupae and adults of the spruce budworm, but because young larvae are concealed in the foliage, predation had been light on the first three instars.

The same behavior was observed in the field. The number and type of prey brought to one large, centrally located nest (measuring 95 cm in height and 190 cm in diameter at the base) were counted during the last week of June 1974.

The total daily predation was estimated by counting the number of insects brought to the nest along three representative trails and adjusting for the total (seven trails). Observations were made 10 min each hour from 9 a.m. until 4 p.m., and 1-min observations at night (every 10 min for 1 h) at 11 p.m. and 3 a.m. About 65% of the prey

brought to the nest was *C. fumiferana* (2% adults and 63% late-instar larvae), while 35% were other insects. The average estimated number of *C. fumiferana* larvae brought to the nest per hour on each trail was 97, for a total of about 8,100 larvae for the whole nest (seven trails) for the 12 daylight hours. Activity at night was found to be about 42% that of daytime, for a predation of about 3,400 larvae. The estimated total for one nest for 1 day was, therefore, about 11,500 larvae.

Since the foregoing method gave a rough estimate, and was subject to important variables such as weather and the attitudes of observers, a second method of evaluating the effect of *F. lugubris* predation was used. It consisted in comparing the amount of defoliation incurred in infested trees in the area around the ant nests, with the amount in infested trees immediately outside this area. The degree of defoliation was determined by using the method employed by the Quebec Department of Lands and Forests in their spruce budworm spray operations.

It was found in 1974 that trees in the vicinity of the nest had suffered 30.9% defoliation; in the control area defoliation was 42.5%. Similar measurements made during the summer of 1975 showed a defoliation of 42.8% in the area around the nests and 63.1% in the control area. These observations indicate that *F. lugubris* is an important predator of the spruce budworm, capable of reducing the damage caused by as much as 20% during the early years of infestation. However, owing to the inundation of the area frequented by the ants by massive flights of fecund budworm females originating from distant epicenters, the ant population was not capable of surmounting or controlling the infestation. However, it would appear that *F. lugubris* can be an important control factor at endemic population levels or during the initial phase of a developing outbreak.—R.J. Finnegan, Laurentian Forest Research Centre, Sainte-Foy, Que.

A Relationship between the Timing of Budworm Larval Spraying and Subsequent Egg-mass Densities.—In an operational spray program against spruce budworm larvae, *Choristoneura fumiferana* (Clem.), the objective dictates the preferred time to spray. It is generally conceded that early-larval spraying maximizes foliage protection while late-larval spraying maximizes larval mortality. Webb (For. Chron. 31:342-352, 1955) noted about a 50% population reduction when third-instar larvae (L3) were sprayed compared with a rate of kill of about 90% when older larvae were sprayed at a later date.

An analysis of egg-mass densities recorded in sprayed areas of New Brunswick in recent years suggests that there might be an added bonus to late-larval spraying. Each year in August, egg masses are counted on about 1,000 plots in the province to predict budworm populations in the following year. We used these data to measure, on a broad geographical scale, the effect that larval sprays had on the egg deposition of surviving female moths. (It was recognized that the eggs found in many plots would be laid by both resident and invading females, but it was also assumed that the impact of invasion would decrease as the size of the sprayed area increased.) The egg-mass counts were classified according to the number of sprays applied and the larval development at the time of spray application. Larval development was estimated by transposing the actual spray date to accumulated heat units, by means of the appropriate heat-unit curve for the year, and then transposing the accumulated heat units to larval development, by means of the known

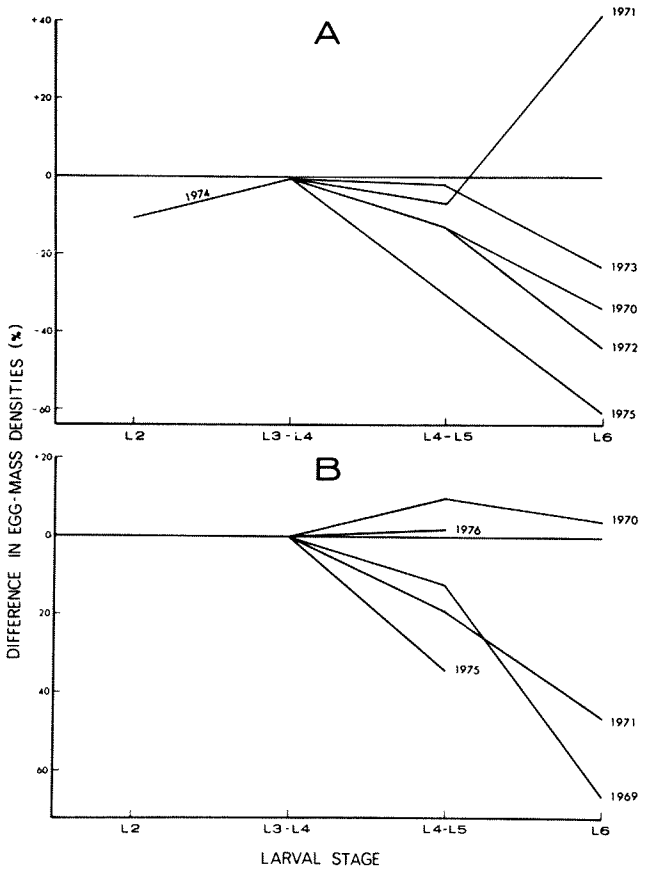

Figure 1. Differences (%) between egg-mass densities in areas sprayed at different times during the larval stage and densities in areas sprayed at L3-4. (A) Areas sprayed once. (B) Areas sprayed twice.

TABLE 1

Mean egg-mass densities in areas sprayed during different stages of larval development

	1969	1970	1971	1972	1973	1974	1975	1976
Number of applications	One Two	One Two	One Two	One	One	One	One Two	Two
Hectares sprayed (millions)	1.0	0.8 0.8	1.7 0.6	1.7	1.5	1.5	0.5 1.7	3.1
Larval development at time of treatment[a]	Mean egg-mass density/10 m²							
L2						563		
L3-L4	447	570 558	420 631	241	373	629	447 292	87
L4-L5	395	496 613	391 509	210	366		194	89
L6	154	377 567	598 341	140	288		175	

[a]In two application areas timing refers to first application.

relationship between these two variables (Miller et al., Bi-mon. Res. Notes, 27:33-34, 1971). Some adjustments were made for late phenological areas. Thus, each egg-sampling point was classified according to: no spray; one, two, or three applications of spray; and larval development at the time of each application. Egg-mass densities for areas with similar spray histories were combined to give a mean density.

Table 1 shows the total number of hectares sprayed once and twice each year in New Brunswick from 1969 to 1976 and the mean egg-mass densities stratified by larval development at the time of treatment. These data were used to calculate the difference (%) between egg-mass densities in areas sprayed at different times during larval development and densities in areas sprayed at the L3-L4 stages. In general, fewer egg masses were found in late-spray areas (Fig. 1, A and B), doubtless because late sprays leave fewer surviving females to lay eggs.

This broad-brush analysis shows definite advantages for late-larval spraying except for one pitfall. As pointed out by Webb (1955), if spraying is too late in the larval period the amount of foliage saved by the treatment approaches zero. In other words, where foliage protection is critical late-larval spraying should be avoided. However, as a control strategy where foliage protection is not highly critical (early in an outbreak or during the collapse of an outbreak) the later a larval spray the more effective it will be as a population suppression technique when applied over relatively large areas.—C.A. Miller and R.A. Fisher, Maritimes Forest Research Centre, Fredericton, N.B.

Abnormal Wood Formation in the Tops of Aphid-damaged Balsam Fir.—Severe damage by balsam woolly aphid (*Adelges piceae* Ratz.) frequently kills the tops of young balsam fir trees in Newfoundland. Schooley (For. Chron. 52:143-144, 1976) outlined how subsequent recovery may allow such trees to produce new leaders and resume normal height growth. Remaining in these trees as evidence of aphid attack is abnormal xylem, called "redwood," that was formed as a result of aphid feeding (Balch, Can. Dep. Agric. Publ. 867, 1952). Compression wood is also formed during recovery when branches are reoriented to form new leaders. It is difficult to distinguish between these types of wood because both have the same appearance: they are highly lignified, reddish, hard, and brittle. This note describes how each type of abnormal wood can be distinguished from the other on the basis of its location in relation to the initiation of recovery growth.

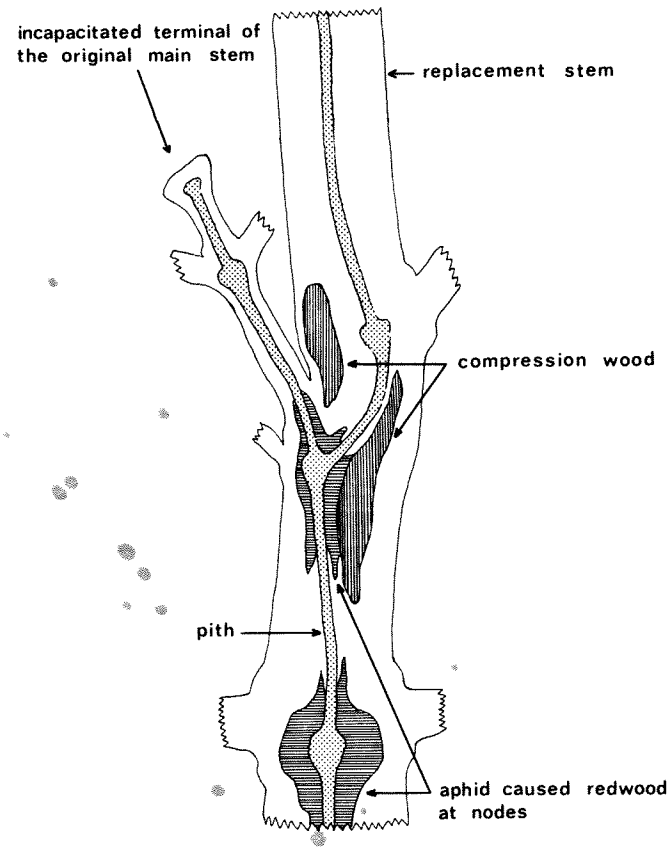

Figure 1. Midsectional view of a tree stem on which a whorl branch replaced the original leader. The locations of aphid-caused redwood and compression wood caused by branch reorientation are indicated.

The tops of ten 18-year-old trees, each with a lateral branch that had been reoriented to replace the leader killed by aphid attack, were bisected longitudinally. Average annual radial increments of the stem immediately below the point of origin of the replacement leader decreased from 2.0 to 1.0 to 0.7 mm during the 3 years prior to recovery. In the year of recovery and 3 years thereafter, increments were 0.9, 0.9, 1.1, and 1.2 mm. These data indicate growth recovery but do not show the unequal or eccentric radial growth that occurred on all trees as a result of leader replacement. This is illustrated in Fig. 1, which shows a longitudinal midsectional view of a typical aphid-damaged tree stem at the position where a whorl branch replaced the original leader and unequal growth occurred on the convex and concave sides of the slight crook formed during leader replacement. Immediately below the crook, radial growth was greater for several years on the side of the stem where the reoriented branch originated. Radial growth on the replacement stem above the crook was usually uniform.

The typical locations of redwood and compression wood are also shown in Fig. 1. Redwood was always concentrated at the nodes and produced in the wood formed before recovery of the tree from aphid attack. This was usually in the three or four annual rings adjacent to the pith. Compression wood was found in the annual rings formed after recovery. An elongated patch of compression wood developed along the stem beneath the crook formed by unturned branches. Also, a second patch usually developed in the concave side of the crooks, but this abnormal wood was initiated 1 or 2 years later than compression-wood formation beneath the crooks.

The information reported here will assist in planning studies to characterize the growth and development of young balsam fir trees that are periodically damaged by the balsam woolly aphid.—H.O. Schooley, Newfoundland Forest Research Centre, St. John's, Nfld.

Field Tests of NRDC 143 (Permethrin) against the Whitemarked Tussock Moth in Nova Scotia.—The experimental insecticide NRDC 143 25% EC (Permethrin) appears to be a highly effective control agent for the whitemarked tussock moth, *Orgyia leucostigma* (J.E. Smith), some geometrid species, and the balsam fir sawfly.

Tussock moth larvae are difficult to control with insecticides and, since the demise of DDT, no equally effective chemical has been found. This was argued by the United States Department of Agriculture in 1974 and, as a result, permission was granted to use DDT against the western species, the Douglas-fir tussock moth, *Orgyia pseudotsugata* (McD.) (Ellefson, J. For. 72:326-327, 1974).

The eastern species, the whitemarked tussock moth, is similar to the western species. It is about the same size and has a similar life cycle and feeding pattern. It has been a destructive pest of shade trees, balsam fir, and blueberries, particularly in Nova Scotia, and outbreaks covering a large portion of the province have occurred at intervals as short as 6 years. The principal damage in the forest has been to balsam fir, which can be killed in 1 year. After about 3 years, outbreaks usually collapse suddenly from a virus disease.

Over several years prior to 1976, the authors field-tested various insecticides and have failed to find any compound as effective as DDT. Of the compounds tested, Dylox appears to be the most effective chemical, but higher dosages are required to kill the tussock moth than to kill other insects, such as the spruce budworm, *Choristoneura fumiferana* (Clem.).

In July 1976 the insecticide NRDC 143 was evaluated in field tests on populations of the whitemarked tussock moth larvae feeding on balsam fir Christmas trees in northern Nova Scotia.

In the first set of trials, the dosages 18, 35, 52, and 70 ml active ingredient (a.i.) in 1 137 liters water/ha were applied with a hydraulic sprayer to runoff. Six trees were used per treatment. Once the effects of these treatments had become evident, a 9-ml treatment was applied 48 h

TABLE 1

Effect of NRDC 143 on larvae on individual trees sprayed to runoff in field experiments made with a hydraulic sprayer

Dosage ml/ha	Tussock moth larvae/shoot per tree [a]		Mean no. of dead larvae collected on 810-cm² trays		
	Before spray	48 h after spray	Tussock moth Geometrids [b]	Sawfly [c]	
0	1.1	1.0	0	0	0
9	0.9	<0.1	3	1	3
18	0.8	0	7	13	2
35	1.0	0	12	4	6
52	1.5	0	14	7	9
70	0.9	0	10	9	7

[a] Sample size = 18 shoots per 6 trees per treatment.
[b] *Ectropis crepuscularia, Nepytia canosaria, Melanolophia* sp.
[c] *Neodiprion abietis.*

TABLE 2

Effect of NRDC 143 on tussock moth larvae feeding on 73-m² blocks of balsam fir Christmas trees in field experiments made with a mist blower

Dosage	No. of trees	No. of larvae (top leader and first whorl)		Total living larvae per tree after spray
		Before spray	24 h after spray	
0	16		2.1	6.7
70 ml/ha	26	1.2	<.1	0.1

after the first applications. Larvae were sampled on the lead shoot and two adjacent laterals of each of six branch tips per tree (total of 18 shoots/tree) immediately before and 48 h after spray application. Dead larvae dropping from the trees were collected in 810 cm² canvas trays that had been placed one beneath each tree before spraying. Immediately after spraying, 20 larvae from each treatment, except the 9 ml/ha treatment, were collected on sprayed foliage and reared in open trays in the laboratory. Twenty-four hours after spraying, foliage was collected from each treatment and was used as food for tussock moth larvae that had been collected from unsprayed trees.

A second field test on a 73 m² block was carried out at a rate equivalent to 70 ml a.i./ha applied with a mist blower. Larvae were counted on the leader and first whorl of each tree before, and 24 h after, application. At the end of the experiment, each tree was searched for surviving larvae.

The results of both experiments were quite spectacular. All the sprayed larvae collected and reared in trays were dead within 4 h after spraying. All unsprayed larvae reared on sprayed foliage were dead within 2 days. Results of the field experiments (Tables 1 and 2) show that the insecticide at 70 ml/ha gave virtually complete control. The dead larvae included late-instar geometrids and early-instar sawflies, both kinds having been observed on the foliage but not counted. Except for the ml/ha treatment, in which an average of two tussock moth larvae per tree survived, no living larvae of any kind, including geometrids and sawflies, were found on the trees 24 to 48 h after spraying.

As in previous chemical control experiments carried out on the tussock moth, the results were partly confounded by the presence of the virus disease. At the end of the experiment, mortality in unsprayed areas from disease was 4%. Eventually, most of the larvae in the area succumbed to the disease, which usually appears in the second year of an outbreak. Consequently, unless suitable test areas are found during the first year of the outbreak, it is very difficult to find disease-free sites.

In summary, relatively small dosages of NRDC 143 appear to provide effective control for the tussock moth and the other defoliators encountered in these tests. Recent work by P.D. Kingsbury, Chemical Control Research Institute, Ottawa, Canada (personal correspondence), has shown that heavy deposits of NRDC 143 (140 ml/ha) are a substantial hazard to aquatic environments. Obviously, this will restrict the use of the chemical in areas where aquatic systems can be endangered. Nevertheless, NRDC 143 shows real potential for helping to solve recurring problems with the tussock moth.—D.G. Embree and G.F. Estabrooks, Maritimes Forest Research Centre, Fredericton, N.B.

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