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BI-MONTHLY RESEARCH NOTES

A selection of notes on current research conducted by the Forestry Branch, Department of Forestry and Rural Development

BOTANY

Hybrid between Tamarack and Japanese Larch Appears Promising in South-central New Brunswick.—In 1956, an attempt was made to hybridize native tamarack (*Larix laricina* (Du Roi) K. Koch) with Japanese larch (*L. leptolepis* (Sieb. and Zucc.) Gord.) at the Acadia Forest Experiment Station in south-central New Brunswick. The cross tamarack ♀ X Japanese larch ♂ was successful while the reciprocal cross failed to yield viable seeds. The hybrid seeds were sown in beds at the Acadia Forest Experiment Station nursery in the spring of 1957, together with seeds resulting from controlled self-pollination of tamarack and Japanese larch, and seeds resulting from open-pollination of these two species and European larch (*L. decidua* Mill.).

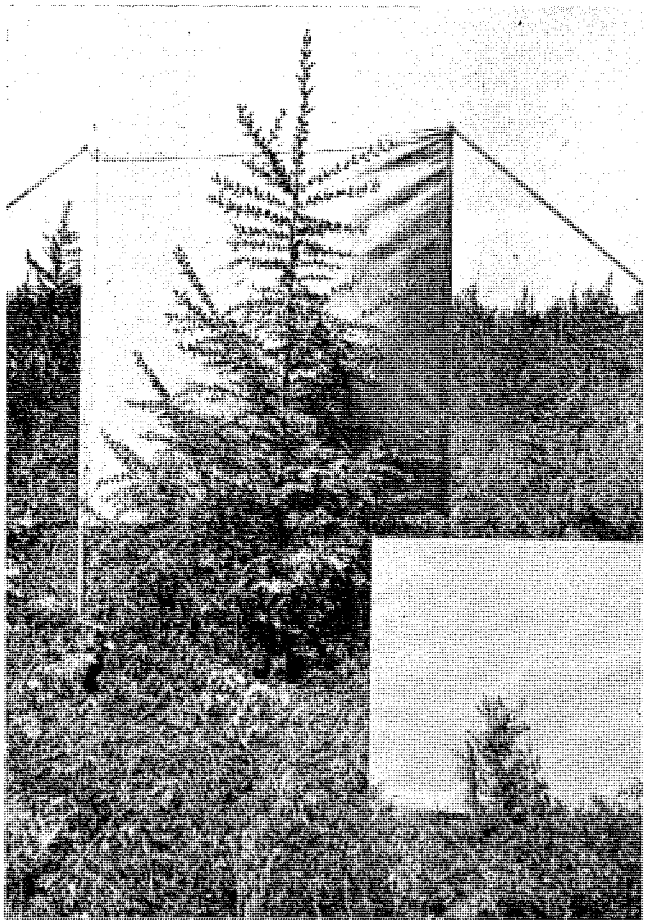

FIGURE 1. The trees shown here are the same age and have the same tamarack mother tree. The small, weak specimen in the foreground resulted from self-pollination; the vigorous tree in the background is the result of the interspecific cross, tamarack ♀ × Japanese larch ♂.

In 1959, the 2-year-old seedlings were transplanted along with small lots of 1+1 European larch, Polish larch (*L. decidua* var. *polonica* (Racib.) Ostenf. and Syrach), and Kurile larch (*L. gmellinii* (Rupr.) Litvin. var. *japonica* (Reg.) Pilger) obtained from the Petawawa Forest Experiment Station, Ontario. Early in June 1960, all the larch material was planted in plots on a well-drained site at 10 × 10-ft spacing. Tamarack seedlings were planted in rows between the plots as controls.

After seven growing seasons (from seed germination) the tamarack X Japanese larch hybrid had the greatest average height (Table 1). The seedlings resulting from self-pollination of tamarack were considerably smaller than the other larches (Fig. 1). In general, with the exception of the seedlings resulting from self-pollination of tamarack, all the larches attained greater average heights in 7 years than 10-year-old red spruce (*Picea rubens* Sarg.) and black spruce (*P. mariana* (Mill.) BSP.) growing on the same site 2.8 ft and 3.1 ft, respectively).

TABLE 1

Comparative heights of 7-year-old larch

Name	Origin of seed	No. trees	Av. height (ft)	Height ratio*
1. Tamarack ♀ × Japanese larch ♂	Tree A × Tree B	4	7.4	1.8
2. Tamarack	Open pollination of Tree A	50	5.0	1.2
3. Japanese larch	Open pollination of Tree B	4	4.7	1.2
4. Japanese larch	Self-pollination of Tree B	12	3.9	1.0
5. Tamarack	Self-pollination of Tree A	2	2.2	0.5
Other Larches				
6. Polish larch	Four known seed sources in Poland	25	5.5	1.3
7. Kurile larch	Southern Saghalin via plantation near Wakkanai, Japan	9	4.8	1.0
8. Japanese larch	Open pollination of locally grown tree	33	4.5	1.0
9. European larch	Several seed sources represented	110	4.3	1.0

*Ratio: Average height of plot trees/Average height of control trees.

Rapid juvenile growth of planting stock is desirable because it reduces the maintenance required to control competing vegetation. *Larix* species have this attribute and this rapid growth is not confined to the juvenile stage. Tamarack growing on good sites in Maine may average 18 inches in diameter and 60 ft in height after 45 years (H. S. Betts. U. S. Dept. Agr., Forest Serv. American Woods: Tamarack. 1945) compared with balsam fir (*Abies balsamea* (L) Mill.) which averages less than 7 inches in diameter and only 52 ft in height afer 60 years (H. S. Betts. U. S. Dept. Agr., Forest Serv. American Woods: Balsam fir. 1945). In addition to rapid growth, *Larix* species have dense wood. Tamarack wood has an average specific gravity of 0.50 compared to 0.35 for balsam and 0.40 for red spruce (Canadian Woods. 2nd ed. Can. Dept. Resources and Development, Forestry Branch, Forest Products Division. 1951).

At a time when the demands for lumber and pulp are increasing, the potential value of *Larix* species and hybrids should not be overlooked.—H. G. MacGillivray, Forest Research Laboratory, Fredericton, N.B.

ENTOMOLOGY

Notes on the Biology of *Epinotia criddleana* Kft.— *Epinotia criddleana* was described by Kearfott (Can. Entomologist 39: 58-59. 1907) as *Proteopteryx criddleana* from adult material collected at Aweme and Rounthwaite, Manitoba. Heinrich (Bull. U.S. Nat. Mus. 123: 1923) transferred it to the genus *Epinotia* and considered it to be a pale variety of *Epinotia nisella* Clerck, but it is now considered as a distinct species (MacKay 1964, personal communication).

According to Forest Insect and Disease Survey records, *E. criddleana* is common in Ontario, Manitoba, Saskatchewan and Alberta. The principal host is *Populus tremuloides* Michx. but larvae occasionally feed on *P.* balsamifera L., *Salix* spp., and *Quercus macrocarpa* Michx.

Late instar larvae of *E. criddleana* can be confused with those of *Pseudexentera oregonana* Wlshm. because both species feed on aspen and mature larvae are superficially similar. Larvae of *P. oregonana* which were misidentified as *E. criddleana* were described by MacKay (Mem. Ent. Soc. Can. 10, 1959 and Can. Entomologist 94 : 626-643, 1962). On the basis of information and material provided by the author this error was detected and subsequently rectified by a redescription of *E. criddleana* (MacKay. Can. Entomologist 97: 666-668). The following notes will serve to further aid in distinguishing all stages of the two species.

In the study area near Cochrane, Alberta, *E. criddleana* completes one generation per year, overwintering in the egg stage. Eggs are laid from the second week of August to mid-September with the peak occurring in late August. They are usually deposited in overlapping rows of six or seven eggs on a twig and contiguous with the base of a bud. Each egg is disc-shaped, about 0.74 mm in diameter. The exposed surface is convex, rugose, and slightly flattened at the margin. Freshly deposited eggs appear orange but turn reddish-brown after about 7 days, blending with the colour of the twig and bud.

Hatching commences early in the spring before the buds flush. In 1964, hatching was complete by the third week of May. The young larvae bore through the inner bud scale and feed on the tissue of the developing twig causing stunting or destruction of the embryonic leaves. After the larvae reach the third stadium, they leave the initial buds and fasten the flat surfaces of two leaves together with silk, between which they skeletonize the inner surfaces. This feeding is evident as a pale green blotch which later turns brown. Larvae may construct more than one shelter prior to pupation. When feeding is completed in the fourth instar, most larvae become inactive pre-pupae for several hours before dropping to the ground. In the laboratory, the pupation period was completed in approximately 14 days. In the field, adults were observed in flight until mid-September.

The four larval instars may be distinguished by differences in coloration. First instar larvae (about 1.3 mm long) are translucent-yellow with black head capsules and greenish brown prothoracic and anal shields. Second-instar larvae (about 4.0 mm long) are similar except for paler body colour. Third-instar larvae (about 6.8 mm long) differ in that the body and anal shield are nearly white, the prothoracic shield is pale yellow with a brown posterior border. Fourth-instar larvae (about 12.5 mm long) are translucent dull white, becoming pale yellow and turning to opaque pale yellow when feeding has been completed. The head, instead of being black as in the previous instars, is yellow with dark brown ocellar and frontal area. The prothoracic and anal shields, spiracles and setal pinaculae are the same colour as the body.

Fourth-instar larvae of *E. criddleana* may be readily distinguished from late-instar larvae of *P. oregonana* by differences in colour, setal pattern and feeding behaviour. On *P. oregonana,* the head capsule, setal bases and spiracles are brown; the prothoracic shield is of body colour with varying degrees of brown pigment on the lateral and posterior margins. On *P. oregonana* setae D1 on the anal shield are longer than setae D2 where on *E. criddleana* setae D1 are shorter than setae D2. *P. oregonana* late-instar larvae feed within a single rolled leaf as opposed to the double leaf shelter constructed by *E. criddleana.*—D. S. Kusch, Forest Research Laboratory, Calgary, Alta.

Sex Attraction in Lodgepole Needle Miner.—The attraction of male lodgepole needle miner moths (*Coleotechnites starki*) to females was assessed from a trap experiment carried out during the summer of 1966. Each trap consisted of 25 females caged in a mesh covered cardboard container fastened to the centre of a 1 × 1 ft plywood board. The cardboard and the board were coated with 'Stick-um'. It is uncertain whether all the females were virgin, as they were obtained from mass rearings.

Forty trees were selected in an 80-year-old lodgepole pine stand, heavily infested with needle miner, and a trap attached in the upper or middle crown of each. Twenty traps with caged females and 20 similar traps without caged females were randomly allocated among the 40 selected trees; aspect was also randomized. The experiment began July 22 and continued until August 5, when all moths caught were removed and sexed. At the end of this period some of the caged females were still alive.

The traps with caged moths caught 971 males and 67 females while the control traps caught 157 males and 50 females. There was no significant difference in the number of females caught but there was a highly significant difference in the male to female ratio between traps with and without caged females. The difference in the number of males to females in the control traps can probably be attributed to a difference in flight behaviour between sexes. It was observed that moths landing on the vertical sticky surfaces often tumbled down the board and escaped. The traps would probably have been more successful if orientated horizontally with the sticky side up. This evidence, that the female produces a sex attractant, could provide the basis for detection techniques or adult activity indices.—P. I. Van Eck, Forest Research Laboratory, Calgary, Alta.

The leaf roller *Pseudexentera oregonana* Wlshm.— This leaf roller is active on trembling aspen (*Populus tremuloides* Michx.) early in the spring in western Canada. It has often been listed in the Annual Report of the Forest Insect and Disease Survey as causing serious defoliation from western Manitoba to the interior of British Columbia.

The insect was first described by Walsingham (Illus. Lepid. Heter. Brit. Mus. 4:62) in 1879 as *Semasia ? oregonana.* Heinrich (U.S. Nat. Mus. Bull. 123. 1923) placed this species in the genus *Exentera* Grote in the revision of the North American moths of the tribe Eucosmini of the subfamily Olethreutinae, and suggested that in all probability *oregonana* was a colour variety of *improbana.* Several years later Heinrich (Can. Entomologist 72:243. 1940) noted that *Exentera* was a synonym of *Eucosma* Hubner and proposed the genus *Pseudexentera* for the species formerly placed in *Exentera* in 1923. On the basis of the female genitalia, McDunnough (Can. Entomologist 72:243-244. 1940) suggested that *oregonana* is not a race of *improbana* but a valid species. Most of the literature still referred to is at *P. improbana oregonana* until a comparison with the type in the British Museum (Natural History) by P. E. S. Whalley in 1965 confirmed McDunnough's opinion that it is a valid species (MacKay. Can. Entomologist 97:666-668. 1965).

Adults of *Pseudexentera oregonana* have been collected in southern Manitoba in late March and early April, and the larvae from new foliage only, which occurs in the southern areas from mid-April to mid-May. This suggests that the larvae are probably present before the leaves unfurl. When feeding is completed around late May to the third week in June, the larvae construct silken cases in the soil. Pupation takes place in late July or early August, and the adult emerges early the following spring.

Larval parasites recovered from rearings in the Winnipeg Laboratory and identified at the Entomology Research Institute, Ottawa, are as follows—Ichneumonidae: *Campoplex validus* (Cr.); *Campoplex* sp.; *Exochus* sp. near *peroniae* T. & T.; *Glypta* sp.; *Horogenes* sp. Braconidae: *Macrocentrus iridescens* French. Encyrtidae: *Parasilophrys gelechiae* How. Tachinidae: *Cyzenis* sp. poss *festinans* (Ald.); *Cyzenis* sp., *Eulasiona comstocki* Tsnd.

The only predator that has been observed feeding on the larvae is the stink bug, *Podisus modestus* Dall. Fungi in the genera, *Fusarium* and *Aspergillus*, have been found in dead unparasitized larvae, but it is not known whether these fungi are parasites or saprophyts.

Observations indicate that the large tortrix and the forest tent caterpillar are more serious defoliators than the leaf roller, *P. oregonana*. In outbreak areas, populations of the leaf roller are greatly reduced through defoliation of the host trees by the large aspen tortrix but not appreciably reduced through that by the forest tent caterpillar. The latter overwinters in the egg stage and the larvae become active early in the season, as do those of the leaf roller, but they do not mature as quickly and therefore do not remove all of the foliage before the leaf roller larvae mature. The large aspen tortrix, however, overwinters in the second instar larval stage and therefore commences feeding early in the spring and destroys most of the foliage before the leaf roller larvae can complete their development. This probably accounts for the reduction of the leaf roller populations that occurred most notably during outbreaks of the large aspen tortrix in northern Manitoba and Saskatchewan in the 1950's.—H. R. Wong and J. C. E. Melvin, Forest Research Laboratory, Winnipeg, Man.

PATHOLOGY

Occurrence of *Cylindrocladium scoparium* Morg. in Quebec Forest Nurseries.—*Cylindrocladium scoparium* Morg. (Fungi Imperfecti, Moniliaceae) is a well-known pathogen of forest nursery seedlings. The fungus has been reported from many areas of the world where it causes damping-off, root rot, and foliage blight of seedlings. In the fall of 1965, the fungus was isolated from soil at the Quebec Provincial nursery at Berthierville (Sutherland, J.R., and R. Keable, Can. Dept. Forestry, Entomol. and Pathol. Branch, Bi-Mon. Prog. Rept. 22 (1): 2. 1966). This finding suggested that *C. scopartum* might be responsible, at least in part, for some of the damping-off and root rot problems at Berthierville and other nurseries in Quebec. The purpose of the present study was to determine, in a qualitative way, the presence and distribution of the fungus in several Quebec forest nurseries.

Soil samples were collected during August, September, and October 1966. The nurseries, the counties in which they are located (given in parentheses and an asterisk denotes a Provincial Government nursery), and the number of soil samples collected from each were: Berthierville* (Berthier), 50; Compton* (Compton), 12; Drummondville (Drummond), 12; Duchesnay* (Portneuf), 10; East Angus (Compton), 10; Laterriere* (Chicoutimi), 10; Modern Paving at N.D. du Bon Conseil (Drummond), 5; New Carlisle* (Bonaventure), 30; Normandin* (Roberval), 25; Grande Piles* (Laviolette), 50; Saybec* (Matapedia), 5; Ste-Luce* (Rimouski), 10; St-Modeste* (Rivière-du-Loup), 15; Trecesson* at La Ferme (Abitibi-Est), 25; and Valcartier (Quebec), 15. The number of samples collected depended upon the size of the nursery and the relative abundance of damping-off and root rot damage. The nurseries sampled are representative of the majority of the nurseries in the Province which have a wide variety of climatic, soil, and biotic environments.

Each sample consisted of several soil cores, taken to a depth of 8 inches, from around the root zone of seedbed and transplant seedlings where damping-off had killed plants, or where root rot symptoms were present. The samples, of about 1 lb. size, were placed in polyethylene bags, sealed, and brought to the laboratory. The soil was passed through a ¼-inch mesh screen to remove rocks and organic debris.

Two methods were used to determine the presence of *C. scoparium*. The first was the apple technique (Campbell, W. A. Plant Disease Reptr. 33: 134-135. 1949). One apple was inoculated, in two places, with a portion of soil from one sample. The inoculated apples were incubated at room temperature for 10 to 14 days. Ten pieces of tissue were taken from the margin of the rotted area beneath the skin of each apple and placed on 10:2 glucose-yeast extract agar in petri dishes. The plates were incubated at room temperature to determine the presence of the fungus. The second method was a modification of the alfalfa trapping technique (Bugbee, W. M., and Anderson, N. A. Phytopathology 53:1267-1271. 1963). Each soil sample was placed in a polyethylene bag on a greenhouse bench. The edges of the bag were rolled down so that the soil was held in an open container. The soil was brought to field capacity with distilled water, and 19 alfalfa seeds (var. DuPuis) were sown in each soil sample. Greenhouse temperatures were kept at 20 to 25°C, and distilled water was added to the samples as needed. When the alfalfa seeds started to germinate, the edges of the bags were rolled up and the tops closed. This arrangement provided a high humidity which was ideal for damping-off of the alfalfa. All the seedlings which damped-off were removed with flame-sterilized forceps and placed in petri dishes with a small amount of sterile, distilled water. One or two healthy seedlings were also placed with their damped-off counterparts to provide additional substrate for growth and sporulation of the fungus. After 7 to 10 days incubation the seedlings were examined, using a stereomicroscope, for the characteristic conidiophores and spores of *C. scoparium*. In all cases where the fungus was present, its identity was confirmed by transferring a few spores to glucose-yeast extract agar and observing the characteristic microsclerotia beneath the developing fungus colony.

Cylindrocladium scoparium was found in 17 of the 284 soil samples assayed. All the positive isolations of *C. scoparium* were obtained with the alfalfa trapping technique. Thus it would seem that this technique is better than the apple technique for assaying soils for the fungus. Table 1 shows the nurseries where the fungus was found and the tree species with which it was associated.

TABLE 1

Occurrence of *C. scoparium* in Quebec Forest Nurseries

Nursery	Tree Species					
	Pinus resinosa		*Pinus mugo*	*Pices glauca*		*Picea rubens*
	T.*	S.**	T.	T.	S.	T.
Berthierville	9	1	1	1	0	1
Grandes Piles	0	0	0	0	1	1
Normandin	0	0	0	2	0	0

*T.= Transplant seedling, age > 2 years.
**S.= Seedbed seedlings, age < 2 years.

The rather high rate of occurrence of *C. scoparium* at Berthierville is interesting because it could indicate that the fungus is responsible for some of the seedling losses at that nursery. More precise studies need to be made before this can be determined with certainty. Another interesting point is that *C. scoparium* is present in the two main nurseries (Berthierville and Grandes Piles) which produce seedlings for transplanting in other Provincial nurseries and for reforestation in Quebec. Quite likely the fungus was introduced into the Normandin nursery on seedlings from either Berthierville or Grandes Piles. However, no explanation can be given as to why the fungus is not present in the other Provincial nurseries all of which receive transplants from the two main nurseries.—J. R. Sutherland, Forest Research Laboratory, Quebec, P.Q.

Resistance of Jack Pine to *Scleroderris lagerbergii* Gremmen.—*Scleroderris lagerbergii* Gremmen (=*Crumenula abietina* Lagerbert), a fungus causing Scleroderris canker, has been identified as the cause of widespread mortality in young red, jack, and white pine plantations in northern Ontario (Dept. of Forestry of Canada, Ontario Region Insect and Disease Conditions May-June 1966) and in red and jack pine plantations in Upper Michigan and northern Wisconsin (U.S. Forest Serv. Res. Pap. NC 3, 1966). In Upper Michigan and northern Wisconsin, the fungus was found in 66% of the red pine plantations and 86% of the jack pine plantations, causing mortalities of 40 and 39% respectively.

In its fifth year, a plantation at Longlac, Ontario, established for the study of variations within and among provenances of jack pine across its geographic range, 99% of the trees showed disease symptoms; *S. lagerbergii* was identified as the causal agent. This report discusses the possibility that among the healthy trees were three provenances having a degree of resistance to the pathogen.

The plantation contained 92 provenances collected from Maine to the Northwest Territories. Each provenance was represented by 100 trees distributed in 10-tree plots across 10 randomized blocks. Each plot was 10 ft long and one foot wide. The experimental area was 92 × 100 ft. Seeding was done in 1962 and empty spots replanted with one-year old seedlings in 1963.

A count on July 25 1966, indicated that a total of 90 of the original 9200 trees displayed no disease symptoms. After 1 month these 90 trees were re-examined and all remained healthy. Statistical tests were performed to test the hypothesis that these were randomly distributed throughout the 92 provenances, using the expansion of the binomial $(a+b)^{100}$

$$(a = \text{probability of disease, } \frac{9200-90}{9200} = 0.99,$$

$$b = \text{probability of escape } \frac{90}{9200} = 0.01)$$

to provide the expectation of how many provenances would have zero trees healthy, how many would have one tree healthy, etc. Small plot size and low percentages of healthy plants prohibited statistical treatment of provenance data by blocks.

From Table 1 it is apparent that no provenances would be expected to have more than four healthy trees, if the healthy trees were randomly distributed among the provenances. The probability of a provenance having more than five healthy trees is negligible. From the evidence in Table 1, it is virtually certain that several provenances had more healthy trees than one might expect by chance.

In addition to the provenance effect there was also a block effect caused, perhaps, by a 10-ft high, north-south shelterbelt of red pine on the east side of the experiment in front of one block. The percentage of healthy trees within the resistant provenances decreased with increasing distance from the shelterbelt. In the last three blocks only two trees remained healthy against an expectation of 28 on a random chance basis. This block effect does not bias the provenance comparisons because all provenances were the same distance from the shelterbelt. It does indicate that if there is resistance it may only be functional in sheltered areas.

TABLE 1

Probabilities of trees escaping infection, assuming that healthy trees are randomly distributed throughout the provenances (following the binomial distribution)

No. of healthy trees	Probability	Expected No. of provenances	Actual No. of provenances
0	1.000	92.0	92
1	0.626	57.6	31
2	0.256	23.6	21
3	0.075	6.9	13
4	0.017	1.6	7
5	0.003	0.3	3
6	0.000	0.0	3
7	0.000	0.0	2
8	0.000	0.0	2
9	0.000	0.0	2
10	0.000	0.0	1
11	0.000	0.0	1
12	0.000	0.0	1
13	0.000	0.0	1
14	0.000	0.0	1

Those provenances having more healthy trees than one might expect by chance are listed in Table 2. Among them are two provenances, Nipisquit River, N.B., and Baskatong Lake, P.Q., which were superior in growth rate to the local, for the first 4 years. These both grew 7% faster than Caramat (local) and had 4% healthy trees compared with 0% for Caramat. The three provenances with the highest percentage of healthy trees lie in a straight line near 50°N latitude from the Gulf of St. Lawrence to central Quebec. There were very few healthy trees in provenances west of Terrace Bay, Ont., or north of 50°N latitude.

TABLE 2

Provenances having 4 or more percent escapes from infection by *Scleroderris lagerbergii*

Provenance	% healthy trees	Probability of chance occurrence*
Nipisquit River, N.B.	4	.017
Baskatong Lake, P.Q.	4	.017
Kanaupscow Lake, P.Q.	4	.017
Terrace Bay, Ont.	4	.017
Lac Sault-au-Cochon, P.Q.	6	.000
Mistassini Post, P.Q.	9	.000
Little Calumet River, P.Q.	14	.000

*Probability of occurrence of as many or more healthy trees as that observed, with the assumption that healthy trees are distributed randomly throughout the provenances, following the binomial distribution.

Two items of evidence support the theory that disease escape was due to resistance associated with provenance: the non-random distribution of disease among provenances and the non-random geographic origins of the postulated resistant provenances. Further research is necessary to test this theory. If it is confirmed then production of jack pine resistant to *S. lagerbergii* should be possible through selection and propagation.—A. H. Teich, Petawawa Forest Experiment Station, Chalk River, Ont.

SILVICULTURE

Crown Width/Diameter Relationship of Open-Growing Jack Pine on Four Site Types in Manitoba.—During the past decade, several investigations have been made in North America on the development of the tree crown in relation to stem diameter and the density of the surrounding stand (Smith, Comm. Forestry Rev. 42. 1963; Vezina, Forestry Chron. 38. 1962, and Forestry Chron. 39. 1963). The results of these studies have helped forest managers to decide on spacing distance in plantations, to plan intermediate and harvest cuttings, and to forecast yield in forest stands. So far, none of the studies has provided quantitative evidence on the effect of site on the crown width (CW)/diameter (DBH) relationship of open-grown trees. This paper compares relationships of CW/-DBH on four of the most common site types in southeastern Manitoba (dry nutritionally poor "d"; fresh nutritionally poor "of"; fresh nutritionally intermediate "mf" and a drier subtype "mf-") as described by Mueller-Dombois (Can. J. Botany 42. 1964), and presents a comparison of these data with similar results obtained for jack pine in Quebec.

Some 150 open-growing jack pine trees of various ages, with good form, with no evidence of disease, and little, if any, insect damage, were selected from the four site types. Data collected included diameter outside bark at breast height; (DBH), bark thickness, radial growth and age at breast height, as well as live crown width (average of the greatest and smallest crown-width projection). Individual regressions of crown width (CW) on DBH were fitted to each site type and convariance analysis was used to compare these relationships.

The relationship between CW and DBH is similar on the four sites. Minor differences in the position of the curves could not be associated with corresponding changes (increase or decrease) in site quality. Regression coefficients (a and b) and correlation coefficients (r) are shown in Table 1. The strength of the association between variables is highly significant, with DBH accounting for about 80% of all variation of CW.

TABLE 1

CW/DBH regression statistics for open-grown jack pine in southeastern Manitoba and in Quebec

Site Type	Regression Coefficients		Standard Error of Regn.	Correlation Coeff. r	Range in DBH	Sample Size
	a	b				
d	2.13	1.80	1.99	0.90	3–12	44
mf—	1.83	1.84	2.16	0.88	3–12	46
of	4.21	1.59	2.44	0.90	3–15	38
mf	3.13	1.68	2.17	0.90	4–13	20
Common Manitoba	2.77	1.73	2.17	0.90	3–15	148
Quebec	1.76	2.04		0.96	1–11	84

The F-ratio, obtained by the convariance analysis, was found to be non-significant, indicating that the CW/DBH relationship is essentially the same on these four sites. Therefore, a common curve may be considered to describe the CW/DBH relationship. A similar comparison of these data with results obtained by Vezina in Quebec (Forestry Chron. 39. 1963) showed a highly significant difference.

These results indicate that the CW/DBH relationship of open-grown jack pine may be constant within a given area for a range of site conditions. Significant difference between the relationships in Manitoba and Quebec suggests that factors other than site, e.g., genetic and/or climatic, have important influence.

It is anticipated that these CW/DBH relationships will be used in the near future in the development of hypothetic stand models for jack pine. The models will be employed to forecast growth and yield of jack pine for given management objectives. —I. E. Bella, Forest Research Laboratory, Winnipeg, Man.

Germination and Early Survival of Jack Pine on Three Sites in Southeastern Manitoba.—In 1963, a study was begun about 60 miles east of Winnipeg on the Sandilands Forest Reserve to compare jack pine (*Pinus banksiana* Lamb.) germination and early survival for three sowing dates on three sites. The sowing dates were October 18, 1963, April 16, 1964 (50% of ground snow-covered), and April 27, 1964; the sites were dry, fresh and moist sands (Mueller-Dombois, Can. J. Botany. 42. 1964). The experiment was established in a split-plot design, with 1/8-milacre plots broadcast-sown with 50 Arasan- and Endrin-treated seeds, having a viability of 96% in the fall of 1963. There were 20 replicates for each combination of seeding date and site. Plots were examined at 1- to 2-week intervals during the summer of 1964, in May 1965, and September 1966. The study was established in a cut- and burned-over area that originally supported mature jack pine; in 1963 site preparation had been carried out with a D-4 class tractor equipped with a V-shaped blade. In the preparation of 5-ft-wide furrows, all duff and about 4 inches of mineral soil were removed.

The effect of both site and sowing date on germination was found to be highly significant (1% level). Over-all germination averaged 18%, being 39% on the moist site, 6% on the fresh site, and 8% on the dry site. Mean germination on the moist site was significantly higher than on either the fresh or the dry site. The difference between mean germination on the fresh and the dry site was not significant. Best germination resulted from fall sowing (21%); it was intermediate from spring sowing on snow (17%) and lowest from spring sowing after the snow had melted (14%). Mean germination on plots sown in the fall was significantly better than that on plots sown in the spring after the snow had melted. Significant differences were not demonstrated between fall-sown plots and plots spring-sown on snow or between the latter and plots that were sown after the snow had melted.

Of all germination, 47% took place before May 29, and 23% between June 10 and 26; the remainder occurred sporadically throughout the summer. May germination resulted from favourable soil-moisture conditions that were a consequence of nearly 2.5 inches of rain between late April and May 18. Drought conditions between May 19 and June 5 (0.10 inch of rain) inhibited germination in early June, but 3 inches of rain between June 6 and 13 resulted in high germination during the period June 10 to 26. Peak germination on fresh and moist sites occurred prior to May 29. During this period, 63 and 48% respectively of the germination occurred on the two sites. Nearly 50% of the germination on the dry site occurred between June 10 and June 26.

Forty-one per cent of the germinants died before September 1966; mortality averaged 38% on the moist site, 56% on the fresh site and 47% on the dry site. Most mortality on the dry and the fresh site occurred during the first summer and was attributed primarily to heat and drought. On the moist site mortality was attributed mainly to spring flooding and, after the first season, to vegetative competition. Early mortality due to spring flooding and vegetative competition on the moist site was more prolonged than that attributed to heat and drought effects on the fresh and the dry site (Fig. 1).

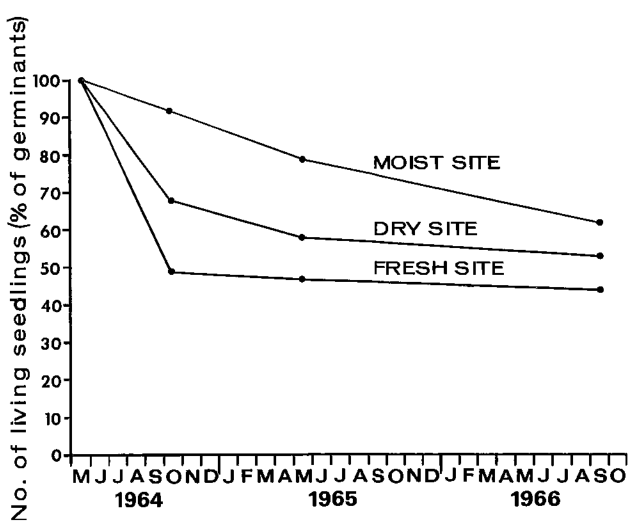

FIGURE 1. Number of living jack pine by site—spring, 1964 to fall, 1966.

The average number of seedlings per plot in September 1966 is summarized in Table 1. The effects of both site and sowing date were found to be highly significant (1% level). The number of seedlings was significantly greater on the moist site than on either the fresh or the dry site; the difference between these last two was not significant. On the moist site 4 seeds were required to produce a 3-year seedling, on the dry site 24 seeds, and on the fresh site 38 seeds. Fall sowing proved significantly better than spring sowing whether before or after the snow had melted; there was no significant difference between the two spring sowings. Although differences among interaction means were not tested for significance, it appears that the benefits of fall sowing are to be obtained on dry and fresh sites. The time of sowing made little difference on the moist site.

TABLE 1

Average number of surviving seedlings per 100 seed sown, by sowing date and site, September 1966

Site	Sowing date				Plots having at least 1 seedling
	October 10, 1963	April 16, 1964	April 27, 1964	Average	(%)
Dry	7.7	2.5	2.3	4.2	67
Fresh	5.2	1.8	0.7	2.6	47
Moist	25.3	25.0	22.2	24.2	95
Average	12.7	9.8	8.4	10.3	
Plots having at least 1 seedling (%)	88	63	57		

In previous work, Cayford (Dept. Northern Affairs and National Resources, Forestry Br., Tech. Note 79. 1959. Dept. Forestry, Tech. Note 106. 1961) reported that direct seeding with jack pine is a suitable technique for restocking open areas in southeastern Manitoba. The present study has provided some additional insight into the effects of both sowing date and site and has clearly demonstrated the importance of each to germination and early survival.

The 1964 growing season was characterized by somewhat above-normal precipitation and several short hot and dry periods. Thus, the results are similar to those that could be expected during years of favourable growing conditions.

Results suggest that germination should not normally be a problem on moist sands, but do indicate that it might be unsatisfactory on dry and fresh sands in years of normal or below-normal precipitation. Improved germination on the latter sites might result from a sowing technique that buried seed (Horton and Wang, unpublished data). Results also suggest that autumn sowing might be preferable on dry and fresh sites. This is in contrast to findings in Ontario which indicated no difference between autumn and spring sowing (Horton and McCormack, Dept. Forestry, Tech. Note 100. 1961). Observations indicate that autumn-sown seeds had become embedded in the sand and were probably in a favourable position to absorb soil moisture.—J. H. Cayford, Directorate of Program Coordination, Ottawa, Ont., and R. C. Dobbs, Manitoba-Saskatchewan Region, Winnipeg, Man.

Epicormic Branching in Pruned White Spruce.—Epicormic branches (epicormics) are shoots that originate from dormant or adventitious buds on the tree bole. They occur commonly on many hardwoods but are common on relatively few conifers including *Abies* spp. (Cosens, R. D., J. Forestry 50: 939-940, 1952) and *Picea* spp. (Herman, F. R., U.S. Forest Serv., Res. Pap. PNW-18, 1964). Epicormics tend to develop when exposure of the bole is suddenly increased, as by thinning or green pruning, and may be a response to the altered physiological balance occasioned by these treatments (Kramer, P. J. and T. T. Kozlowski, Physiology of Trees, McGraw-Hill, New York, 1960. p. 387). Epicormics present a problem to conifer management only where the objective is production of knot-free lumber or veneer.

Because white spruce (*Picea glauca* (Moench) Voss) has been used primarily for the production of common lumber grades, the growing of relatively knot-free trees has been of minor importance. However, it has been shown that pruning this species would be profitable under favourable market conditions (Berry, A. B., Forestry Chron. 40: 122-128, 1964), and in the future greater emphasis will likely be placed on managing white spruce for clear lumber production. Under these circumstances it becomes important to know the extent to which epicormic branching is associated with pruning and thinning.

The fact that epicormics might be a factor in the future management of white spruce for clear lumber production became evident at the Petawawa Forest Experiment Station when they were observed developing in a 25-year-old plantation after crown thinning and pruning in 1962. The experiment was designed to determine the optimum basal area to be maintained for the production of sawlogs. Thinning was carried out in three areas to reduce the basal area of the stand to different levels which would be maintained by further thinnings at 10-year intervals. A fourth area was selected as a control. In each of the four areas, 150 crop trees per acre were pruned to a height of 17 ft. Most branches pruned were dead, but the operation removed an average of 13% of the live crown length. All other trees in the four areas were pruned to head-height. Pruning was carried out in late summer 1962 and thinning during the following winter.

In 1965, a study of the formation of epicormics subsequent to treatment was carried out on eight permanent sample plots, two in each of the four areas. Epicormics were found on crop trees on all plots, and their production was clearly correlated with intensity of treatment. Heavier thinning not only resulted in more crop trees producing epicormics, but in more of these sprouts per tree. In consequence, the most heavily treated plots produced nearly 15 times as many epicormics per acre as the controls (Table 1). Relatively few sprouts were observed on non-crop trees, i.e., trees from which only dead branches had been removed. The data indicate that a combination of pruning live branches *and* thinning are necessary to the formation of appreciable numbers of epicormics in these stands.

TABLE 1

Epicormic branching on crop trees as related to residual basal area per acre.

Residual basal area	Trees with epicormics	Epicormics per crop tree bearing epicormics	Epicormics per acre
(sq ft/ac)	(per cent)	(number)	(number)
162 (control)	8	3.2	40
140	25	4.2	157
110	50	5.4	405
80	55	7.1	587

The epicormics ranged to ½ inch in diameter. Those on crop trees were removed at an average rate of about 1.5 minutes per tree (including walking time), compared to the initial time of 15 to 20 minutes per tree to prune to 17 ft.

Although the extent to which sprouting will occur in the future is unknown, the formation of epicormics may be a crucial factor in the management of white spruce for high grade lumber. If epicormics are allowed to remain the objective of the original pruning would be defeated, yet the cost of repeated removal could eventually offset any increase in value associated with the clear wood produced.—A. B. Berry and M. R. Innes, Petawawa Forest Experiment Station, Chalk River, Ont.

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O.H.M.S.

DEPARTMENT OF FORESTRY
AND RURAL DEVELOPMENT

BI-MONTHLY RESEARCH NOTES

IN THIS ISSUE:

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BI-MONTHLY RESEARCH NOTES

A selection of notes on current research conducted by the Forestry Branch, Department of Forestry and Rural Development

BOTANY

Preliminary Report on the Possible Occurrence of Hybrid Firs in North-central Alberta.—Balsam fir (*Abies balsamea* (L.) Mill.) grows under a wide variety of climatic and edaphic conditions, and ranges from the Atlantic coast of Canada westward to the northeastern border of British Columbia (Native Trees of Canada shows its range only as far west as central Alberta). Alpine fir (*Abies lasiocarpa* (Hook) (Nutt.) grows on well-drained upland sites and extends from the west coast of Canada eastward into Alberta. Moss (Can. J. Botany, 31:212-252. 1953.) reported the occurrence of balsam fir and alpine fir south of Lesser Slave Lake, Alberta, and proposed that further attention should be given to the ranges of the two species of *Abies* in Alberta, and to the question of intergrading of these species.

As a follow-up of the Moss' proposal, the author collected specimens of needles, cones, bark, and resin of bark blisters, in 1965 from a tree with characters deviating from balsam fir on the southern shore of Lesser Slave Lake.

The main purpose of this preliminary research was to determine the histological and morphological characteristics of the needles, and to identify some distinct phenotypical characteristics parallel to the variability of volatile constituents and terpene content in the balsam of trees.

Chemotaxonomy has been used by several authors (Mirov 1961, Tech. Bull. No. 1239 U.S.D.A.; Zavarin 1965, Phytochem. 4:141-148 to examine systematics and evolutionary problems in conifers. This method is based on the analysis of the balsam for its volatile constituents by gas-liquid chromatography. Zavarin demonstrated that balsam fir had a higher terpene content than the alpine fir. He also showed that balsam fir may be separated into a western form with no Δ^3 carene and an eastern form with Δ^3 carene.

For comparative analysis of alpine fir, balsam fir and the putative hybrid, samples were taken in the same way from an identified alpine fir tree from Lake Louise, Alberta, and an identified balsam fir tree from Riding Mountain, Manitoba.

The cytological characteristics were assessed by Roller's method (Forest Sci. 12:348-355, 1966). Only the traits presented in Table 1 exhibit significant differences between alpine fir and balsam fir, and show the intermediate attributes of the putative hybrid.

Since no alpine fir was observed in the vicinity of the tree sampled at Slave Lake, the possibility exists that the tree sampled was a genotypical variation of balsam fir rather than a hybrid between alpine and balsam fir. Final proof of intergrading between balsam and alpine fir must await further study.—K. J. Roller, Forest Research Laboratory, Winnipeg, Man.

Air Temperatures near Wet Soils under Tall Grass and Forest Shade in Central Alberta.—Temperature data descriptive of forest sites within the boreal region of Alberta are lacking. Geiger (Climate near the ground, Harvard University Press, Cambridge, Mass. 1965) describes what one might expect under comparable situations elsewhere, but this is of limited value when assessing regional conditions for germination and growth. This study was therefore initiated to determine how suitable permanent seepage sites of high forest productivity are for the establishment and growth of white spruce (*Picea glauca* (Moench) Voss). These sites commonly support the grass *Calamagrostis canadensis* (Michx.) and a closed forest canopy. *Calamagrostis* is a serious competitor with white spruce on wet and moist sites in this area of Alberta.

The study was confined to wet sites (moisture regime 7; Hills and Pierpoint, Ont. Dept. Lands & Forest, Res. Rept. 42, 1960), approximately 5 miles apart, near Chisholm (54° 55′ N, 114° 10′ W), Alberta. One site is devoid of forest cover and the other has 130 ft^2 basal area/acre of trembling aspen (*Populus tremuloides* (Michx.)), white spruce, and balsam poplar (*Populus balsamifera* L.), the latter two comprising less than 20% of the cover. The grass is 80 cm high and equally dense on both sites as a result of soil-site disturbances by logging and oil explorations about 10 years before this study. Both sites have weak grey-wooded soil profiles developed in clay till.

Four sample plots, 1 × 2 m, were located in the open and six under forest shade. The tall grass was cut and soil raked to expose black humus on two plots in the open and two under shade, while the two other plots in the open were left in tall grass as were two under forest shade. The additional two plots under shade were located on ground scarified 4 years pre-

TABLE 1

Discernible traits of the tested trees

Elevation (ft)	Species	Location	No. stomata in 1 mm strip cross needle axis		Resin canal index	Resin canal dia: mm	No. rows stom-ata	Hydrocarbon of balsam				Vas. bundle of needle			Lenticel on bark		
		Lat. ° Long. °	Ab	Ad			Ad	β-pinene	β-phell-andrene (%)	limo-nene	Δ^3 carene	Verti-cal Column No.	VERTICAL Row No. of— xylem	phloem	No. in 16 sq. in.	Length cm	Visi-bility
800	Balsam fir	Riding Mt. 50.5 100.4	98	8	23/5	0.14	1	47.4	10.6	31.2	—	8.6	3.8	6.7	80	0.5	Barely
1800	Intermediate	L. Slave L. 55.3 115.0	98	13	39/10	0.14	1.7	30.5	24.5	19.5	13.0	5.5	5.8	7.2	15	15<	Visible
5680	Alpine fir	L. Louise 51.3 116.3	79	20	45/12	0.19	3.0	16.0	38.0	26.6	10.0	9.0	5.3	5.8	26	<15	Well visible

Legend: Ab—abaxial side of needle.
Ad—adaxial side of needle.

viously. Temperatures were measured with unshielded thermocouples (40-gauge wires) at 0.1 and 90 cm above the ground at hourly intervals between 9 a.m. and 4 p.m. on seven sunny days between June 11 and August 4, 1965. For simplicity, data presented in Fig. 1 show only three representative times: 9 a.m., noon, and 3 p.m.

The temperature data for all seven days and for paired plots were combined because of their close similarities. The arithmetic averages illustrate four differences between plots in the open without grass cover and plots under forest shade with grass: The forest shade alone reduced the average air temperature (at 0.1 and 90 cm) by 2.6° C between 9 a.m. and 3 p.m. This value is based on all hourly readings between these time limits. In addition, tall grass lowered air temperatures on the average by 1.1° C at 0.1 cm both in the open and under the forest. Air temperatures at this same level peaked just above 21° C at noon under shade while they did not reach their maximum (just above 24° C) till 4 p.m. in the open (Fig. 1). The rapid morning rise is probably due to the stand being open to the east, which permitted the sun to reach the ground. The afternoon drop is probably caused by the disappearance of the sun's rays. Finally, the temperatures over shaded and scarified ground (at 0.1 cm) were intermediate between those under tall grass and those over humus both under forest shade.

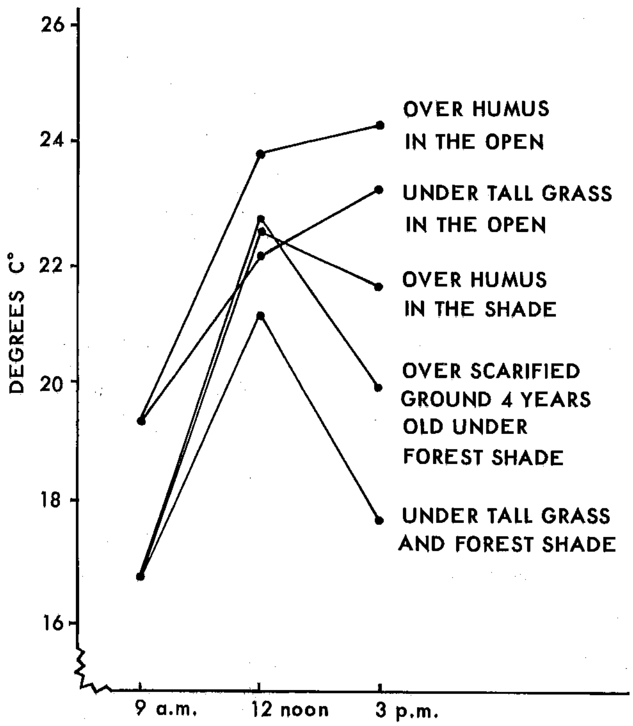

FIGURE 1. The influence of tall grass, forest shade, and scarification on temperatures 0.1 cm above the ground between 9 a.m. and 3 p.m.

The combined influences of tall grass and forest shade reduce air temperatures just above the ground by 3.7° C. This is of the approximate magnitude found by Geiger (1965). The temperatures would affect both germination (U.S.D.A., For. Sev. Misc. Publ. 654. 1948) and early growth of trees (Kramer and Kozlowski, Physiology of Trees, 1960) adversely because they did not reach optimal levels (between 25 and 35° C) for these phenomena in the open even on warm, sunny days. On the study sites, therefore, vegetation competition or shade lower air temperatures below the optimum for both the establishment and growth of white spruce. The forest cover is over twice as effective in lowering air temperatures than is lesser vegetation.—A. K. Hellum, Forest Research Laboratory, Calgary, Alta.

ENTOMOLOGY

Relation of Attack by Ambrosia Beetle (*Trypodendron lineatum* (Oliv.)) to Felling Date of Spruce in Central British Columbia.—In British Columbia, all the studies of *Trypodendron* attack in relation to felling date have been in the coastal forest where long growing seasons and mild winters are normal. The data presented here were obtained in central British Columbia, near Prince George where the growing season is relatively short and the winters cold. *Trypodendron* breeds in both climates but differences are apparent in the relationship of attack density to the felling date of logs.

During studies of *Dendroctonus* in white spruce, *Picea glauca* (Moench) Voss, trees were felled at each of two sites in May, July and September 1964, May and July 1965, and May and July 1966. The sites were 100 miles apart at Kerry Lake to the north of, and in the Naver Forest to the south of Prince George. The felled trees were cut into four 20-ft logs but a few logs were reduced in length to 14 ft or less. A glass-barrier trap was placed on each log of each tree and emptied at 2-week intervals. In August 1966, counts were made of *Trypodendron* holes in the wood where the bark had been removed on the shaded side of each log.

The long logs (14-20 ft) felled in July 1964 and 1965 were heavily attacked the following spring and large flight-trap catches were obtained at both the Naver Forest and Kerry Lake. The 1964-felled logs in the Naver Forest were also slightly attacked in 1964 (Table 1, flight trap records); the attack occurred in early August a few weeks after felling. Long logs felled in September and May at the same two locations were nearly free from attack during the year of felling and the following year. Flight-trap collections over these logs were also relatively small (Table 1).

TABLE 1

Attack density and flight number of *Trypodendron* related to the felling date of spruce in two areas of Central British Columbia.

Felling date of trees	Holes per square foot*		Beetles in flight traps					
	Naver	Kerry	1964	Naver 1965	1966	1964	Kerry 1965	1966
July 1964	18.2	25.6	116	492	—	2	888	—
Sept. 1964	0.0	0.8		27	—		52	—
May 1965	0.8	0.2		45	40		5	41
July 1965	23.0	24.8		2	479		3	307
May 1966	0.0	0.0			3			12
July 1966	0.0	0.0			0			0

*Means based on half-square-foot samples: 60 on trees felled in 1964; 40 on trees felled in 1965; 32 and 16 respectively on trees felled May and July 1966

The lack of attack on September-felled longer logs and the dense attack on July-felled logs indicated a difference from the attack preference shown by this insect on logs in the coastal forest where September-felled logs were densely attacked and July-felled were only slightly attacked. This may result from differences in the tree species, the climatic differences or a combination of both. It appears that in this climate only spruce trees felled well before the onset of winter are attractive to *Trypodendron* during the spring swarming flight. Short sections (3 ft and about 8 ft in length) felled in September and May were, however, frequently attacked during the first spring. Previous studies (e.g., Dyer, E. D. A., and J. A. Chapman. Can. Entomologist 97: 42-57. 1965.) have shown that short log sections become attractive more rapidly than corresponding long logs.

Winter felling and logging have been common practice in spruce stands of the Prince George District and would tend to minimize damage from ambrosia beetle attacks. Year-round logging, however, is now becoming more common and it is probable that summer-felled logs will be damaged if not utilized before beetle flight the following spring.—E. D. A. Dyer, Forest Research Laboratory, Victoria, B.C.

A Chemical Sex Attractant for the Spruce Budworm.—Studies of the sex attractant of the spruce budworm moth have centered on the collection and separation of the exudates released by the female moths (J. A. Findlay and D. R. Macdonald, 1966, Chemistry in Canada, 18: 47-48). Several of the major components of the pheromone-containing mixture were identified in 1964 and 1965, including oleic, linoleic and palmitic acids. A second line of investigation was adopted during the 1965 moth season when commercial samples of these common fatty acids were tested in the field for attractiveness to spruce budworm moths using standard spruce budworm moth trapping techniques (Greenbank, D. G., 1963. *In* Mem. Entomol. Soc. Can. No. 31).

One of the compounds tested, technical grade palmitic acid, proved to be slightly attractive to male spruce budworm moths. Further testing showed that material separated by vapour-phase fractionation of a steam distillate of the crude acid was even more attractive. Small amounts of one fraction were competitive in attractiveness with single caged virgin female moths in the field tests. Gas chromatographic analysis indicated that there were at least nine major components in this fraction and a bio-assay technique was used to determine which of these could induce a response from male budworm moths. Gases emerging from a Perkins-Elmer 800 gas chromatographic unit were diluted with compressed air and passed through a cage containing four male moths. One component aroused a single male moth to flight activity for the duration of its emergence from the chromatographic unit on four successive trials.

Two mg of this component were isolated from 1.5 kg of commercial palmitic acid (90% obtained from Aldrich Chemical Co. Ltd., Milwaukee, Wisconsin, U.S.A.). The mass spectrum of this trace impurity displayed a molecular ion of mass 265 and a fission pattern indicative of an aliphatic nitrile. The identity was confirmed by comparison of the compound with an authentic synthetic sample of n-octadecanitrile.

This compound was field tested during the latter part of the moth flight season in 1966. Two standard moth trap boards were baited with approximately 1 mg pure crystalline n-octadecanitrile on July 19 and 20. Six more traps were baited with the same dose on July 21 and the traps were operated until July 26. Three traps were baited with single virgin female spruce budworm moths throughout the trials and the average daily catch of male moths per board is shown in Fig. 1. Only two moths were caught on an unbaited trap during the trial.

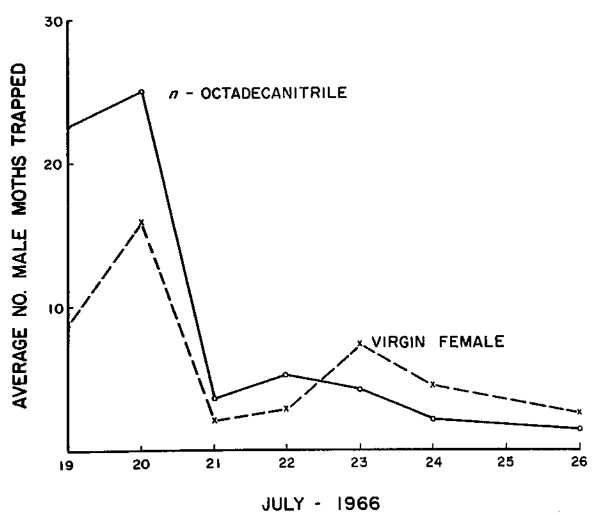

FIGURE 1. Comparison of average number of male spruce budworm moths lured daily by n-octadecanitrile and by single virgin female spruce budworm moths.

We have also ascertained in field tests that this nitrile and some homologs are comparable in attractiveness with crude exudates collected from several hundred virgin female moths.

These data indicate that n-octadecanitrile is highly attractive to male spruce budworm moths. More extensive assays are planned for 1967, when varying concentrations of the attractant will be tested in areas with different densities with budworm moths. Tests are also planned in areas infested with closely related species. Further analysis will be made to determine whether similar compounds can be isolated from exudates of virgin female moths. This work is based, in part, on research supported by a grant from the Department of Forestry and Rural Development.—D. R. Macdonald, Forest Research Laboratory, J. A. Findlay and C. S. Tang, Department of Chemistry, University of New Brunswick, Fredericton, N.B.

FOREST PRODUCTS

Effect of *Fusarium oxysporum* Growth on the Decay of Birch Wood by *Coprinus micaceus*.—Twenty-seven out of 29 white birch posts (*Betula papyrifera* Marsh.) and all 29 *Populus* species posts treated with a water soluble preservative (composition: sodium fluoride 34%, potassium dichromate 34%, sodium arsenate 25%, dinitrophenol 7%) by diffusion process and placed in a test plot at the Petawawa Forest Experiment Station at Chalk River, Ont., failed within 12 years due to decay by *Coprinus micaceus* (Bull. ex Fr.) Fr. In the hardwood posts *C. micaceus* was associated with *Fusarium oxysporum* (Schl.) em Snyder and Hansen and to a lesser extent *Fusarium solani* sensu Snyder and Hansen and *Trichoderma viride* Pers. ex. Fr.

Because of the common association of *C. micaceus* and *F. oxysporum* in the decayed posts, a study was made on the effect of the interrelation between the two fungi in the decay process.

Soil-block tests were established using ¾-inch white birch sapwood cubes buried in soil, pH 5.3, containing 25% moisture. The procedure outlined by Sedziak (Can. Dept. of Forestry Mimeo 0-149.1949) was modified slightly with regard to the position of the blocks in the soil and the method of inoculation. The soil and wood blocks were autoclaved at 15 psi for 45 minutes. The fungi for inocula, *C. micaceus* or *F. oxysporum*, were first grown on birch slips placed on a 2% malt agar medium contained in Petri dishes. When growth was well established, a slip was placed on the exposed top of the transverse surface of each test block. Each block was inoculated with a primary fungus followed later by a secondary fungus. The tests were done in quadruplicate and all cultures were incubated in a room maintained at 27°C and 70% relative humidity. Weight losses were based upon the oven-dried weights of the wood blocks before the test.

The primary fungus was incubated for 1 month before the introduction of the second fungus. When *C. micaceus* was the primary colonizer, *F. oxysporum* was grown in association with the wood-rotting fungus for the last 2 months, *C. micaceus* was grown as the secondary fungus in association with *F. oxysporum* for 3 months when the mould was used as the primary colonizer of the wood.

Results of the association of *C. micaceus* and *F. oxysporum* in the decay of white birch blocks is shown in Table I.

F. oxysporum caused only slight weight losses in the birch blocks when grown alone. These losses approximate those obtained in experimental decay studies with other moulds. Differences in weight losses from the *C. micaceus* controls were minor when the wood blocks were colonized by *F. oxysporum* for 1 month prior to inoculating the blocks with *C. micaceus*. However, when *C. micaceus* was grown as the primary fungus and *F. oxysporum* as the secondary fungus, the resulting weight losses were 81.5% higher than the losses obtained by the activity of the wood-rotting fungus alone.

TABLE I

Effect of *Fusarium oxysporum* or decay of birch wood by *Corpinus micaceus*. Decay period of 3 months.

Primary fungus	Secondary fungus	Average weight loss (%)	C.V.*	Increase in decay over *C. micaceus* controls (%)
F. oxysporum		6.2	9.7	
C. micaceus		23.8	16.7	
C. micaceus	*F. oxysporum*	43.2	2.6	81.5
F. oxysporum	*C. micaceus*	26.0	14.6	9.2

*Coefficient of variation

The lack of any noticeable antagonistic action of *F. oxysporum* in limiting or preventing decay by *C. micaceus* indicates that the two competing fungi are tolerant of each other in their saprophytic colonization of the wood substrate. The greater weight losses which result whenever the mould is grown in wood already infected with *C. micaceus* is a phenomenon that has been noted when certain other moulds and wood-rotting are involved in the decay process. This suggests a symbiotic relationship which tends to accelerate the rate of decay of wood under service conditions. However, when moulds colonize the wood before wood-rotting fungi, an antagonistic reaction has been observed in other cases.—J. K. Shields, Forest Products Laboratory, Ottawa, Ont.

Ultrastructure of the Gelatinous Layer in Tension Wood Fibres of Trembling Aspen (*Populus tremuloides* Michx.).—When a tree (angiospermous) is displaced from its vertical orientation, a unique physiological change occurs in the cambial cells in the upper portion of the leaning stem or branch. This induces a complete reprogramming for the protoplasm which deviates from its normal function of secondary wall formation and produces abnormal cell wall in the xylem fibre derivatives. This portion of the wall, known as the gelatinous layer, usually replaces the S_3 and S_2 layers of the secondary wall. The gelatinous layer in tension wood fibres is known to cause excessive shrinkage, distortion, splitting and even collapse of the wood during industrial processing, thus reducing the commercial value of the wood.

Over 50 years ago, Hartig (Holzuntersuchungen, Springer, Berlin. 1901) described the occurrence of tension wood fibres. Since then intensive discussions on this subject have been published. More recently, there has been some disagreement among investigators of tension wood regarding the nature and submicroscopic morphology of the gelatinous layer. As late as 1964 Sachsse (Holz Roh- Werkstoff, 22) proposed a wall model for this structure describing it as having a honeycomb structure. Contrary to this model, Cote and Day (For. Prod. J. 12. 1962: Cellular Ultrastructure of Woody Plants, Syracuse Univ. Press. 1965) have maintained that the gelatinous layer possesses a lamellar organization with the microfibrillar orientation predominantly parallel to the fibre axis. Investigators on tension wood appear to have aligned themselves with one concept or the other. Disagreement over the internal morphology of the gelatinous layer may have stemmed from artifacts introduced into the seemingly porous and delicate nature of this structure during preparative procedures. Possible dangers lie in the use of unfixed or poorly fixed materials using methacrylate as the embedding medium. The latter is known to cause serious swelling even in the normal wall during solvent exchange, removal of embedding medium from the thin sections, and drying and heating during replica and shadow preparations. In the current investigation, the foregoing procedures followed by other workers have been completely replaced by a more gentle and sensitive technique to preserve the gelatinous wall in near-original condition. Briefly, fresh pieces of tension wood from the outer ring of 2- to 3-year-old trembling aspen were fixed in low percentage buffered glutaraldehyde with osmium tetraoxide used for post-fixation. A gradual dehydration procedure was followed using a closely graded alcohol and propylene oxide series with final embedding in a mixture of epon and araldite. Ultra-thin sections cut with a diamond knife were stained with uranyl acetate and lead citrate before examination in a Philips Model 100 electron microscope. This technique for election microscopy is purported to give preservation of tissues far superior to that of methacrylate preparations and is known to yield most reliable results.

Figures 1 and 2 illustrate two electron micrographs of transverse and longitudinal sections of tension wood fibres. In these micrographs are seen well-preserved fibre walls in which middle lamella, primary wall, S_1, S_2, and gelatinous layer are apparent. Uranyl acetate and lead citrate enter the interstices of the wall surrounding the cellulose microfibrils and stain the amorphous chemical components of the wall, not the crystalline cellulose microfibrils (see Heyn, J. Cell Biol. 29. 1966). Thus the dark-staining areas of the wall are occupied presumably by the non-crystalline substances. It appears, then, that the gelatinous layer is not completely free from the non-cellulosic wall fractions as has been assumed by some workers (Norberg and Meier, Intern. Assoc. Wood Anatomists. News Bull. 1. 1966). In the electron micrographs the intact gelatinous layer with its inner undulated margin (Fig. 1) is seen adhered closely to the S_2 layer of the secondary wall. This appears to be a natural disposition. The gelatinous layer which is occasionally withdrawn from the secondary wall proper even in the fresh materials giving a convoluted appearance is obviously an effect of shrinkage or preparative artifact due to a porous nature of the gelatinous layer. Frequently there appears to be a narrow band of electron dense materials in the transition region between the gelatinous layer and the S_2 layer. This may be due to an additional deposition of wall substances in this region.

As shown in Figs. 1 and 2, the gelantinous layer is clearly differentiated from the S_1 and S_2 layers. In transverse section (Fig. 1) the cellulose microfibrils are clearly distributed at random within the densely staining substances of the gelatinous layer. The microfibrils in the gelatinous layer are strongly

FIGURE 1. Transverse section (X 25,500) of tension wood fibres showing middle lamella, M; primary wall, P; secondary wall, S_1, S_2; gelatinous layer, G; and cell lumen, L.

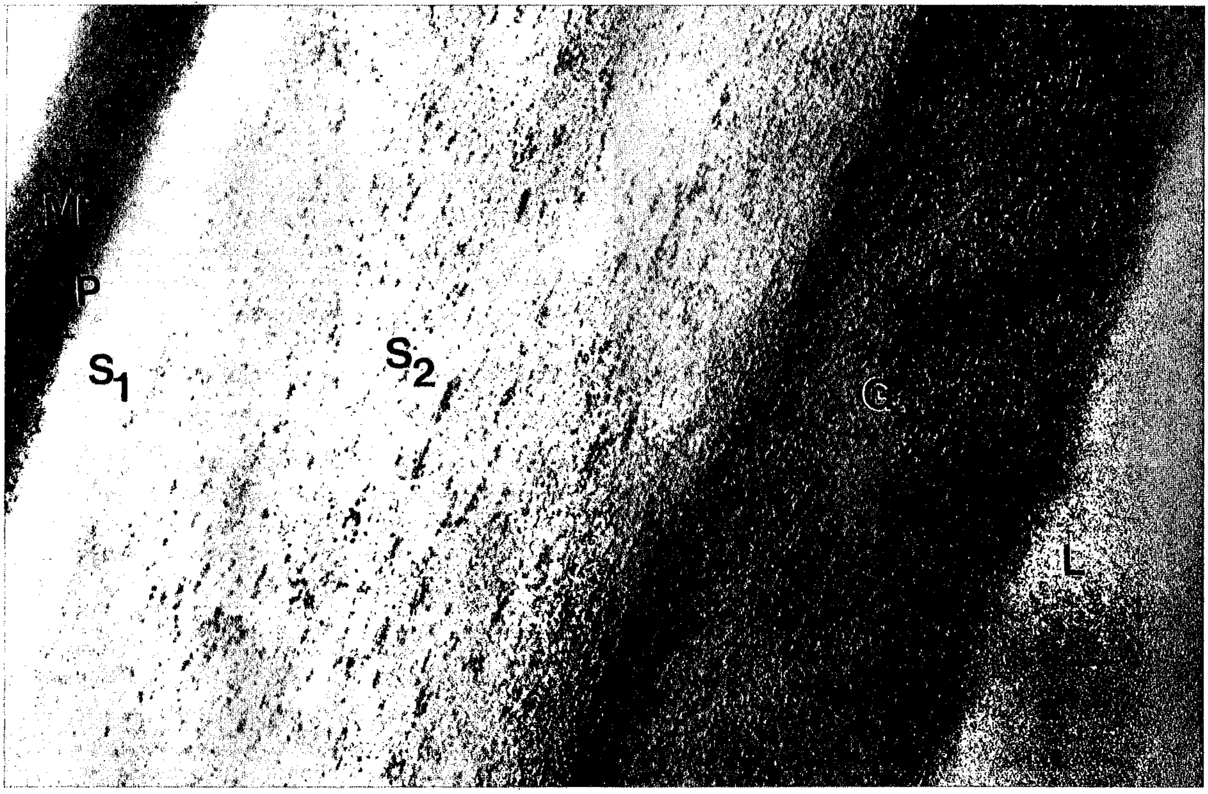

FIGURE 2. Longitudinal section (X 30,000) of tension wood fibres (legend as in Figure 1).

oriented at a steep angle to the long fibre axis and they are arranged predominantly parallel to one another as illustrated in the longitudinal section (Fig. 2). In this illustration it is observable that the microfibrils in the S_2 layer are oriented parallel to one another with an angular dispersion similar to that of the microfibrils in the gelatinous layer. Thus it is seen that the gelatinous layer is composed of parallel longitudinally-oriented microfibrils with a random distribution within the entire layer. Therefore, the gelatinous layer in tension wood, in trembling aspen at least, is neither a honeycomb nor a lamellar structure as postulated by other workers. —A. J. Mia, Forest Products Laboratory, Ottawa, Ont.

PATHOLOGY

Stimulatory, Inhibitory, and Lytic Effects of a Soil Solution on Fungi.—A soil solution was collected in October 1965 from tension plate lysimeters (glass coated aluminum oxide, pores 100 μ), inserted to a depth of 12 inches in a sandy soil at Midhurst, Ont. The area had been cleared from a pine plantation in 1962 and was used as an experimental nursery. The soil solution was stored for 5 months at 0°C and concentrated 20 x in a flash evaporator at 45°. Hundreds of fungi were isolated mainly from soil, and from healthy and diseased tree seedlings. Stimulatory, inhibitory and lytic effects of the soil solution were tested against 27 selected isolates. All fungi were grown on 1.5% water agar until the colony diameter was about 2 cm. Two methods were used to add small amounts of the concentrated soil solution to the periphery of the agar, but not touching the colony: (1) Two drops placed on the agar surface at one location and (2) six drops inserted in a circular hole made in the agar at another location. As control, drops of sterile distilled water were similarly applied at two additional locations in each dish. The responses of the fungi were observed microscopically 20 hours later.

The responses were qualitatively similar but stronger at the six-drop area than at the two-drop area. There were no marked responses in nine of the isolates. These included the most common associate of healthy and diseased seedlings, *Fusarium redolens* Wr., and the most common mycorrhizal parasite, *Cenococcum graniforme* (Sow.) Ferd. & Winge. Three isolates grew markedly faster near the areas than elsewhere. Such stimulatory responses occurred in a *Mortierella* sp., *Ceratobasidium cornigerum* (Bourd.) Rogers, and *Rhizoctonia dichotoma* Saksena & Vaartaja. Growth was strongly inhibited in three isolates which included some of *Waitea circinata* Warcup & Talbot and of *Mortierella elongata* Linneman. Twelve isolates were inhibited to a lesser degree. These included *Mortierella* spp. and *Penicillium janthinellum* Biourge, which was very common in the soil of the experimental nursery. *P. janthinellum* produced a pink pigment near the areas, but elsewhere the pigment was yellow. Early lysis of hyphae occurred abundantly in four isolates. At the areas where the soil solution was applied, *Fomes annosus* (Fr.) Cke. (obtained from Dr. D. Punter) produced an increased number of conidiophores and these were covered with more encrusting granular material than elsewhere on the agar. Increased crust formation occurred also at the hyphae and at the cystidia-like branches of another fungus commonly isolated from soil. This was thought to belong to the class Basidiomycetes because of the presence of possible cystidia, and moniloid chains of conidia and because of its strong mushroom smell. In more intensive studies, to be published elsewhere, similar results were obtained with other soil solutions and two other fungi: *Thanatephorus practicolus* (Kotila) Flentje was often stimulated while *Pythium ultimum* Trow was inhibited. The fungal responses as studied here suggest new research approaches to supplement the well known theory of Dobbs and Hinson about general fungistasis in soils.—O. Vaartaja and V. P. Agnihorti, Forest Research Laboratory, Maple, Ontario.

Fungi Isolated from the Beech Scale, *Cryptococcus fagi* (Baer.).—The role of the beech scale (*Cryptococcus fagi* (Baer.) in the spread of the fungus *Nectria coccinea* var. *faginate* Lohm., Wats. and Ayers, and in the develoment of the beech bark disease is obscure (Brown, R. C. 1934. J. Econ. Ent. 27: 327-334; Ehrlich, J. 1934. Can. J. Res. 10: 593-692; Shigo, A. L. 1962. Station Paper 168, N. E. For. Expt. Stea., U.S.D.A., 13 pp) To elucidate the fungus-insect relationship culturing *Nectria* from *C. fagi* was attempted.

Insects were collected near Rocky Brook, York County, New Brunswick, where beech were moderately infested with *C. fagi* and heavily infected with *N. coccinea* var. *faginata.* Five beach trees were selected each week from May 15 to November 15, 1963. Fungus isolations were made from 10 specimens of *C. fagi* from each tree, resulting in 50 isolation attempts per week and an overall total of 1200. Sub-culturing from mixed cultures brought the total to 1374.

The insects were removed from the bark with a sterile needle and transferred to test tubes containing streptomycin malt-yeast agar. Second-instar nymphs were used from May 15 to July 5, adults from July 10 to September 3, and first-instar nymphs from Sept. 3 to Nov. 15. The constituents of streptomycin malt-yeast agar were: malt extract 10g, yeast extract 2g, Bacto-agar (Difco) 17g, and distilled water 1,000 ml. The solution was autoclaved for 15 minutes at 15 psi, cooled to about 75°C, and 5 ml of dihydro-streptomycin sulfate (Lilly) solution (1%in H_2O) was added aseptically. Cultures were incubated in the dark at 24±2°C. Fungi appearing consistently were identified. Cultures resembling *N. coccinea* var. *faginata* or *Fusarium* spp. were transferred to streptomycin wheat germ agar and incubated at 22±2°C with alternating 12-hr. light (fluorescent at 200±25 ft-c) and dark periods; conditions known to induce sporulation of *Nectria.* Streptomycin wheat germ agar was prepared with wheat germ 20g, dextrose 2g, Bacto-agar (Difco) 17g, and distilled water 1,000 ml. The wheat germ was ground to a fine powder and added to 200 ml of distilled water and kept in a water bath at 70°C for 1 hr and shaken occasionally. This mixture was then filtered and the filtrate mixed with Bacto-agar, dextrose, and 800 ml of distilled water before autoclaving. Streptomycin was added as previously outlined.

Less than 1% of the cultures from *C. fagi* were *N. coccinea* var. *faginata.* Apparently the beech scale rarely carries *Nectria* externally, but this does not preclude the possibility that the insect carries the fungus internally. Eight of the twelve *Nectria* cultures were obtained from first-instar nymphs, one from a second-instar nymph, and three from adults. This distribution may be due to the abundance of maturing perithecia in the late summer and early fall when the insect is mobile as a first-instar nymph.

The 152 *Fusarium* cultures were identified as two species, *Fusarium redolens* Wr. and *F. avenaceum* (Fr.) Sacc. With the exception of *Phialocephala bactrospora* Kendrick, all other imperfect fungi were identified only to genus. The isolation of *P. bactrospora* was the first record for eastern North America. The assistance of Dr. C. Booth Commonwealth Myclological Institute, for his identification of the *Nectria* and *Fusarium* species and Dr. W. B. Kendrick, University of Waterloo, Waterloo, Ontario, for his identification of *P. bactrospora* is gratefully acknowledged.—G. I. Stone, Forest Research Laboratory, Fredericton, N.B.

SILVICULTURE

Effect of Pre-planting Root Exposure on Survival of Jack Pine Seedlings in Manitoba.—In the spring of 1965 a test was carried out in southeastern Manitoba to determine the effect of root exposure time on the subsequent survival of planted 2-0 jack pine (*Pinus banksiana* Lamb.). Stock was obtained from the Provincial Department of Mines and Natural Resources nursery at Hadashville, 30 miles northeast of the planting site.

After lifting, seedlings were exposed to direct sunlight for periods of 0, 1, 2, 5, 15 or 30 minutes prior to planting. Forty seedlings were exposed to each drying period; half of these had their roots dipped in water prior to exposure as further test of the effect of root desiccation. Roots of undipped seedlings were damp at time 0, slightly damp after 1 minute exposure, and parched after longer exposure times. The roots of dipped stock remained wet after 1 minute of exposure, some were wet after 2 and 5 minutes of exposure but all were dry after 15 minutes of exposure.

Seedlings were planted in rows of five at 3- by 6-ft spacing, in a randomized block design, on a dry sand flat which had been prescribed-burned in July of the previous year. Planting was done on April 29 under warm (70°F), sunny and very windy (20 to 40 mph) weather conditions. During the subsequent growing season temperatures were slightly below normal and precipitation about normal for the area.

Data were subjected to an analysis of variance. Neither root exposure time nor dipping of roots nor their interaction had a significant effect on survival after 2 years. Survival was good to excellent for all treatments (Table 1).

TABLE I

Survival of planted stock at the end of two growing seasons.

Exposure (minutes)	Number of seedlings surviving (of 20 planted)	
	Dipped stock	Undipped stock
0	16	15
1	15	18
2	15	14
5	13	16
15	12	14
30	16	14

Results of this study indicate that root exposures up to 30 minutes will not adversely affect the survival of 2-0 jack pine seedlings when favourable post-planting weather conditions prevail. Further replications are contemplated to study survival when post-planting weather conditions are more severe.—H. P. Sims, Forest Research Laboratory, Winnipeg, Man.

(*Continued from back cover*)

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O.H.M.S.

DEPARTMENT OF FORESTRY AND RURAL DEVELOPMENT

BI-MONTHLY RESEARCH NOTES

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CANADA
DEPARTMENT OF FORESTRY
AND RURAL DEVELOPMENT

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BI-MONTHLY RESEARCH NOTES

A selection of notes on current research conducted by the Forestry Branch, Department of Forestry and Rural Development

BOTANY

On the Use of Tyrosine as a Tree Fertilizer.—Studies made by Bradfute and McLaren (Inf. Tech. Microb. Inst. Pasteur 1, 1961) have demonstrated that some organic compounds such as amino acids and proteins can be absorbed as such by plants. Recently (Nat. Canad. 40: 177-192, 1963) during the course of an investigation on the free amino acid content in some forest plants of the mosses, herbs, and dwarf shrubs strata, we have noted that tyrosine occurs in large quantity in the air-dried leaves of ligneous plants. Further investigations (Nature, Lond. 212(5064): 844, 1966), made this time on tree needles only, have revealed the relative abundance of tyrosine in plant leaves could be associated with the presence of lignin. In the light of these results, it was postulated that addition of tyrosine to soil should be beneficial to ligneous plants such as tree seedlings, even under adverse conditions of soil and climate. Due to the low mineral nutrient content in the soil of the planting site, it was necessary to add a complete fertilizer to soil. NPK (2-10-20) fertilizers at the rate of 0, 100, and 200 lb./acre, and L-tyrosine in powder at the rate of 0, 0.1, and 0.5 g/tree were added to soil.

The planting site selected for this field experiment is located at Valcartier in one of the two "frost pockets" where Pomerleau and Ray (Dept. North. Affairs and Nat. Res. Forestry Branch Tech. Note No. 51, 1957) studied occurrence and effects of summer frost in a conifer plantation. In the very same area, two plantations had failed completely during the 3 years following their establishment. In the spring of 1963, black spruce (*Picea mariana* (Mill.) BSP.) of 3-0 stock, and jack pine (*Pinus banksiana* Lamb.) of 2-1 stock, were graded for size uniformity and planted in a randomized block arrangement with six replications of nine treatment combinations.

At the end of the third growing season, the results of the experiment were as follows:

1. The number of frosty days recorded during the 1963, 1964 and 1965 growing seasons were, respectively 22, 21, and 22 days.
2. Discoloration of tree needles was considerably less on seedlings planted in areas treated with tyrosine than on seedlings planted in areas treated with NPK alone or in untreated areas.
3. In the control plots, mortality of black spruce and jack pine was 46% and 19% respectively; while in plots fertilized with tyrosine, mortality varied from 4% to 7%, for both species.
4. On the plots treated with tyrosine, height growth of black spruce was from 67% to 79% greater than on plots not treated with tyrosine. The difference for jack pine varied from 192% to 216%.
5. Total height growth response to tyrosine fertilization for the years of 1963, 1964, and 1965 exceeded the probability level of 1% for black spruce and 5% for jack pine. (Table 1).

The plantation was re-examined in the fall of 1966, and the results were similar to those of the previous year. The development of this plantation made in the most adverse conditions will continue to be closely followed. In the meantime, further investigations on the effect of some amino acids on tree growth and resistance to frost is being conducted in hydroponic solutions using, in alternation, amino acids and inorganic substances.—J. D. Gagnon, Forest Research Laboratory, Sillery, P.Q.

TABLE 1

Variance ratios for black spruce and jack pine after three growing seasons

Source of variation	D.F.	Variance ratios		Snedecor's "F" values	
		bS	jP	P=.05	P=.01
Replications	5	1.92	1.15	2.45	3.51
Treatments	8	*4.11*	1.27	2.18	2.99
NPK	2	1.69	.39	3.23	5.18
Tyrosine	2	*13.07*	*3.72*	3.23	5.18
NPK X Tyrosine interaction	4	.84	.48	2.61	3.83
Error	40				
TOTAL	53				

ENTOMOLOGY

Chemical Control Studies on the Balsam Woolly Aphid (*Adelges piceae* (Ratz.)).—Results of preliminary experiments on the potential effectiveness of some insecticides against the balsam woolly aphid indicate that there are chemicals that exhibit toxicity to this insect. Of the compounds tested, two carbamate insecticides (Baygon and NIA-10242) appear to exhibit greater toxicity than do the organophosphorus compounds (Table 1). To date, no ærial application of the test insecticides has been undertaken to determine operational effectiveness. The data, however, suggest that the above two carbamates may be effective in controlling the balsam woolly aphid on plantation and ornamental stock, but confirmation by field experimentation is required before any recommendation can be made.

British Columbia

Preliminary laboratory and field investigations were conducted at Victoria and Duncan, in 1966 for the control of the balsam woolly aphid using the insecticidal compounds listed in Table 1 in the solvent dimethyl sulfoxide (DMSO), and the penetrating agent Invadine. These compounds were tested in the laboratory as contact insecticides against all stages of the aphid on excised infested bark discs. The field test consisted of both contact and systemic effects on standing infested tree trunks of grand fir (*Abies grandis* (Dougl.) Lindl.). The results indicate that the insecticides Baygon and NIA-10242 are superior to all materials tested under the conditions of the experiments. There are indications that solvents and penetrants play an important role in the effectiveness of the compounds.

Newfoundland

During the period 1963 to 1966, 27 insecticides (Table 1) were field tested against the balsam woolly aphid as a foliar spray on infested balsam fir trees (*Abies balsamea* (L.) Mill.) using ground spray equipment (W. W. Hopewell and D. G. Bryant, Bi-Mon. Prog. Rept. 22 (2): 1, 1966).

The results indicate that Baygon was superior to all other compounds tested.

New Brunswick

Experiments on the control of the balsam woolly aphid were conducted at Fredericton, N.B., in 1966 under laboratory conditions using egg masses, infested twigs and infested, potted balsam fir. Eighteen insecticides (Table 1) were tested as direct ovicides, contact insecticides and as systemic insecticides. Results of these tests indicate NIA-10242, Baygon, Bidrin, Diazinon and Matacil were promising materials.—A. P. Randall, W. W. Hopewell and P. C. Nigam, Chemical Control Research Institute, Ottawa, Ont.

TABLE 1

Toxicity rating of insecticidal compounds against the balsam woolly aphid

Insecticide		British Columbia		Newfoundland	New Brunswick
Name	Type	Lab.	Field	Field	Lab.
AC 47470	O-P	—	—	N	—
AC 47772	O-P	—	—	M	—
Aphidan	O-P	—	—	S	—
Aramite	O-P	—	—	S	—
Bayer 29493	O-P	S	N	—	—
Bayer 37289	O-P	—	—	M	—
Baygon	C	H	H	H	H
Bidrin	O-P	S	N	M	H
Ciba 8514	Misc.	M	N	M	N
Ciba 8874	O-P	M	N	M	—
Ciba 9491	O-P	N	N	N	—
Diazinon	O-P	H	M	M	M
Dicapthon	O-P	—	—	S	N
Dimethoate	O-P	—	—	S	—
Di-syston	O-P	—	—	—	N
DuPont 1179	O-P	—	—	S	?
Dursban	O-P	—	—	H	?
Dylox	O-P	M	M	S	?
Formothion	O-P	M	M	S	N
Lindane	C-H	—	—	—	N
Matacil	C	—	—	—	M
Malathion	O-P	—	—	S	—
Menazon	O-P	—	—	M	—
Meta-systox-R	O-P	S	N	S	N
Nellite	O-P	—	—	N	—
NIA-10242	C	H	H	—	H
Phosphamidon	O-P	N	N	S	N
Sumithion	O-P	S	N	S	N
Thimet	O-P	—	—	N	?
Thiocron	O-P	—	—	N	—
Vamidothion	O-P	—	—	N	—
Zectran	C	—	—	M	N

LEGEND: H= Highly effective. M= Moderately effective. ?= Doubtful.
S= Slightly effective. N= Non effective. —= Not tested.
C-H= Chlorinated Hydrocarbon. O-P= Organophosphorus.
C= Carbamate.

Low Fecundity of the Spruce Budworm Attributed to Unusually High Temperatures During Immature Stages.—During the summers of 1965 and 1966 experiments were conducted at Black Sturgeon Lake Field Station, Ontario, on the ovipositional habits of the spruce budworm, *Choristoneura fumiferana* (Clem.). In 1965 the mean fecundity of 69 females was 179 ± 8. This includes all females, even those laying only a few eggs. The maximum number was 335; 31 of the females produced over 200 eggs. During 1966, using the same genetic stock and the same techniques, the fecundities were far lower. The mean fecundity of seven females from mating experiments set up exactly as in 1965 with foliage in moist sand in lantern globes, was 109 ± 30; the most fecund female produced 249 eggs, the only figure over 200. In other experiments in 1966 in which pairs of budworm were placed in glass jars with foliage, 15 females had a mean fecundity of 84 ± 9 while in a further 38 matings in which the females were presented with a variety of artificial foliage in lantern globes, the mean fecundity was 48 ± 7. Low fecundity was also found in three 3 × 3 × 9 ft cages and in a glass house in each of which 10 pairs of budworm were released. The average number of eggs for the 40 females was 34.

Clearly, there was some factor, or factors, present in 1966 but not in 1965 to cause such consistently poor success in reproduction. Nothing in the experimental condition could be found to account for this. Budworm are commonly confined in jars for mating purposes with no ill effects (Stehr, G. W. Can. Entomologist 86: 423-428, 1954) and frequently lay a full complement of eggs even when no foliage is available. In both 1965 and 1966 some of the adult budworm were stored in a refrigerator at 2°C for up to 10 days until suitable mates were available. However, no correlation was found in 1965 between fecundity and the length of storage period up to 10 days of either the males or the females.

Weather station records at Black Sturgeon Lake show that during the last 10 days of the average larval period in 1966, June 22 to July 2, the mean maximum daily temperature was 30.2°C, 7°C above the average for the same period for the previous 18 years, and 11°C above the average for the comparable development period in 1965. On July 1, 1966, a maximum of 35°C occurred. The average pupation date for males was July 1, for females July 3. During the pupal period, July 2 to July 12, the mean maximum daily temperature was 28.2°C, 4°C above the 18-year average, and 6°C above the comparable period in 1965. Throughout the late larval and pupal periods the insects were reared in the insectary where temperatures are known to approximate those in the Stevenson screen.

Development rates in 1966 reflected the high temperatures. Thus, the average pupation date in 1966 was only 2 days later than in 1965 in spite of the fact that larval development in May was delayed by a late spring. The duration of the pupal stadium in 1966 was much shorter than in 1965 (8.7 ± .27 days for males and 8.6 ± .28 days for females in 1966 versus 15.0 ± .09 days for males and 14.5 ± .14 days for females in 1965). No data are available to compare pupal sizes for the 2 years, but in 1966 the average weight of seven female pupae was 95.9 ± 12.1 mg. and of nine males 75.7 ± 3.5 mg. These are well above the average weights for the spruce budworm (Campbell, I. M., Can. J. Genet. and Cytol. 4: 272-288, 1962). No significant differences were found between the sizes of the adults in the 2 years as measured by the length of the forewing. Therefore, the low fecundities in 1966 cannot be attributed to smaller individuals, for the adults were larger than average and, based on wing measurement, at least as large as in 1965.

G. W. Stehr (personal communication) has confirmed that, in general, rapid development of the budworm is correlated with larger insects and higher fecundity, which supports the theory that warm conditions in the larval period favour the initiation of outbreaks (Greenbank, D. O., *In* Mem. Entomol. Soc. Can. 31, 1963). Conditions in 1965 were apparently favourable for the larvae, although the maximum temperatures were lower than average, and resulted in large larvae and high fecundity. Greenbank (*ibid.*) cites mean maximum temperatures of between 18 and 23°C during the late larval periods for the years 1945 to 1949 at Green River. These were the years during which the outbreak in that region developed and his data for the length of the late larval periods show that larval development was faster in those 5 years than during the next nine years. In 1966 at Black Sturgeon Lake the budworm developed rapidly and attained a large size, which was to be expected from the high temperatures, but the expected high fecundities failed to materialize. It is possible that the 1966 temperatures were above optimum and that this caused partial sterilization of the males as has been demonstrated for other insects (Bursell, E., *In* Physiology of Insects Vol. I, Academic Press, 1964. Wellington, (Henson, W. R., Ph.D. Thesis, Yale Univ. 1951) considers that budworm larvae in their feeding tunnels may frequently encounter temperatures in the range of 35.8 to 40.0°C. The possibility that exposure to such high temperatures for short periods during the late larval and pupal periods may affect the reproductive success of the spruce budworm is of fundamental importance in its population dynamics.—C. J. Sanders, Forest Research Laboratory, Sault Ste. Marie, Ont.

Metabolism of 4-hydroxyproline in White Spruce (*Picea glauca* (Moench) Voss) and in the Spruce Budworm (*Choristoneura fumiferana*).—A survey by Steward and Durzan (*In* Plant Physiology: A Treatise, Academic Press, N.Y. Vol. IV A) of the free amino acids in plants has shown that hydroxyproline seldom occurs free but is found primarily in protein. When uniformly-labelled ^{14}C-L-arginine is applied to terminal buds of leader shoots of white spruce, the carbon of arginine moves readily to proline and appears in bound hydroxyproline (Table 1). Since no free hydroxyproline was found in spruce, except in pollen, proline when incorporated into protein must have been hydroxylated. This phenomenon is well-known in other organisms (Meister, Biochemistry of the Amino Acids, Academic Press N.Y. p. 711-729, 1966).

Amino acid analyses of budworm larvae (instars V-VI) that were feeding on balsam fir and white and red spruce reveal a striking absence of hydroxyproline (not > 2 μmoles/g dry wt) in acid hydrolysates of the 70% alcohol-insoluble (protein) fraction. Occasionally traces of free hydroxyproline occurred in the soluble fraction and probably arose when leaf or bud protein was digested. This indicates that larvae were unable to incorporate free hydroxyproline into protein or, more important, to hydroxylate the existing bound proline to hydroxyproline.

TABLE 1

Specific activity of carbon in proline and hydroxyproline derived from uniformly-labelled ^{14}C-L-arginine (172 x 10^3 cpm/mg C) applied to apices of terminal buds of white spruce saplings

	Specific activity (counts per minute/mg C)			
	24 hr	48 hr	72 hr	96 hr
Free proline	37,260	25,060	21,520	10,890
Proline (protein)	2,120	2,790	2,600	1,810
Hydroxyproline (protein)	2,600	4,770	7,590	7,350
Ratio of activity (hydroxyproline/proline)	1.2	1.7	2.9	4.1

In contrast to arginine, both proline and hydroxyproline are not known as essential amino acids in the diet of insects. Of many amino acids tested, only proline consistently evoked feeding responses in budworm larvae (R. J. Heron, Can. J. Zool. 43, 247-269, 1965). High levels of arginine in conifer buds serve as a rich source for this essential amino acid, and proline appears to be a chemotactic stimulant for feeding with little added nutritional significance. The protein metabolism of spruce buds differs with budworm larvae in its ability to form hydroxyproline from proline.—D. J. Durzan, Petawawa Forest Experiment Station, Chalk River, Ontario.

FOREST MANAGEMENT

Volume Estimates of White Spruce in the Mackenzie Delta from Large-Scale Aerial Photographs.—The Forest Management Research and Services Institute is engaged in a series of research projects to develop an efficient system for the application of large-scale aerial photography in forest inventories. As part of these studies an experimental inventory of the southern portion of the Mackenzie River Delta was begun in 1966. This inventory relied upon general coverage photographs at a scale of 1:15,840 and a 1 to 2% sub-sample with large-scale photos at 1:2,000. To exploit the information available on the large-scale photographs, useful relationships must be found between the photo measurements and the variables to be estimated, such as volume and diameter.

Past investigations of these relationships have successfully relied upon independent variables which involve tree height and crown dimensions (G. M. Bonnor. Forestry Chron. 40: 339-346, 1964; Can. Dept. Forestry, Forest Res. Branch Mimeo. 64-H-10, 1964) or upon more complex models which included variables which expressed the relationship of trees to their neighbours or the degree of crowding in a stand. For example, Sayn-Wittgenstein and Aldred (Photogrammetr. Eng. 23:69-73, 1967) found that a consistently good equation for estimating the volume of hardwoods and softwoods from an area near the Petawawa Forest Experiment Station in Ontario included the independent variables: tree height (H), crown area, and the count of the trees growing in a circular area surrounding the tree under consideration, with the radius of this circle equal to the height of the subject tree (NH).

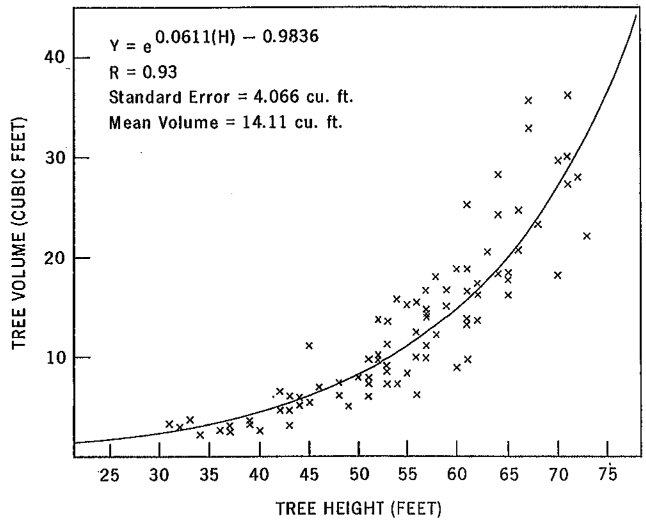


FIGURE 1. Best total cubic foot tree volume function found from stepwise regression analysis.

Different rules apply in the Mackenzie River Delta. Ninety white spruce trees were selected, felled, and measured to determine the total volume of each tree. Before felling the trees were photographed from the air at 1:2,000 and photo-measurements of height, crown area, and a host of variables such as (NH) which express crowding or competition were measured. It was then determined whether these variables contributed significantly towards estimates of total volume, but none proved useful after (H), or transformations of (H) had been introduced. The best function is shown (Fig. 1). (The values for two trees—one, height 89.0, volume 84.2 and the other, height 81.0, volume 33.3—are not included in the figure, but were used in the calculations.)

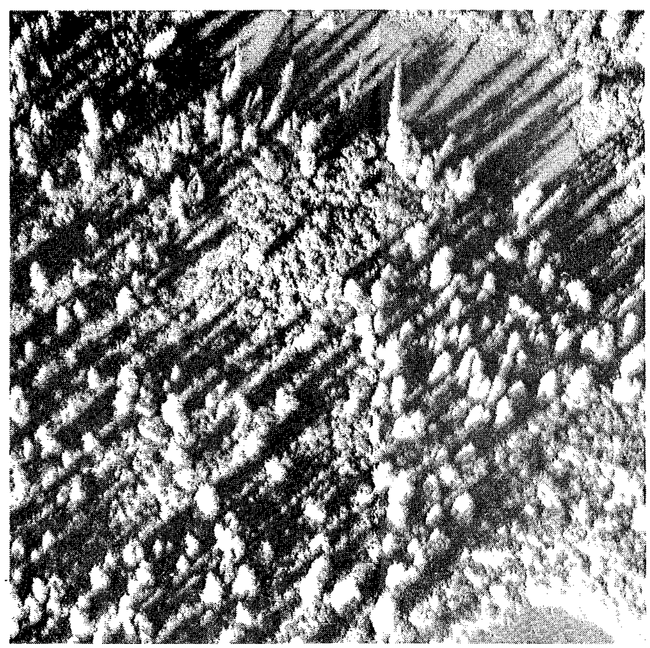


FIGURE 2. Oblique photograph of white spruce in the Mackenzie Delta (Approx. 1:2,500.).

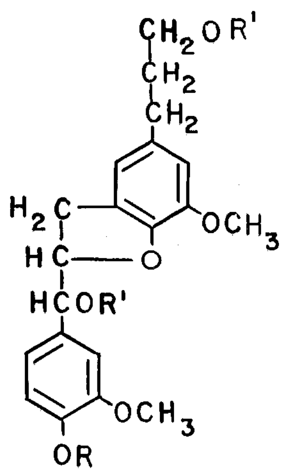
A partial explanation of this result may be found in the narrow, often spire-like white spruce crowns (Fig. 2). Their shape is a result of the harsh climate and to some extent of genetic characteristics. The growth of branches is hampered by snow pressure, and the crippling effects of ice and wind; height growth, on the other hand, is less inhibited. Trees under the protective influence of neighbours tend to develop wider crowns, which counteracts the usual restraining effect of neighbours on crown development. The result is that crown size and competition bear a complex and unusual relationship to tree volume. The only consistently powerful relationship is between height and volume.—A. H. Aldred and L. Sayn-Wittgenstein, Forest Management Research and Services Institute, Ottawa, Ontario.

FOREST PRODUCTS

The Presence of a New Phenylcoumaran in Western Hemlock (*Tsuga heterophylla* (Raf.) Sarg.) Sapwood.—The presence of a lignin dimer (I) with a β,γ linkage rather than the well known α,β linkage has been discovered in western hemlock in yields of 0.1 to 0.3% (moisture-free, extractive-free basis). Its detection on silica gel thin-layer plates [R_F=0.60 in chloroform-methanol (7:3), R_F=0.24 in chloroform-methanol (7:1)] was enhanced by its reaction with diazotized sulphanilic acid (DSA). The initial orange colour development with this reagent, diagnostic for α-hydroxy guaiacyl compounds, changes to a characteristic red after several hours. This colour change has been useful in its purification from closely associated α-hydroxy guaiacyl compounds in hemlock extractives which remain yellow-orange after detection with the DSA reagent.

Although attempts to crystallize I or its derivative (II or III) were unsuccessful, a high degree of purity was attained for III by preparative thin-layer chromatography [R_F=0.23, silica gel; cyclohexane-ethyl acetate (3:2)]. This purity was confirmed by C and H analysis (calculated for III, carbon 65.6, hydrogen 6.55; found 65.6, hydrogen 6.59%).

The structure for I was determined by the use of high resolution nuclear magnetic resonance, decoupling experiments and mass spectrometry on I and its derivatives II and III. Infra-red and ultra-violet analysis were also confirmatory. Degradation and synthesis experiments are being investigated. Final proof of structure will be presented elsewhere.



I R=R'=H

II R=CH3 R'=H

III R=CH3 R'=COCH3

FIGURE 1. The presence of a new phenylcoumaran in western hemlock.

In addition to the presence of I in western hemlock as an aglycone there is evidence that it may also occur as a glucoside. It was found that one of the previously reported phenolic glucosides (Goldschmid and Hergert, Tappi 44:858-870, 1961) of western hemlock sapwood extractives produced significant amounts of I on hydrolysis with 2% aqueous oxalic acid. Since, however, the glucoside gave an orange colour with DSA, the sugar moiety must be attached through an alcoholic rather than a phenolic linkage. Reference compounds of dehydrodiconiferyl alcohol and guaiacylglycerol-β-coniferyl ether were extremely useful as comparative compounds and were obtained through the kindness of Dr. K. Freudenberg.—G. M. Barton, Forest Products Laboratory, Vancouver, B.C.

Isolation of Products from the Extractives of Eastern White Cedar (*Thuja occidentalis*).—Very little research has been carried out on the extractives of eastern white cedar (*Thuja occidentalis* L.). The only products reported have been the tropolones α and γ thujaplicin, cedrene, cedrol, and two sesquiterpene alcohols. There has been no report of any attempts to isolate and identify any of the non-volatile products. Accordingly, a project was initiated at the Ottawa Forest Products Laboratory to isolate and identify these products.

The acetone-soluble extractives removed from ground heartwood by soxhlet extraction were fractionated by precipitation with ether, benzene, and, finally, petroleum ether. The ether-insoluble portion contained highly condensed material, while the volatile products remained soluble in the petroleum ether solution. The benzene and petroleum ether-insoluble fractions contained the less condensed non-volatiles.

Using conventional two-dimensional paper chromatography with butanol-acetic acid-water (4:1:5) followed by 2% acetic acid in the other direction the benzene insoluble fraction showed seven spots. The lowest Rf number relating to the butanol-acetic acid-water was 0.64; this ruled out most glycosides, tannins, and phlobaphenes which would have lower Rf numbers. Leucocyanidins also usually have lower values with butanol-acetic acid-water and are probably not present in the benzene insoluble fraction. The spots obtained, however, were not distinct and each one was probably a mixture of several products.

Thin-layer chromatography proved to be far superior to paper chromatography for separating the products of the cedar extractives. Avicel (a microcrystalline cellulose from the American Viscose Co.) produced very good thin-layer plates which gave results similar to paper chromatography. Also, it had the great advantage of completing the separation in less than a quarter of the time required on paper. Much better separations were obtained with plates of Merck silica gel (Fig. 1) and a developing agent of benzene-acetic acid-methanol (45:4:8). The benzene insolubles consisted of about seven separate products; the petroleum ether insolubles contained a similar number of products in a higher Rf range. The ether insolubles contained mostly condensed materials with low Rf numbers, while the petroleum ether solubles had products with high Rf values. No spray was required to make the spots visible. With the silica gel all spots turned either brown, yellow, or grey shortly after the plates were removed from the developing chamber. These colours became even more intense after 1 or 2 days indicating that some slow degradation was taking place. This could be an oxidation of the phenolic products catalyzed by the iron present in the silica gel. Some chelate formation with the iron and $CaSO_4$ binder may also occur. A spray with ferric chloride-potassium ferricyanide confirmed that all products were phenolic and a sulphuric acid spray showed that no other materials were present. When the products were isolated from preparative silica gel plates only part of each isolated fraction was still acetone soluble. A treatment with acid to break any complex formation still left most of the material insoluble in acetone. Thus, the change appeared to be irreversible and the silica gel was considered to be unsuitable for preparative work.

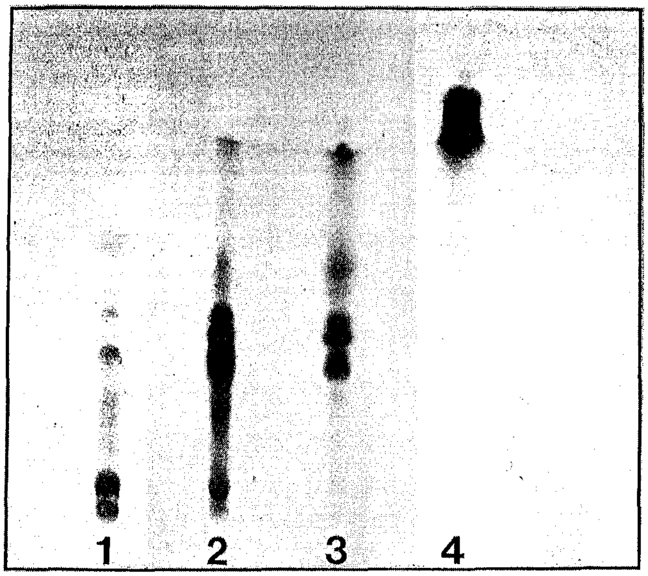


FIGURE 1. Thin-layer chromatogram of cedar extractives on silica gel G with benzene-acetic acid-methanol as developing agent. 1-ether insolubles, 2-benzene insolubles, 3-petroleum ether insolubles, 4-petroleum ether solubles.

Thin-layer plates prepared from polyamide powder also gave good separations with the benzene-acetic acid-methanol system. The chromatographed material did not become highly coloured on the plates and, when isolated from preparative plates, it appeared to be unchanged. Figure 2 shows a preparative plate of benzene insolubles, half of which has been sprayed with diazotized benzidine to make the bands visible. Actually, for isolating the products, no spray is used since the bands are visible under ultra-violet light. The polyamide containing the various bands was eluted with methanol or ethyl acetate-acetic acid-water (2:1:1).

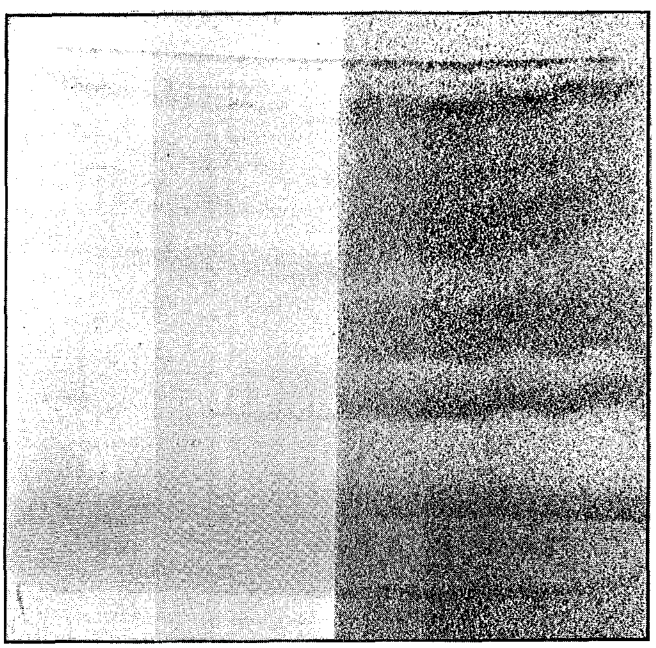


FIGURE 2. Preparative polyamide thin-layer chromatogram of the benzene insoluble fraction of cedar extractives.

With Woelm polyamide for thin-layer chromatography or with Polypenco polyamide from Polymer Corporation it was not possible to prepare plates 1 mm in thickness as with silica gel G or avicel. Even with starch as a binder the best Polypenco plates were only 0.25 mm thick. However, since the polyamide has a high capacity it was possible to separate the products from 0.1 gm of sample on one preparative 20 cm × 20 cm plate. Several products are now being isolated from such plates and these are being studied.—N. Levitin and G. Bigras, Forest Products Laboratory, Ottawa, Ont.

PATHOLOGY

Occurrence of *Cryptodiaporthe populea*, the Perfect State of *Dothichiza populea*, in Quebec.—Prior to 1957, *Cenangium populneum* (Pers.) Rehm was thought by many to be the ascogenous state of *Dothichiza populea* Sacc. & Briard. This assumption was based on a report by Voglino in 1911 (see A. M. Waterman. Forest Sci. 3:175-183, 1957). In 1957, it was clearly demonstrated by Butin (Nachr. Bl. Dtsch. Pflazenschutzd. 9:69, 1957) that *Cryptodiaporthe populea* (Sacc.) Butin was the perfect state of *D. populea* in Europe. Almost simultaneously, Waterman (*loc. cit.*) showed that *Cenangium populneum* and *D. populea* were also different entities in North America, but failed to detect the perfect state of the latter. Since then, to our knowledge, the occurrence of *Cryptodiaporthe populea* in association with *Dothichiza populea* has not yet been reported in North America.

Recently, several collections of cankered Lombardy poplars were made at Cap Rouge, Quebec, on which fructifications of a *Cryptodiaporthe* were commonly associated with *D. populea*. Cultures obtained from both ascospores and conidia were identical to one another and to other authentic isolates of *D. populea*, thus establishing the link between the two stages. Perithecia, collected both in August and December 1966, corresponded closely to the description of *C. populea* given by Müeller & Arx (Beitr. Krypt.-flora Schweiz, 11 (2), 1962). Mature asci, however, were slightly smaller than previously described, measuring from 60-80 × 8.0-14.0 μ. Also, ascospores became septate tardively; they measured from 12.8-16.0 × 4.8-8.0μ. Although pycnidia were still observed in early December, it would appear that perithecia are the main overwintering structures of the fungus.

These observations confirm the results of Butin and should definitely serve to dissociate *Cenangium populeum* from Dothichiza canker of poplar.—G. B. Ouellette, Forest Research Laboratory, Sillery, P.Q.

Killing of White Pine Trees by Snowshoe Hare Feeding.—The snowshoe hare (*Lepus americanus*), also known as the varying hare or snowshoe rabbit, is predominantly found in the northern portion of Ontario, preferring coniferous cover. Periodic fluctuations in the population of snowshoe hares result in fairly regular peaks, occurring on the average, every 9.6 years. The most recent provincial peak was reached during the period 1958-60. Prior to this, a noticeable peak occurred in 1934-35, followed by a minor peak in the early 1940's, and an abortive peak in 1951.

During the winter of 1958-59 there was an over-population of snowshoe hares in the forests of the Upper Ottawa Valley, in relation to the supply of available food. The effects of their voracious feeding on a 14-year-old white pine plantation at Chalk River were examined. Observations were made on the type of damage caused, and on the resulting tree mortality in an 0.25 acre sample plot in the plantation. A total of 490 white pines was present on this sample plot in the spring of 1959, and their average height and DBH were 9.2 feet and 1.41 inches respectively. The tallest tree was 14 feet in height and the largest DBH was 2.69 inches. The smallest tree was 2.5 feet in height with no measurable DBH.

The plantation was first examined on May 6, 1959, and the effects of the large population of snowshoe hares were immediately obvious. Apparently, since the ground was covered with droppings, and every tree had been chewed to some degree, a great number of hares had selected this particular plantation for a resting habitat sometime during the winter of 1958-59.

The hares damaged white pines by chewing off the distal portions of the terminal and lateral shoots (twigs with foliage). The obliquely cut surface of the branch had a fairly smooth appearance. Shoots of white pine were severed from 1 foot above the ground up to heights of 5 and 6 feet, which were reached by the hares standing on top of the snow. Hardwood tree species which had found their way into the plantation and grew between the rows of white pines were killed outright, having had their outer bark and phloem gnawed down to the xylem along their main stems.

A tally of the white pine trees in subsequent years showed the following: No trees died during the summer of 1959 as a result of hare feeding during the previous winter. In 1960, six severely chewed trees died. Mortality reached a peak in 1961 with 10 trees unable to survive the severe damage caused by the hares 2 years earlier. In 1962 only two trees died and by 1963, 4 years after the feeding, mortality ceased.

Table I shows the relationship between the size of all the trees in the 0.25 acre sample plot and those killed by snowshoe hare feeding. A total of 18 white pines died following the severe hare feeding and none was over 6 feet in height or had a DBH of over 0.50 inches. All 10 trees that were 4.5 feet or less in height were killed. The bulk of the trees in the plot were over 6 feet tall and had DBH's over 0.50 inches, and none of these trees died as a result of the hare feeding damage. It is apparent that had the plantation been younger with the majority of the trees under 6 feet in height, serious mortality would have resulted.

TABLE I

Hare-killed trees separated into height and DBH groups.

Height Group (ft)	Total trees	Hare-killed trees		DBH Group (in.)	Total trees	Hare-killed trees	
		No.	%			No.	%
4.5 and lower	10	10	100.0	No measurement possible	10	10	100.0
4.6–6.0	20	8	40.0	0.01–0.50	23	8	34.8
6.1–8.0	68	0	0.0	0.51–1.00	69	0	0.0
8.1–10.0	298	0	0.0	1.01–2.00	321	0	0.0
Over 10.0	94	0	0.0	Over 2.00	67	0	0.0
Total or Average	490	18	3.7	Total or Average	490	18	3.7

Because of the cyclic nature of the populations of the snowshoe hare, which is caused by the interaction of biological potential and environmental resistance, another peak may be expected in the year 1969. There are several ways in which damage to trees from snowshoe hares may be avoided. Since white pine is more palatable to the snowshoe hare than other tree species, e.g. white spruce, the latter species should be preferentially planted in the years immediately preceding peak hare years. Predators of the snowshoe hare which include carnivorous animals, hawks, and owls should be encouraged. Chemical repellents sprayed on the foliage of trees are effective against hares during the year of application, but new growth which develops subsequent to spraying is fed on by hares. Hares may be excluded from plantations by wire fencing. The above measures would be most beneficial if used to protect trees in plantations which were less than 6 feet in height. S. N. Linzon, Forest Research Laboratory, Maple, Ont.

SOILS

A Soil Sampler for Extraction of Intact Soil Cores From Forest Soils.—The characterization of a soil profile or the evaluation of the effects of treatment on a soil, usually necessitates the taking of undisturbed soil samples. Since forest soils are frequently stony and coarse, it is often difficult to obtain undisturbed samples. Soil samplers described by Richards (U.S. Agricultural Handbook No. 60, 1954) and Steinbrenner (Soil Sci. Soc. Proc. 15, 1950) are used primarily for the extraction of surface cores. The sampler described here, successfully removed intact soil cores to a pre-determined depth from two inter-mountain podsol soils described by Kelley and Spilsbury (Report No. 3, British Columbia Soil Survey, 1949) now described as degraded acid brown wooded (Rept. Sixth Meeting Natl. Soil Surv., Can. Dept. Agr. 1965) with a profile type: *L-H*, *Ae*, *Bfh*, (*Bf*), *C*. The cores were sufficiently free from contamination for chemical and physical analyses.

The complete sampler consists of an exterior extractor and an interior liner. The exterior portion is made up of a cutting head, a sectioned shaft, and a T-shaped vented top. The cutting head has a hardened cutting edge, a machined shoulder on which the core liner rests, and ½" of machine thread. The inside diameter (I.D.) of the cutting head is slightly smaller than that of the liner to prevent sticking and compacting of the soil core. Shaft sections are made from 3-inch I.D. seamless steel tubing with ½" of machine thread so sections may be coupled to any desired length. It has proven convenient to machine shaft sections to the length of liner. To protect the threaded portions of the sections as the sampler is driven into the soil, slightly less than one-half (3⁄16") of the tube wall is utilized by the thread; the remaining portion is machine-faced to meet evenly and tightly with the adjoining section. The sampler top has ½" of machine thread to join it to the upper end of the shaft, an air-escape vent, and a 12" T-handle. Rounding the sampler top helps to maintain the sampler in a vertical position as it is driven into the soil.

Cylindrical liners are fitted inside the extractor shaft. Fifteen-ounce, lacquered preserving cans, with both end flanges rolled, are suitable liners. Sampling to a desired depth is accomplished by joining an appropriate number of cans with tape. The rolled end-flanges help to maintain the cylindrical shape of the liner and reinforces the end that rests on the shoulder of the cutting head.

The assembled unit may be driven into the soil with a heavy sledge hammer. On tightly compacted soils, particularly in the "C" horizons, placing a hardwood block upon the extractor top reduces vibrations as the unit is driven into the soil. Small rock fragments and stones are either pushed aside by the curved surface of the cutting head or imbedded in the soil core. Obstructions too large to enter the extractor or to be pushed aside, may sometimes be overcome by rotating the unit as it is driven into the soil. Roots are easily cut if the head is kept sharp and hard.

Extracting cores from dry sandy soils, excessively wet clayey soils and soils with considerable surface litter require special care. Moistening dry sandy soils facilitates obtaining cores. Compaction of the surface litter within the core sampler may be avoided by pre-cutting the litter layer with a cutting tool equal in diameter to that of the extractor cutting head. To prevent contamination of the core and to minimize the loss of surface soil, the lid of the top liner section should not be removed, but it must be vented. Because the outside diameter of the cutting head is greater than that of the shaft the danger of the soil sticking to the sides of the extractor shaft is reduced. After the sampler has been driven into the soil to the desired depth, it is rotated to break the core evenly from the soil mass.

After removal of the sampler from the soil, the screw top is removed and the liners pushed through the shaft sections with a plunger-type tool. Removal of the tape that joins the liners together permits separation of the core into sections. The cores may be sealed within the liners and stored in a cold room to minimize chemical and physical change.

The soil sampler is made of readily available and inexpensive materials. The total cost of the entire unit including case hardening of the cutting head and sufficient shaft sections to extract cores 2 feet in length is about $65.00. The cost of liners and splicing tape for a 2-foot core is about 25 cents. Plans for this soil sampler may be obtained from the author. —J. Baker, Forest Research Laboratory, Victoria, B.C.

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O.H.M.S.

J. B. Rousseau

DEPARTMENT OF FORESTRY
AND RURAL DEVELOPMENT

BI-MONTHLY RESEARCH NOTES

IN THIS ISSUE:

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CANADA
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BI-MONTHLY RESEARCH NOTES

A selection of notes on current research conducted by the Forestry Branch, Department of Forestry and Rural Development

BOTANY

Cone Production Induced by Drought in Potted Douglas-Fir—Flower bud formation in forest trees has been frequently linked with hot, dry spring and summer weather, and seed crop periodicity to climatic variation (J. D. Matthews, Forestry Abstracts 24. 1963). Holmsgaard and Olsen (Forstlige Forsøgsvaesen i Denmark, 30. 1966), have recently demonstrated induction of flowering in beech by drought treatment. Optimum response was on plants dessicated between June 17 and August 12. With this exception, relative importance of the effect of temperature versus the effect of moisture stress has not been separated nor the critical time and duration of flower-inducing weather closely defined. Three of six Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco) clones grafted in 1959, to provide research material for such studies, produced cones each year since 1962 when held outdoors. In 1964, the heaviest cone year, 10% of the planted, and 42% of the potted, open-bed grafts of these clones produced cones. Individuals held in the greenhouse were always devoid of reproductive tissues.

If above-average temperature is a direct requirement for floral initiation in Douglas-fir, the greenhouse environment should have favored cone production. Alternatively, the possibility of a cold requirement for pre-conditioning prior to the period of bud differentiation did not seem consistent with the erratic flowering response of the species to its natural environment. It was suspected that routine watering of the grennhouse-held plants was more conducive to vegetative growth than floral initiation. The outside plants, which were dependent upon natural precipitation with occasional supplementary watering, were periodically subjected to periods of moisture stress which could have temporarily arrested growth and favored flower bud initiation.

To test the role of moisture stress on cone production a reciprocal transfer of greenhouse and outside grafts was made on April 28, 1964. Shoot growth on greenhouse plants was already well advanced while vegetative buds were just beginning to swell on the outside plants. The material at each location was equally divided for a 60-day wet or dry treatment extending to June 28, after which routine watering was resumed. Each of the four groups contained 20 plants equally composed of six original greenhouse plants and 14 original outside plants. The outside location was changed from open beds to a lath shadehouse at the beginning of the experiment. Rain was excluded from the outside plants during the treatment period by plastic sheeting over the shadehouse roof.

The wet series were watered to runoff at 1-to-3-day intervals, and the dry series were restricted to between 50 and 150 ml of water per pot at intervals of 2 to 5 days. The water added to the dry series averaged 30 ml a day spread over the surface of the 7-inch pots. All material was brought into the greenhouse on May 1, 1965, for cone counts and to provide a uniform environment for the second season's growth. Data from the two clones represented in the experiment were combined since both clones responded similarly to treatment.

Reproductive tissues were not found on any of the plants in the wet series, whereas 11 out of 40 produced cones in 1965 in response to the previous year's drought treatment (Table 1). Cone and seed development appeared normal. Among the original outside plants, cone production response was much stronger when drought treatment was applied in the greenhouse than when applied to plants retained outside. This may be attributed to more favorable temperature and light conditions for continued bud development in the greenhouse or to the much more severe growth reduction of the outside plants due to drought.

TABLE 1

Effect of Location and Moisture Stress on Cone Production and Height Growth

Movement April 28, 1964	No. of plants	No. Reproductive	Total Cone Count 1965		Mean Height Growth (cm.)	
			Female	Male	1964	1965 (Greenhouse)
Dry Series						
Greenhouse to Outside	6	1	0	1	15	5
Retained Greenhouse	6	0	0	0	17	17
Retained Outside	14	2	3	140	4	4
Outside to Greenhouse	14	8	10	463	6	11
Wet Series						
Greenhouse to Outside	6	0	0	0	20	11
Retained Greenhouse	6	0	0	0	23	21
Retained Outside	14	0	0	0	8	7
Outside to Greenhouse	14	0	0	0	8	13

Plants which had been continuously held in the greenhouse before treatment contributed only one male cone in response to drought. Shoot growth had started at the time treatment commenced and bud initials on the new shoots may have been developed to the stage where differentiation into reproductive buds could no longer be altered by treatment. Owens and Smith (Can. J. Botany 42:1031-1047. 1964) reported that reproductive primordia of Douglas-fir are histologically distinguishable from vegetative primordia when elongation commences on the new shoots on which they develop. Since growth was advanced, drought reduced height growth of the original greenhouse plants to a lesser degree than that of the later-flushing, original outside plants. Height growth reduction continued into the second year in all four dry-series groups. The cone induction response of individual plants within groups showed no correlation with the severity of height growth reduction in the year of treatment.

Post-experiment observations further support the hypothesis of a regulatory role of moisture stress in floral initiation of Douglas-fir. Thirty-four of 102 grafts of two clones continuously held in the greenhouse and subjected to a much reduced routine watering regime in 1965, bore flowers of either or both sexes in 1966. Again in 1965, 100 Douglas-fir, 2+2 transplants, were lifted about 1 week before vegetative bud break, potted and held in the shadehouse. In addition to transplant shock at a susceptible growth stage, the stock was inadvertently allowed to dry out after potting. This resulted in a severe height growth reduction and 16% mortality. Two seedlings bore one female cone each and three seedlings bore 3–5 male cones in 1966, suggesting the possibility of stimulating cone production in very young juvenile material by controlled drought treatment.

These cone production responses from moisture stress suggest that floral initiation, in long-lived species with pronounced seed crop periodicity, may require critically timed conditions that are temporarily unfavourable to vegetative growth. Current experiments are seeking the optimum timing, duration and level of moisture stress for control of floral initiation.—L. F. Ebell, Forest Research Laboratory, Victoria, B.C.

ENTOMOLOGY

Erratum: Vol. 23—No. 2, page 11

In TABLE I, the heading "Beetles in flight traps" applies to the last six columns; "Kerry" applies to the last three columns, and "Naver" applies to columns 4-6.

A Record of *Tetropium cinnamopterum* Kirby in White Spruce Logs in Central British Columbia—*Tetropium cinnamopterum* Kirby, has been considered of minor importance when compared with *Monochamus* sp. in the deterioration of timber (Gardiner L.M., Can. Entomologist 89(6): 241-263. 1957; and Richmond H.A. and Lejeune R.R., Forestry Chron. 21(3): 168-192. 1945). During a pathological study in 1965-66 in central B.C., however, the author observed a heavy attack by *T. cinnamopterum* in white spruce (*Picea glauca* (Moench) Voss) stored in two different areas. *Monochamus* was confined to lodgepole pine (*Pinus contorta* Dougl. var. *latifolia* Engelm.). Insects were identified by Dr. D. A. Ross, Forest Research Laboratory, Vernon, B.C.

Galleries of *T. cinnamopterum* up to 8 cm total length and 5 cm in depth occurred commonly (> 15 holes per sq ft) in 135 spruce veneer logs at Williams Lake, B.C. Material was originally winter-felled and stored in piles from April to October, 1965. Twenty adults emerged in December from an 18-inch log section, 12-inches in diameter, stored inside for three weeks.

In 150 winter-felled spruce logs at Upper Fraser, B.C., piled from April to October, 1966, larvae were first noted in the inner bark during June. They continued to feed in this region during August and penetration into sapwood was apparently completed in a period of not more than seven weeks. Adults emerged from 2×4-inch lumber cut from these logs and kept at 68-70°F in Vancouver in November and again in March, following four months of outside storage and another four weeks in the laboratory.

Holes were oval, ranging from 4×2 mm to 5×3 mm. The L-shaped galleries penetrated the sapwood approximately radially, then turned sharply to follow the boundary of heartwood and terminated in a pupal chamber slightly larger than the tunnel. (Fig. 1).

FIGURE 1. Oval holes and L-shaped gallery of *T. cinnamopterum* in white spruce log section.

Monochamus sp. was reported commonly by Gardiner in fire-killed Ontario pine, and by Richmond and Lejeune in fire-killed Saskatchewan white spruce. In Finland, Juutinen (Rev. Appl. Ent. 45: p. 451. 1957) noted that *Tetropium* sp. practically confined its attack to felled spruce.

This association with spruce was also suggested in the B.C. sample and the role of wood species, fire damage, and climate, in attack by *T. cinnamopterum* requires clarification. In addition, the absence of *Monochamus* sp. from stored white spruce logs should also be confirmed.—J. W. Roff, Forest Products Laboratory, Vancouver, B.C.

First Record of *Pleolophus basizona* Parasitizing *Neodiprion swainei*—*Pleolophus basizona* (Grav.), a European parasite liberated in the late nineteen thirties in an attempt to control the European spruce sawfly (*Diprion hercyniae* (Htg.)), has been found parasitising the Swaine jack-pine sawfly (*Neodiprion swainei* Midd.) during population studies on the latter in various localities in Quebec in 1964 and 1965 (Table 1). In addition to the localities shown in Table 1, *P. basizona* was also recovered from *N. swainei* during 1965 at Lake Oriskany, Laviolette County, and Lake Potherie, St. Maurice County.

Studies during 1966 have revealed that *P. basizona* is bivoltine on *N. swainei*. The estimates presented in Table 1 were obtained from collections made in the fall and thus are representative of populations of *P. basizona* overwintering on *N. swainei*. The adult parasites emerged from host cocoons in late May and early June, and immediately attacked current generation sawfly cocoons. Both pupae and adult sawflies were attacked in the cocoon. Second generation populations of *P. basizona* were considerably higher than first generation populations, undoubtedly because the second generation emerged in midsummer, before *N. swainei* spun its cocoon. Thus the parasite must restrict its attacks to as yet unemerged current generation host cocoons, or survive as adults until cocoon formation by the following generation of the host in September. Because *P. basizona* is bivoltine, its impact on host populations is potentially much greater than indicated in Table 1. Studies are now in progress to evaluate the importance of this parasite on *N. swainei*.

This is the first record of *P. basizona* parasitising *N. swainei*. It was previously recovered from *D. hercyniae* in a number of localities in Quebec and in Ontario (Finlayson, Thelma. Can. Entomologist. 92:20-37, 1960). In Ontario *P. basizona* has been known to occur in abundance on *N. sertifer* (Geoff.) (L A. Lyons, Proc. Ent. Soc. Ont. 94: 5-37, 1964). Also, a collection of cocoons of *N. lecontei* (Fitch) from Namur, Papineau County, Quebec, made in October 1966, yielded two female specimens of *P. basizona*.

TABLE 1

Occurrence of *Pleolophus basizona* Grav. in *Neodiprion swainei* cocoon samples in Quebec in October 1964 and 1965

Year and Plot No.	Number of *P. basizona*		Number of cocoons reared	% Parasitism
	♂	♀		
1964				
Plot III	4	7	763	1.4
Plot IV	8	11	179	10.6
Plot V	14	33	593	7.9
1965 (by dissection—*sex unclassifiable*)				
Plot III	—	0	25	0
Plot IV	—	4	260	1.5
Plot V	—	3	61	4.9

Plot III—Lac des Iroquois, Roberval County
Plot IV—Rivière à Mars, Chicoutimi County
Plot V —Lac Caouasacouta, Laviolette County

Liberation records of *P. basizona* in Quebec have been published (B.M. McGugan and H.C. Coppell, Biological Control of Forest Insects. Tech. Comm. 2, Com. Inst. Biol. Control. Commonwealth Agr. Bur. (Gt. Brit.) 1962). The present study indicates that *P. basizona* has spread widely since its introduction in Quebec and is now well established on *N. swainei,* thus affording a reservoir of this parasite in the event of future *D. hercyniae* outbreaks. J. McLeod and R. Martineau, Forest Research Laboratory, Sillery, P.Q.

FOREST MANAGEMENT

Determining sample-plot volume increment by stem analysis of selected trees—Fifty to sixty year black spruce *Picea mariana,* (Mill.) BSP, fire-type stands (100 stems per acre in 4 to 7 inch dbh classes, mortality in these dbh classes is extremely rare) were sampled in central Newfoundland with a view to developing a simple method of obtaining a reliable individual sample of increment based on tree tally for a sample plot of suitable size and on stem analysis of a minimum number of selected trees from the plot.

The following hypotheses were tested:

1) A sample plot 9/100 acre in size provides an unnecessarily large sample for the purpose of determining basal area per acre and basal area per tree at one location in these extremely uniform stands (Slightly larger plots, 1/10 acre have been in common use in other Newfoundland studies).
2) The average 10-year volume increment (determined by stem analysis) put on by 2 or 3 trees nearest average basal area at breast height approximates very closely the average increment per tree put on by trees on which the average is based.

Data of fifteen 9/100 acre square sample plots, each divided into nine 1/100 acre subplots, were collected to test the first hypothesis. A graph was developed for each plot using cumulative averages of more and more subplots. (Fig. 1).

In 13 cases out of 15 basal area per acre, and in 14 cases out of 15 basal area per tree, fell within 10 percent of their respective means when 1/20 (five 1/100) acre plots were considered.

Near each plot twenty trees were felled in a group and stem-analysed for the volume increment study. Graphic analysis of the cumulative average volume increment for the last 10 years of stems nearest to average basal area produced extremely erratic results. For example, 10 percent accuracy based on stem analysis of 4 stems was only achieved in 4 out of 15 groups.

The first hypothesis was accepted and the second rejected. Plot size can be reduced below 9/100 acre in stands of this character without seriously reducing the accuracy of the individual plot sample of basal area per acre and average basal area per tree. However, the current volume increment of small number of trees of average basal area was not found to be a reliable measure of the average increment of all trees on which the average was based.

TABLE 1

Number of 1/100 acre subplots required to achieve given accuracy

Plot No.	Basal Area per Acre 5%	Basal Area per Acre 10%	Basal Area per Tree 5%	Basal Area per Tree 10%
1	8	7	3	2
2	3	3	1	1
3	5	5	5	3
4	5	1	2	2
5	4	2	4	2
6	4	3	4	4
7	8	7	6	2
8	8	5	5	2
9	5	3	4	4
10	4	3	7	2
11	4	4	7	7
12	6	4	4	3
13	6	5	2	1
14	5	3	3	3
15	5	4	3	1

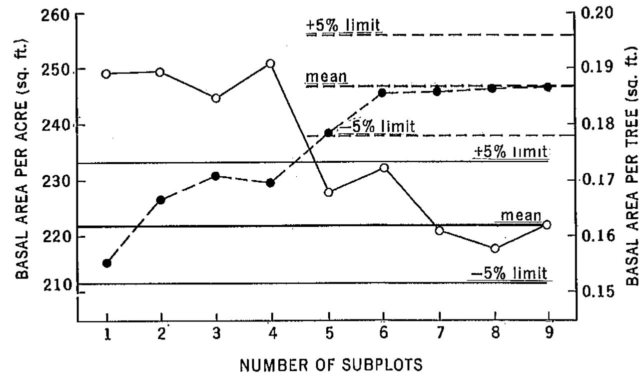

FIGURE 1: Cumulative average basal area for plot No. 3

Therefore in a stand survey using increment plots of the nature considered here error introduced by reasonable reduction of plot size should be readily compensatable by a reasonable increase in number of plots; but error introduced in the individual plot sample by erratic variations in the increment of trees of, or nearest to, average basal area could require either an unreasonably high number of trees in each plot to be cut for stem analysis or an unreasonably high number of increment plots to be measured to provide acceptable statistical accuracy.—D. E. Nickerson and D. Bajzak, Forest Research Laboratory, St. John's, Newfoundland.

FOREST PRODUCTS

Choker Line Forces in Skidding Saw Logs—Recent investigations into power requirements in the initial movement of timber from stump to loading point—the skidding phase of logging—were made by the Ottawa Laboratory staff to determine the effect of various operational and terrain factors on the forces induced in the choker line. Carried out at the Petawawa Forest Experiment Station, the significance of the following factors on force was evaluated: (a) soil type, (b) trail slope, (c) load configuration, (d) log position (e) soil moisture content, (f) load weight, (g) speed.

The measured response to the above factors, the coefficient of skidding C, is the ratio of the force (parallel to the skidding surface) required to skid the load to the weight of the load. Measurements were recorded for 256 skidding turns, at two "study levels"[1] for each of the seven factors.[1] The computed C values were incorporated into an analysis of variance to determine the statistical significance of the factors, both individually and in various combinations (interactions). The following factors were found to be important by themselves in determining C:

(1) *Load Configuration*: The load was either suspended by one end 2½ feet from the ground. or flat on the ground.
(2) *Slope*: either zero or 7 degrees.
(3) *Load Weight*: either one log, or four logs. Note that since C is a coefficient, incorporating weight, the importance of this variable is probably attributable to characteristics of the load other than weight.
(4) *Soil*: either pure sand, or a gravel-sand mixture.

Of greater interest, particularly from an experimental viewpoint—was how the factors, in various combinations with one another, acted to increase or decrease the force

[1] In this note "factor" means the type of treatment or condition being studied. "Level" refers to the degree or state at which the factor occurs.

required to skid logs over the ground surface, in a manner that could not be predicted from the individual factors themselves. In combination with load configuration, the following factors were significant in influencing force: log position, load weight, soil moisture, slope, and soil type.

It will be noted that log positions and soil moisture, in addition to the four factors listed previously now make a significant contribution to total force. Listed below are the coefficients of skidding for each of the situations. To determine[2] an approximation of the force necessary to skid a given load, the following equation, including a correction factor (for slope) is given:

$$\text{Force} = W\,[C + \sin X - 0.09 + 0.015\,X\,)]$$

where W = load weight, pounds

X = angle of ascent, degrees

Note: For values of C in Combination No. 4, the correction factor is not applicable and the equation becomes: Force = WC

Combination		Description	Coefficient of Skidding "C" $= \frac{\text{Force}}{\text{Weight}}$
1	Load flat	Logs butt first	0.83
	Load flat	Logs top first	0.81
	Load suspended one end	Logs butt first	0.37
	Load suspended one end	Logs top first	0.41
2	Load flat	Single log	0.80
	Load flat	Bundle of four logs	0.84
	Load suspended one end	Single log	0.39
	Load suspended one end	Bundle of four logs	0.39
3	Load flat	Low soil moisture content	0.79
	Load flat	High soil moisture content	0.85
	Load suspended one end	Low soil moisture content	0.38
	Load suspended one end	High soil moisture content	0.40
4	Load flat	Slope 0°	0.72
	Load flat	Slope 7°	0.92
	Load suspended one end	Slope 0°	0.32
	Load suspended one end	Slope 7°	0.47
5	Load flat	Sandy soil	0.91
	Load flat	Gravel soil	0.73
	Load suspended one end	Sandy soil	0.41
	Load suspended one end	Gravel soil	0.37

Although the scope of the study was purposely narrow (16-foot, white pine logs, all approximately of the same diameter) some interesting points of a practical nature may be noted. The most striking (see Table) is the great saving in power due to suspending one end of the load as opposed to ground skidding. Although this trend is predictable, it is interesting to note that the force required may be considerably more than doubled depending on the factor levels employed.

Another feature worth noting (Combination No. 1) is that it requires less power to skid tops foremost when the load is flat on the ground; when suspended by one end, the butts should be positioned foremost. The actual gains are slim but such orientation will effectively increase the size of the load possible with a tractor of given drawbar power rating. For example, a tractor with a rating of 8,000 pounds pull can skid a load of 19,500 pounds, suspended one end and tops foremost, or a load of 21,500 pounds if all the butts were aligned foremost.

Using the results of this pilot study as a basis, more detailed investigations were undertaken in which tree-lengths of eight species were skidded over widely-varying terrain conditions. These data are currently being evaluated.— W.W. Calvert and A.M. Garlicki, Forest Products Laboratory, Ottawa, Ont.

[2] The determination will be valid when conditions duplicate those prevailing during the study.

PATHOLOGY

Microfloral variations within second-growth sugar maple trees in Ontario—Studies on the quality of sugar maple in second-growth stands in the Haliburton-Muskoka region of Ontario have been undertaken cooperatively by the provincial and federal governments. This report deals with the identity of fungi, and the frequency of occurrence of both fungi and bacteria isolated from various regions of living trees: dead branches, branch stubs, defective (stained or decayed) trunk heartwood adjacent to branch stubs, defective trunk heartwood and sapwood associated with trunk injuries, and defective trunk heartwood not close to either visible branch stubs or trunk injuries.

Sample trees ranged in age from 28 to 111 years, and from 1.8 to 9.4 in. dbh. Branch stubs ranged in diameter from 0.15 to about 1.4 in. and the period since death from 2 to 65 years. Trunk injuries included felling and skidding scars, fire scars, frost cracks, sun scald, bark cankers, and broken tops. Three or four branch stubs, protruding 1 ft or less from the trunk, and adjacent trunk defects were sampled in each of 260 trees; four dead branches, including stubs, those portions within 1 ft of the trunk, and adjacent trunk defects were sampled in 14 trees; one trunk injury and one dead branch were examined in 16 trees; and in 48 trees either one or two trunk injuries were studied. In the two latter groups of 64 trees wherein trunk injuries were sampled, isolation attempts were also made from defective trunk heartwood at locations as far as possible from the trunk injuries or visible branch stubs.

Table 1 shows that the percentage of isolation attempts that yielded fungi or bacteria varied greatly depending on the region sampled. The majority of isolation attempts from dead branches, branch stubs, and defective trunk heartwood or sapwood associated with trunk injuries yielded fungi or bacteria. Only 28.4% of the isolation attempts from defective trunk heartwood directly above or below branch stubs yielded organisms. This is a slightly lower proportion of positive attempts than was obtained from defective trunk heartwood removed from branch stubs and trunk injuries in the uppermost 65% of tree lengths of second-growth sugar maple reported earlier (Basham and Taylor, Plant Dis. Reptr. 49: 771-774, 1965). This, plus the fact that 69.5% of the isolation attempts from branch stubs, including those portions buried deeply within the trunks, yielded fungi or bacteria, indicates that dead branches and branch stubs are not significant as avenues of entrance for organisms to sugar maple trunk heartwood.

TABLE 1

The frequency with which organisms were isolated from various sources in second-growth sugar maple

Source of inoculum	Number of isolation attempts	Number of attempts that yielded fungi or bacteria	Percentage of attempts that yielded fungi or bacteria
A: Dead branches	274	223	81.4
B: Branch stubs	1,961	1,362	69.5
C: Defective stem heartwood adjacent to branch stubs	1,270	361	28.4
D: Defective stem heartwood and sapwood associated with trunk wounds	1,182	932	78.8
E: Defective stem heartwood *not* close to wounds or to visible branch stubs	1,090	387	35.5

Further evidence of this is provided in Table 2. The micropopulation encountered in defective trunk heartwood adjacent to the stubs was similar to that encountered in defective trunk

TABLE 2
Organisms isolated from various sources in second-growth sugar maple

Organism	Percentage of non-sterile cultures obtained from each source				
	Source A[1]	Source B[1]	Source C[1]	Source D[1]	Source E[1]
Nodulisporium sp. 5[2]	15.8				
Phomopsis sp. 1[2]	14.6				
Hendersonia sp. 1[2]	9.6				
Unknown A	5.8				
Collybia velutipes (Curt. ex Fr.) Kummer	5.0				
Rhinocladiella A		14.5			
Stachybotrys atra Corda		8.2			
Gliocladium roseum (Link) Thom		5.3			
Ceratocystis sp.		5.0			
Phialophora melinii (Nannf.) Conant		4.6	8.9	21.2	5.9
Bacteria			16.6	9.9	3.6
Crichocladium canadense Hughes			11.1	12.8	49.1
Torticium vellereum Ell. and Cragin			7.8		4.1
Nodulisporium sp. 1 complex [2,3]			7.5		10.3
Verticillium sp. 2 [2]				10.8	
Coniochaeta kellermanni Ell. and Ev.				7.8	

[1]Refer to Table 1.
[2]In Herbarium DAOM (Ottawa).
[3]Probably includes several species.

heartwood distant from stubs and trunk injuries; however, it was very different from that found in the branch stubs. The much closer similarity of the micro-populations isolated from defective trunk heartwood and from defective trunk heartwood and sapwood associated with injuries suggests that trunk wounds are more important than branch stubs as avenues of entrance for fungi and bacteria into the heartwood of living second-growth sugar maple.

Table 2 shows that three quite different micro-populations were encountered in dead branches, branch stubs, and in defective trunk heartwood. In fact, the five fungi most frequently isolated from dead branches and the two fungi most frequently encountered in branch stubs were practically limited in their occurrence to those sites. This is not surprising when one considers the physical and chemical differences in the source substrates. Changes in meteorological conditions cause much greater fluctuations in moisture content and temperature in dead branch tissue than in branch stubs, particularly in those portions buried within the trunks. Trunk heartwood moisture content and temperature presumably fluctuate even less. Living cells are present in the trunk heartwood (Good *et. al.*, Can. J. Botany 33: 31-41, 1955); they are virtually absent in branch stubs and are non-existent in dead branches. This difference may constitute a more important influence over the infection capabilities of the micro-organisms.

The fungi associated with most of the trunk rot encountered in young sugar maple in Ontario are *Polyporus glomeratus* Peck, *Pholiota spectabilis* (Fr.) Kummer, and *Fomes igniarius* (L. ex Fr.) Kickx (unpublished data). These fungi were not isolated from dead branches, and were represented in the sampled branch stubs by a single isolation of *P. glomeratus.* P. *glomeratus* was encountered infrequently in all three sources of defective trunk heartwood, and the relatively few isolations of P. *spectabilis* and F. *igniarius* from these trees were almost all from defective trunk heartwood or sapwood associated with wounds. This is further evidence that trunk wounds are the major means by which trunk-rot fungi gain entrance to the heartwood of living sugar maple.

Mycelial interactions observed in pairing fungi on 2% malt agar plates show that *Hendersonia* sp. 1, one of the fungi most frequently isolated from dead branches, markedly inhibits the growth of the three major trunk rot fungi; and that *Stachybotrys atra* Corda, which was frequently encountered in branch stubs, has a similar effect on *P. glomeratus* and *F. igniarius.* In vitro tests to determine whether and to what extent this relationship occurs in sugar maple wood are currently in progress.—J. T. Basham and L. D. Taylor, Forest Research Laboratory, Maple, Ontario.

SILVICULTURE

Growing Lodgepole Pine and White Spruce Container-Planting Stock under Reduced Light Intensities—During the past few years encouraging results have been obtained in Alberta with experimental container planting (Ackerman *et al.,* Can. Dept. For., For. Res. Br. Publ. 1093, and Mimeo 65-A-6, 1965). The program is now in the pilot-trial stage on the lease area of North Western Pulp and Power Ltd. with 250,000 plantings in 1965 and 600,000 plantings in 1966.

The 1965 8-week lodgepole pine (*Pinus contorta* Dougl. var. *latifolia* Engelm.) and white spruce (*Picea glauca* (Moench) Voss var. *albertiana* (S. Brown) Sarg.) were grown at a single level in a 20′ × 40′ plastic-covered greenhouse. Although no insurmountable problems were encountered in production, the economic advantage of growing stock in tiers, thereby doubling or tripling production from a given facility, was immediately apparent. A study was therefore undertaken in 1965 to test the hypothesis that lodgepole pine and white spruce seedlings could be grown successfully at the reduced light levels associated with tiering, without providing illumination in addition to that required to extend the photoperiod.

The study was done at the Kananaskis Forest Experiment Station (elevation 4500 ft) in a greenhouse orientated E–W. The south aspect of the house was whitewashed to reduce heating from the high radiation levels normally experienced at this elevation. Air temperature in the greenhouse was maintained between 70° and 80°F throughout the experiment.

Instead of tiers with various separations, a light gradient was created by installing a sloping, white-painted surface above a 3-ft bench. Minimum and maximum separations, measured from soil surface to overhead surface, were 9 and

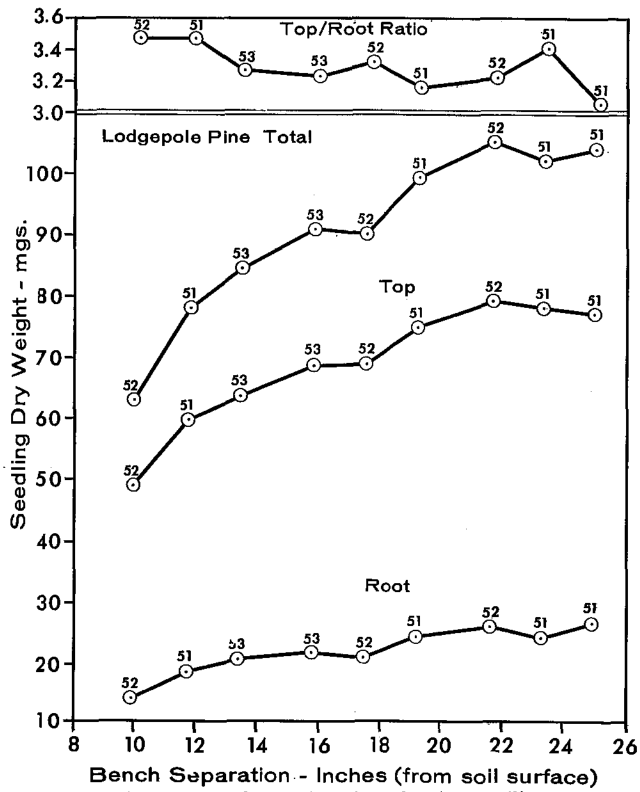

FIGURE 1. The growth of 8-week lodgepole pine seedlings under reduced light intensities

25 inches respectively. Although it was not possible to obtain radiation measurements in absolute terms during the course of the experiment, uncalibrated radiometers indicated 35 to 40% of open-bench radiation at the minimum separation of 9 inches and 50 to 55% of open-bench radiation at the maximum separation of 25 inches.

The seedlings were grown in 5-oz plastic containers, in perlite subirrigated with a complete nutrient solution. Containers were placed on the bench in 18 columns of 9, each column spaced across the entire width of the bench. The two species, spruce and pine were alternated in the rows. A 16-hour photoperiod was maintained by low-intensity incandescent light. Seedlings were lifted 8 weeks after germination, washed and oven-dried for top and root dry-weight determinations. Differences in dry weights between columns of seedlings were analyzed by analysis of variance.

The growth period for production of 8-week stock in this area would normally start in April and terminate in September. To cover the normal growth period, the experiment was repeated during two 8-week periods; the first started in April and the second in July, 1965. Although the mean weight of the lodgepole pine seedlings varied in the two experiments, there was no significant difference between experiments in the effect of the light gradient for either pine or spruce. Consequently, data from the two experiments have been combined.

The light gradient had a significant effect on the growth of lodgepole pine, top and root (Fig. 1). Growth of this species increased with light level to a maximum at the 21-inch separation. At the minimum separation of 10 inches, seedlings were little more than half their maximum size. Although the top-root ratio appears to decrease with increasing separation, only the difference between extremes is significant at the 5% level of probability.

The light gradient induced by the sloping overhead surface also had a measurable effect on the growth of white

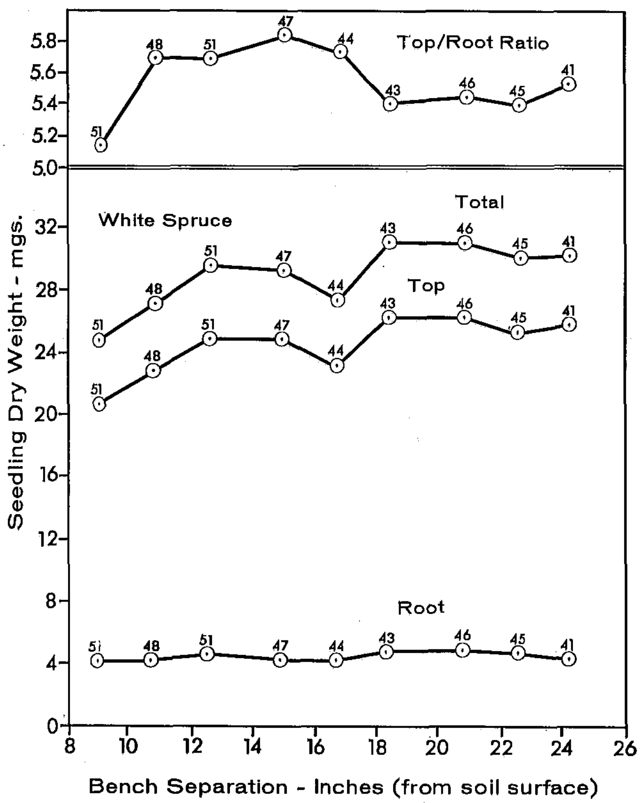

FIGURE 2. The growth of 8-week white spruce seedlings under reduced light intensities.

spruce seedlings (Fig. 2). However, the effect was evident for top growth only and is not statistically significant at separations greater than 11 inches. Spruce seedlings grown at the minimum separation of 9 inches were approximately 80% of maximum size. The growth loss was thus relatively small compared with that observed for lodgepole pine seedlings under the same conditions.

These data suggest that it is feasible to produce lodgepole pine and white spruce planting stock in the reduced light intensities that result from the presence of an overhead surface. However, owing to the variability in orientation and structure of greenhouses and light conditions during any given growth period, it is not possible to recommend, with confidence, separations that will have general application. If it is accepted that the light gradient resulting from the sloping overhead surface employed in this experiment approximates the effect of tiers at various separations, a distance of 24 inches or more would satisfy both the light requirement and the need for "working" space in the Kananaskis greenhouse. If both species are grown simultaneously, the relatively intolerant lodgepole pine should occupy the best lighted positions in the greenhouse.

In the program of North Western Pulp and Power Ltd. the seedlings are grown in the greenhouse for 4 weeks, followed by "toughening" in cold frames for an additional 4 weeks. The marked and abrupt increases in radiation level attending removal of stock from tiers in the greenhouse can result in chlorosis of spruce and reddening of pine seedlings. To reduce this injury a transition period with 50% lath shade in the cold frames is recommended.—R. F. Ackerman, Forest Research Laboratory, Calgary, Alta.

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O.H.M.S.

DEPARTMENT OF FORESTRY AND RURAL DEVELOPMENT

BI-MONTHLY RESEARCH NOTES

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BI-MONTHLY RESEARCH NOTES

A selection of notes on current research conducted by the Forestry Branch, Department of Forestry and Rural Development

ENTOMOLOGY

The Balsam Wooly Aphid on Christmas Trees.—During 1966 a number of preventative measures, such as a curtailment of moving *Abies* nursery stock, were initiated to reduce the possible spread of the balsam woolly aphid to uninfested areas of British Columbia. In some parts of the province young *Abies* are grown, cut and transported for sale as Christmas trees. The movement of potted Christmas trees was prevented by the ban on nursery stock, but transport of cut trees was still allowed. The following observations were made to determine whether this was a hazardous practice.

Three Christmas tree-sized (7 ft) *Abies amabilis* (Dougl.) Forbes, and some branches, moderately infested by overwintering balsam woolly aphid, were cut from an area west of Duncan, Vancouver Island, on 2 Dec., 1966. On 14 Dec., two trees and a branch were brought into a room with a mean temperature of 72°F and a relative humidity of 30%. One tree had the basal 6 inches of its stem immersed in water; the other tree and branch were left dry. The third tree and remaining branches were left outdoors to simulate unsold stock.

Eight fixed examination points were established on the trees and branches, and observations of the aphids were made weekly from 14 Dec. to 17 Jan. The aphids on the branch indoors were the first to deteriorate; they started to dry out by 20 Dec., and were all dead by 28 Dec. Aphids on the trees indoors resumed development, moulted, and produced new wax by 28 Dec. but all were dead on both watered and dry trees by 3 Jan. The aphids on the tree and branches left outdoors remained dormant, neither moulting nor producing new wax. Their condition was unchanged on final examination 17 Jan. When brought indoors, they resumed development, but soon died from desiccation.

Dormant aphids on *Abies* trees and branches taken indoors over the festive season pose no threat of spreading the infestation. During the winter months the aphids are in the non-motile dormant stage, so spread would not occur during transport. There is a remote possibility that the aphids could survive on unsold trees left piled outdoors resuming development in the spring, although the production of viable eggs seems unlikely. Unsold *Abies* Christmas trees should, therefore, be burned.—T. A. D. Woods, Forest Research Laboratory, Victoria, B.C.

An Aspirator for Mass-collecting Ants.—During the the course of recent investigations on ants as potential control agents of insect pests in nurseries and plantations in Quebec, a portable aspirator that efficiently trapped practically all of the ants of a nest was developed. The equipment devised is simple, compact, and driven by a battery. The apparatus consists of three parts: an aspirator unit, a collection chamber, and a power supply.

The aspirator is an adaptation of a portable plastic automobile vacuum cleaner (Fig. 1). The air intake consists of a 2-foot length of flexible hose 1.25 inches in diameter. The dust bag is removed to minimize air resistance.

The collection chamber is made from a 1-gallon cardboard icecream container with a special cover and air filter. The cover is made of 0.125-inch acrylic plastic, and will accept 0.625-inch clear, flexible plastic collecting tubes. The

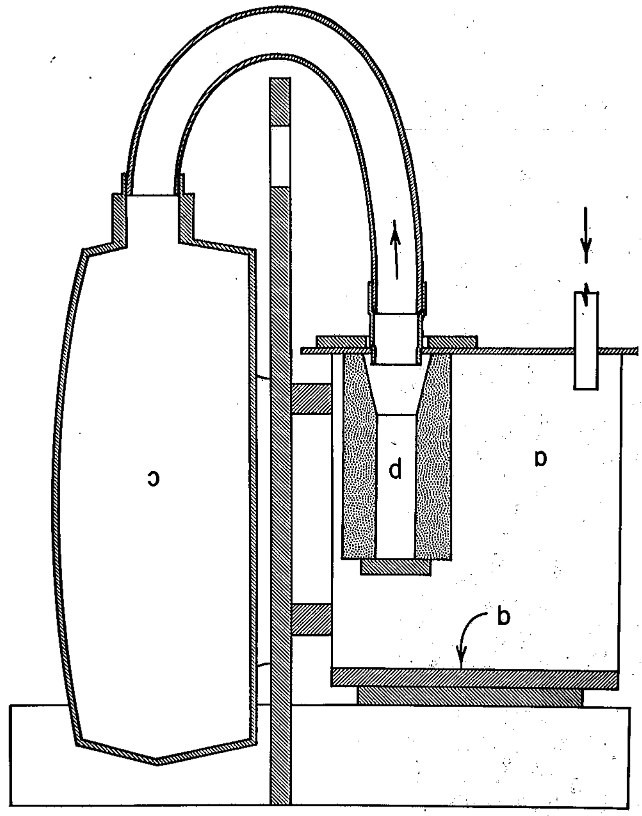

FIGURE 1. Diagram of aspirator showing (a) collection chamber; (b) air filter; (c) aspirating unit; (d) reinforced bottom of collection chamber.

cover also holds the air filter, which is a 5-inch section of cylindrical, water-filter cartridge with a 1-inch hole in the center (type "Auno Water-Pure"). The upper end of this filter is tapered to receive the aspirator tube as shown in Fig. 1. The bottom of the container is re-inforced with a 0.375-inch disc of plywood. The base is sealed with masking tape.

Power is supplied by a small rechargeable, 12-volt, wet battery weighing about 24 pounds, similar to that used in small suburban tractors. The battery is recharged by using a special adaptor fitted into the cigarette lighter of a vehicle with a 12-volt electrical system.

The aspirator and collection chamber are mounted side by side on a wooden frame in such a way that the collection chamber can be easily replaced. The battery is encased in a handy carrying box. It was found that a fully charged battery could drive the aspirator at high speed for approximately 1 hour, which is sufficient time to collect nests containing 10,000 ants or more. On extended field trips, during which daily collections are made, a constant supply of power is assured by using two batteries alternately, and recharging them whenever the vehicle is in motion.

Details of construction will be supplied by the author.—R. J. Finnegan, Forest Research Laboratory, Quebec, P.Q.

The Biological Control of *Neodiprion swainei* Midd. with a Nuclear-Polyhedrosis Virus—The Swaine's jack-pine sawfly, *Neodiprion swainei* Midd., causes serious defoliation of jack pine. It is attacked by a nuclear-polyhedrosis that develops in the cells of the midgut epithelial tissues. The polyhedra are crystal-like protein masses measuring 1–2μ in length in which a few dozen virus particles, measuring approximately 200 mμ, are enclosed. The polyhedra can be obtained by aqueous maceration and sedimentation of cadavers of larvae that have succumbed to the virus. Water suspensions of polyhedra can be stored until needed for practical application since the polyhedra are insoluble in water or mineral oils.

Tests have shown that spraying with polyhedra at a concentration of 1–5 million per ml at 1–3 gal per acre is sufficient to control the insect. Mortality is higher and occurs more rapidy when young larvae are sprayed. However, larvae sprayed in the first instar die in the second instar; they do not contain many polyhedra within their cadavers, and the possibility of a natural post-spray spread of the disease is considerably reduced. It has been recommended that the treatment be applied when larvae are in the second instar. Some larvae infected during the second instar succeed in spinning cocoons and become carriers of the viral infection, which is transmitted to their progeny. The mortality caused by trans-ovum transmission of the virus may reach 60-70% after 1 year.

Temperature is an important factor in determining the efficacy of the virus disease. Effective development of the disease occurs only when environmental conditions are optimal for host development. The undesirable effect of low temperature is mostly observed on third-instar and older larvae.

There is also a close relationship between the physiological condition of the insect and disease development. For example, tests on the influence of light on disease development showed that larvae infected with virus reared in natural light died 7 days sooner than those kept in darkness.

In 1959, a stock of polyhedra was prepared for experimental aerial spraying in 1960. Two spray formulae were tested. In addition to the virus, the first consisted of water, latex, and dry-blood solution; the second consisted of a magmabentonite, fuel oil, and Span emulsion. A virus concentration of 1×10^6 polyhedra per ml was dispersed at rates of 0.5 and 4 gal per acre at the end of July over a severely infested jack-pine stand in which the population density was 5 million larvae per acre just before spraying. The temperature in August and September was average for the season and the spraying resulted in 95% mortality after 25–30 days. Relatively high mortality was also recorded in the drift areas. One year after spraying, the population was only 2,000 larvae per acre.

A large quantity of polyhedra was prepared in 1963 and during the following summer, 4,000 acres of jack-pine in the Lake St. John region were sprayed with virus concentrations of 1×10^6 and 1.5×10^6 polyhedra per ml. The suspensions of polyhedra were dispersed, in a water, latex, dry-blood solution at a rate of 1–1.5 gal per acre, over a stand that had been defoliated for several consecutive years and where tree mortality was imminent. A large percentage of the larvae feeding in the upper crowns succumbed to the virus. They were mostly second-instar larvae. Infected older larvae succeeded in completing their development. The viral epizootic expected in the sprayed territory was partially inhibited by a period of cold, rainy weather that persisted from the second day after spraying until mid-September. Mortality due to the virus varied in the treated areas and never exceeded 76%. Summer 1965 was also cold and the viral epizootic from trans-ovum transmission was less than expected. However, microscopic examinations of the midgut of a large number of larvae collected at random in the sprayed areas showed that the virus had become established in the population. In 1966 only 0.6 colonies per tree remained of a population which averaged 82 colonies before spraying in 1964. Moreover, the insect did not spread to the surrounding non-infested localities. Microscopic examinations in 1966 revealed that the virus was still present in a large portion of the population. Therefore, one may conclude that the virus contributed to the control of jack pine sawfly in these stands, although lack of food because of extensive tree mortality in 1964 and 1965 was also a contributing factor.

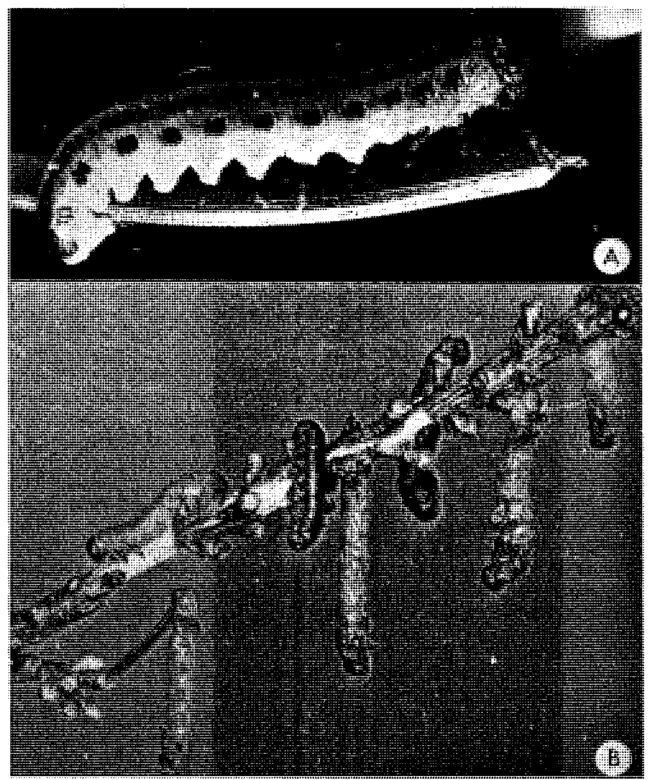

FIGURE 1. A. Larva of the jack-pine sawfly;
B. Some larvae killed by the virus disease.

A field experiment was conducted in the fall of 1963 to determine if larvae infected with the virus could introduce the disease through trans-ovum transmission to progeny. A large number of larvae of *N. swainei* were infected with low dosages of virus prior to spinning. The 200,000 cocoons obtained from this population were stored in special racks placed in the soil over winter and distributed in a healthy population of *N. swainei* just prior to emergence in the spring. The virus was detected in the population during the fall of the same year. The following spring, egg clusters were collected from this population and reared in sterile conditions. The considerably higher mortality due to virus noted in the experimental population in comparison to that of the controls indicated trans-ovum transmission of the virus. This affords a satisfactory method for introducing the virus into virus-free populations.

It may be concluded from 1960 and 1964 spraying experiments that unfavorable meteorological conditions may reduce the action of the virus but the virus can be used successfully as a preventive measure as it remains viable during long periods of unfavourable weather following application.

Both chemical and biological methods of control have their respective merits and it is difficult to compare the two, The possibility of using the virus obtained from *N. swainei* for the biological control of the jack-pine sawfly has been clearly established. The research carried out in this area has passed the limits of the laboratory or limited field tests. It is only after the application of the virus has been tried as a control operation that it will be possible to definitely determine its value.—W. A. Smirnoff, Forest Research Laboratory, Sillery, Que.

Hybrid Poplars Damaged by the Cottonwood Leaf-mining Beetle, *Zeugophora scrutellaris* Suffr.—Damage by the cottonwood leaf-mining beetle has been observed as early as 1903 in Manitoba by Criddle (E. H. Strickland, Can. Entomology 52:1-5. 1920), who noted that it was especially abundant on native cottonwoods in river bottoms. The increased use of hybrid poplars in plantations, shelterbelts, and as ornamentals on the prairies, has been accompanied by an apparent increase in populations of *Z. scutellaris.* This is particularly evident in Saskatchewan where two recent outbreaks have been reported.

Stewart (Can. Ins. Pest Rev. 9:102. 1931; 11:59. 1933; 12:154. 1934; 13:17. 1935; 14:68. 1936; 15:58. 1937) indicated that *Z. scutellaris* caused considerable damage to cottonwoods, and to Russian, Saskatchewan, and northwest hybrid poplars in 1931 to 1937 in the southern areas of Saskatchewan and Alberta. The second outbreak occurred in 1966 in an area bounded by Maple Creek, Limerick, Lafleche, Swift Current, Cabri and Sceptre in southwestern Saskatchewan. The leaves of certain hybrid poplars used as ornamentals and in shelterbelts in this area, were conspicuously skeletonized by adults and mined by larvae of a bettle, the description, life history and habits of which fit that of *Z. scutellaris* reported in Canada by Strickland (*op. cit.*) and deGryse (Dom. Can. Dept. Agri. Pam. 47 N.S. 1925); and in the United States by Grave (J. Morph. 30:245-259. 1917), Weiss and Nicolay (Ent. News 30:124-127. 1919) and MacAloney (*in* Craighead, U.S. Dept. Agri. Misc. Pub. 657:273. 1950).

Limited information on the source and exact parentage of the hybrid polars attacked by the cottonwood leaf-mining beetle in southwestern Saskatchewan in 1966 make identification of the host very difficult. Leaf shape indicates that the damage was most common on at least two different hybrids. One of them appears to be Saskatchewan poplar, a natural hybrid of *Populus deltoides* Marsh. X ? according to Cram (For. Chron. 36:204-208. 1960) and the other is apparently another hybrid of *P. deltoides* X ?. There are some indications that *Z. scutellaris,* like the poplar bud-gall mite (*Aceria parapopuli* (Keifer)), prefers certain hybrid poplars over others (Brown and Stevenson. Ann. Rept. Forest Insect and Disease Sur. Can. Dept. Forestry. 1964). It is hoped that future studies will reveal which hybrids are less susceptible to attacks by this beetle—H. R. Wong and G. N. Still, Forest Research Laboratory, Winnipeg, Manitoba.

FOREST PRODUCTS

Coating Adhesion to Weathered Wood—In exterior use, wood is subject to surface degradation arising from agents such as moisture, sunlight, micro-organisms, and atmospheric gases. The presence of a protective coating reduces the rate of degradation but the coating and wood surface still continue to degrade at a greater or lesser rate depending on the nature of the protective system and failure, however long delayed, must be expected. In repainting, the surface of the weathered wood is not the same as a fresh wood surface and changes in coating adhesion can be expected. It can also be expected that coating adhesion will be influenced by initial surface degradation if the wood surface is long exposed to a weathering environment before it is coated. For these reasons it was of interest to examine the effect of such an exposure prior to the application of a coating on its adhesion to the wood substrate. An experiment along this line was conducted as part of a broader study on the elucidation of the mechanisms of the surface degradation of wood, and the investigation of factors which can be varied to control the degradation.

A two-component urethane coating was employed which was found to adhere to a fresh wood surface with a strength greater than that of the wood itself. When two aluminum cylinders were glued to each side of a coated test specimen and tested on an Instron tensile testing machine, only wood failure occurred with no breaking at the wood-to-coating interface. To determine if changes in the wood surface through weathering would lead to reduced adhesion of the coating sufficient to yield failure at the interface, a schedule of accelerated weathering was carried out on test panels.

Test panels (6″ × 2¾″ × ¼″) were cut from freshly-planed and sanded wood and conditioned at 50% R.H. and 70°F. Control specimens were coated and exposed in a conventional carbon-arc weatherometer. After exposure for periods up to approximately 400 hours, the panels were cut into pieces of 1″ × 1″ × ¼″. Two aluminum cylinders were glued to each side, and the test specimens were tested in an Instron tensile testing machine equipped with special attachments for holding the cylinders. The strength of the paint-wood bonds was evaluated by examining the nature of the interface where failure occurred and by noting the force necessary to break the bond. Similar experiments were carried out with panels which were exposed before the application of the coating. Eighteen test panels were used for each set of experiments to offset any inherent variations in the test specimens.

With all species used in the investigation, complete wood failure occurred when the panels were painted before exposure in the weatherometer, and up to 20 days exposure in the weatherometer had no measurable effect on the adhesion of the coating. On the other hand, exposure of wood prior to coating gave varying results. It was observed that in most cases exposure of the panels before coating caused a marked decrease in the adhesion of the coating. An examination of the test specimens indicated that a combination of wood and coating failure occurred at the interface. Hence, the results were evaluated on the basis of the extent of paint failure that occurred at the interface.

Results obtained with red pine, western hemlock, western larch and spruce indicated an increase in paint failure with increased exposure. With eastern white cedar, ponderosa pine and white pine there was an initial major increase in paint

TABLE 1

Adhesion of the coating to wood used for exterior purposes

Wood Species	Percentage paint failure		
	Panels painted before exposure (397 hours)	Panels exposed before painting	
		106 hrs	154 hrs
Ponderosa pine	No paint failure observed	40	0
Red pine		0	60
White pine		80	0
Eastern white cedar		100	80
Western larch		—	40
Eastern hemlock		—	0
Western hemlock		—	80
Spruce		—	20
Western white pine		—	0

failure due to exposure, followed by a decrease in paint failure when exposure was extended from 106 to 154 hours. This decrease in paint failure was particularly significant in the cases of ponderosa pine and white pine. Practically no effect on adhesion was noticeable on eastern hemlock and western white pine under the test conditions used. The results are summarized in Table 1.

It would appear that deleterious effects of weathering occur in almost all cases but that the picture is complicated by increased adhesion on further weathering in some cases. Continuing studies are being directed toward measuring the degradative changes occurring in the wood surface which can lead to such reverses in the adhesion pattern.—R.L. Desai, Forest Products Laboratory, Ottawa, Ont.

Volatile Products of Photodegradation of Cellulosic Materials—In a previous note (Desai, Bi-mon. Res. Notes 22(5), 1966) the results of examination of the volatile products of photodegradation of cellulose by gas chromatography were reported. Out of the several peaks in the chromatograms of the photolysis products, only four were tentatively identified as due to acetaldehyde, propionaldehyde, acetone and methane on a Carbowax 20M column. Further studies have been carried out for the positive identification of these compounds and others corresponding to some of the remaining peaks. This note describes the results obtained with four additional columns packed with Ucon 50HB-5100 (two columns with two different supports), silica gel and alumina. The Ucon columns were used for cross-checking the results obtained with the Carbowax column while the latter two columns were used for the identification of hydrocarbons and other gases which could not be separated on the Carbowax and Ucon columns.

The cellulosic material used and the experimental procedure followed were identical to those used previously (Desai, loc. cit.). The method of component identification was by comparison of the retention times of the chromatogram peaks for the unknown volatile photolysis products with those for the reference compounds. The retention times, calculated relative to the peak due to air, for the various peaks in the chromatograms of the photolysis products as well as of the mixture of reference substances for the columns packed with polar phases Carbowax and Ucon are given in Table 1 while those obtained with solid adsorbents, silica gel and alumina are given in Table 2.

Table 1 shows that the results obtained with the two Ucon columns agree closely with those obtained with the Carbowax column. Further (Tables 1 and 2), five additional compounds, which have not been detected so far in the gaseous photolysis products of cellulose, have been identified. These are methane, ethane, methyl formate, ethyl alcohol and methyl ethyl ketone. It was not possible to separate n-butyraldehyde from methanol and ethanol with the column packings used in this study. Hence, no definite conclusion can be drawn regarding its presence in the photolysis products. The presence of methane and probably ethane has also been detected in the mass spectrum and the infra-red spectrum of the volatile photolysis products.

In addition to the compounds identified so far by the gas chromatographic studies of gaseous products of photodegradation of cellulose, there remain about five chromatogram peaks to be assigned. Of these, three are relatively large while the others are small. Further studies are in progress to identify compounds corresponding to these peaks.—R. L. Desai and J. A. Shields, Forest Products Laboratory, Ottawa.

TABLE 1

Relative retention times (min)* of known compounds and unknown components

Compound	Column No. 1 25-ft Carbowax 20M on Haloport —temp 100°C		Column No. 2 10-ft Ucon Polar 50HB-5100 on Chromosorb— temp 22°C		Column No. 3 25-ft Ucon Polar 50HB-5100 on Haloport— temp 50°C	
	Known	Unknown	Known	Unknown	Known	Unknown
Air	1.00	1.00	1.00	1.00	1.00	1.00
Acetaldehyde	2.09	2.08	1.79	1.79	1.92	1.90
Methyl Formate	2.54	2.54	2.36	2.36	2.40	2.40
Propionaldehyde	3.00	3.00	2.94	2.92	3.02	3.02
Acetone	3.39	3.38	3.31	3.36	3.59	3.59
Methanol	4.42	4.40	4.94	4.96	3.93	3.90
N-Butyraldehyde	4.42	4.40	4.94	4.96	5.31	5.26
Ethanol	5.26	5.22	6.99	6.99	5.31	5.26
Methyl Ethyl Ketone	5.26	5.22	5.90	5.88	6.22	6.10

*Expressed relative to the air peak.

TABLE 2

Relative retention times (min)* of known compounds and unknown components

Compound	Column No. 4 25-ft Silica Gel— Temp 100°C		Column No. 5 25-ft Activated Alumina—Temp 78°C	
	Known	Unknown	Known	Unknown
Hydrogen	0.78	0.78	0.91	0.91
Air	1.00	1.00	1.00	1.00
Carbon Monoxide	1.20	1.20	1.11	1.11
Methane	1.44	1.45	1.48	1.47
Ethane	4.22	4.24	2.74	2.76
Carbon Dioxide	6.23	6.18	†	†

*Expressed relative to the air peak.
†Irreversibly adsorbed at the column temperature used.

PATHOLOGY

Nomarski Interference Contrast Method for Examining Temporary Mounts of Fungi.—The identification of fungi inhabiting wood is generally done by using microscopic methods on both the fungi in wood sections and the fungi isolated from the wood. Recently, much use has been made of phase contrast microscopy for such examinations, this method having many advantages over conventional staining methods. However, phase contrast is most useful for very thin sections, or smears, and the thick temporary mounts used in the initial identification of fungi in wood are far from ideal. Due to the bright halos surrounding the images of specimens examined under phase contrast, detailed structure is often obscured, especially where overlapping of the images occurs. Also, any foreign particles present in the mount will cause interference under phase contrast because of their individual large halos. This is especially annoying when temporary mounts are being examined for fungus spores.

Because of these disadvantages in the phase contrast method, the transmitted light interference contrast method, as suggested by Nomarski (G. Nomarski, J. Phys. Radium 16: 95. 1955) and manufactured by Carl Zeiss Limited, was tested. Temporary mounts of a fungus were examined and photographed using both Nomarski and phase contrast methods. These photographs (Fig. 1) clearly show the following advantages of the Nomarski method:

(i) No troublesome halos surround the observed images, permitting surface detail to be studied more clearly. Also, there is no resulting loss in resolution between adjacent structures.

(ii) The relatively thin depth of focus and lack of interference between objects above and below the field of focus allows good observations to be made with thick sections.

(iii) There is no interference due to the presence of small foreign particles in the mount.

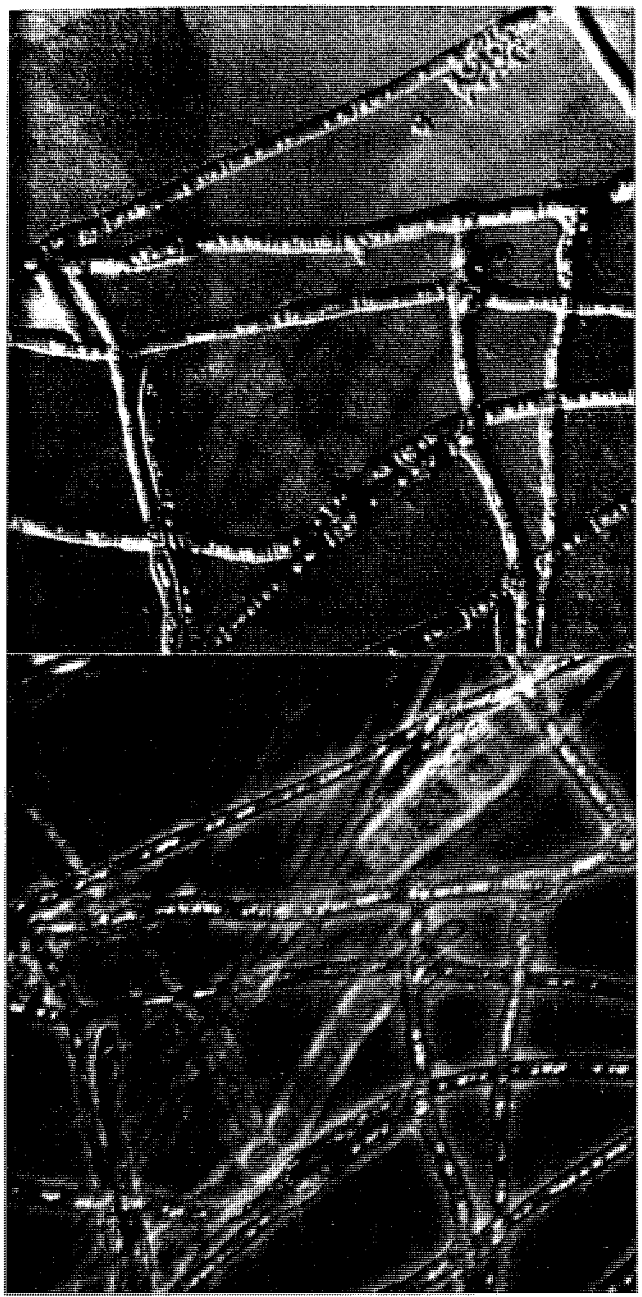

FIGURE 1. Temporary mounts in KOH of fungus isolated from heartwood of yellow cedar. Upper, by Nomarski method; Lower, by phase contrast method. X640.

The Nomarski method also renders birefringent material visible. Bajer and Allen (Science, 151, 3710: 572. 1966) clearly demonstrated the presence of spindle fibers during nuclear mitosis using this method.

Both the Nomarski and phase contrast methods of microscopy should be considered to be complementary, the Nomarski method not superseding the phase contrast method. The Nomarski method renders visible "rates of change" of optical thickness, whereas phase contrast renders visible only optical thickness. Each method, therefore, provides its own information about the observed object and, providing great care is taken in interpretation of the results, both methods are of great value.—Roger S. Smith, Forest Products Laboratory, Vancouver, B.C.

Evaluation of Antibiotics to Control Infections of White Pine Blister Rust—A spray program to test the effectiveness of several antibiotics and chemotherapeutants against *Cronartium ribicola* J. C. Fisch, on white pine (*Pinus strobus* L.) was initiated in 1959. The first chemical to be tested was acti-dione and the results were subsequently published (Cafley, J. D., Bi-Monthly Prog. Rept. 16(3): 2-3, 1960).

Accounts of the success of acti-dione in controlling blister rust, especially from the western United States, were initially very encouraging and stimulated additional experimentation which has been continued until the present time.

Tests were conducted in nine areas in Ontario; three were in private plantations and six in provincially operated county forests, namely, Vivian, Limerick, Grey, Lavant, Guthrie, Dufferin, Rocklyn, Shelburne and Wimbush. The plots were selected on the basis of rust density rather than on geographic location. Rust incidence varied from 12 to 40% or higher, and the trees in some areas had more than one canker. Cankers within reach of the ground were measured and treated by means of basal (stem and branch), direct canker, or foliar spray. A total of 4,898 cankers received treatment between 1960 and 1965. The five fungicides and the formulations used are listed in Table 1. Concentrations of these chemicals ranged from 50 to 600 ppm. The carriers used included water, several commercial stove and fuel oils, and oil/water emulsions. A variety of solvents were used to inhibit crystallization of the active agent from the carrier.

In 1960 two methods were employed to assess canker development. One consisted of marking the horizontal and vertical limits of the cankers with common nails at the time of treatment. These nails remained but if the canker enlarged, progress of the growth was marked with aluminum nails. The second method was a classification of cankers based on macroscopic appearance. A canker with a 'dead' margin differs from an active canker in color and, usually, in the amount of resin flow present. The term 'dead' in the sense used here, means irreversible inactivation of cankers.

TABLE 1

Inactivation of blister rust cankers treated with various therapeutants.

Therapeutant	'Dead' cankers average %	No. of trials	Total cankers treated
Checks[a] (no treatment)	18.1	25	419
Controls			
Fuel or stove oil	23.2	31	443
Fuel or stove oil plus solvent[b]	25.4	21	122
Cycloheximide[c]			
Acti-dione concentrate BR	34.8	25	267
Acti-dione concentrate BR plus solvent	17.6	49	431
Acti-dione new formulation (13,709)	15.3	20	98
Acti-dione new formulation plus solvent (13,709)	15.2	31	145
Acti-dione derivatives (13, 818, 154B, 222A, 221A)	39.7	2	73
Acti-dione aerosols (9144)	37.5	11	128
Acti-dione foliar	28.1	6	57
Phytoactin[d]			
Basal application	28.0	95	821
Foliar application	12.2	9	196
Streptimidone[e]	16.1	3	56
Nickel nitrate	19.6	3	56
o-phenylphenol	35.7	6	171

[a]Water control and checks combined.

[b]Solvents supplied by Upjohn Co., additive B, 183, 184, Triton X-155 and X-1956.

[c]Supplied by Upjohn Company, Kalamazoo, Mich., U.S.A.

[d]Supplied by Pabst Laboratories, Milwaukee, Wisc., U.S.A.

[e]Supplied by Parke-Davis and Company, Detroit, Mich., U.S.A.

A resume of the data obtained by the visual classification method is presented in Table 1 for trials applied from 1962-1965 inclusive.

Table 1 shows that three of the acti-dione treatments were less effective than the carrier alone and obviously had no antifungal activity. The same was true of streptimidone and nickel nitrate. The foliar applications of acti-dione and phytoactin were also disappointing, especially the latter. Acti-dione derivatives produced the greatest therapeutic effect, closely followed by acti-dione aerosols and o-phenylphenol. Nevertheless, the degree of canker inactivation was still below the minimum requirement for an operational spray program. Moreover, acti-dione BR concentrate and acti-dione new formulation proved to be extremely phytotoxic when a solvent was added and caused the mortality of all trees in some trials. Pole-sized trees in the 'flush' period of growth were very susceptible.

An extensive program was undertaken with phytoactin because early in the trials there were indications that this antibiotic might prove to be effective, particularly in view of its negligible phytotoxicity. Aerial application of such a chemical would greatly reduce costs in time and facilitate wider coverage. A total of 1017 cankers were treated, 821 receiving direct canker or basal applications and 196 foliar treatments. Unfortunately the phytoactin treatments in general proved to be even less effective than the equivalent acti-dione treatments.

Further studies in this program will be curtailed and the investigation will be confined to re-assessing treated cankers. These observations probably will continue for 2 years. In the light of these results and the proven ineffectiveness of these chemicals, officials of the Ontario Department of Lands and Forests deserve to be commended for withholding any large-scale spray control program until these products could be thoroughly evaluated. It can be concluded that, at present, eradication of *Ribes* species is the only reliable means of controlling the spread of white pine blister rust.—J. D. Cafley, Forest Research Laboratory, Maple, Ontario.

Further Selectivity Test of Fungitoxicants—Selective fungitoxicity is of importance as a research tool and for developing ecologically sound chemical control of soil-borne plant diseases. The screening program for selective toxins reported earlier (O. Vaartaja. Dept. Forestry Bi-Mon. Prog. Rept. 21(6) 1965) has been continued. Results for seven interesting new chemicals tested are reported here. Detailed results are given for the following five: Botran (2,6-dichloro-4-nitroaniline, obtained from Upjohn Co.), Daconil (tetrachloroisophthalonitrile (Diamond Alkali Co.), Terrazole (5-ethoxy-3 trichloromethyl-1,2,4-thiadiazole (Olin Mathieson), 1-chloro-2-nitropropane (Niagara Chem.), and pine oil. The chemicals were incorporated into agar as described earlier and tested against the following 19 organisms: BACTERIA: *Bacillus* sp.; MUCORALES: *Mortierella* spp. (2 strains); *Rhizopus* sp.; PERONOSPORALES: *Pythium ultimum* Trow; THELEPHORACEAE: *Corticium* sp., *Thanatephorus praticolus* (Kotila) Flentje, *Waitea circinata* Warcup & Talbot, *Peniophora* sp., *P.* (?) *cremea* (Bres.) Sacc. & Syd., *Stereum sanguinolentum* Alb. & Schw., *Thelephora terrestris* (Ehrh.) Fr.; POLYPORACEAE: *Fomes annosus* Fr.; MONILIACEAE: *Monilia* sp. (suspected as an imperfect stage of basidiomycete), *Penicillium janthinellum* Biourge, *Trichoderma viride* Pers. ex Fr., *Fusarium solani* (Mart.) App. & Wr.: MYCELIA Sterilia: *Cenococcum graniforme* (Sow.) Ferd. & Winge, *Sclerotium rolfsii* Curzi. These could be grouped into five ecological groups shown in Table 1: M=known or suspected mycorrhizal fungi, D=wood decayers, V=virulent soil-borne pathogens, S=soil-borne weak pathogens or saprophytes, C=competitors of pathogens. At least some of the fungi (Table I) exhibited specific responses to each of the five chemicals but the specificity was not related with the ecological or taxonomic groups.

Table 1

The lowest inhibitory[1] concentration of five fungitoxicants to 19 organisms

(Group and) species	Botran	Chloro-nitro propane	Daconil	Pine oil	Terrazole
(M) *Monilia* sp.	(>1000)	(500)	(50)	(2000)	500
C. graniforme	(>1000)	(500)	200	(500)	500
T. terrestris	(200)[i]	10[i]	10[i]	20[i]	(50)
Corticium sp.	(1000)	500[t]	(200)	2000[t]	500
(D) *F. annosus*	(1000)	200	(50)	(2000)	500
Peniophora sp.	(>1000)	10[i]	(500)	20[i]	500
P.? cremea	(>1000)	(50)	200	(2000)	(500)
S. sanguinolentum	(>1000)	(500)	10	(2000)	500
(V) *P. ultimum*	(1000)	(10[i]	(500)	100[i]	10[i]
T. praticolus	(>1000)	10	(200)	(500)	500
S. rolfsii	(>1000)	200	500	2000	(500)
(S) *W. circinata*	(1000)	50	(200)	500	500
F. solani	(>1000)	(200)	(>500)	2000[t]	500
(C) *T. viride*	(1000)	500	500	2000[t]	500
P. janthinellum	(1000)	(200)	>500[t]	2000[t]	500
Bacillus sp.	(1000)	(500)[i]	(200)	(>2000)	500
Mortierella spp.	(1000)	10[i]	200	(2000)	500
Rhizopus sp.	200[i]	500[t]	>500[t]	2000[t]	>500[t]

1 parentheses enclose values of full inhibition for those chemicals that were partly (>50%) inhibitory at any lower concentration.
[i], unusual inhibition.
[t], unusual tolerance.
>, more than the value given.

Botran, which is known to be particularly inhibitory to *Botrytis* and *Rhizopus* species, was unusual in showing strong fungistatic but little fungicidal effect. All toxicants were inhibitory to most of the fungi without inhibiting germination of seed of red pine (*Pinus resinosa* Ait.) at the highest concentration tested. In many cases the concentration that completely inhibited a fungus was quite low, suggesting usefulness of these chemicals in disease control. This seemed particularly true with Terrazole, which was very potent against the important nursery pathogen, *P. ultimum*. Such selectivity might be doubly effective in unsterilized soil. In addition to direct suppression of a pathogen, such a chemical would permit and enhance the natural biological control exerted by unsuppressed competing fungi. A high degree of inhibition was also found for *Pythium* and *T. praticolus* with chloronitropropane and for *Pythium* with pine oil. In addition to the five chemicals listed in Table 1, methylarsene oxide was studied; it completely inhibited *P. ultimum* and *T. terrestris* at a lower concentration (50 ppm) than most of the other organisms (200-500 ppm). This chemical did not fulfill my expectations based on previous findings with another arsenic compound of particular potency against *Rhizoctonia*. Octachloropropane (Hooker Chem. Co.) was also effective against most of the fungi at 100-500 ppm but with little specificity.—O. Vaartaja, Forest Research Laboratory, Maple, Ont.

(*Continued from back cover*)

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O.H.M.S.

DEPARTMENT OF FORESTRY
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BI-MONTHLY RESEARCH NOTES

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BI-MONTHLY RESEARCH NOTES

A selection of notes on current research conducted by the Forestry Branch, Department of Forestry and Rural Development

BOTANY

Natural Layering of Red Spruce in Quebec.—The vegetative propagation, by layers, of red spruce (*Picea rubens* Sarg.) was observed on several occasions in southern Quebec on moist and wet sites. As far as is known, this is the first time that layering has been observed in this species. The phenomenon was very similar to that commonly observed in black spruce (*Picea mariana* (Mill.) BSP.). However, the formation of layers takes place less frequently in red spruce, because of its less frequent occurrence on wet sites.

Layerings can be identified in the early stage by tracing the stem to its origin on the parent tree (Fig. 1). Up to three layering generations still connected have been found to date. Under favourable conditions layers developed an adequate root system and assumed the appearance of seedlings. The point of upward turning of the layer branch coincided with the development of the layer root system.

Upon rupture of the connection with the parent, through either mechanical or physiological processes, the layers were capable of independent growth. The layer may remain connected to the parent tree for several decades until it is shed naturally.

Layer connections above and below ground showed the structure typical of a branch—central pith surrounded by primary and secondary xylem and distinct annual rings. The primary root of red spruces of seed origin has a diarch primary xylem between two large resin canals and annual rings without distinguishable late and early wood.

Once layering is established, it may be assumed that its continued growth depends on the same conditions as that of a tree originating from a seedling. In suitable environmental conditions the layers develop into well-formed individual trees and only an examination of the root system can reveal their origin from layering.

FIGURE 1. Red spruce layers still attached to the parent tree.

Layering in red spruce was observed where the parent trees retained green branches near the ground and where these branches became imbedded in a rooting medium that remained moist through the year. It was observed that sphagnum and, to a lesser extent, hylocomium and hypnum moss species offered favorable ground cover for layering. Generally *Polytrichum* spp. did not favor the rooting of branches. Red spruce layerings were not found in young dense stands in which natural pruning removed all green branches near the ground or in stands on slopes with rapid drainage or on sites exposed to drought.—W. Stanek, Forest Research Laboratory, Quebec, P.Q.

ENTOMOLOGY

Variation in Sex Ratio and Prolonged Diapause in *Neodiprion swainei* Midd. Associated with Larval Mortality.—One source of variation in the sex ratio of *Neodiprion* sawflies is mortality that acts differentially by removing proportionately more of one sex than of the other. Differential mortality in late larvae and cocoons is well documented, and is associated with the longer feeding period and larger size of females relative to males. In *N. swainei* and many other sawflies a large portion of the larval mortality occurs during the first two stadia (L.A. Lyons, Can. Entomologist 94: 49-58. 1962). Size, behavioral and temporal differences between males and females during this period are apparently negligible, but since males are haploid and females diploid, there is some basis for postulating, as did Schedl (Proc. VII Int. Congr. Ent. 3: 2052-2104. 1939) that the sexes are unequal in "valence" or general survival ability. In 1958 a small-scale experiment was undertaken to determine whether the early larval mortality of *N. swainei* acted differentially.

In the field there was no way of preventing early mortality, and the sex of larvae could not be identified until the cocoon stage. However, since larvae could be reared relatively successfully for the remainder of the feeding period, especially if kept in large groups, it was anticipated that the presence of a relationship between the extent of early mortality and the sex ratio of surviving cocooned larvae would be evidence of differential mortality. Colonies of young third-instar *N. swainei*, with their egg clusters, were collected from small jack pines near Clova, Quebec. Early larval mortality, which varied from 5 to 84%, was calculated for each colony from the numbers of hatched eggs and living larvae. To promote survival for the remainder of the feeding period, the larvae were reared in one of six groups according to the extent of early mortality. Emergence of adult sawflies and parasites, almost all of which were *Spathimeigenia spinigera* Tns. (Diptera: Tachinidae), was recorded as well as the number of larvae that remained in eonymphal diapause in cocoons. Some female adults from each group were dissected for egg counts.

The pertinent relationships yielded by the experiment, are shown in Table I. Mortality in rearing, most of which occurred during the third instar, was directly associated with larval mortality before rearing. The proportion of females among survivors of the larval period was directly associated with pre-rearing, rearing, and total larval mortality. The rate of parasitization of surviving larvae was apparently indepen-

TABLE I

Summary of *N. swainei* Rearing Experiment

Group No.	1	2	3	4	5	6
Mortality class (%)	0–16	0–33	17–33	34–67	34–67	68–84
No. colonies	4	9	6	6	11	3
Mortality before rearing (%)	9.3	24.5	29.5	43.5	44.4	78.0
Mortality during rearing (%)	8.5	7.3	19.2	18.4	17.8	34.5
Sex Ratio (%♀♀)	69.0	64.6	74.1	76.7	74.9	89.5
Parasitization of ♂♂ (%)	17.0	30.0	41.7	21.4	25.4	50.0*
Parasitization of ♀♀ (%)	36.5	48.2	43.8	42.4	43.2	5.9
Prolonged diapause (%)	41.7	40.4	30.9	17.3	32.8	0

*One of two cocoons.

dent of mortality, but was greater for females than for males. The incidence of prolonged eonymphal diapause among surviving larvae was inversely associated with the rate of larval mortality, but was equal in males and females. There were no significant differences between groups in fecundity, adult size, cocoon size, or time of emergence, and no relation between mortality and size of the rearing group.

Assuming that rearing groups were equal in intrinsic quality or vigor and in primary sex ratio, and that the variation in early mortality per colony was due to variation in the intensity of the lethal factor, the relationships stated above would be expected if (1) the agent that killed varying proportions of first- and second-instar larvae had a delayed effect that continued to operate when the remaining larvae were brought under identical rearing conditions, (2) male larvae were more susceptible to mortality than females, and (3) the disposition for subsequent prolonged diapause, which must have been induced early in development, was equally deleterious for survival for males and females. The difference between males and females in rate of parasitization is open to more than one interpretation, the most plausible being that initial attack of first- and second-instar larvae was independent of sex but more deleterious for the immediate survival of males than of females. An alternative interpretation, used by Tripp (Can. Entomologist 94: 809-818, 1962) to account for a similar difference in larvae exposed until much later in the feeding period, is that the rate of attack was initially greater in females. However, there is no evidence that young female larvae were more exposed to attack than males, and it is hard to believe that an adult parasite, attacking as rapidly as *S. spinigera,* would be able to exercise selection among early larvae that are very small in relation to itself.

Tentatively, early larval mortality seems to have operated differentially at least against males, if not also against larvae destined to enter prolonged diapause. However, the underlying assumptions of equal distribution of primary sex ratio and diapause tendency among colonies in the initial population have not been confirmed. It seems clear, nevertheless, that events early in the life cycle must have more important population consequences than the mere level of mortality would suggest.—L. A. Lyons, Forest Research Laboratory, Sault Ste. Marie, Ontario.

Parasites and Predators of *Phyllophaga* spp. in Southeastern Manitoba—White grubs have caused severe damage to pine seedlings in plantations in southeastern Manitoba (R.M. Prentice and V. Hildahl, Ann. Rept. Forest Insect and Disease Surv., Can. Dept. Agr., Ottawa, 1958). As part of a study of these insects in this area, a preliminary survey has been made of the parasites and predators of *Phyllophaga.* According to Criddle (Can. Agr. Gaz. 5:449-454, 1918) and Davis (Ill. Nat. Hist. Bull. 13(5):1-138, 1919), parasites are effective in reducing populations of white grubs.

Phyllophaga adults, collected in mid-June in light traps and by hand picking at night, were placed in rearing cages in the laboratory on fresh poplar foliage. To ensure complete development of parasites the adults were kept for 7 weeks before dissection. *Eutrixa exilis* (Coq.) was the most common

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dipterous parasite attacking *P. nitida* (Lec.), *P. anxia* (Lec.), and *P. drakii* (Kby.). The parasite glues its egg to the underside of the abdomen of the beetle. Eggs hatch in about 7 days and the maggots penetrate the abdominal cavity. As many as seven maggots may develop within the abdomen of a single beetle. This parasite does not always kill the beetle but generally damages the reproductive organs, thereby affecting the size of populations in the next generation. The percentages of *Phyllophaga* adults attacked by *E. exilis* in 1964 and 1966 collections, number of adults shown in parentheses, were as follows:

Year	*P. anxia*	*P. nitida*	*P. drakii*	Totals
1964	33(6)	11(56)	9(86)	11(148)
1966	25(20)	0(2)	6(139)	9(161)

Numerous tachinid adults (*Cryptomeigenia* sp.) were captured in light traps during the flight period of *Phyllophaga* adults. This genus, according to Sabrosky and Arnaud (*In* U.S.D.A. Agr. Handbook 276, 1965), parasitizes *Phyllophaga* larvae but specific identification of this parasite is virtually impossible at the present time. Criddle noted that *Cryptomeigenia theutis* (Walk.) killed about 50% of the beetles in 1914. The present study has not revealed any parasitism of white grubs by *C. theutis.*

The tiphiid parasite, *Tiphia micropunctata* Allen, was found attached to the fold of skin on the dorsum between the second and third thoracic segments on seven larvae. In addition a species of *Sarcophaga* was reared from a white grub larva.

Predation of white grubs by adults of *Vespula maculata* (Linn.) and *Bembix spinola* Lep. was observed.

We thank the Officers of the Entomology Research Institute, Research Branch, Canada Department of Agriculture, Ottawa, for the identification of the parasites.—J. C. E. Melvin and L. D. Nairn, Forest Research Laboratory, Winnipeg, Man.

A Study of the Dispersal of Balsam Woolly Aphid Crawlers by Small Animals—A Study was initiated during 1966 to determine whether the motile stage of the balsam woolly aphid (*Adelges piceae* (Ratz.)) was dispersed by phoresy. "Fall-traps" designed to collect small creatures that frequent the forest litter were set out in aphid infested stands of grand fir (*Abies grandies* (Dougl.) Lindl.) on Vancouver Island, and amabilis fir (*A. amabilis* (Dougl.) Forbes) near Vancouver.

The traps consisted of 1-gal anti-freeze containers set into the earth with their rims at ground level. Pieces of $\frac{1}{4} \times 12 \times 12$ inch plywood supported by a large nail through each corner served as covers. The covers were placed about 1 inch above the traps to allow the entry of small animals from the sides, but minimize the capture of airborne aphids from above. Each trap contained about 1 qt. of water, plus a small amount of wetting agent (anterox) to hasten the drowning of the captives and to wash the crawlers off them.

A 5×8 inch card with a 3×6 inch gridded center section treated with tanglefoot was placed on each trap cover. Examination of the sticky cards, coincident with the weekly emptying of the traps, provided an indication of the effectiveness of the covers and an indication of the abundance of aphids dropping in the vicinity of the traps.

Any larger animals caught were washed thoroughly and disposed of in the field. In the laboratory, the washings and trap contents were poured through a series of soil screens (40, 60, 80, and 120 mesh). The coarse mesh screens removed leaves and other large debris whereas the fine particles, including the crawlers, were collected by the 120-mesh screen. To obtain a fairly uniform distribution, the fine matter was washed through a No. 4 filter paper laid flat in a 20 mesh screen. The dried filter papers were held flat by a plastic square scored with a $\frac{1}{4}$-inch grid and the entire surface of the filter examined under a dissecting microscope.

Table I shows the results of 296 trap collections from four sample areas. The traps captured a number of insects, mostly ground beetles; mammals, mostly *Sorex* sp.; and a mixture of frogs, newts, and salamanders. If the above organisms were absent, the traps were considered empty even though they occasionally contained earthworms and centipedes. The incidence of crawlers in the traps increased when either mammals or amphibians were captured even though two of the four sample areas had low aphid populations. Table II shows data taken from the sample area with the highest aphid population.

The overall average number of crawlers per empty trap collection was 0.20, maximum 0.62 for a sample area with a high balsam woolly aphid population. The sticky cards in the latter area caught 7.80 crawlers per square inch each week. That is, if the traps were uncovered approximately 300 aphids per week would have fallen into each trap.

TABLE I

The occurrence of crawlers of *A. piceae* in fall-traps in relation to other organisms captured in all areas.

Trap contents	No. of samples	No. of samples containing crawlers	% of samples containing crawlers	Average no. of crawlers per sample*
Empty	66	8	12	1.6
Insects	176	23	13	1.9
Mammals	47	14	30	2.6
Amphibians	7	3	43	4.7

*Based on the number of samples containing crawlers.

TABLE II

The occurrence of crawlers of *A. piceae* in fall-traps in relation to other organisms captured in an area with a high aphid population.

Trap contents	No. of samples	No. of samples containing crawlers	% of samples containing crawlers
Empty	16	6	37.5
Insects	52	17	33.0
Mammals	16	12	75.0
Amphibians	4	3	75.0

Crawlers of the balsam woolly aphid that fall to the forest litter may be transported by small animals. However, the relative numbers so transported appear to be insignificant and the chance of a crawler dropping on a small animal would be slight. It was not possible to determine whether crawlers carried into the traps were living or dead, but the data suggests that the crawlers do not initiate the phoresy by way of response to body warmth of either the mammals or the amphibians.—T.A.D. Woods and M. D. Atkins, Forest Research Laboratory, Victoria, B.C.

FOREST MANAGEMENT

Erratum: Vol. 23, No. 4, p. 8, third line under "FOREST MANAGEMENT" should read "1,000 stems per".

FOREST PRODUCTS

Electrical Resistance of Wood vs. Stress.—The Wood Physics Section of the Vancouver Forest Products Laboratory has found that the direct-current electrical resistance perpendicular to the grain of western red cedar changes with stress applied parallel to the grain.

An increase in tension stress to approximately 2,000 psi over a 30-second period decreases the resistivity by approximately 1.5%. The resistivity increases again almost linearly when the stress is relieved. The observations were made at controlled climatic conditions of 45% relative humidity and 72°F on specimens that had been electrically conditioned for approximately 45 minutes prior to testing.

In the time interval of investigation the resistivity changes observed seem to be little affected by climatic fluctuation, piezo-electric charge development, and stress-induced change in equilibrium moisture content. The observation suggests that a direct resistivity measurement, under certain conditions of controlled environment and fairly short time spans, might be used to replace more conventional strain-measuring techniques used in mechanical dynamic or quasi-static testing of wood; for example, monitoring the resonance frequencies in non-destructive vibration tests could be conceived as a technically possible application.—Lars Bach, Forest Products Laboratory, Vancouver, B.C.

A Kinetic Study of the Degradation of Wood-Glue Bonds—Using ultra-violet spectrometers and gas chromatographs, the degradation of the glue-wood bond has been studied as a chemical (hydrolysis) reaction (Gillespie, R. H., Forest Prod. J. 15(9) 369. 1965). A mechanism for this degradation is proposed and has been found to follow first order kinetics. A plot of log(a—x) versus time was linear for the above systems; thereby indicating first order kinetics, "a" representing final formaldehyde concentration and "x" representing formaldehyde concentration at any time "t". Kinetic results for four formaldehyde glues (melamine, urea, melamine-urea and phenol) and the glue-wood species of these glues have been obtained. The kinetic results include half life of the reaction at 25°C, activation energy, pre-exponential factor and entropy of activation. The measured activation energies ranged between 17 (urea formaldehyde) to 30 (melamine formaldehyde) K cal/mole. Since the hydrolysis rates for the phenol formaldehyde and phenol formaldehyde-wood systems were too slow to be measured, the activation energies for their hydrolysis would be much greater than 30K cal/mole. The results indicate that chemical bonding is taking place between the glue and wood, and therefore the degradation rate constants based on the glue-wood species rather than the glue samples should be used to provide a quantitative index of their durability. The half life of the hydrolysis rates provide a convenient index of durability. The ranking of the above glue-wood species in ascending order of their hydrolysis rates measured in this investigation are:

Bonds	Rank	Hydrolysis half-life at 25°C
Phenol formaldehyde-wood (most durable)	1	much greater than 716 hr.
Melamine formaldehyde-wood	2	716 hr.
Melamine-urea formaldehyde-wood	3	42 hr.
Urea formaldehyde-wood (least durable)	4	8 hr.

This ranking is in agreement with the service lives of these glues (Northcott, P. L., and W. V. Hancock, A.S.T.M., S.T.P. 401. 1966). Thus phenol formaldehyde-wood has the most durable bond towards hydrolysis attack whereas urea formaldehyde-wood has the least. This is the expected result when one looks at the following proposed mechanism. Urea formaldehyde is used to illustrate the hydrolysis mechanims:

$$\text{R-}\overset{\text{O}}{\overset{\|}{\text{N}}}\text{C-NH-CH}_2\text{-NH-R}' + \text{H}^+ \underset{\text{Rapid}}{\rightleftharpoons} \text{R-}\overset{\text{O}}{\overset{\|}{\text{N}}}\text{C-NH-CH}_2\text{-}\overset{\text{H}^+}{\overset{|}{\text{N}}}\text{H-R}' \quad (1)$$

$$\text{R-}\overset{\text{O}}{\overset{\|}{\text{N}}}\text{C-NH-CH}_2\text{-}\overset{\text{H}^+}{\overset{|}{\text{N}}}\text{H-R}' \underset{\text{Slow}}{\longrightarrow} \text{R-}\overset{\text{O}}{\overset{\|}{\text{N}}}\text{C-NH-CH}_2^+ + \text{NH}_2\text{-R}' \quad (2)$$

$$\text{R-}\overset{\text{O}}{\overset{\|}{\text{N}}}\text{C-NH-CH}_2^+ + \text{H}_2\text{O} \underset{\text{Rapid}}{\longrightarrow} \text{R-}\overset{\text{O}}{\overset{\|}{\text{N}}}\text{C-NH}_2 + \text{H}^+ + \text{CH}_2\text{O} \quad (3)$$

In this mechanism, the proton is regenerated and the major product is formaldehyde. The experimental results show that the reaction is accelerated in acid solutions and has a slightly lower activation energy in acid than in water.

There is no available site for proton attack in the phenol formaldehyde structure, whereas the urea and melamine formaldehyde glues provide a lone pair of electrons on a nitrogen atom adjacent to the methylene group. The hydrolysis rate for phenol formaldehyde and phenol formaldehyde-wood was too slow to be measured at 100°C, the highest temperature used in this investigation.

Because of the different hydrolysis rates found for the formaldehyde glues and formaldehyde glue-wood species, the writer proposes that a hitherto unexpected chemical bond is involved in the glue-wood hydrolysis reaction (G. E. Troughton, unpublished data). The results of the present investigation indicate that covalent bonding takes place between the wood and glue. One possibility is an oxymethylene bond which could be formed by an elimination reaction between the secondary hydroxyl group in cellulose and the CH_2OH group in the glue. Arrhenius parameters calculated for the hydrolysis of this bond using model compounds have similar values to those calculated for the wood-glue reaction (Jones, D. M., J. Textile Research *34*: 263. 1964).—G. E. Troughton, Forest Products Laboratory, Vancouver, B.C.

PATHOLOGY

Greenhouse Evaluation of Seed Treatment Chemicals for the Control of Conifer Seedling Damping-off—The great number of fungicides available for seed treatment necessitates the development of a rapid, efficient test of their effectiveness that correlates closely with their effect under field conditions. Laboratory methods using agar plates seeded with damping-off fungi (O. Vaartaga. Phytopathology 46:387-390, 1956) or greenhouse tests using potted sand (R.M. Waldron and J.H. Cayford, For. Res. Lab., Wpg., Unpubl. Int. Rep. 65-MS-4, 1964) have limited value because they do not approximate field conditions. Chemicals may be ineffective in soil although effective on an agar medium (O. Vaartaja. Can. Dept. Agr., For. Biol. Div., Bi-Mon. Prog. Rept. 15(2):2, 1959).

TABLE I

Effect of seed treatment chemicals on damping-off and germination of white spruce, jack pine, and red pine under greenhouse conditions.

Conifer Species	Seed Treatment	Grams Chemical per Seed	Germination Ave/100 Seeds Sown	Damping-off Ave/100 Seeds Sown	Net Stand Ave/100 Seeds Sown
White Spruce	Control	—	53	36	17
	Orthocide-50 (captan 50% active—Chevron Chemicals)	2.0	17	4	13
		0.5	25	13	12
	*Arasan (thiram 75% active—Du Pont)	2.0	42	18	24
		0.5	42	20	22
	*Polyram (zinc metiram 80% active—Niagara)	2.0	31	9	22
		0.5	24	9	15
	Spergon (chloranil 95% active —U.S. Rubber)	2.0	28	18	10
		0.5	31	18	13
	duTer (tri phenyl tin hydroxide 20% active—Green Cross)	2.0	2	0	2
		0.5	3	1	2
	USR 461 (oxathiin derivatives 75% active—U.S. Rubber)	0.5	20	6	14
		0.1	33	21	12
	USR 735 (oxathiin derivatives 75% active—U.S. Rubber)	0.5	18	7	11
		0.1	30	22	8
Jack Pine	Control	—	74	72	2
	Orthocide-50	2.0	75	72	3
		0.5	71	69	2
	*Arasan	2.0	83	71	12
		0.5	76	72	4
	*Polyram	2.0	46	34	12
		0.5	61	54	7
	Spergon	2.0	83	76	7
		0.5	73	72	1
	duTer	2.0	17	13	4
		0.5	13	12	1
	USR 461	0.5	37	34	3
		0.1	74	72	2
	USR 735	0.5	14	13	1
		0.1	64	61	3
Red Pine	Control	—	71	69	2
	*Orthocide-50	2.0	45	14	31
		0.5	61	19	42
	*Arasan	2.0	78	11	67
		0.5	75	26	49
	*Polyram	2.0	64	6	58
		0.5	63	9	54
	*Spergon	2.0	69	32	37
		0.5	64	42	22
	duTer	2.0	0	0	0
		0.5	1	0	1
	USR 461	0.5	47	23	24
		0.1	64	62	2
	USR 735	0.5	42	38	4
		0.1	72	67	5

Seed treatment tests were carried out in the greenhouse at Winnipeg using soil naturally infested with damping-off fungi, notably *Pythium* spp. and *Rhizoctonia* spp., obtained from the Pineland Nursery at Hadashville, Manitoba. The soil was placed in bench beds and treated seed sown in rows at a rate of 100 seeds per plot, with a total of 180 eight-inch-long plots per bed. The treatment plots were sown with seed pelleted with fungicide using 4% methyl cellulose as a binder applied at a rate of 3 ml per 10 g of seed. The check plots were sown with nontreated seed. Seed of white spruce (*Picea glauca* (Moench Voss), jack pine (*Pinus banksiana* Lamb.), and red pine (*Pinus resinosa* Ait.), were treated with seven fungicides, each at two rates of application for a total of 15 treatments per species including controls. Post emergence damping-off, total germination, and chemical injury data were recorded over a 1-2 month period, with the final evaluation made when the seedlings were aproximately 2 months old.

The severity and incidence of damping-off in the tests were greater than generally observed under field conditions. The extent of disease control is shown in Table I with asterisks to indicate the most interesting chemicals.

All seeds treated with Spergon germinated more rapidly than with other treatments and initial stands were good; however, 3-4 weeks after germination damping-off became quite severe. Further tests, to be included in a later report, gave similar results.

Poor germination (Table I) and chlorotic seedlings in a few cases were the obvious effects of chemical injury. DuTer (tri phenyl tin hydroxide) caused the greatest reduction in germination in all three species. The amount of germination of seed treated with USR 461 and USR 735 (both oxathiin derivatives) was inversely proportional to the amount of chemical applied. Of the better chemicals it appears that Arasan causes the least amount of injury. Others such as Orthocide-50 reduced germination of white spruce and red pine, but not of jack pine seeds; Polyram reduced seed germination in white spruce and jack pine but not in red pine; and Spergon reduced seed germination in white spruce. Chlorosis was severe where the seeds were treated with duTer.

Control of damping-off in these tests was generally poor as indicated by the data on jack pine. The severity of these tests was possibly due to a high concentration of inoculum in the soil enhanced by optimum environmental conditions for fungal development in the greenhouse. However, a test of this nature provides an excellent means for eliminating the less fungitoxic and more phytotoxic chemicals from field trials. Greenhouse evaluations can provide rapid and more frequent evaluations, for example, testing of seed treatments may be continuous throughout the entire year in the greenhouse, as compared to one planting per season in the field. The final test of a chemical is the field trial. This procedure will limit such trials to more promising chemical.—L. W. Carlson and J. Belcher, Forest Research Laboratory, Winnipeg, Manitoba.

Microflora of Hail Wounds.—Following severe hail storms in Quebec in 1960 and 1961 (H. A. Tripp *et al.* Bi-Mon. Prog. Rept. 18(3): 1-2, 1962), a study was undertaken to determine the fungi colonizing the hail wounds. For this purpose, numerous stem and branch samples, over ½ inch in diameter, were collected from an average of 10 damaged but still living trees selected from an average of 10 the study areas (Table I). Isolations were made on 2% malt agar slants using chips of wood removed immediately below the exposed wood, that was usually showing stain, at wound sites. To obtain these chips, the layer of weathered wood was removed or the sections were split with sterilized tools.

In general, only about 20% of the isolation attempts each year yielded Basidiomycetes (Table I), of which 60% were of the *Peniophora cinerea* group. This fungus was particularly common on balsam fir, tamarack, and hardwoods with the exception of aspen. *Peniophora septentrionalis* Laurila occurred frequently on spruce, especially at Clova; it was also obtained for the first time from jack and white pine. Other Basidiomycetes, not isolated more than three times from the same tree species, included: *Stereum sanguinolentum* (Alb. & Schw. ex Fr.) Fr. on tamarack, black spruce, and white and jack pine; *S. chailletii* (Pers ex Fr.) Fr., *Trametes* sp., and *Schizophyllum commune* Fr. on balsam fir; *Sistotrema brinkmanii* (Bres.) J. Erikss., on jack pine; and *Fomes igniarius* (L. ex Fr.) Kickx, on birch. Dr. M. K. Nobles confirmed the identification of this group. The imperfect fungi most commonly isolated included, in order of frequency: *Aureobasidium pullulans* (de Bary) Arnaud, *Pleurophomella* and similar fungi, *Phoma* spp., *Cytospora* spp., *Alternaria tenuis* series, *Coniothyrium* spp., *Epicoccum nigrum* Link, and *Fusarium* spp. These fungi represented 48% of the successful isolations, but only 22% of the total number of species obtained.

TABLE I

Results of isolations made from hail wounds sampled in October, 1961 and 1962

Tree species	Locality[1]	Number of isolations		
		Basidiomycetes	Imperfect fungi or Ascomycetes	Bacteria or sterile
Jack pine	A, C	17	77	0
White pine	B, C	11	41	6
Black spruce	A, B	13	84	7
White spruce	C	1	13	4
Balsam fir	A, B	19	76	18
Tamarack	B, C	18	27	8
Trembling aspen	A, B, C	2	49	4
White birch	B, C	26	38	1
Red maple	C	12	16	0
Other deciduous	A, B, C	22	86	15
Total		141	507	63

[1]A. Clova, Abitibi East County; B. Chapeau de Paille, Laviolette County; C. Saint-Lambert, Levis County. Trees from A and B were from 1 to 3 inches dbh; trees from C were 1 to 5 inches dbh.

By culturing from fruiting structures collected on bark or wood of hail-damaged trees, it was possible to show that the ascogenous stages of two of the *Phoma* species, one species of *Coniothyrium*, and one species of *Dendrophoma* were species of *Pleospora*. One species of *Phoma*, obtained only from aspen, was similar to a species commonly isolated from frost cankers near Causapscal, Matapedia County, and from branch stubs in Alberta (D. E. Etheridge. Can. J. Botany 39: 789-816, 1961). The *Cytospora* species corresponded mostly to *Leucostoma*, which killed a large number of aspen, balsam fir, and jack pine trees at Clova. Although not obtained in isolation trials, sapwood-rotting fungi such as *Stereum purpureum* (Pers. ex Fr.) Fr., *Cryptochaeta rufa* (Fr.) Karst., and *Punctularia* (*Phlebia*) *strigozo-zonata* (Schw.) Talbot were also collected on several dead or dying trees at Clova. Elsewhere, a few trees had died and wounds had almost completely calloused by 1962.

These results are in agreement with those of Linzon (For. Chron. 38: 497-504, 1962) that important heartrot fungi seldom become established in fresh hail wounds, and also that imperfect fungi influence the establishment of wood-rotting organisms. Of special interest was the isolation of *S. sanguinolentum* from all conifers but balsam fir, its main host, in the areas sampled.—G. B. Ouellette, Forest Research Laboratory, Sillery, Que.

SILVICULTURE

Debudding Lodgepole Pine in Alberta.—Debudding, also known as bud pruning, finger pruning and Russian pruning, is the annual removal of lateral buds with the objective of producing knot-free wood. The method was developed by P. G. Krotkevich. (Reviewed in Journal of Forestry 38 (10) 1939).

In 1950 a study of the application of this technique to lodgepole pine (*Pinus contorta* Dougl. var. *latifolia*

Engelm.) was initiated in Alberta. This note evaluates debudding as a silvicultural treatment of lodgepole pine on the basis of tree height and diameter measurements taken annually for 13 years.

The project was established at an elevation of 4,700 feet on the Kananaskis experimental forest in the Subalpine Forest Region (J. S. Rowe, 1959. Canada Forestry Br. Bull. 123). The site is a dry, gravelly, river terrace sloping gently to the west. The treated stand originated after a fire in 1936 and has a Site Index of 50-60 at stump age 70.

Treatment consisted in the removal of all branches above 2 or 3 basal whorls, which were left to develop normally. From 1950 to 1962, inclusive, all lateral and adventitious buds were removed early in the growing season, when the buds were large and soft but had not burst. Debudding was terminated when the average length of clear bole reached 16.9 feet.

Diameter at breast height to the nearest tenth inch and height to the nearest tenth foot were measured annually in the autumn.

Figure 1 shows diameter and height growth of the treated and control trees. Statistical analyses indicate that diameter growth of control and treated trees was not significantly different in 1950 but was highly significant in 1962 as a result of treatment. Height-growth differences were highly significant both in 1950 and in 1962. The analysis was confounded by a slight variation in the site of treated and untreated trees. This explains the difference in average height of treated and control trees in 1950. By 1962 this difference had increased, and it is possible that the treatment had had a minimal effect on height growth.

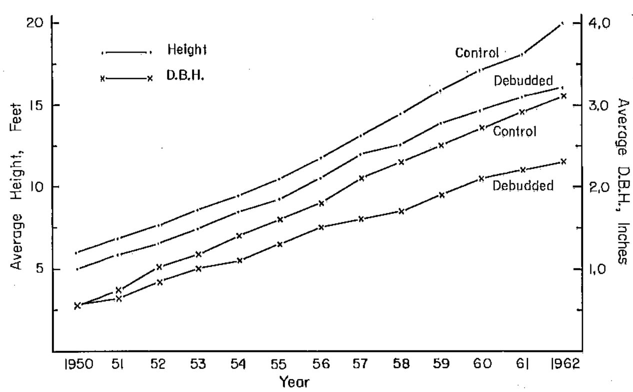

FIGURE 1. Effect of debudding on height and dbh.

There was no significant mortality as a physiological result of bud pruning, but faulty debudding technique caused a 15% loss between 1958 and 1962.

Prolific adventitious budding has negated the practicability of applying this treatment to lodgepole pine in the Kananaskis experimental forest. In 1953, for example, 97 per cent of the debudded trees produced stem buds. The amount of adventitious budding has varied greatly between trees and has generally increased with age. The removal of adventitious buds takes 3 to 4 times longer than the removal of nodal buds. New adventitious buds can usually be rubbed off, but growth that has been undetected for one season frequently requires removal by a knife. Other workers have found adventitious budding to be a problem common to bud pruning treatments.—H. J. Johnson, Forest Research Laboratory, Calgary, Alta.

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