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GENETICS AND TREE IMPROVEMENT

Vegetative Propagation of Trembling Aspen with Auxins.—Vegetative propagation of woody plants is of great benefit in forest genetics. It provides the opportunity to copy intact genotypes of selected trees and to assemble them at convenient locations in gene and clone banks and in seed orchards, where they can be maintained and multiplied as original genotypes or reconstituted into desirable ones by control pollination. Both original and desirable genotypes can be used for genetic and silvicultural investigations and in forestry practice.

Thimann and Delisle (J. Arnold Arbor. 20:116-136, 1939) found most conifers and many hardwoods unaffected by the root-promoting effects of auxins, although these properties were recognized in 1934 and the techniques had been steadily refined. Trembling aspen (*Populus tremuloides* Michx.) is one such species (Snow, J. For. 36:582-587, 1938, and Afanasiev, J. For. 37:37-41, 1939). These negative results and the subsequent success of Farmer (J. For. 61:385-386, 1963) and Zufa (For. Chron. 47(1):36-39, 1971) in vegetative propagation of this species from root sections discouraged research on the use of auxins on branch cuttings. In recent years trials of exotic and hybrid poplars in Newfoundland necessitated the vegetative propagation of the local trembling aspen. Discouraging results of vegetative propagation from root sections prompted the use of branch cutting with auxin treatment. An exploratory test was conducted in 1975. The results are reported in this note.

To minimize genetic diversity, cuttings were taken from a small even-aged stand of trembling aspen, comprising one or two related clones, at Shoal Harbour in eastern Newfoundland (lat. 48°11'N, long. 53°58'W). The trees were 12 yr old and 4-5 m high. Approximately 250 cuttings, 25 cm long and 1.5 cm thick at the base, were collected in mid-November 1974 from the current year's shoots in the upper one-third of the trees. The cuttings, wrapped in wet paper towels and placed in polyethylene bags, were stored for 8 wk at 0°C. One hundred cuttings, free from mold, were prepared for treatment with auxins by clean-cutting both ends, the cut at the lower end slanting at 45°. Two slices of bark (3.0 x 0.5 cm) were removed from the base of each cutting a little above the end to facilitate absorption of auxins.

The experiment was established in a five-replicated completely randomized design with 20 treatments. The treatments consisted of distilled water (control), three auxins with proprietary names in one concentration provided by the manufacturers, and four auxins with generic names in four concentrations of each. Two proprietary auxins, manufactured by Turtox/Cambosco Ltd., were "Turtox Hormone Powder" and "Turtox Hormone Salve." Both contained α-napthalene acetic acid 10 ppm, vitamin C 5 ppm, and vitamin B_1 5 ppm in the inert vehicles of talc and lanolin respectively. The third was "Hormodin 3" (containing 0.8% 3-indole butyric acid), manufactured by Merc Chemicals Ltd. These are equivalents of 10 mg/L of α-napthalene acetic acid in the first two cases and 8 000 mg/L of 3-indole butyric acid in the third case. The four nonproprietary auxins were 3-indole acetic acid, 3-indole butyric acid, 3-indole propionic acid, and α-napthalene acetic acid. The four concentrations were 50, 100, 200 and 400 mg/L. The bases of the cuttings were dipped in each of the three proprietary auxins, and the excess auxin was shaken off. The bases of the cuttings treated with the 16 solutions of nonproprietary auxins and distilled water were soaked in the respective solutions for 24 h, after which they were placed in 5% sucrose solution for 72 h (Thimann and Delisle, 1939). Each cutting was planted in a separate Jiffy pot in vermiculite with two-thirds of the cutting in the planting medium. The experiment was placed in a growth chamber and maintained at a temperature of 18°C and 85% relative humidity.

TABLE 1
Summary of results

Treatment	Number of rooted cuttings with auxin concentrations of			
	50 mg/L	100 mg/L	200 mg/L	400 mg/L
3-indole acetic acid	0	2	0	1
3-indole butyric acid	0	0	0	0
3-indole propionic acid	1	1	1	0
α-napthalene acetic acid	2	0	1	0

One level tablespoonful of "Supergrow 20-20-20 water soluble" fertilizer in 4.5 L of tap water was used every 2 wk to fertilize the whole experiment. Watering was done daily with just sufficient water to keep the growing medium moist at all times. The cuttings were examined for root formation after 6 wk, by which time the unrooted ones had died.

Cuttings treated with distilled water, Turtox Hormone Salve, and Hormodin 3 did not root at all. Three of the five cuttings treated with Turtox Hormone Powder rooted. Table 1 summarizes the results of the remaining cuttings treated with nonproprietary auxins.

The preliminary indications available from this exploratory experiment are (1) that it is possible to root branch cuttings of trembling aspen with auxin treatment and (2) that Turtox Hormone Powder and 3-indole acetic and α-naphthalene acetic acid in concentrations of 100 and 50 mg/L respectively seem to offer most promise for use in future experiments.—M.A.K. Khalil, Newfoundland Forest Research Centre, St. John's Nfld.

Microsporogenesis in *Larix laricina* in eastern Newfoundland.—Microsporogenesis in *Larix* occurs over a period of approximately 6 mo from late October to early April. Pollen mother cells (PMC) normally develop from Interphase I to the diplotene (or resting) stage around early November, remain in diplotene during the winter months, and complete development in March. The pattern of microsporogenesis in *L. decidua, L. kaempferi* and *L. sibirica* has been studied in Sweden (Ekberg et al., Hereditas 59:427-438, 1968) and that in *L. kaempferi, L. decidua* and *L.* x *eurolepis* in northeast Scotland (Hall and Brown, Silvae. Genet. 25:3-4, 1976). Microsporogenesis in *L. laricina* has received very little attention except for a study of abnormal chromosome development during meiosis (Chandler and Mavrodineau, Contrib. Boyce Thompson Inst. 23[4], 1965). The wide distribution and economic potential of the species has recently prompted research on its genetics.

In 1976, a study was begun on microsporogenisis in *L. laricina* in a seedling-origin seed production area in eastern Newfoundland (lat. 47°23', long. 53°14'). The study is part of a more extensive project concerning factors affecting seed production in *Larix* in Newfoundland. Fourteen trees averaging about 2 m in height were selected from the plantation, and each was a source of flowering material collected weekly between early November 1976 and the end of April 1977. Sporogenous material was fixed in ethanol: propionic acid (3:1) and the PMC's were stained in acetic carmine. The proportion of PMC's in each stage of microsporogenesis for each sampling date was determined. Approximately 300 PMC's were observed for each tree at each date.

Results showed that all PMC's had passed from the inactive

Interphase I stage through the three active prediplotene stages to the inactive diplotene stage by the end of November. The inactive diplotene stage persisted throughout the winter, until late March-early April, when the PMC's resumed their activity and passed through the active stages from diakinesis to the formation of microspores. In samples obtained 7 April up to 87.5% of PMC's were in stages of active division, and by 27 April all PMC's had formed microspores. In two of the trees, 5% of the PMC's advanced from diplotene on 4 and 24 January for no apparent reason; the remaining PMC's completed cell division in early April at the same time as those in the other trees. No chromosomal abnormalities were observed in any of the trees studied. The phenomenon whereby a small proportion of PMC's complete meiosis in midwinter has been reported for *L. decidua* (Eriksson, Stud. Forest Suec. 63, 1968) and for *L. kaempferi* and *L. decidua* (Hall and Brown, Silvae. Genet. 25:3-4, 1976). If a large proportion of PMC's were to complete meiosis in midwinter, it could be expected that nonviable pollen would be produced because temperatures below -2° to -3°C cause chromosomal damage (Ekberg et al., 1968). The net effect would be to reduce seed production, the reduction being proportional to the number of trees with nonviable pollen. In seed orchards or seed-production areas these trees would have to be identified and removed.

These data show that microsporogenesis occurs during the winter in *L. laricina* and that the stages of most active cell division occur in late March-early April. The study is being continued to determine the effect of climate on seed production of *L. laricina* in eastern Newfoundland.—J. Peter Hall, Newfoundland Forest Research Centre, St. John's, Nfld.

PATHOLOGY

Conifer Seed Pathogenicity Tests with Forest Cup Fungi.—Recently, we (Paden et al., Can. J. Bot. 56:2373-2379) showed that *Caloscypha fulgens* (Pers.) Bouldier (Ascomycetidae, Pezizales) is the perfect state of the fungus causing a serious disease of conifer seeds. Since numerous other operculate discomycetes occur in habitats similar to that of *C. fulgens*, and also fruit during the spring, we suspected that they might affect seedling establishment by killing naturally shed or direct-sown seeds. The object of this study was to determine the potential pathogenicity of several of these fungi to Douglas-fir, *Pseudotsuga menziesii* (Mirb.) Franco, and Sitka spruce, *Picea sitchensis* (Bong.) Carr. seeds.

The fungi tested were: *Pithya cupressina* (Fr.) Fuckel, *P. vulgaris* Fuckel, *Plectania melastoma* (Sow. ex Fr.) Fuckel, *P. milleri* Paden & Tylutki, *P. nannfeldtii* Korf, *Sarcosoma latahensis* Paden & Tylutki, and *Urnula hiemalis* Nannf. These fungi had been cultured from germinating ascospores from ascocarps collected at several locations in the northwestern United States and British Columbia. Potential for pathogenicity was assessed by sowing seeds in sand, in petri dishes, inoculating them with a test fungus (Salt, Trans. Br. Mycol. Soc. 63:339-351), and then germinating the seeds at 20°C for 16 h (no light) and 30°C for 8 h (2260 lx). Since a preliminary study showed that all of the fungi grew well at 10-20°C, two experiments were made. In the first, inoculated seeds were incubated at 10°C for 1, 2 or 4 wk and then germinated; in the second, they were incubated at 20°C for 4 wk before being germinated. Seeds that failed to germinate were surface-sterilized with 30% H_2O_2 for 0.5 h (Sutherland et al., Bi-mon. Res. Notes 34:20-21), plated on 2% water agar, and incubated at 20°C for 3 wk to detect the presence of the test fungi. For analysis, the germination data were transformed to the arcsin and subjected to analysis of variance; the means were compared by means of the Student-Newman-Keul's test (Steel and Torrie, Principles and procedures of statistics, McGraw-Hill, New York, 1960).

Table 1 shows that, regardless of incubation period or temperature, none of the fungi affected germination of Douglas-fir or Sitka spruce seeds. When germination of Douglas-fir seeds, kept at 10°C, was compared over the 1-, 2-, and 4-wk incubation periods, some significant differences in germination were observed. However, these differences were not likely caused by fungi, because germination of inoculated seed did not differ from that of control seeds within each incubation period. None of the test fungi were isolated from any of the seeds that failed to germinate, and no germinants showed any evidence of disease. We conclude from these data (Table 1) and observations that none of the test fungi are pathogenic on seeds or germinants of Douglas-fir and Sitka spruce. To our knowledge, this is the first time that the fungi used here have been tested for pathogenicity. Our negative results do not imply that these or similar fungi should not be tested further for pathogenicity to other species of seeds or germinants or that they do not cause other diseases such as foliage or root diseases.—Jack R. Sutherland, Pacific Forest Research Centre, Victoria, B.C., and J.W. Paden, Department of Biology, University of Victoria, Victoria, B.C.

TABLE 1
Results of pathogenicity tests with seven species of cup fungi and seeds of Douglas-fir and Sitka spruce

Fungi	Incubation temperature, seed species inoculated, and pregermination period*							
	10°C						20°C	
	Douglas-fir			Sitka spruce			Douglas-fir	Sitka spruce
	1 wk	2 wk	4 wk	1 wk	2 wk	4 wk	4 wk	4 wk
Pithya cupressina	79def	50ab	84def	78a	88a	80a	47a	86a
P. vulgaris	85def	40a	93f	85a	87a	98a	44a	90a
Plectania melastoma	66bcd	46a	73cde	87a	81a	94a	40a	94a
P. milleri	73cde	61a	83def	83a	83a	84a	47a	85a
P. nannfeldtii	89ef	57abc	83def	87a	90a	95a	40a	94a
Sarcosoma latahensis	78def	49ab	77def	83a	86a	87a	34a	87a
Urnula hiemalis	81def	55abc	78def	82a	83a	91a	42a	90a
Control (no fungus	82def	72cde	84def	89a	89a	91a	46a	93a

*Column values are mean (based on four replicates of 50 seeds each) percentage germination. Valid statistical comparisons can be made among or within those columns underlined by the same line, wherein means followed by the same letter do not differ significantly (P=.05).

ENTOMOLOGY

Cocoon Parasite of the European Pine Sawfly Introduced into Newfoundland from Ontario.—The European pine sawfly (*Neodiprion sertifer* [Geoff.]), an important pest of hard pines (*Pinus* spp.), was accidentally introduced into North America. It was first collected in New Jersey, U.S.A., in 1925 (Hamilton, J. Econ. Entomol. 36:236-240, 1943) and near Windsor, Ont., Canada, in 1939 (Raizenne, Can. Dep. Agric. Publ. 1009, 1957). This sawfly was first recorded in Newfoundland in 1974 (Clarke et al., Can. For. Serv. Inf. Rep. N-X-129, 1974), where it appeared on ornamental pines in St. John's. Since that time it has spread, and can now be found on ornamental pines and in pine plantations within a radius of about 15 km around that city.

Several native and introduced parasite species attack the European pine sawfly in Ontario (Griffiths, Can. Entomol. 91:501-512, 1959; Griffiths et al., Commonw. Inst. Biol. Control, Tech. Commun. 4:150-162, 1971). In Newfoundland, however, laboratory rearings showed a general lack of parasites attacking this sawfly. It was therefore decided to introduce some of the more important parasite species from Ontario. *Pleolophus basizonus* (Grav.), a European ichneumonid that attacks the cocooned sawfly prepupae, was selected for introduction first because it is an abundant and constant parasite of the European pine sawfly in Ontario (Lyons, Proc. Entomol. Soc. Ont. 94:5-37, 1964). This note presents data on this introduction and on the recovery of the parasite progeny.

P. basizonus were obtained from a stock of this species maintained at the Great Lakes Forest Research Centre in Sault Ste. Marie, Ont. Rearings of this parasite in Ontario were carried out, by standard techniques (Griffiths, Can. Entomol. 101:907-914, 1969), from January to June 1977. Sawfly cocoons exposed to *P. basizonus* were stored at 2°C until shipment from Sault Ste. Marie on 4 July. The cocoons were received on 5 July in Newfoundland and were reared in lots of about 500

in a cardboard box equipped with a clear plastic emergence vial. The boxes were kept at 21°C and 70% RH. Parasites began to emerge on 18 July; they were removed from the vials twice a day and, to ensure mating, were kept in a screen cage (30 x 30 x 56 cm), with raisins and water provided until release. The parasites were released twice a week from 21 July to 15 August inclusive at 9.7 km outside of St. John's (52°47' long. and 47°37' lat.) in a sawfly-infested plantation comprising Scots pine, *Pinus sylvestris* L., and Jack pine, *Pinus banksiana* Lamb. in about equal proportion. Totals of 631 males and 376 females were released.

Parasitism by *P. basizonus* was determined on naturally occurring cocoons and on planted cocoons. Naturally occurring cocoons were collected from 20 litter and soil samples (30 x 30 x 8 cm) taken from under the crown of sawfly-infested trees. Three trays (20 x 20 x 3 cm, covered with 0.5 cm mesh screen on the bottom and top) were placed at the release site with laboratory-reared cocoons to expose them to attack by *P. basizonus*. Each tray contained 50 sawfly cocoons, which were replaced once a week with fresh ones. Cocoons totalling 600 were exposed to parasites in this manner. These and the cocoons obtained from the soil samples were reared in the laboratory at 21°C and 70% RH until October, then stored at 2°C for 3 mo, and then reared again.

Only five sawfly cocoons were obtained from the 20 soil samples, and no parasites emerged from them. Of the 600 sawfly cocoons exposed to parasites in the trays, 30% emerged as sawfly adults, 37% died of unknown causes in the cocoon stage, 11% were parasitized by *Mastrus aciculatus* (Prov.), and 22% were parasitized by *P. basizonus*.

M. aciculatus, an ichneumonid, has been reared from the European pine sawfly in Ontario (Griffiths, Can. Entomol. 91:501-512, 1959), but this is the first record of it from this host in Newfoundland. The recovery of *P. basizonus* from such a large percentage of the planted cocoons indicates that at least one generation of parasites has survived. However, the successful establishment of this parasite may be verified only through several years of monitoring.

Technical assistance in this study was provided by D.L. Oliver and K.E. Pardy.—Imre S. Otvos, Newfoundland Forest Research Centre, St. John's, Nfld., and K.J. Griffiths, Great Lakes Forest Research Centre, Sault Ste. Marie, Ont.

Biological Observations on Overwintering Larvae of the Large Aspen Tortrix in Alberta.—The large aspen tortrix, *Choristoneura conflictana* (Wlk.), is a serious pest of aspen in North America. The life history of this insect and the damage caused by it have been reported in Canada (Prentice, Can. Entomol. 87:461-473, 1955), in California (Wickman, J. Econ. Entomol. 56:593-596, 1963), and in Alaska (Beckwith, USDA Forest Serv., Pac. Northwest Forest Range Exp. Stn. Res. Note PNW-81, 1968). Eggs of the large aspen tortrix are laid from mid-June to early July and hatch in July. First-instar larvae feed on leaf surfaces. In late July or August they undergo their first molt and then hibernate; second-instar larvae apparently do not feed the first summer, remaining in hibernation until new growth starts in the spring. Pupation usually occurs in early June, but this depends on the climate. This note reports on the site and parasites of overwintering larvae of the large aspen tortrix in Alberta.

According to Prentice (1955), in Manitoba and Saskatchewan the second-instar larvae overwinter in bark crevices and moss at the base of living trees. In their current studies on the biological control of *C. conflictana* in Alberta, however, W.G.H. Ives and J.A. Muldrew (pers. commun.) have noted that overwintering larvae were found beneath the slightly loosened bark of the trunk and branches of dead trembling aspen. Their observations agree with those of Wickman (1963) in California and Beckwith (1968) in Alaska.

The parasites associated with the large aspen tortrix in Manitoba and Saskatchewan have been listed by Prentice (1955), who also produced survey rearing records for New Brunswick, Ontario, and Alberta. Three additional species of parasites not listed by Prentice (1955) have been identified in Alberta. They were recovered from overwintering second-instar larvae collected by Ives and Muldrew in early March 1978 at Hondo, Alta., and sent to J.C. Cunningham, Forest Pest Management Institute, Sault Ste. Marie, Ont., for virus host range studies. About 2,500-3,000 surplus larvae were reared on an artificial diet (Grisdale, Can. Entomol. 105:1553-1557, 1973) in 21.3 mL cream cups kept at 23.9°C with a relative humidity of 50-55% (Cunningham et al., Can. Entomol. 105:767-773, 1973). An approximately 50% level of parasitism was noted for these second-instar *C. conflictana* larvae from Alberta (D. Grisdale, pers. commun.). The parasites were returned to the Edmonton laboratory, where they were identified as *Macrocentrus iridescens* French (Hymenoptera: Braconidae), *Glypta inversa* Cress. (Hymenoptera: Ichneumonidae), and *Agathis annulipes* (Cres.) (Hymenoptera: Braconidae). Collecting overwintering larvae in late winter and rearing them revealed also that the three parasites attacked the large aspen tortrix larvae in their first year.

The most common parasite was *M. iridescens*, followed by *G. inversa* and then by *A. annulipes*. The recovery of the latter two species in Alberta confirms observations by Torgersen and Beckwith (Can. Entomol. 106:1247-1265, 1974) that *G. inversa* and *A. annulipes* attack first- or second-instar larvae of *C. conflictana*, and the rearing results indicate further that *M. iridescens* also attacks first- or second-instar larvae of *C. conflictana*.

It is interesting to note that Torgersen and Beckwith (1974) found *G. inversa* to be the most common parasitoid attacking early larvae of the large aspen tortrix in interior Alaska but did not recover any *M. iridescens*, which was predominant in Alberta. The predominance of *Macrocentrus* over *Glypta* in Alberta is suggestive of the relationship between the same two parasitic genera of the oriental fruit, *Grapholitha molesta* (Busck), in Ontario. Steenburgh and Boyce (Annu. Rep. Entomol. Soc. Ont. 69:65-74, 1938) observed that as *Macrocentrus ancylivorus* Roh. became more plentiful, *Glypta rufiscutellaris* Cress. became increasingly less important. This may offer an explanation for the absence of *Macrocentrus* and the predominance of *Glypta* in the interior of Alaska.—H.R. Wong, Northern Forest Research Centre, Edmonton, Alta.

High Populations of a Carabid Beetle Associated with Spruce Budworm.—Numerous large, black carabid beetles (*Calosoma frigidum* Kby.) were noted in two white spruce (*Picea glauca* [Moench] Voss) plantations near Sault Ste. Marie, Ont., in early June 1977. The beetles were seen eating late-instar spruce budworm (*Choristoneura fumiferana* [Clem.]) larvae, and it is possible that they played some part in reducing budworm populations in the plantations.

The two plantations were visited at least once a week from mid-May to the end of July in connection with other studies. Plantation A (250 ha) was planted with white spruce and, in one location, with Norway spruce (*P. abies* [L.] Karst.), in 1925-28; plantation B (12 ha) was planted during the same period with white spruce only. Both plantations now contain considerable jack pine (*Pinus banksiana* Lamb.) and occasional white pine (*P. strobus* L.). The dominants are 15-17 m tall, but there are numerous small openings dominated by *Vaccinium* species. Located on sandy, gravelly river terraces on either side of the Goulais River, a few kilometers north of Searchmont, these are the only white spruce plantations in the vicinity. Natural stands dominated by balsam fir (*Abies balsamea* [L.] Mill.) and white spruce occur in small patches along river valleys nearby, but most of the area is covered by hardwood with a low proportion of white spruce.

Twenty-five 45 cm branch tips were taken from each plantation on 26 May, 1977, and examined for spruce budworm larvae. In plantation A counts averaged 32.0 larvae/branch tip and in B they averaged 31.8. At this time, fourth-, fifth-, and sixth-instar larvae accounted for 25%, 45%, and 30%, respectively, of the total. On 30 June, pupal populations averaged 0.08/45 cm branch tip in A and 0.04 in B—99.8 and 99.9% less, respectively. Egg populations, sampled on 27 July, averaged 0.86 egg masses/45 cm branch tip in A and 0.71 in B (equivalent to approximately 85 and 70/10 m^2, respectively).

The carabids were first noticed on 6 June, on the lower stems of the spruce. A quantitative assessment was made on 16 June. Initially, attempts were made to obtain estimates of density by beating foliage over drop sheets. However, only five beetles were dislodged from 50 trees. Several beetles remained on the foliage after beating, and more were observed on the higher foliated branches that were out of reach of the beaters than on the dead lower branches. A visual assessment was therefore made on both foliated and defoliated portions of trees. Fifty trees 8-10 m high, all in plantation B, were examined. Observations were restricted to the base and to branches up to 2 m above ground. The trees were categorized as (a) having no living needles on the observed branches, (b) having foliage on the periphery of some branches, (c) having well foliated branches down to the ground. Beetle counts are given in Table 1. Fifty-two beetles were seen on the 50 trees—six on the tree boles and 46 on branches. As many as six were seen on one tree, but 25 trees had no beetles, although 20 of the 35 well-foliated trees had at

TABLE 1
Numbers of *Calosoma frigidum* on lower 2 m of plantation white spruce trees, Sault Ste. Marie, 16 June, 1977

Category of tree (lower 2 m)	No. of trees	No. of trees on which indicated no. of beetles were found							Total no. of beetles	Avg. no. per lower 2 m section
		0	1	2	3	4	5	6		
a) No foliage	10	7	3	0	0	0	0	0	3	0.3
b) Peripheral foliage	5	3	1	0	0	1	0	0	5	1.0
c) Fully foliated to ground	35	15	9	4	4	1	1	1	44	1.26
Total	50	25	13	4	4	2	1	1	52	1.04

least one each. More beetles were on the foliage than on dead, bare branches, and they were distributed with fair uniformity over the foliage to the tops of the trees. Consequently, a spruce 15 m high might have had as many as 40 beetles on it. Beetles were seen crawling over current foliage and eating budworm larvae. They also seized and ate larvae placed in front of them, but we did not attempt to quantify consumption. No quantitative estimates of beetle populations were made in plantation A, but 25 beetles were counted up to a height of 1.5 m on the branches of one 7 m high white spruce, and this suggests that populations in A were at least as high as those in B.

On 22 June both plantations were visited so that beetles could be collected for further study. However, a 45 min search of the litter and dead stumps, and under loose bark, failed to locate any beetles or the remains of beetles.

We have no quantitative data on the impact of these beetles on budworm populations, but their size, numbers, and manner of searching the current foliage suggest that they may have played an important role in reducing budworm populations in these two populations near Searchmont. Where they came from and where they went is not known.—C.J. Sanders and K. van Frankenhuyzen, Great Lakes Forest Research Centre, Sault Ste. Marie, Ont.

Pine Oil Delays Attack of Ambrosia Beetles on Piled Log Sections.—Field tests show that pine oil applied to single Douglas-fir log sections has a repellent effect that delays and reduces the attack by ambrosia beetles (Nijholt, Can. Entomol., in press). Pine oil is a mixture of naturally occurring secondary and tertiary terpene alcohols refined from by-products of the pulp and paper industry. Its repellent effect is such that complete coverage of the log surface may not be necessary. To test this theory, an experiment on piled logs was conducted in the spring of 1978 in a second-growth forest near Caycuse, B.C. Twelve sections (75 cm long) were cut from four fall-felled Douglas-fir trees and were covered with a plastic sheet. On 10 May, the log sections were randomly arranged in two piles placed 5 m apart; the outer bark surfaces and ends of one pile were sprayed to the drip point with undiluted pine oil (sample provided by Northwest Petrochemical Corporation, Anacortes, Wash. 98221, under the commercial name "Norpine 65"), and a garden-type pressure sprayer (Hudson Manuf. Co. Model #6622) was used. The second pile was left untreated.

The sides of the piles, made up of log sections numbered 1,2, and 4 (Fig. 1), were facing eastward toward the adjacent experimental area, where flight activity and attacks had been noted in the previous 2-wk period.

The untreated pile was attacked on the day after exposure and was severely infested during the main flight activity around 20 May. The treated pile showed no attacks until 2 June, 23 days later, when five dust piles were noted. Three days later this number increased to 40. Most of the initial attacks occurred in places where two bark surfaces met (A in Fig. 1). This was attributable to the thigmotropic behavior of the beetles. Nevertheless, a 3-wk delay in attack was achieved with the pine oil treatment.

The experiment was terminated after 42 days, on 21 June, and the bark was stripped from all log sections. The surface of each section was divided into eight longitudonal segments. The entrance holes made by *Trypodendron lineatum* and *Gnathotrichus* spp. were counted in each segment. Treatments reduced the attack damage from 24.3 to 3.3 holes

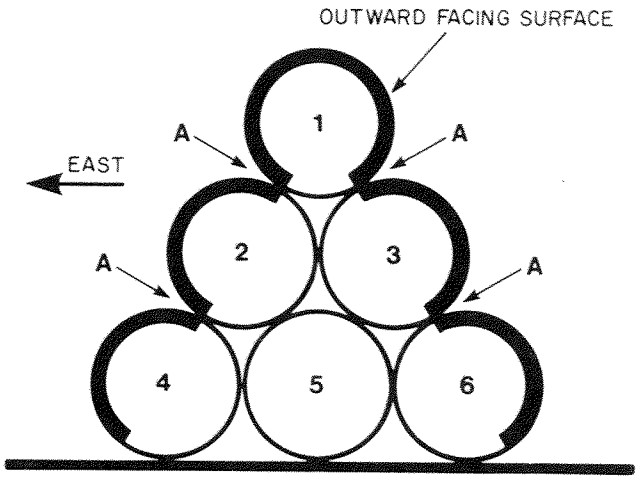

Figure 1. Diagram of position of log sections in pile, indicating outward and inward facing surfaces.

TABLE 1
Numbers of attack holes made by *Trypodendron lineatum* and *Gnathotrichus* spp. on piled sections of Douglas-fir 42 days after treatment with pine oil

		Treated			Untreated		
		Tryp.	Gnath.	(Tot.)	Tryp.	Gnath.	(Tot.)
Log section no.	1	31	16	47	154	13	167
	2	10	21	31	149	5	154
	3	0	4	4	133	13	146
	4	2	29	31	201	12	213
	5	0	1	1	114	3	117
	6	3	13	16	149	9	158
TOTALS		46	84	130	900	55	955

TABLE 2
Number of attack holes made by *Trypodendron lineatum* and *Gnathotrichus* spp. on outward- and inward-directed surfaces of piles Douglas-fir log sections 42 days after treatment with pine oil

	Treated		Untreated	
	Outward	Inward	Outward	Inward
Number of holes made by:				
Trypodendron	38	8	545	355
Gnathotrichus	76	8	30	25
TOTALS	114	16	575	380

per 0.1 m^2. Virtually all holes in the log sections of the untreated pile were made by *Trypodendron* (Table 1). Logs from the treated pile had 88% of the holes located on outward facing surfaces (Fig. 1); 60% of the holes were so located on comparable segments of the untreated pile (Table 2). Interpretation and comparison of results were complicated because, when the treated log sections no longer repelled the beetles, they were exposed to populations that were numerically and proportionally different from those present when the untreated logs were attacked. Log sections no. 5 (Fig. 1) were completely covered by other logs; the one in the treated pile received the least amount of spray

yet appeared to have been the most successfully protected (Table 1).

Experiments are planned to further improve and test the effectiveness of this type of treatment and to combine the use of these repellents with pheromone-based strategies to achieve protection from ambrosia beetle damage, as well as a reduction in local beetle populations.—W.W. Nijholt, Pacific Forest Research Centre, Victoria, B.C.

Chemical Control Trials on the Box Elder Twig Borer in Alberta.—The box elder twig borer, *Proteoteras willingana* (Kft.) is a common pest of the box elder, *Acer negundo* L., in shelterbelt plantings in the Prairie Provinces. In severe infestations many dormant buds and new shoots are destroyed and the destruction causes stunting and disfigurement of trees and seedlings. This note reports on the results of eight chemical insecticides applied as soil drenches in 1973 and 1974 and as foliar sprays in 1975, 1976, and 1978 to control this insect in three locations in Alberta.

The development of *P. willingana* in Alberta is about 2 wk later than that reported for Indian Head, Sask., by Peterson (Can. Entomol. 90:639-646, 1958). In Alberta, female moths usually lay a single egg near the midvein on the underside of the leaf in mid-July. After hatching from late July to mid-August, the first- and second-instar larvae, appearing from early to late August, skeletonize the mesophyll of the leaves. When the larvae reach the third instar, between mid-August and early September, they migrate down the leaf petiole to the twig and bore into a leaf bud. The fourth instar and an occasional fifth, appearing from June to mid-September, spin hibernacula in the fall and then overwinter. In the spring they become active and leave the hibernacula to resume feeding in the buds. In early June the fifth-instar larvae bore downward into the current shoots, the extensive feeding and tunnelling causing the tips to swell and form spindle-shaped galls. These galls usually become desiccated and die. Mature seventh-instar larvae leave the galls in early July, drop to the ground, and pupate in the duff and leaf mold. Adults emerge in late July, and egg-laying begins a few days later.

Insecticides used for the soil-drench trials were placed at the base of the tree in early May before insect activity began and were drenched with water to enhance translocation of the chemicals. Dimethoate, aldicarb, carbofuran, diazinon, oxydemeton-methyl, mexacarbate, and phorate were applied in 1973 and 1974 at Erskine, Stettler, and Bashaw at the rate of 4.5 g active ingredient/cm basal diameter for granular concentrates and 5.6 mL a.i./cm for emulsifiable concentrates. All plots consisted of 10 trees each, including the control plots. Percentage insect control was determined by applying Abbott's formula (J. Econ. Entomol. 18:265-267, 1925) to counts of living and dead larvae on eight 45 cm branches taken from each tree in the treatment and control plots approximately 8 wk after treatment.

Foliar sprays were applied with a hydraulic sprayer unit in early August 1975, 1976, and 1978. Plots consisted of two replicates of 0.04 ha each in a randomized block design in a box elder, or Manitoba maple, shelterbelt at Erskine. Spray solutions were applied at a pressure of 60 kg cm^{-2} and a rate of 114 L per plot at 0.5 mL a.i./L with a spreader sticker (Atplus 526) added at the rate of 0.25 mL/L. Percentage insect control was determined 24 h later by the previously described method. Results of all field tests are shown in Table 1.

Soil drenches did not perform well, except in one test with dimethoate that gave excellent borer control. Low soil moisture may have been a contributing factor. Foliar-spray results were good except for the 1975 test with diazinon, possibly because of rain showers that came shortly after application. No phytotoxicity was recorded on box elder from either soil or foliar application of the chemicals tested. Foliar sprays in Alberta should be applied in late July or early August for 2-3 consecutive years for maximum control. Dimethoate and diazinon are now registered for foliar application on box elder to control the box elder twig borer.—J.A. Drouin and D.S. Kusch, Northern Forest Research Centre, Edmonton, Alta.

TABLE 1
Results of chemical control field tests on the box elder twig borer, *Proteoteras willingana* (Kft.), 1973-76 and 1978

Material	Type	Location	Living (L) and dead (D) larvae and percentage control (%)													
			1973			1974			1975			1976			1978		
			L	D	%	L	D	%	L	D	%	L	D	%	L	D	%
Dimethoate	SD[1]	Erskine	0	3	100	2	5	66	—	—	—	—	—	—	—	—	—
Dimethoate	H[2]	"	—	—	—	—	—	—	—	—	—	10	29	73	3	13	76
Aldicarb	SD	"	22	18	45	—	—	—	—	—	—	—	—	—	—	—	—
Carbofuran	SD	"	19	9	32	—	—	—	—	—	—	—	—	—	—	—	—
Carbofuran	SD	"	—	—	—	18	3	1	—	—	—	—	—	—	—	—	—
Carbofuran	SD	Stettler	74	25	18	—	—	—	—	—	—	—	—	—	—	—	—
Diazinon	SD	Erskine	10	4	29	—	—	—	—	—	—	—	—	—	—	—	—
Diazinon	H	"	—	—	—	—	—	—	15	8	33	—	—	—	2	7	70
Oxydemeton-methyl	SD	Stettler	27	8	16	—	—	—	—	—	—	—	—	—	—	—	—
Mexacarbate	SD	Bashaw	22	8	27	—	—	—	—	—	—	—	—	—	—	—	—
Phorate	SD	"	39	5	11	—	—	—	—	—	—	—	—	—	—	—	—
Malathion	H	Erskine	—	—	—	—	—	—	—	—	—	5	20	79	—	—	—
Control plot		"	22	0	100*	6	1	86*	29	1	97*	64	3	96*	64	3	96*
Control plot		Stettler	33	3	92*	—	—	—	—	—	—	—	—	—	—	—	—
Control plot		Bashaw	2	0	100*	—	—	—	—	—	—	—	—	—	—	—	—

[1]SD = soil drench.
[2]H = hydraulic spray.
*Percentage living larvae in control plot.

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