FBI - MONTHLY

RESEARCH NOTES

IN THIS ISSUE:

Vol. 24 - No. 1, JANUARY-FEBRUARY 1968

CANADA
DEPARTMENT OF FORESTRY
AND RURAL DEVELOPMENT

Published under the authority of
The Honourable Maurice Sauvé, P.C., M.P.
Minister of Forestry and Rural Development
Ottawa

BI-MONTHLY

RESEARCH NOTES

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

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BOTANY

Foliar Moisture Content as a Criterion for Resistance to Frost and Scleroderris Canker in Jack Pine.—Plant-tissue moisture, an easily measured character, has been shown to affect frost tolerance (Langlet, Meddelanden Från Statens Skogsförsöksanstalt, 29, p. 428. 1936), and resistance to various canker diseases in a number of tree species (Bier. Can. J. Bot., 37: 229-238, 781-788, 1140-1142, 1959). This note reports a correlation between dry-to-turgid needle weight of jack pine (*Pinus banksiana* Lamb.) provenances at Chalk River, Ont., and the responses of the same provenances to frost stress and infection by *Scleroderris lagerbergii* Gremmen at Longlac, Ont., 600 miles away.

Ninety-two provenances from Maine to the Northwest Territories were common to each location. At each location each provenance was represented by 100 trees distributed in 10 randomized blocks in single-row plots with 1 × 1 ft spacing. Seeding in the spring of 1962 was followed by replanting of empty spots with 1-year-old seedlings in 1963.

A moderate amount of frost damage was apparent at Longlac in 1965. In the same nursery apothecia of *S. lagerbergii* were found on young red pine, *Pinus resinosa* Ait., (Punter, The Forestry Chronicle 43: 161-164, 1967) and were probably present in the jack pine provenances as well. By the following year 99% of the jack pine trees were infected by the fungus (Teich, Bi-monthly Research Notes 23: 5, 1967).

Needle samples of all provenances were taken from five field replications at Chalk River on 15 Oct. 1965. In each replicate a provenance sample consisted of 10 fascicles from the middle of current year leader growth of 10 trees. To bring the needles to maximum turgidity they were placed in a germination cabinet at 100% relative humidity for 48 hours. Each sample, weighing about 4 g, was then weighed to the nearest milligram, placed in an oven at 80°C for 36 hours to dry to a constant weight and reweighed.

Variations among both provenances and blocks were statistically significant (p=.001). The smallness of the error variance (C.V.=0.5%) indicated a similar sequence of provenance performance within the five blocks. While the mean ratio was 0.47, the provenances ranged from 0.43 to 0.51, with southern provenances low and northern provenances high.

Provenances with high dry-to-turgid needle weight ratios at Chalk River tended to have less frost and fungal damage at Longlac than those with lower ratios. This relationship appeared to hold for all ratios up to 0.48 (Fig. 1). Frost and fungal damage were negatively and significantly (p=.001, 90 degrees of freedom) correlated with the needle ratios r=.64 and r=.99 (following a probit transformation) respectively. Frost damage did not appear to be an essential predisposing condition for infection. Many frost-hardy provenances were completely infected by the fungus. Only 9% of the variance in number of disease-free trees could be explained by percent survival following frost stress.

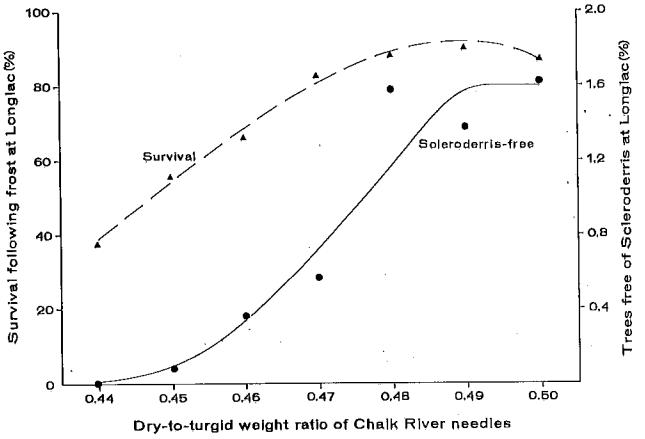

FIGURE 1. Correlation of jack pine dry-to-turgid needle weight ratio at Chalk River with frost tolerance and incidence of *Scleroderris*-free trees at Longlac.

Correlation between two characters can be genetic or environmental in origin. Where both traits are measured in the same trees it is difficult to separate genetic from environmental effects. If site affects both leaf characteristics and frost tolerance, a tree on a favorable site would be high in both criteria and a tree on a poor site would be low in both criteria, resulting in a phenotypic correlation, whether or not genetic correlation existed. This problem was avoided by testing provenances at two different locations in replicated and randomized experiments. Nongenetic influences associated with location, season and stage of development on leaf ratios at Chalk River could not contribute to the level of frost and fungal damage at Longlac. The tendency of the provenances to maintain their sequence of performance for the correlated characters, despite the environmental differences, supports the hypothesis that the observed correlations are genetic.

Additional testing of the surviving trees and the provenances in general is desirable to confirm the hypothesized resistance of the survivors and the observed trait relationships. The surviving trees from the Longlac experiment are being propagated to test their resistance by exposure to inoculum under controlled conditions. Most of the provenances are now growing in other experiments similar to those at Longlac and Chalk River. Future frost and disease stress will test the theory that leaf dry-to-fresh weight ratio information obtained in one experiment can be used to predict frost and disease performance in a range of environments. If confirmed, then genetic improvement in frost tolerance and resistance to *S. lagerbergii* may be possible by selecting trees for propagation whose progeny will be high in dry-to-turgid needle weight ratios. This criterion may be of particular value in the absence of frost stress or conditions favorable to disease development.—A. H. Teich, Petawawa Forest Experiment Station, Chalk River, Ont.

ENTOMOLOGY

Microorganisms Isolated from *Malacosoma americanum and Malacosoma disstria* in the Province of Quebec.—A meticulous search for pathogenic diseases in populations of *Malacosoma americanum* (F.) and *Malacosoma disstria* (Hbn.) has been conducted since 1960 in central and southern Quebec. During the past four years, this work was particularly rewarding due to the heavy infestations of these two Lepidoptera that existed in this area. The most important diseases observed are recorded below.

In 1960, a nuclear-polyhedrosis was found in the populations of *M. americanum,* but at that time the virus caused only 5-10% mortality in the pre-pupal stages. In 1964-65, a viral epizootic spread throughout the Province and mortality reached 20%. In 1966, 30-50% mortality was recorded in some areas. In 1967, populations of this insect were reduced to an endemic level. Although no viral epizootic was observed in natural populations of *M. disstria,* rare and solitary cases of nuclear-polyhedrosis and cytoplasmic polyhedrosis were recorded during the summer of 1965. The cytoplasmic polyhedrosis appears to be the first record for *Malacosoma* sp. larvae.

Among the several bacterial diseases observed on larvae of *M. americanum,* special attention was given to that caused by *Clostridium brevifaciens,* a disease first observed in 1965 at Plessisville and Sherbrooke, P.Q., where it was found endemically. *Bacillus cereus, Serratia marcescens,* and *Psuedomonas* sp. also were identified in larvae. These three species were always found together, but mortality was not significant. The species of bacteria found on *M. disstria* were the same, but even rarer than in the case of *M. americanum.*

The fungi *Beauveria bassiana, Isaria farinosa,* and *Aspergillus fumigatus* were isolated on larvae of *M. americanum,* but mortality was too low to be of any significance. Fungal infections were more numerous on *M. disstria.* This was especially true of *Isaria farinosa* which attacks the pupae.

A few larvae of *M. disstria* that had died as a result of attack by the microsporidian, *Nosema disstria,* were found during the summer of 1965. In 1966, the microsporidian was observed throughout the Province but mortality was not significant. However, a microsporidial epizootic occurred during late fall and early spring of 1966-67. Examination of egg clusters made during that period revealed that 30% of the larvae in eggs had succumbed to microsporidian infection. The microsporidian epizootic was especially effective during the spring of 1967, killing up to 90% of the first- to third-instar larvae in some areas. Such infections were not observed in field populations of *M. americanum.*

In conclusion, it is possible to state that a nuclear-polyhedrosis may have contributed to the population collapse of *M. americanum,* while the reduction in populations of *M. disstria* was attributable, at least in part, to a microsporidian, *Nosema disstria.*—W. A. Smirnoff, Forest Research Laboratory, Sillery, Quebec.

Laboratory Screening of Insecticidal Compounds for Comparative Contact Toxicity against Sawflies and Forest Tent Caterpillar.—Each year, new insecticidal compounds are screened in the laboratory to select the more promising ones for field trials. This report describes the tests for 10 compounds, nine were organophosphorus and one carbamate. Ten compounds were tested against black-headed jack-pine sawfly larvae (*Neodiprion pratti banksianae* Roh.), nine against larch sawfly larvae (*Pristiphora erichsonii* (*Htg.*)) and five against forest tent caterpillar larvae (*Malacosoma disstria* (Hbn.)). Their toxicity was compared with DDT as a standard insecticide (Table 1).

The experiments were conducted under laboratory conditions by a very similar method to that described by Randall & Nigam in 1966 (Bi-Mon. Prog. Rep. *22* (1):3). A modified Potter's tower, adjusted to deliver a constant volume of spray approximately ½ gallon per acre, except where otherwise specified, was used. Seven concentrations of each of the insecticides were sprayed, except in the case of Ciba-9491, Matacil and SD-8447 when five concentrations were used. Thirty to sixty larvae per concentration, in groups of 10 larvae per replication, were sprayed for contact toxicity. The insecticide solutions were formulated in Velsicol AR-50G dyed with 0.5% orasol red. The formulations were sprayed directly onto the CO_2 anaesthetized larvae and 9 cm No. 1 Whatman filter-paper samples.

TABLE 1

Toxicity of insecticidal compounds against three species of insects

Insecticide		Black-headed Jack-pine Sawfly 4th Instar		Larch Sawfly 4th Instar		Forest Tent Caterpillar 3rd Instar	
Name	Type	Deposit in oz. per acre	24 hr Corrected† % Mortality	Deposit in oz. per acre	24 hr Corrected† % Mortality	Deposit in oz. per acre	24 hr Corrected† % Mortality
Abate	O-P	3.075	54	2.424	100		
Anthio	O-P	0.415	100	0.375	100	3.400	37
Baytex	O-P	0.338	100	0.627	100		
Ciba 9491	O-P	0.833	100				
Cyan 47031	O-P	1.378	100	0.696	100	1.378	37
Dibrom	O-P	0.043	100	0.081	97	0.864	100
SD 8447	O-P	0.430	100	0.228	100		
Thimet	O-P	0.400	100	0.159	100	3.470	73
Zytron	O-P	3.500	100	3.504	59		
Matacil	C	0.408	100	0.429	100		
DDT	C-H	26.946	85**	3.848	93	7.420	50*

† By Abbott's formula
* at 48 hr 100%
** 72 hr after treatment
O-P Organophosphorus
C-H Chlorinated Hydrocarbons
C Carbamate
1% active ingredient @ 1 gallon per acre (GPA) = 1.121 $\mu g/cm^2$ = 1.6 oz./acre.

The deposits of an insecticide for the replications of each treatment were determined colorimetrically by elution of the dye from filter-paper and the actual deposits were calculated against a standard reading for each concentration of insecticide. The average deposit of all the replications of each concentration in ounces per acre is presented in Table 1. The deposit in ounces per acre is calculated from the formula given at the bottom of Table 1. Mortality observations were taken at 24, 48 and 72 hours and corrected for natural mortality by Abbott's formula.

The compounds tested are listed below with their chemical names:

Abate—O,O,O,O,-tetramethyl O,O-thiodi-p-phenylene phosphorothioate

Anthio—S-((formylmethylcarbamoyl) = methyl)O, O-dimethyl phosphorodithiorate

Baytex—O,O-dimethyl O-[4-(methylthio) - m - tolyl] phosphorothioate

Ciba 9491—O,O-dimethyl-O - 2,5 - dichloro - 4 - iodophenyl thiophosphate

Cyan 47031—P,P-diethyl cyclic ethylene ester of phosphonodithioimidocarbonic acid

Dibrom—1,2 dibromo-2,2 - dichloroethyl dimethyl phosphate

SD 8447—2-chloro-1-(2,4,5-trichlorophenyl) vinyl dimethyl phosphate

Thimet—O,O-diethyl S-(ethylthio) methyl phosphorodithioate

Zytron—O-2,4-dichlorophenyl O-methyl isopropylphosphoramidothioate

Matacil—4-dimethylamino-m-tolyl methylcarbamate

DDT—1,1,1 - trichloro - 2,2 - bis = (p-chlorophenyl) ethane

usually dense, show poor growth, and have little or no spruce understory. This suggests the possibility that the site requirements of these two closely related insect species are different. Or, *N. banksianae* may be considerably more abundant throughout the area than was originally supposed, but if its habitat differs from that of *N. swainei,* the reason why it was not found in areas where *N. swainei* occurred would be explained. If this assumption is correct, *N. banksianae* might be serving as a major alternate host for some of the important parasites of *N. swainei,* notably the introduced *Exenterus amictorius* Roh. and *Pleolophus basizonus* Grav. (J. M. McLeod Can. Dep. For. Bi-Mon. Prog. Rep. 22(2):2. 1966; J. M. McLeod and R. Matineau. Bi-Mon. Res. Notes 23:27-28. 1967). Further investigations are planned.—J. M. McLeod, Forest Research Laboratory, Sillery, Quebec.

Lodgepole Terminal Weevil (*Pissodes terminalis* Hopkins) in the Alberta/Northwest Territories Region.—This pest of young pine was described by Hopping (Can. Entomol. 52: 132-134. 1920) from specimens collected in the interior of British Columbia. Other workers (Drouin, Sullivan and Smith, Can. Entomol. 95: 70-75. 1963 and Stark, R. W. and D. L. Wood, Can. Entomol. 96: 1208-1218. 1964) have studied *Pissodes terminalis* in their respective areas. This insect has been collected throughout the western half of Alberta and in the Fort Providence and Yellowknife areas of the Northwest Territories. At present the largest known infestation in this region is at Saskatchewan Crossing in Banff National Park.

Throughout this region, the incidence of weevil attack is greatest in open-grown stands of regeneration lodgepole pine (*Pinus contorta* Dougl. var. *latifolia* Engelm.) and jack pine (P. *banksiana* Lamb.). Insect damage is restricted to the terminal leader. The first superficial indication of weevilling appears about mid-summer when infested terminals take on a sorrel color; later they turn a deep red. Although Drouin, Sullivan and Smith (loc. cit.) noted that in Saskatchewan most infested terminals wilt to form a distinct or partial curl, no indication was found of this characteristic in Alberta. In fact, 90% of the terminals killed by *P. terminalis* in Alberta remain erect.

Although the death of the leader causes a loss of one year's height growth, this is not considered serious. Normally, this loss is recovered within 2 or 3 years, providing the tree is not attacked in succeeding years. Generally, the loss of the terminal leader results in one or more of the laterals in the whorl immediately below the killed portion gaining supremacy and assuming the role of the dominant leader. This may cause a crook or fork in the bole. When weevil attacks reoccur on the same tree for three or more consecutive years, the numerous terminals result in cabbage-like top and subsequently a cull tree.

In Alberta, *P. terminalis* has one generation per year. Adult weevils emerge in the spring and remain active until mid-summer. Eggs are deposited singly in feeding punctures usually in the lower half of the internode of the terminal leader. Generally one or two larvae, occasionally three, and rarely five are found in a terminal. A mean number of 2.7 larvae was found in a sample of 94 leaders. However, one larva is capable of killing the leader. After hatching, the larvae mine upward through the phloem tissues, leaving the outer bark intact. The leader dies when it is girdled by the larvae which presumably overwinter in the pith region.

Seven hymenopterous parasites obtained through mass and individual rearing. *Bracon pini* Muesebeck, *Brachistes* sp., *Eurytoma pissodis* Girault, *Eurytoma* sp. nr. *cleri, Eurytoma* sp., *Rhopalicus pulchripennis* (Crawford), *Dolichomitus terebrans nubilipennis* (Viereck). *D. terebrans nubilipennis* (Viereck) and *E. pissodis* Girault were most abundant. The highest incidence of parasitism occurred during the late stages of larval development. All parasites overwintered as larvae or pronymphs and the adults emerged late in the spring.

At the present time, population levels of *P. terminalis* are insufficient to warrant either silvicultural or chemical control measures. However, in Alberta the management of lodgepole pine is exceedingly important and foresters should be alerted to the hazard of this weevil.—R. E. Stevenson and J. J. Petty, Forestry Branch, Calgary, Alta.

Polyandry in Spruce Budworm.—It has been assumed that the female spruce budworm (*Choristoneura fumiferana* Clemens) seldom or never mates more than once since, in cage experiments, the female seldom copulates a second time (Smith, S. G., Can. Entomol. 85: 141-151. 1953), and in the field, mated females do not attract males to traps (Greenbank, D. O., Mem. Entomol. Soc. Can. 31: 87-99. 1963). During a recent preliminary study on spruce budworm reproduction, this assumption was tested.

Female moths were collected from epidemic populations at Kingsley and Rocky Brook, New Brunswick. The mean age of the population was arbitrarily based on the appearance of the first adults in the field. The number of times a female had mated successfully was determined by removing the bursa copulatrix, carefully dissecting it, and counting the spermatophores. In some of the older females it was noticed that the main body, or corpus of the spermatophore, had broken down. However the "stalk", or collum of the spermatophore persisted in the neck of the bursa copulatrix and it was possible to estimate the number of spermatophores by counting the remaining colla.

The proportion of females with two or more spermatophores each increases as the adult population ages (Table 1). In fact, two or more spermatophores were obtained from 51.6% of the mated females.

TABLE 1

Mating histories of female spruce budworm moths, based on spermatophore counts, from two epidemic populations

Locality	Mean age of adult population in days	No. of females with indicated No. of spermatophores						Total females examined
		0	1	2	3	4	5	
Kingsley	3–4	1	9	2	0	0	0	12
	7–8	4	30	11	0	0	0	45
	10–11	1	21	12	6	1	0	41
Rocky Brook	10–11	1	5	7	6	0	0	19
	11–12	0	6	11	1	0	0	18
	12–13	0	5	7	2	0	1	15
	13–14	1	14	20	8	1	0	44
Totals		8	90	70	23	2	1	194

The increase in the proportion of females with more than one spermatophore suggests that each spermatophore is the result of a separate mating and that only one spermatophore is transferred each time. A similar condition was observed in the oriental fruit moth, in which a single spermatophore is known to be transferred at each mating (Dustan, G. G., Can. Entomol. 96: 1087-1093. 1964).

Although the female spruce budworm moth fails to attract males to traps after she has mated (Greenbank, loc. cit.), there is no evidence to suggest that she ceases to be receptive to the male. C. G. Butler (Biol. Rev. 42:42-87. 1967) suggests that many female insects stop releasing, and probably producing, the sex attractant either during or soon after mating, the olfactory sex attractant serving only to bring the two sexes close enough for visual and tactile attractants to come into play. Since it has been demonstrated that male

spruce budworm moths in captivity are capable of mating several times (Campbell, Can. Entomol. 93: 1160-1162. 1961), it seems likely that in a normal population with a 1:1 sex ratio, a proportion of the females mate more than once.

Further investigation of spruce budworm reproduction is planned, especially in relation to different population levels. —I. Outram, Forest Research Laboratory, Fredericton, N.B.

Newly Hatched Western Hemlock Looper Larvae Successfully Reared on Forced Foliage of American Larch —Newly hatched larvae of the western hemlock looper (*Lambdina fiscellaria ludubrosa* Hulst) have been successfully reared in the laboratory in the winter months on new foliage of American Larch (*Larix laricinia* (Du Roi) K. Kock). The larvae used were obtained from eggs produced by adults reared in the laboratory. The adults originated from eggs supplied by the U.S.D.A. Laboratory, Portland, Oregon. To simulate dormancy, the eggs were stored for 12 weeks in sealed petri dishes at 34°F. The eggs were than put on moist filter paper in petri dishes and maintained at 70°F. As the larvae hatched, they were transferred to American larch foliage.

The foliage was obtained by collecting small dormant American larch branches from natural stands. Dormancy was broken by holding the branches at 70°F and 70-80% relative humidity, with the cut ends in water. Sufficient foliage developed in approximately 10 days to establish the larvae.

The young larvae readily established themselves and molted to the second instar in 6-7 days, at which time eastern hemlock (*Tsuga canadensis* L. Carr) foliage was added. As the American larch foliage was consumed, the larvae migrated to the hemlock foliage which was used for the remainder of the rearing period. As a check, some newly hatched larvae were put on eastern hemlock foliage, and the results are given in Table 1.

TABLE 1

Survival of western hemlock looper when newly hatched larvae are reared on American larch and eastern hemlock

American larch			Eastern Hemlock		
Larval Instar	No. of Larvae	% Survival from first Instar	Larval Instar	No. of Larvae	% Survival from first Instar
1st	285		1st	793	
2nd	277	97.19	2nd	290	36.54
3rd	277	97.19	3rd	279	35.27
4th	267	93.69	4th	218	27.56
5th	267	93.69	5th	218	27.56
pupae	248	87.01	pupae	218	27.56
adults	242	84.91	adults	198	25.03
male	125		male	102	
female	117		female	96	

In a second trial, 93.84% of the larvae started on American larch foliage survived beyond the first instar, compared to 24.85% started on eastern hemlock foliage.

The critical period in the laboratory rearing of western hemlock looper is during the first few days after eclosion, when a tender young foliage is required. American larch appears to meet all the requirements: it can be readily obtained from natural stands and dormancy can be broken under controlled conditions.—A. S. Danard, Chemical Control Research Institute, Ottawa, Ontario.

***Thera juniperata* L., an Introduced Insect Pest of *Juniperus* in Ontario.**—This geometrid, *Thera juniperata* L. (=*T. procteri* Brower), is known on all species of juniper in Europe. The first reference to its occurrence on the North American continent is made by Brower (Bull. Brooklyn Entomol. Soc. 35:138-140. 1940) who then considered it, "a rare species in the eastern States". According to Ferguson (The Lepidoptera of Nova Scotia, N.S. Inst. Sci. Proc. 23:161-375. 1954), the pest was introduced into eastern Canada on imported nursery stock and was first collected there near Halifax, N.S., in 1945. Records of the Forest Insect and Disease Survey reveal its occurrence in Ontario 1 year earlier, in 1944, near Hamilton. In ensuing years, the insect was collected at scattered points in southern Ontario. In 1953, some damage to ornamentals was reported in the Ottawa area, (C. Graham McNay. Entomol. Soc. Ont. 84:142. 1953).

In the Sault Ste Marie area, *T. juniperata,* first collected on planted nursery stock in 1958, has increased in number, reaching outbreak proportions in 1966. This increase in prominence prompted further study on the insect. Special surveys, which were carried out by the Forest Insect and Disease Survey in 1965 and 1966, revealed the insect to be present in the Mactier area of the Parry Sound District and in small numbers around Pembroke and Sudbury. It could not be found to the north of Sault Ste. Marie, nor in northwestern Ontario. Larvae were collected from the three native species of *Juniperus, common* juniper (*Juniperus communis* (L.)), the variety *J. communis depressa,* and red cedar (*J. virginiana* var. *crebra* Fern & Grisc.), as well as from several horticultural varieties.

The female moth lays bright yellow eggs, singly or in loose clusters of 2-6, on the upper or lower surface of the foliage during September and early October. The eggs overwinter on the foliage and hatch in June. In the laboratory there are five instars and the larvae change from orange-yellow in the first instar to a rich green when fully grown. The mature larva is marked by two creamy dorsal stripes bordered by a narrow yellow-green sub-dorsal line. A conspicuous red spiracular line, underscored by a yellow-green sub-spiracular stripe, develops in the 4th or 5th instar. Pupation takes place from mid-August to early October on the foliage or on the ground surface beneath the host. The adults emerge shortly thereafter.

In small numbers, the larvae feed on the edges of the foliage, resulting in slight discloration, but in outbreak numbers, the loopers cause virtually complete defoliation and a wilting and loss of branchlets. Conspicuous browning of damaged foliage is a typical symptom of severe attack.

The following parasites were reared from larval collections: two tachinids, *Phrynolydella eufitchiae* (Tns.) and *Compsilura concinnata* Mg.; and four ichneumonids: *Itoplectis conquisitor* (Say), *I. quadricingulatus* (Prov.), *Amblyteles* sp., *Stenobarichneumon agitator* Hein. and one ichneumonid hyperparasite, *Gelis tenellus* (Say). The incidence of parasitism has been low, seldom exceeding 5%, with an overall incidence among almost 2000 larvae reared since 1962 of less than 1%. —F. A. Bricault, Forest Research Laboratory, Sault Ste. Marie, Ont.

Sex Attraction in the Douglas-Fir Cone Moth *Barbara colfaxiana* (Kft.)—In the spring of 1967 an experiment was conducted at Keremeos, B. C., to obtain information on sex attraction in the Douglas-fir cone moth, (*Barbara colfaxiana* (Kft.)). Twenty-four traps, each consisting of a 1x1-foot piece of plywood coated with a thin layer of Tanglefoot, were set out in an area known to be infested by the cone moth. At the center of each board a small screen cage, used for housing moths, was inserted in a 2-inch hole in the plywood (Frank M. Davis and C. A. Henderson, J. Econ. Entomo. 60: 279-280. 1967). Traps were supported vertically on 2x2-inch posts 4 to 5 feet above ground level.

On April 25 trapping commenced. Moths used in the experiment were reared from Douglas-fir cones collected the previous summer at Keremeos. Date for starting the test was determined from information on moth acitvity in relation to host flower development. Unmated females, males, and pairs were placed in the screen cages (Table 1). Traps were checked at 2-hour intervals, from 9 AM to 9 PM, during the period April 25 to 28 and May 9 to 11. The study was concluded on May 29.

Few moths were caught during the periods of regular observation as the weather was cool, showery and windy. The majority (51) were taken from April 28 to May 9 when traps were not checked until the end of the period. Traps were functional during the period April 25 to May 29, with the exception of intervals during the unattended periods when some test moths died. Because the moths are crepuscular, flight was observed only in the late afternoon and evening. The earliest recorded daily catch was at 5 PM.

The catch of male moths is shown in Table 1. No females were trapped. Although it was not possible to make continuous observations throughout the period of moth activity, the data show that male *B. colfaxiana* were strongly attracted to virgin female moths. Of 66 moths trapped, 63 (95%) were attracted to females, 3 (5%) to pairs and none to males. Eggs were laid in two cages that contained paired moths.

TABLE 1

Barbara colfaxiana male moths caught in moth-baited traps

No. traps	No. moths			Moths Trapped No. per trap		
	male	female	Total	Max	Min	Avg
5	0	1	33	15	1	6.7
4	0	2	23	13	0	5.7
1	0	6	7	7	7	7.0
4	1	1	2	2	0	0.5
4	2	2	1	1	0	0.2
4	2	0	0	0	0	0.0
2	0	0	0	0	0	0.0

These tests indicate that sex attraction plays an important role in the biology of *B. colfaxiana,* and that further study may provide a basis for sampling, behavior studies and control of this insect.—A. F. Hedlin and D. S. Ruth, Forest Research Laboratory, Victoria, B.C.

FOREST PRODUCTS

Extractives of an Ancient Pine.—During construction of a highway in North Vancouver, B.C., a stand of pine trees was discovered under the ground which had obviously been killed by a mud slide. Although one of these pines could not be positively identified as to species (Dr. R. W. Kennedy of this laboratory) its age was 32,200 ±3,300 years by radiocarbon dating performed by the Geological Survey of Canada. Petrification of the wood had started, and the bark was compressed and cracked. The fibrous character of the wood, however, was still evident and it was decided to examine its extractives because such aged wood has rarely been examined.

The wood was ground to a meal in a Wiley mill and extracted. Preliminary extractions were unsuccessful because of the alkalinity of the matrix, so that finally a mixture of acetone (2:1.) and hydrochloric acid (5 ml) was used. The extractive yield from 313 grams of wood meal was 12 grams, some of which was soluble silica. The crude extractives were fractionated into acids (soluble in dilute sodium bicarbonate), phenols (soluble in dilute sodium hydroxide), and neutrals (the remainder). Each of these fractions was examined chromatographically to identify its components, using known compounds for comparison.

The phenols comprised 37% of the extractives. Paper chromatography (method of Lindstedt and Misiorny, Acta Chem. Scand. S: 121-129. 1951) and thin-layer chromatography (method of Sato and von Rudloff, Can. J. Chem. 41:2165-2174. 1963) showed the absence of all the common pine-heartwood phenols except pinocembrin, which was itself present in only minor amounts. A large part of the phenol fraction was a siliceous complex which streaked with either chromatographic system.

The acid fraction comprised only 6.8% of the extractives. The only compound identified by thin-layer and gas-liquid chromatography were ferulic and vanillic acids, presumably arising from lignin degradation. There were none of the fatty or resin acids that one would expect to find in a conifer.

The large neutral fraction (56.2% of the extractives) contained 1,4a-dimethyl-7-isopropyl-1,2,3,4,4a,9,10,10a-octahydrophenanthrene, previously isolated from a forest soil (Swan, Forest Prod. J. 15:272. 1965) and identified by comparative thin-layer and gas-liquid chromatography. In addition, the fraction contained β-sitosterol, similarly identified, and a complex mixture of many other Liebermann-Burchard positive materials, i.e., steroids. Fats were absent.

It was concluded that the original chemical components of the wood were subjected to alkaline anaerobic conditions leading to reductive decarboxylation reactions; such conditions were previously found sufficient to produce the above hydrocarbon from the resin acids. Thus, there were none of the expected acids, fats, or reactive phenols present in the extract. The only compounds able to withstand the long subterranean immersion were the non-polar, relatively unreactive ones such as β-sitosterol.—Eric P. Swan, Forest Products Laboratory, Vancouver, B.C.

PATHOLOGY

Corky Root Disease of Douglas-fir Seedlings.—An increase in a disease of Douglas-fir seedlings, known locally as "corky root", has been observed in several British Columbia nurseries during the past 5 years. The symptoms comprise a swollen appearance of the tap root, paucity or complete absence of lateral roots, and severe stunting of the shoot. The disease occurs in patches which are increasing in number and size.

The nurseries involved are located on widely different soil types, but they have been either cropped with Douglas-fir for many years, or have previously supported a Douglas-fir forest.

Information gathered recently from soil fumigation trials, intensive nematode sampling, and modified fungus culturing techniques has implicated the nematode, *Xiphenema bakeri* T. D. Williams, and the fungus *Cylindrocarpon radicicola* Wollenweber. There is no evidence that physical and nutritional properties of the soil are having an effect.

Soil samples from unfumigated patches of stunted seedlings yielded an average of 135 *bakeri* per pound of oven-dry soil. In plots fumigated with the nematocide D-D, no *X. bakeri* survived and seedlings were healthy. *C. radicicola* has been isolated with frequencies greater than 40% from diseased seedlings, and less than 10% from healthy seedlings in all affected nurseries. Stained sections of roots showed heavy masses of fungal cells just below the periderm. The infection score of sections from infected roots, based on density of fungus growth in the root, was almost four times that of healthy root sections.

One difficulty that delayed recognition of the importance of the fungus was its apparent sensitivity to standard methods of surface sterilization. Use of an ultrasonic cleaner with an antiseptic solution "Cavi-cide" (Mettler Electronics, Pasadena, Calif.) has greatly increased recovery of the fungus, especially if the vibrating action is "damped down" by placing the root sections in small nylon mesh baskets.

C. radicicola may be capable of inciting the disease alone or through some toxin (Evans *et al.,* Plant and Soil 26:253-260. 1967), but its close association with *X. bakeri* suggests that an interaction of both organisms may be occurring. It is hoped that inoculations with the nematode, fungus, and fungitoxin will clarify the role of each agent.

I am indebted to W. R. Orchard, Plant Pathologist, Research Station, Department of Agriculture, Saanichton, B.C., for identification and counts of nematodes.—W. J. Bloomberg, Forest Research Laboratory, Victoria, B.C.

Rot of Birch Caused by *Coprinus micaceus*.—*Coprinus micaceus* (Bull. ex Fr.) Fr. was the main cause of decay in birch and poplar fence posts treated with a salt type of preservative in a test plot at the Petawawa Forest Experiment Station, Chalk River, Ont. (Shields, Bi-Mon. Res. Notes 23:12-13, 1967). The tolerance of this fungus and *Fusarium oxysporum* Schlecht. em. Snyder & Hansen to components of the preservative have been discussed by Madhosingh (Forest Prod. J. 11:20-22, 1961; Can. J. Microbiol. 7:554-567, 1961).

Decay of birch wood by *C. micaceus* produces a pale yellowish brown rot under laboratory conditions. However, the presence of the associated fungus, *F. oxysporum*, in the treated posts results in a light grayish-red discoloration, mainly in the sapwood areas. Initially, the infected wood appears to be firm and exhibits a brash break when force is applied to the posts. The rot has been described as a brown rot type on the basis of the color and brashness of the wood. However, the more advanced rot appears somewhat fibrous in nature.

To clarify the type of rot reported to be caused by *C. micaceus*, a chemical analysis was made on wood blocks decayed to an average weight loss of 24%. Specimens for analysis were obtained from white birch sapwood blocks decayed for 3 months in laboratory tests (Shields, *loc. cit.*). The results of this analysis (Table 1) are compared with data

TABLE 1

Chemical analyses of white birch, *Betula papyrifera*

—	Sound wood	Tappi reference	Decayed wood	Tappi reference
Moisture	5.58		5.80	
Hot water solubility	2.71	T1m-45	3.30	T1m-59
1% NaOH solubility	20.1	T4m-44	24.8	T4m-59
Alcohol-benzene extraction	4.48	T6m-50	4.00	T6m-59
Lignin	18.48	T13m-45	28.30	T13-m-45
Holocellulose	79.3	(i)	73.1	(i)
Alpha-cellulose	40.97	(i)	48.40	T203 os-61
Holocellulose/lignin	4.29		2.58	

(i) Procedure described by L. E. Wise *et al.* (Paper Trade J. 122(2) Jan. 1946).

for sound white birch sapwood taken from Clermont and Schwartz (Pulp and Paper Mag. of Can. 52:103-105, Dec. 1951). The ratio of holocellulose to lignin in the decayed wood falls within the range of 1.83 to 5.07 given for hardwoods with an intermediate type of rot by Kawase (Res. Bull. Coll. Exp. For. Hokkaido Univ. 19(2). 1958), whereas in typical brown rots the ratio is less than one. The higher lignin content in wood infected by *C. micaceus* suggests that the rot caused by this fungus is close to a brown type. However, on the basis of the chemical analysis of the wood and the physical characteristics of the more advanced decay, the rot cannot be placed in this group and should be classified as an intermediate rot. In addition, spot tests on cultures of *C. micaceus* with gum guaiac dissolved in alcohol resulted in a positive reaction for extracellular phenol oxidases which is a characteristic of many fungi causing the intermediate type of decay.—J. K. Shields and L. P. Clermont, Forest Products Laboratory, Ottawa, Ont.

Role of *Trichoderma viride* in Reducing Storage Decay of Birch Logs.—Decay of land-stored hardwood logs causes considerable loss to wood industries in Canada. Control of decay by *Trichoderma viride* Pers. ex Fr. was noted in softwood logs by Lindgren and Harvey (Proc. For. Prod. Res. Soc. 5: 250-256. 1952) while Kobliska (Rec. Ann. Conv. Brit. Wood Preserv. Assoc. 165-175. 1961) reported that deterioration of hardwood logs was reduced by living *T. viride*. Recent field trials (Shields and Atwell, For. Prod. J. 13(7): 262-265. 1963) indicated that some control of storage decay occurred when logs were colonized by *T. viride* (strain D47). To substantiate these results, the following experiment was designed.

Sound, 4-foot-long logs of white birch (*Betula papyrifera* Marsh.) were selected from newly cut trees. These were divided into three groups of three logs each and the freshly cut ends of all but the controls were sprayed with a spore and mycelial suspension in water as follows:

Group 1—Inoculated with *T. viride* (D47) immediately after fresh cut ends were exposed on the logs and 2 weeks later by *P. adustus* Willd. ex Fr., (S164).

Group 2—Freshly cut ends were inoculated with *P. adustus* only at the start of storage.

Group 3—Ends of the controls were sprayed with sterile water at the start of storage.

The logs were stored in one pile, exposed to a natural environment, from early May to late November and were then examined for the presence of decay. Isolations of fungi were attempted every 15 to 20 cm on both sides along the length of 7-cm-thick flitches sawn from the center of each log. Small wood chips were aseptically transferred to malt agar medium from the wood 2 to 4 cm inside the bark and from the older inner portions of each flitch. The prevalence of the fungi used in the inoculation treatments and the number of non-inoculated microorganisms isolated from the logs are given in Table 1.

TABLE 1

Numbers of isolates of microorganisms from birch logs after 7 months' outside storage

Fungi	Inoculation treatment group*		
	1	2	3
T. viride (D47)	241	2	1
P. adustus (S164)	1	212	136
Other decay fungi (not inoculated)	1	0	109
Fungi inperfecti (not inoculated)	1	7	50
Bacteria	33	2	3
No. microorganisms isolated	25		14
Total isolations attempted	302	223	313
Numbers of species of fungi	4	5	14

*See text for explanation of treatment groups.

The presence of *T. viride* (D47) in the logs almost completely prevented colonization by *P. adustus* for the duration of the test despite a later attempt to inoculate the logs with the wood rotting fungus. Logs inoculated with only *P. adustus* yielded mostly this fungus, while the controls had large numbers of this and other wood rotting fungi. Fewer species of wood inhabiting fungi colonized logs artificially inoculated with either *T. viride* or *P. adustus*. Logs inoculated with either *T. viride* or *P. adustus* had few or no discolored areas because of the lack of competing microorganisms, whereas the control logs had dark streaks and bleached zones resulting from the activity and interaction of several species of fungi.

TABLE 2

Basic specific gravities obtained in white birch logs after 7 months' storage

Inoculation	Basic sp gr (volume green, weight oven-dried)		Reduction in basic sp gr (%)
	Range	Average*	
T. viride (primary)	0.534–0.538	0.536	
P. adustus (secondary)			
P. adustus (alone)	0.448–0.461	0.456	15
Control (non-inoculated)	0.485–0.502	0.491	8

*Average results were based on 4 replicates obtained from a log in each treatment group.

The basic specific gravities of samples taken from the logs are listed in Table 2. The sample blocks, approximately 7 × 5 × 3 cm, were obtained from the central areas some 30 cm from the end zones of one representative log in each group. The basic specific gravities of wood samples obtained from logs inoculated with *P. adustus* alone and from the controls at the end of storage were reduced by averages of 15 and 8%, respectively, when compared with values obtained for those logs inoculated initially with *T. viride*.

The successful control of storage decay by growing *T. viride* in recently felled white birch logs is contingent upon the ability of the mold to rapidly colonize the substrate before wood rotting fungi can become established. The use of antagonistic fungi to reduce discolorations and decay in land-stored logs would appear to be an alternate method of controlling deterioration where other means of protection are not possible.—J. K. Shields, Forest Products Laboratory, Ottawa, Ont.

Spore Discharge of *Scleroderris lagerbergii* Gremmen.—*Scleroderris lagerbergii* Gremmen, a Discomycete known to be associated with dying of branches and stems of various species of conifers, was first collected in the Province of Quebec by the author in 1964 on black spruce (*Picea mariana* (Mill.) BSP.) and white spruce (*P. glauca* (Moench) Voss). Subsequently, the fungus was also found on jack pine (*Pinus banksiana* Lamb.), lodgepole pine (*P. contorta* Dougl. var. *latifolia* Engelm.), red pine (*P. resinosa* Ait.), Scots pine (*P. silvestris* L.), and white pine (*P. strobus* L.). Examination of the specimens collected in Quebec revealed that the fruiting bodies of *S. lagerbergii* on pine matured earlier than those on spruce. To obtain additional evidence, the discharge of conidia and primary ascospores of *S. lagerbergii* was investigated on black spruce and jack pine. Two aspects, the duration of spore discharge and the effect of relative humidity, were studied.

The duration of spore discharge on black spruce was determined at Lake Jacques Cartier (alt 2,700 ft) in 1966 and on jack pine at Valcartier (alt 600 ft) in 1967. The beginning of the discharge period on black spruce at Lake Jacques Cartier and on jack pine at Lake Choquette (alt 1,200 ft) in the Laurentide Park was also established in 1967. Jacques Cartier and Choquette Lakes are situated 50 and 90 miles north of Valcartier, respectively. Sixteen spore traps, eight for each spore form, were set up at each locality. Each spore trap consisted of a microscope slide coated with vaseline and suspended 0.5 cm beneath a branch bearing fruiting bodies of *S. lagerbergii*. A 15×10-cm metal plate was placed over each slide. The slides were collected three times per week in the Laurentide Park and daily at Valcartier. The deposited spores were counted under a compound microscope by moving the 40× objective across the slide four times at predetermined points.

The effect of relative humidity on spore discharge was investigated in the laboratory. One hundred per cent relative humidity was obtained with distilled water. Ninety-nine per cent humidity was maintained with saturated KH_2PO_4 and K_2SO_4 solutions at 15C and 98% humidity with KH_2PO_4 at 10C and K_2SO_4 at 20C. Glass preparation dishes (100 × 50 mm) sealed with rubber bands and wax were used as containers.

Discharge of both spore forms of *S. lagerbergii* on spruce began in 1966 in the second week of July and lasted until the second week of October. The maximum discharge occurred in the first week of August. In 1967, discharge of both types of spores began in the first week of July.

Discharge of conidia of *S. lagerbergii* on jack pine began at Valcartier in the third week of May and that of the ascospores in the first week of June. The maximum discharge of both types of spores occurred in the third week of June. No spores were caught after the first week of August. Discharge of conidia and ascospores of *S. lagerbergii* on jack pine in the Laurentide Park began in the first and second week of June, respectively.

Conidia and ascospores from fruiting bodies of *S. lagerbergii* collected on black spruce and jack pine were discharged only at 100% relative humidity.

Differences in climate between Valcartier and Lac Choquette and yearly changes in weather at Lac Jacques Cartier caused variations of up to 2 weeks in the beginning of spore discharge on either host. Spore discharge on black spruce at Lac Jacques Cartier, however, began 5 weeks later than on jack pine at Lac Choquette. Although a delay in spore maturation could be expected at Lac Jacques Cartier because of higher altitude, the 5-week lag in the beginning of spore discharge on black spruce cannot be attributed entirely to climatic factors. Spore maturation on jack pine at Valcartier and Lac Choquette coincides with the beginning of the growing season. This is not the case with *S. lagerbergii* on black spruce at Lac Jacques Cartier; the growing season at this locality begins only 1 to 2 weeks later than at Lac Choquette. Moreover, mature specimens of *S. lagerbergii* were collected on jack pine in the first week of June 1966 at an altitude of 1,800 ft, 30 miles west of Lac Jacques Cartier. The beginning of spore discharge at this locality in the spring of 1967 could not be determined. Although the investigation established the duration of spore discharge and the effect of relative humidity, additional research is required to clarify the observed differences in spore maturation of *S. lagerbergii*.—E. Smerlis, Forest Research Laboratory, Sillery, Que.

Infection of Scots, Monterey and Ponderosa Pines by Western Hemlock Dwarf Mistletoe.—Monterey pine (*Pinus radiata* D. Don.) and ponderosa pine (*P. ponderosa* Laws) are commonly infected with ponderosa pine dwarf mistletoe (*Arceuthobium campylopodum* Engelm. f. *campylopodum* (Engelm.) Gill) in the western United States. Scots pine (*P. sylvestris* L.) was successfully inoculated with ponderosa pine mistletoe (Weir. Bot. Gaz. 66: 1-31. 1918), and was recently found infected with larch dwarf mistletoe (*A. c.* f. *laricis* (Piper) Gill) in a plantation (Graham and Leaphart. J. Forest. 59:375-376. 1961). Our studies demonstrate that the three pine species are also susceptible to hemlock dwarf mistletoe (*A. c.* f. *tsugensis* (Rosend.) Gill) (Table 1).

TABLE 1

Appearance of swellings, shoots, and flowers for hemlock dwarf mistletoe infections on Scots, Monterey, and ponderosa pines

Host	Location of experiments[1]	Date of inoculation	Date swellings observed	Date shoots observed	Year and type of flower[2]
A. Seed from dwarf mistletoe infecting western hemlock (Caycuse, Vancouver Island)					
P. sylvestris	G	May 21/65	Mar. 4/66	June 16/66	1967–M
P. sylvestris	G	May 21/65	June 16/66	Aug. 18/66	—
P. radiata	G	Apr. 28/66	June 21/67	June 21/67	—
P. ponderosa	G	Apr. 23/65	June 16/66	June 19/67	—
P. ponderosa	P	Oct. 18/63	May 7/65	June 14/66	1967–M
B. Seed from dwarf mistletoe infecting lodgepole (shore) pine (Horne Lake, Vancouver Island)					
P. ponderosa	P	Oct. 27/64	June 15/66	Oct. 25/66	1967–M
P. ponderosa	P	Oct. 27/64	June 15/66	June 15/66	1966–F
P. ponderosa	P	Oct. 27/64	Oct. 25/66	Oct. 25/66	1967–M
P. ponderosa	P	Octl 27/64	June 15/66	June 15/66	1967–F

[1]G = Greenhouse; P = Plantation.
[2]M = Male; F = Female.

Inoculations were performed in a greenhouse with mistletoe seed collected in the spring after radicle emergence, and in a plantation using seed collected in the fall before radicle emergence. Those used in the spring were collected from

coastal western hemlock (*Tsuga heterophylla* (Raf.) Sarg.) branches and planted, using lanolin paste as an adhesive. Seeds used in the fall were from mature mistletoe fruit from coastal western hemlock and coastal lodgepole (shore) pine (*Pinus conforta* Dougl.). They were stored for 2-4 weeks at 5C and moistened before planting to effect their adherence to the branches. Dwarf mistletoe from coastal western hemlock and coastal lodgepole pine are considered indistinquishable by F. G. Hawksworth (personal communication. 1966).

Dwarf mistletoe aerial shoot growth and swelling enlargement indicated that all infections were thriving at the time of examination in June 1967. Swellings ranged in length from 22-114 mm, and on 6 of the 9 infections, male or female flowers have been produced. Brooms were initiated in 3 infections on ponderosa pine by the stimulation of dormant needle fascicle buds adjacent to the points of infection. In one case, this stimulation produced a new branch 73 mm in length. A similar reaction occurs in ponderosa pine infected by *A. vaginatum* (Willd.) Presl. f. *cryptopodum* (Engelm.) Gill (Hawksworth. U.S.D.A. Tech. Bull. 1246. 1961).

The range of hemlock dwarf mistletoe does not coincide with the natural range of the three pine species. However, plantations of them are occasionally established in coastal areas of British Columbia, and care should be taken not to locate them near hemlock or lodgepole pine infected with dwarf mistletoe.—R. B. Smith and H. M. Craig, Forest Research Laboratory, Victoria, B.C.

SOILS

Soil Moisture Retention May Be Adversely Affected By Breaking A Hard Pan.—There are approximately 2,600 acres of glacio-fluvial outwash plain of the Medway soil series in Yarmouth and Shelburne counties in southwestern Nova Scotia. Supporting a low-growing ericaceous cover dominated by *Corema conradii* Torr. (crowberry), *Arctostaphylos uva-ursi* (L.) Spreng. (bearberry) and *Gaultheria procumbens* L. (wintergreen), and being flat and boulder-free, they are superficially attractive planting sites. The soil, however, is extremely coarse-textured, has a very low moisture retention capability and is characterized by a massive 'ortstein' pan about 10 inches below the surface. Virtually impenetrable, the pan restricts root development to the uppermost strata.

Plantations on this site type have not been successful. Survival of red pine (*Pinus resinosa* Ait.) has been good but growth has been slow, white spruces (*Picea spp.*) have failed completely.

In May 1967, a provenance seeding trial was set out on the outwash plain at Indian Fields in Shelburne County by H. G. MacGillivray, Tree Biology Section, Department of Forestry and Rural Development, Fredericton. Weeds were controlled by hand cultivation of the seed spots and by cultivation along the rows of spots with a rotary cultivator. In one line of spots in each replicate of the trial, the pan was broken under the seed spots by a small explosive charge. As well as breaking the pan, the explosion destroyed all vegetation in and around the seed spots and no recovery was observed during the following summer. Using two adjacent replicates, advantage was taken of these treatments to study the effects of breaking the pan on soil moisture retention. Comparison with the control and tilling treatments was complicated by the effects of evapo-transpiration from the vegetation growing on them and so, in mid-July, 12 plots, each 3 feet square, were cleared of vegetation by clipping to afford a simple comparison with the explosion treatment.

Periodic sampling down to the upper surface of the pan, at 8 to 10 inches depth, was carried out and the moisture content determined gravimetrically. The results for one season suggested that retention of moisture in the rooting zone was reduced where the pan had been broken, presumably because of enhanced vertical drainage.

TABLE 1

Soil moisture content, percentage by weight

Date of sampling	Moisture Content % (means of 12 tests)				Rainfall since last reading
	Undisturbed	Cultivated not clipped	Clipped not cultivated	Pan broken after cultivation	
24/6	26.5	23.1	—	24.8	1.65 (6 days)
3/7	22.1	22.0	—	21.6	nil
10/7	23.7	24.3	—	23.4	1.31
24/7	31.3	25.6	32.4	22.4*	2.80
1/8	24.2	22.8	25.0	18.4*	0.82
8/8	19.0	18.0	19.2	18.2	1.55
15/8	21.9	22.7	23.4	20.4	2.42
22/8	18.2	20.5	20.1	18.2	2.27
28/8	19.2	20.3	21.0	19.3	0.12
9/9	22.8	20.5	20.2	21.8	1.74
18/9	24.0	24.7	19.8	17.4	1.03
25/9	27.5	24.4	25.5	23.4**	1.61
29/9	24.2	27.8	28.0	22.5**	nil
21/10	24.9	25.9	24.9	21.3**	9.49

Significant differences between clipped and pan broken treatments at the 0.05 and 0.01 probability levels indicated by * and ** respectively.

In 10 of the 11 cases where comparisons between "clipped" and "pan broken" treatments were possible, the clipped plots had a higher moisture content. Five of these differences were found to be statistically different by a chi-square test. In the remaining five and in the one case where the clipped plot had the lower moisture content, samples had been taken within a few hours of a rain storm and differences had not had time to develop (Table 1).

In a very wet summer, such as that of 1967, it may have been advantageous to improve soil drainage but in a drier, more normal year it would undoubtedly be harmful in soils where the strata below the pan are deep, coarse-textured and free-draining.—R. M. Strang, Forest Research Laboratory, Fredericton, N.B.

(*Continued from back cover*)

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FBI - MONTHLY

RESEARCH NOTES

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Vol. 24 - No. 2, MARCH-APRIL 1968

CANADA
DEPARTMENT OF FORESTRY
AND RURAL DEVELOPMENT

Published under the authority of
The Honourable Maurice Sauvé, P.C., M.P.
Minister of Forestry and Rural Development
Ottawa

BI-MONTHLY

RESEARCH NOTES

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

BOTANY

Relationship Between Embryo Development and Germination Behavior in Black Spruce.—Forest geneticists are increasingly concerned with the determination of genetic differences in juvenile populations of tree species in controlled and semi-controlled environments. The principal object is to reduce to a minimum differences in growth behavior caused by environmental variation in the test area, so that purely genetic differences are more easily determined.

In recent years, however, it has been shown that differences in embryo development, usually a non-genetic characteristic in natural populations, can have a striking effect on germination behavior, and thus on the subsequent growth of juvenile populations. Therefore, if two provenances are being assessed for genetic differences in a controlled environment, it is necessary to determine the degree to which the provenances differ in embryo development.

For the reasons stated above, and as a preliminary step in the study of geographic variation in black spruce (*Picea mariana* (Mill.) BSP) in Quebec, four black spruce seed lots, collected on four different dates (Aug. 12, 19, 25 and Sept. 2) in the same year, and in the same general area, were x-rayed to determine embryo development. The same seed was subsequently incubated for 14 days, and germinated at 25 C. Five replications of 100 seeds of each seed lot were used in this study.

Figure 1 gives the results of the x-ray assessment and the germination test. The index of seed maturity, assessed from radiographs, is the per cent of fully developed embryos, with the embryo completely filling the embryo cavity, in each seed lot. The peak value, obtained by germinating the seed is a general index of the rate of germination and is calculated in the manner proposed by Czabator (Forest Sci. 8:386-396, 1962). It will be seen that there is a close relationship between embryo development and germination behavior in black spruce seed.

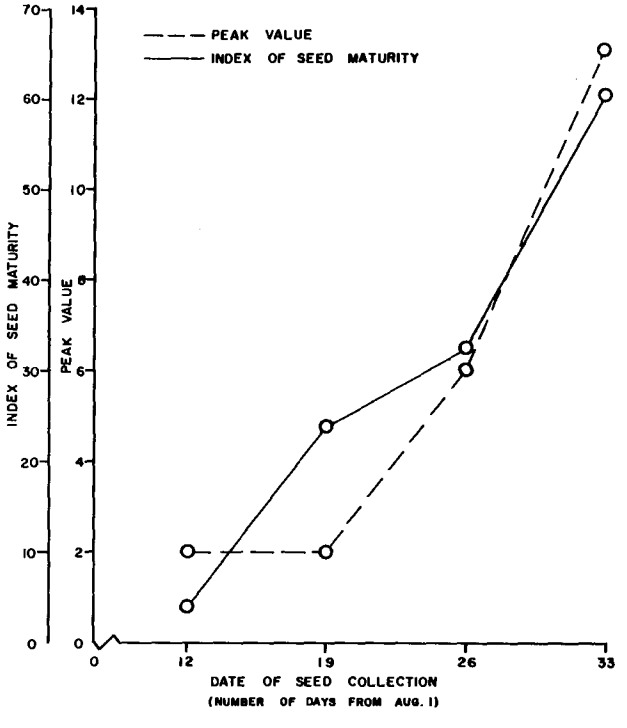

FIGURE 1. Relationship between germination behavior and embryo development. The index of seed maturity is the per cent of fully developed embryos in each of the four seed lots. The peak value is a measure of the rate of germination.

Black spruce seed is relatively small and consequently somewhat difficult to x-ray. Nevertheless, the radiograph of this seed may be read with ease under a binocular microscope. Figure 2 illustrates, to some extent, the quality of the radiograph of black spruce seed and the seed of other tree species that are important in Quebec. It must be noted, however, that there is a considerable reduction in the sharpness of the image in a print made from a radiograph.

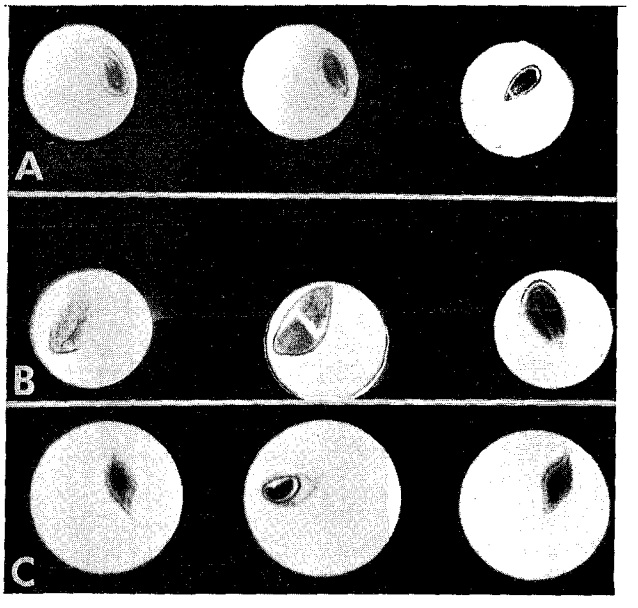

FIGURE 2. Portion of radiograph of the seed of black spruce (A), jack pine, (B), and yellow birch (C). Note the poorly developed embryos, and empty embryo cavity (extreme right) in the black spruce sample. Note also the empty seed (left) and damaged seed (center) of the yellow birch sample.

The x-ray unit used in this study irradiates a large dose of x-rays at a relatively low voltage. It incorporates a double focus 2.0/0.3 mm 1F-0410 beryllium-window tube, so that it is possible not only to examine macro-material but, by changing tube focus, to examine micro-material as well. Seed may also be examined fluoroscopically. Output: Large focus 40 KVP, 10 mA, 30 seconds; small focus 40 KVP, 3 mA, 30 minutes.

This work will continue for black spruce and other tree species that are now being subjected to genecological investigation.—L. Roche, Forest Research Laboratory, Quebec.

ENTOMOLOGY

Natural Control of Larch Sawfly at Carleton, Bonaventure County, P.Q.—Larch sawfly (*Pristiphora erichsonii* Hartig) populations in the Province of Quebec have declined in recent years and were generally quite low in 1966 and 1967. However, a locally moderate infestation was located by the Forest Insect and Disease Survey near Carleton, Bonaventure County, P.Q., in 1966. The forest stand in the collection area consisted mostly of dense 40 to 50-year-old tamarack on dry humus soil covered with dead branches. Of the cocoons collected on 12 June 1967, 200 were dissected. Because the ground was difficult to search, it took a well-trained technician 2 days to find these cocoons.

At the date of collection, a portion of the sawflies had reached the pupal stage and were ready to emerge (Table I). At this time parasitism was 14.5%; total mortality in eonymphs was 31.5%. The predominant parasite species was

TABLE I

Results of dissection of 200 apparently sound cocoons of the larch sawfly at Carleton

Class of individuals	Numbers of individuals affected	Percent of total
Dead eonymphs		
unparasitized[1]	5	2.5
empty cocoons, host remains not found[2]	9	4.5
attacked by fungi	20	10.0
containing dead parasites[1]		
encapsulated *M. tenthredinis* eggs[3]	3	1.5
M. tenthredinis larvae	1	0.5
containing living parasites		
M. tenthredinis pupae	21	10.5
B. harveyi larvae	4	2.0
Living eonymphs		
unparasitized	29	14.5
containing dead parasites		
encapsulated *M. tenthredinis* eggs[4]	54	27.0
containing living parasites		
M. tenthredinis larvae	3	1.5
Living pupae		
unparasitized	18	9.0
containing encapsulated *M. tenthredinis* eggs[5]	33	16.5

[1]Cause of death unknown, probably microorganisms involved.
[2]Death probably resulting from microsporidae.
[3]Two individuals containing 2, and one containing 6, encapsulated *M. tenthredinis* eggs.
[4]Twenty-two individuals containing one, 21 containing two, 7 containing 4, and one containing 5 encapsulations.
[5]Fifteen individuals containing one, 14 having 2 and 4 having 3 encapsulations

Mesoleius tenthredinis (Morley) accounting for 57.5% parasitism. There was, however, only 12.5% total effective parasitism by this parasite, since 78% of the hosts succeeded in encapsulating *M. tenthredinis* eggs. This phenomenon was described in detail by Muldrew (Can. J. Zool. 31: 313-332, 1953). Except for the egg stage, little is known about mortality in other age intervals of *M. tenthredinis*, but it may be low since this parasite continues to heavily attack the host. Activity by the tachinid *Bessa harveyi* (Tnsd.) resulted in 2% parasitism only. Since other workers have observed that at the end of a larch sawfly outbreak *B. harveyi* tends to be rare and *M. tenthredinis* more abundant, one might believe that the infestation at Carleton is on the decline. Microorganisms were also contributing to some sawfly mortality. Entomophagous fungi of the genus *Beauveria* (identified by Dr. W. Smirnoff, of this laboratory) were found on 10% of the insects in the cocoons. Microsporidae were present on 14 eonymphs, causing black spots on the integument, which indicated that hypodermal areas were infected by spores of *Thelohania pristiphorae* (Smirnoff) (J. Invertebrate Pathol. 8: 360-364).—F. W. Quednau, Forest Research Laboratory, Quebec, P.Q.

Temperature in Relation to Development Rates of Two Bark Beetles.—Rates of development in broods of the Douglas-fir beetle (*Dendroctonus pseudotsugae* Hopk.) and the spruce beetle (*Dendroctonus obesus* (Mann.)) at four constant temperatures were investigated in logs from their respective hosts, Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco) and white spruce (*Picea glauca* (Moench) Voss).

Infested and freshly felled uninfested logs were obtained from the central interior of British Columbia. The mature beetles from the infested logs emerged at room temperature (70-74 F). These adults were allowed to attack the fresh host material at a density of four to six pairs per square foot. The logs were maintained at 74 F for 11 days, then separated into different groups for treatment at temperatures of 43 F, 49 F, 57 F and 62 F. Samples, taken at this time, showed that all galleries contained eggs and that a few in the Douglas-fir logs had hatched. Subsequent samples were obtained 22, 42 and 63 days after the temperature treatments began. In addition, logs at 43 F were examined after 296 days and the spruce logs again at 406 days.

An index, representing the stage of brood development, was based on the numbers of each of seven stages (eggs, four larval instars, pupae and young adults) in the samples. On this index, 100% eggs is represented by 100 and 100% adults by 700.

Development rates at the different temperatures are shown in Fig. 1. The two species showed similar development patterns, but the Douglas-fir beetle, showed a greater response to the highest temperature while the spruce beetle appeared better adapted to the lowest temperature. Moreover, some spruce beetle larvae at 43 F were still alive and developing after 406 days, whereas there was no development of Douglas-fir beetle brood at this temperature. Therefore, the threshold temperature for development of the spruce beetle was close to 43 F, while that for the Douglas-fir beetle lay between 43 and 49 F. Data presented by Vité and Rudinsky (Forest Sci. 3:156-167, 1957) indicated that for the Douglas-fir beetle the developmental threshold temperature is below 52 F and possibly 48 F. At 49 F almost 1800 degree-days above 43 F were required for the same development as reached with only 1100 to 1200 degree-days at 62 F.

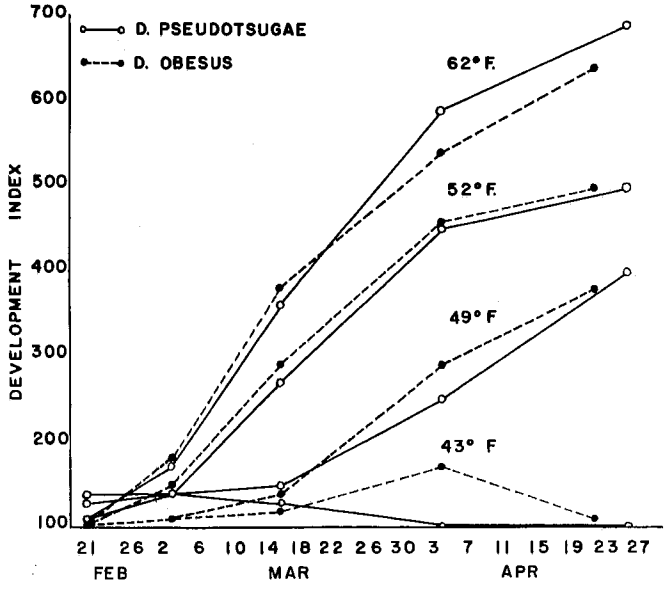

FIGURE 1. The rate of development for *Dendroctonus pseudotsugae* Hopk. and *Dendroctonus obesus* (Mann.) reared under four constant temperatures. The first samples were taken 11 days after gallery initiation.

These results indicate that the spruce beetle is better adapted to the lower temperatures than the Douglas-fir beetle. This is to be expected since the normal environmental conditions are cooler for the spruce beetle. Both species can survive and develop below 50 F, but require less degree-days at 62 F. Thus in nature a small increase in mean summer temperature might result in a relatively large increase in the number of beetles reaching maturity that season.—E. D. A. Dyer, J. P. Skovsgaard and L. H. McMullen, Forest Research Laboratory, Victoria, B.C.

FOREST MANAGEMENT

Tree Volume Estimates using an Upper Stem Diameter.—Tree section measurements from 923 red pine trees (*Pinus resinosa* Ait.) were used to evaluate the accuracy of tree volume estimation from regression equations which include an upper stem diameter measurement. The data included total cubic foot volume (V), calculated from the individual tree sections; stem diameter (outside bark) at breast height (D); total tree height (H) and outside bark diameters (d) at 30, 40, 50 and 60% of H (d_3, d_4, d_5, and d_6). The trees ranged between 0.5 and 138 ft^3 in volume, between 3 and 22 inches dbh, and between 22 and 102 ft in height.

Five step-wise multiple regressions were computed. The first four included D, H, d and 21 of their combinations as independent variables; the last one used only D, H and 15 of their combinations. To give a more equal weight to each tree, a weight of

$$\frac{1}{(D^2H)^2}$$

was used in the regression analyses.

Results of the five computations after selection of the first independent variable are shown in Table I.

TABLE I

Regression equations

Height of d	Equation	Standard Error
(% of H)		(% of V)
30	V= .04804+.002991 DHd	12.9
40	V= .05385+.003204 DHd	11.5
50	V= .06954+.003460 DHd	11.1
60	V= .09156+.003840 DHd	11.8
d excluded	V= .1499+.002483 D^2H	16.2

In each regression, the first variable selected accounted for more than 99% of the total variance. In each case, the next variable selected accounted for less than 0.2% of the total variance and did not reduce the standard errors appreciably. These variables were excluded from the equations.

In each of the first four equations, the first variable (DHd) selected (Table I) was the same. In the fifth equation, d being omitted from the analysis, the first variable selected was D^2H.

The standard errors in Table I indicate that the best height for the measurement of upper stem diameters is around 50% of the total tree height. Also, a comparison of the standard errors of the third and fifth equations shows the considerable reduction brought about by including an upper stem diameter.—G. M. Bonnor, Forest Management Institute, Ottawa, Ont.

Reliability of Standing Tree Volume Estimates Based on Upper Stem Measurements.—Volume estimates of standing trees in a forest are usually based on one or two measurements (either dbh alone, or diameter and height of the tree), and a tabular or graphical arrangement of average tree volumes. However, there are certain advantages in estimating individual tree volumes, e.g., in forest sampling where single trees are used as elementary sampling units (3P or sampling with probability proportional to prediction), in timber quality studies, etc. Recently, more and more emphasis has been placed on using dendrometers to estimate various parameters of interest (upper diameters, relative heights, volumes, etc.) on standing trees. Because of differences in tree form, more precise information can be obtained by this procedure than by the conventional volume table method.

There is a wide variety of dendrometers available today. Some, e.g., the Barr and Stroud, are rather sophisticated and relatively expensive. Others, e.g., the Spiegel Relascope, are simpler and cost less. The Barr and Stroud dendrometer permits indirect diameter measurements by rotating its prisms. The Spiegel Relascope only estimates diameters through its built-in, equal-width bands. Nonetheless, when the instrument is mounted on a tripod, these approximations can be very close to the values observed with more powerful dendrometers.

Total cubic foot volume estimates based on readings with the Barr and Stroud dendrometer and the Spiegel Relascope were compared with volume estimates computed from ground measurements of the trees after felling, for 29 white pines (*Pinus strobus* L.). These trees grew in average stand conditions; they ranged from 8 to 23 inches dbh, and from 54 to 95 feet in height.

Upper diameters and corresponding heights were measured on the standing trees with a Barr and Stroud dendrometer (model FP 12) and a Spiegel Relascope mounted on a tripod. For each tree, 4 to 8 readings were recorded to estimate section heights and diameters. The measurements were taken at convenient points (not necessarily the same ones for the two instruments) along the stem of each tree. Afterwards, the

TABLE I

Estimates of total volumes of individual trees, obtained with two instruments (standing trees) compared with those obtained from ground measurements (felled trees).

	Volume of the Entire Tree (ft^3)			
	Ground Measurements		Barr and Stroud, outside bark	Relascope, outside bark
	inside bark	outside bark		
	44.45	49.64	51.75	45.22
	23.57	24.83	26.19	26.24
	55.49	62.50	57.69	55.49
	50.71	57.95	57.78	51.19
	28.88	31.38	31.00	30.29
	42.16	46.68	48.46	44.18
	35.44	39.48	37.62	32.22
	55.04	62.22	65.07	56.89
	58.61	66.30	66.87	63.28
	76.31	83.96	82.32	88.23
	58.99	66.39	63.66	60.11
	25.40	29.13	28.14	28.00
	16.56	18.91	19.54	18.99
	63.89	71.28	71.33	64.46
	81.36	92.41	93.05	90.79
	22.03	25.38	27.44	23.42
	17.36	19.65	19.98	19.66
	18.68	21.09	21.10	20.19
	19.31	21.37	23.41	24.70
	26.71	28.92	28.04	26.67
	8.08	8.94	9.18	8.74
	18.40	20.10	20.35	19.52
	34.86	38.98	41.18	39.43
	54.71	63.27	63.88	62.76
	62.58	68.28	66.19	64.98
	34.55	37.51	38.17	31.94
	88.89	97.13	96.55	99.95
	31.40	34.67	34.46	33.47
	26.26	29.43	29.89	30.79
Mean	40.71	45.44	45.53	43.51
Standard Deviation	21.46	23.97	23.57	23.56
Standard error of mean	3.98	4.45	4.38	4.37

trees were felled and cut into 8 to 16 ft logs. The section volumes were computed on the basis of the diameters (larger end, middle, smaller end) and the length of each log. A relatively close agreement seems to exist among the volume estimates derived by the various procedures (Table I).

Compared to the Barr and Stroud dendrometer, the Spiegel Relascope yielded less precise estimates of tree volumes. However, its sample regression lines, being of the general form $y=a+bx$ (where y is the tree volume estimate from ground measurements and x is the volume estimate resulting from the instrument readings on standing trees), are within the 90% band of the simultaneous tolerance limits (STL) computed for the Barr and Stroud dendrometer. These limits were calculated so that, for each x, the probability associated with the population of y's (which are assumed to be normally distributed above and below the 'true' line) is 0.90.

The results of this study do not question the overall superiority of the Barr and Stroud dendrometer as a powerful, split-image, magnifying instrument. They merely suggest that for conditions similar to those tested, the Spiegel Relascope, mounted on its tripod, may prove to be a very useful instrument for estimating individual tree volumes (Wilson, Ann. Math. Stat. 38: 1536-1540. 1967).—L. G. Arvanitis, Forest Management Institute, Ottawa, Ont.

FOREST PRODUCTS

Growth of *Aureobasidium pullulans* on Ball-Milled Aspen—*Aureobasidium pullulans* (de Barry) Arnaud, an ubiquitous fungus normally found associated with pectin-containing substances, is known to cause blue or black discolorations in wood structures in Europe and has been grouped with the "blueing fungi". In eastern Canada it colonizes exposed wood surfaces and contributes to weathering. It often discolors paint surfaces or varnish coatings and in some cases contributes to their complete failure. Generally this fungus is considered a secondary organism metabolizing only simpler terminal compounds. The polymorphic nature of the organism under certain growth conditions is demonstrated by the occurrence of yeast-like forms and other variations including filamentous forms.

Cooke and Matsuura (Mycopath. Mycol. Appl. XXI, 15-271, 1963) claim that *Aureobasidium pullulans* cannot utilize cloth (cellulose) strips as a carbon source when growth was attempted in a yeast-extract mineral salts medium. At our laboratory chance contamination by *A. pullulans* of a milled-wood (cellulose and hemicellulose) medium was observed. Aspen (*Populus tremuloides*), ball-milled for 48 hours and washed to remove water soluble material, was refrigerated in a water suspension before its use as a test substrate. After standing several weeks the mixture readily became infected by air-borne spores and supported growth of a yeast-like form of *A. pullulans*. The organism isolated in pure culture on a 2% malt agar medium showed an initial growth pink in color which darkened after several weeks in stock culture. The organism was classified group IA according to Cooke and Matsuura. After transferring stock slant growth to sugar substrate in shake flasks containing 0.1% peptone, 0.1% yeast extract, 0.5% glucose medium, growth in shake culture on ball-milled aspen showed excellent cell propagation within 24 hours. This growth was used to inoculate three separate media each containing 1.5% milled aspen as substrate (Table I). Inoculum was 5% v/v. The test flasks were incubated for 5 days at 28 C on a rotary shaker (130 rpm with 2-inch circular orbit). Growth was assayed by counting cells using a haemocytometer and phase microscopy (Table I). Media containing only yeast extract and wood resulted in the highest cell count. Mineral salt medium having no yeast extract was lower in pH probably causing some inhibition. All three media supported growth of lemon-shaped yeast-like cells. No filamentous forms were observed.

To determine fungal preference to major wood components as the energy source, predominant enzyme content from the culture growth was assayed. Using culture homogenate, tests of enzymic activity were carried out and the end products released were chromatographed. For these tests further growth of culture material was inhibited using a 20 ppm concentraiton of acti-dione (cycloheximide). Both homogenate of the complete culture suspension (5 ml) and clear supernatant (5 ml) were used as enzyme sources and tested against 48-hour milled and washed aspen substrate at 50 C and 10 ml total volume. Test suspensions were buffered at pH 5.5 with 0.2M acetate buffer and the reducing sugars released by enzyme action compared with inactivated controls. Using the reducing sugar determination of Somogyi (J. Biol. Chem. 195:19-23, 1952), figures for enzymically-released reducing sugars were obtained (Table I). Homogenate from Medium I gave the highest values but media containing salts gave higher titers for the culture supernatants and the highest percentage of supernatant activity. Chromatographic separation of the sugars produced by Medium I homogenate resolved mainly xylose and glucose in a 3:1 concentration. A very slight amount of mannose was also noted as well as traces of Low R_f substances.

These analytical data suggest that the growth on wood observed for this organism was predominantly at the expense of wood hemicellulose or the O-acetyl-4-0 methyl glucuronexylan fraction which comprises 24% aspen wood weight (Timell. Wood Sci. Tech. 1:45-70, 1967). Since enzyme action also released some glucose, a lower molecular weight cellulosic fraction may have been utilized. The observed mannose indicated that some of the glucose released possibly came from glucomannan suggesting that this hemicellulose fraction was also metabolized by the organism.

The recognized ubiquity of *A. pullulans* species may stem in part from the fact that hemicellulosic substances are indeed readily metabolized. Existing literature considers that this fungus predominantly utilizes pectin (polygalacturonic carbohydrate). However, a great variety of naturally-occurring cellulosic materials contain appreciable hemicellulose, which could be amenable to attack and in turn provide a wide distribution of this species. Similarly as a secondary organism

TABLE I

Growth and Enzyme Activity on Milled Aspen in Shake Culture after 5 Days at 28C

Medium*	Initial pH	Final pH	Growth Cell Count per ml.	Enzyme activity as reducing sugar		
				Homogenate (mg/ml)	Supernatant (mg/ml)	Supernatant (%)
I	4.8	4.8	3.54×10^6	1.99	0.08	4.2
II	4.5	5.0	2.59×10^6	1.58	0.79	49.9
III	4.0	3.2	1.25×10^6	1.11	0.77	69.9

*I — 1.5% milled aspen and 0.1% yeast extract.
II — 1.5% milled aspen, 0.1% yeast extract, 0.4% $(NH_4)_2SO_4$, 0.01% $MgSO_4$ and 0.01% $CaSO_4$.
III — 1.5% milled aspen and mineral salts of II but without yeast extract.

A. pullulans could conceivably coexist with active true wood-rotters but function in the deterioration of the hemicellulose fractions of wood substance. It is conceivable that the capability for hemicellulose utilization noted for this organism could be put to use where low grade forage material is to be up-graded for consumption as fodder. A rapid growing non-toxic species which preferably maintained the yeast-like configuration presumably could be propagated on such materials to effectively raise their nutritional value. The seemingly meagre growth requirements of this species would be compatible with attaining economical treatment of such materials. Closer examination to determine suitable substrates and growth behaviour of this interesting species is required before many of these questions can be answered.—D. W. Stranks, Forest Products Laboratory, Ottawa, Ont.

PATHOLOGY

Contamination and Desiccation within a Growth Chamber.—Circulating air (frequently recirculation of the same air) is commonly used for maintaining uniform atmospheric conditions at various locations in the interior of growth chambers. The method of air circulation would seem to influence the number of contaminating microorganisms that enter loosely covered vessels used for nutritional and other studies. The following experiment was designed to determine the extent of air contamination obtained on standard nutrient agar media in Erlenmeyer flasks covered with Griffin beakers or plugged with cotton in a 32 ft^3 growth chamber in which the conditioned air entered through evenly distributed small openings in the floor of the chamber. The growth chamber was located in the factory where it was manufactured.

Sixteen 250-ml Erlenmeyer flasks, eight containing 30 ml of malt extract agar (pH 4.6) and eight containing 30 ml of potato dextrose agar (pH 5.6), were placed on a growth chamber shelf, midway up the chamber. Four of the flasks of each medium were stoppered with non-absorbent cotton and four were covered with inverted 50 ml Griffin beakers. Three similar units of sixteen flasks each were placed in covered boxes, one on the growth chamber shelf, one on the top exterior of the growth chamber, and one in an upright incubator maintained at 25 C in the laboratory.

Conditioned air entered the bottom of the growth chamber through ¼-inch slots that ran the width of the chamber in recessed grooves spaced about 2 inches apart. The temperature was maintained at 25 C, relative humidity at 70% light intensity of 3500 ft-c, and the photoperiod was 16 hours. Air circulated at 25 ft^3 per minute and the fresh air vent was shut off.

The flasks containing fresh media that had been autoclaved for 15 minutes at 15 psi were set in place 14 Feb. 1967. The flasks were examined for contamination twice a week during the first 2 weeks and at weekly intervals thereafter until removed on 16 March. The lid was removed from the box on top of the growth chamber on 1 Mar., and factory dust then began to settle on the flasks.

No contamination appeared in any of the flasks following each of the first two readings. On 24 Feb. one beaker-covered flask containing P.D.A. situated in the covered box within the growth chamber contained a colony of bacteria, and on 1 Mar. one beaker-covered flask of P.D.A. on the growth chamber shelf also contained a colony of bacteria. No other contamination developed in the remaining 62 flasks throughout the experimental period.

By 15 Mar. agar in the flasks stoppered with cotton had shrunk to about one-half its original thickness on the growth chamber shelf as had the agar in the flasks within the covered box in the upright incubator. Agar in cotton-stoppered flasks had shrunk to about three-quarters its original thickness in the covered box within the growth chamber, and to about one-quarter its original thickness in the covered box on top of the growth chamber. Agar in the flasks covered with beakers had not shrunk either on the growth chamber shelf or in the covered boxes in the growth chamber and in the upright incubator. It was very warm and dry in the shop where the growth chamber was housed and agar in beaker-covered flasks in the covered box on top of the growth chamber shrunk to about one-half its original thickness.

It may be concluded that the level of contamination was not increased by the circulating air entering the bottom of the growth chamber over the level obtained in the still air in the covered box within the growth chamber. A further conclusion was that moisture loss from the agar medium in beaker-covered flasks in the growth chamber was negligible, while moisture loss from agar media in cotton-stoppered flasks was considerable over the 4 week experimental period.

The authors are grateful to Mr. R. H. Taylor of Controlled Environment Co. Ltd., Winnipeg, Man. for use of growth chamber equipment.—R. D. Whitney, Forest Research Laboratory, Winnipeg, Man. and J. G. Palmer, Forest Disease Laboratory, Laurel, Maryland.

SILVICULTURE

Effect of Water Extracts of Burned Pine Duff on Germination of Jack Pine Seed.—Prescribed burning has found wide use in the United States and elsewhere as a worthwhile silvicultural tool. In 1964 the practice was introduced into southeastern Manitoba on a trial basis primarily to prepare suitable sites for seeding or planting. By 1965 it had been expanded to an operational scale. However, low stocking from direct seedings dampened enthusiasm; now prescribed burning is being used only to reduce fire hazard and to clear sites to facilitate seedbed preparation by mechanical methods.

Toxic or inhibitory substances in the germination medium have been known to cause germination failure in coniferous seed. On burned areas the effect has been attributed to the higher pH and higher concentration of the nutrient solution resulting from soluble ash. Past investigations have yielded conflicting results as noted by Tryon (Ecolog. Monogr. 18:81-115, 1948), Tarrant (Pacific Northwest Forest and Rge. Exp. Sta. Res. Note 105, 1954), and De Keijzer and Hermann (Northwest Sci. 40:155-163, 1966). Both adverse and beneficial results have been recognized in different studies of the same species, while within a single study species differences have been evident. Apparently no studies have been carried out using jack pine (*Pinus banksiana* Lamb.). Therefore the following laboratory experiment was undertaken to determine the effect of water-soluble substances on germination of jack pine seed.

In August 1967, samples of burned duff were collected from two areas in southwestern Manitoba, one burned in August 1966 and the other burned in August 1967. Both areas had supported pure stands of jack pine before logging. Duff samples were thoroughly mixed, oven-dried at 105 C and ground to a fine powder. Extracts of various strengths were made by soaking 50- and 100-g samples of the powder in 500 ml of distilled water for 10, 30 and 60 minute periods. The various mixtures were filtered and a pH measurement was obtained for each filtrate.

Ten lots of 25 seeds each were soaked in each extract for 16 hours at 10 C; distilled water was used as the control. In addition four lots of 25 seeds each were soaked for 16 hours at room temperature (approximately 21 C) in each of the four extracts prepared using the 60 minute soaking time; this was done to determine if temperature in the main experiment had an effect on imbibition of the extract.

Germination was tested by sowing the seeds on blotting paper in a controlled environment germinator which was programmed for 16 hours light at 30 C and 8 hours dark at 20 C. A humidity of close to 100% was maintained for the duration of the test. Germination was recorded weekly for a period of 4 weeks.

Results of the tests are given in Tables I and II. None of the treatments differed significantly from one another or from the control. Also no correlations between pH and germination or between pH and extract concentration were evident. Therefore the findings suggest that jack pine seed on the burned areas are not likely to imbibe water-soluble substances that will inhibit germination.

TABLE I

Germination of Jack Pine Seed after Cold-Soaking in Extracts of Burned Duff

Extract		Extract pH		Number germinated (per 25-seed lot)	
Shaking time (mins)	Sample weight (g) per 500 ml water	1966 burn	1967 burn	1966 burn	1967 burn
10	50	7.2	7.0	22.2	23.7
	100	7.0	7.0	23.4	22.8
30	50	7.2	7.5	22.1	23.4
	100	7.1	7.4	22.7	20.6
60	50	7.1	7.5	23.7	22.4
	100	7.3	7.2	23.0	19.4
Distilled water				23.7	21.1

TABLE II

Germination of Jack Pine Seed after Soaking at Room Temperature in Extracts of Burned Duff

Extract		Number germinated (per 25-seed lot)	
Shaking time (mins)	Sample weight (g) per 500 ml of water	1966 burn	1967 burn
60	50	20.5	20.0
	100	22.2	23.5

Although the experiment was not set up to investigate rate of germination, seed exposed to the warm soaking treatment appeared to germinate sooner than that exposed to the cold soaking treatment. The increase in germination rate may have been the result of faster imbibition and attainment of critical germination moisture content more quickly rather than to any effect of the extract. Stone (in Physiology of Forest Trees, Ch. 33, K.V. Thimann Ed., 1948) found that water uptake by pine seeds soaked at 5 C began immediately and he suggested that all water necessary for germination was imbibed in the first 48 hours. Stone gave no data for seeds soaked at warmer temperatures but found that seeds placed on wet vermiculite at 25 C imbibed sufficient water for germination in 3 days as opposed to 7 days at 5 C. The above observations suggest that water uptake of seed may have been an important factor influencing germination on the prescribed burns. The exposed and blackened surfaces of these areas are hot and droughty and may not maintain sufficient surface moisture for satisfactory germination, thus resulting in poor direct seeding results.—H. P. Sims, Forest Research Laboratory, Winnipeg, Man.

Incompatability of Black Walnut and Red Pine.—An excellent example of the incompatibility of black walnut (*Juglans nigra* L.) and red pine (*Pinus resinosa* Ait.) was observed in a 20-acre plantation in Wellington County, Ontario. The effect of Juglone, a chemical substance excreted from the roots of black walnut trees, has been described, (Schreiner, Morris. Arb. Bull. 1:94-96, 1919; Wheeler and Scott, Amer. Chem. Soc. 41:833-841, 1919; Cook, Phytopathology 11:346, 1921; Massey, Phytopathology 15:773-784, 1925; Schneiderhan, Phytopathology 17:529-540, 1927. Davis, Amer. Bot. 15:620, 1928; Perry, Proc. Penn. Acad. Sci. 6:136-141, 1932; McDaniels and Muenscher, Proc. North. Nut. Gr. Assoc. 27:172-179, 1936; Smith, Soil Sci. 53:385-398, 1942; Brooks, W. Virg. Univ. Agr. Sta. Bull. 347. 31 pp. 1951.). The plantation was established in 1939 by hand-planting 1-year-old walnut seedlings, at an average spacing of 8 x 6 ft, into fully cultivated agricultural land of Harriston loam (Ont. Soil. Surv. Rep. 35, 1963). Eight rows of red oak (*Quercus rubra* L.) seedlings were also planted in a strip through the middle of the plantation. Slow growth in the first two growing seasons suggested a need for protection. To provide this, red pine transplants were planted in rows between every second row of hardwood seedlings.

FIGURE 1. Dying red pine in walnut plantation on the left contrast sharply with healthy red pine in oak plantation on the right.

At the time of inspection in 1965 nearly all walnut trees were healthy and mortality was less than 1%. In contrast, 12% of red pine trees had died recently and severe discoloration and needle loss indicated that the remaining trees were sick or dying. Mortality appeared to have started about 5 years previously and to be the result of walnut poisoning. Evidence of this was provided by the strip in which pine was interplanted with red oak. In contrast to the poor condition of pine in the remainder of the plantation, all trees in this strip appeared perfectly healthy. Their diameter and height growth were normal and they had full crowns with long dark-green needles. The difference between the two stands was so striking that it could be readily observed by walking through the plantation.—F. W. von Althen, Forest Research Laboratory, Sault Ste. Marie, Ontario.

(Continued from page 20)

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FBC - MONTHLY

RESEARCH NOTES

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Vol. 24 - No. 3, MAY-JUNE 1968

CANADA
DEPARTMENT OF FORESTRY
AND RURAL DEVELOPMENT

Published under the authority of
The Honourable Maurice Sauvé, P.C., M.P.
Minister of Forestry and Rural Development
Ottawa

BI-MONTHLY

RESEARCH NOTES

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

BOTANY

An Anomalous Tracheid in Douglas-Fir Earlywood.—In an experiment initiated at the University of British Columbia in 1965, three coniferous species in a 40 year-old stand were subjected to tensile or compressive forces equivalent to the estimated green weight of the entire tree. This study was undertaken to provide information concerning the influence of tree weight on annual increment and tree form. After five growing seasons under these loading conditions, the influence of treatment will be studied by complete stem analysis.

A preliminary examination of Douglas-fir trees was made following three growing seasons under compressive loads which were applied by hanging lead weights close to the bole on the lowest living branch whorl. The response of four trees, each representing a different crown class (dominant, co-dominant, intermediate, and suppressed) was examined at breast height by taking a single ¼ × ¼ inch sample from the most recently formed sapwood to a depth of at least five annual rings. These blocks were sectioned transversely for microscopic examination.

The rate of increase of the two large stems since the weights were applied was unchanged, but a reduction of approximately 20 to 80% was indicated in the intermediate and suppressed trees. The dominant tree displayed a single unusual tracheid (Fig. 1) in a radial file of otherwise normal earlywood cells in the 1967 annual ring. This tracheid had the normal radial diameter expected of an earlywood tracheid, but had a cell wall even thicker than normal latewood tracheids. The thickening was heavily lignified as evidenced by its reaction with phloroglucinol, and contained axially-oriented cellulose, judging by its near-extinction under crossed nicols. This lignified tissue appeared as a tertiary layer in the sense that it occurred as an addition to the normal, relatively thin secondary wall. The general appearance of the cell was reminiscent of a bast fiber in Douglas-fir.

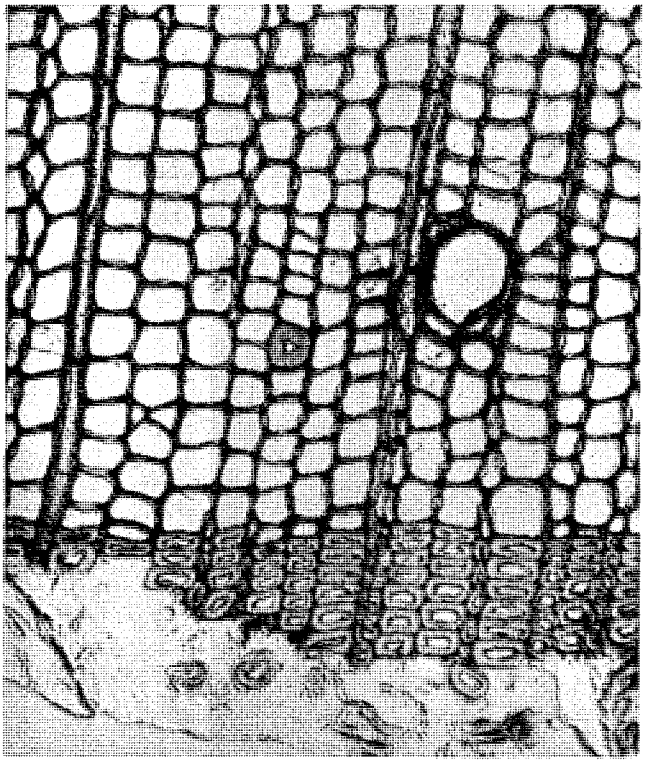

FIGURE 1. A single tracheid with abnormal thickening surrounded by normal earlywood cells.

The physiological significance of this anomalous tracheid is evidence of the complete independence of two processes of cell maturation, enlargement and secondary wall formation. Although this tracheid enlarged normally while in the cambial zone, it developed an extremely thick secondary wall in response to local physiological conditions. The circumstances that promoted excessive wall thickening were of remarkably short duration, since the differentiation of normal earlywood tracheids was immediately resumed in subsequently formed cells originating from the same cambial initial. Secondly, although latewood tracheids having regularly reduced radial diameters but abnormally thin walls due to defoliation have been reported in literature, there is to our knowledge no record of the opposite situation—earlywood cells with abnormally thickened walls. Perhaps the most similar type of tracheid is found in compression wood, but the anomalous cell reported here is dissimilar because its angular shape conflicts with the circular to oval shape of compression-wood tracheids.

At this time it is not possible to attribute this phenomenon definitely to external stresses placed on the stem, but the presence of such an unusual and unreported tracheid warrants a careful microscopic examination of all trees at the conclusion of the experiment. R. W. Kennedy, Forest Products Laboratory, Vancouver, B.C. and L. Adamovich, Faculty of Forestry, Univ. of B.C., Vancouver, B.C.

ENTOMOLOGY

Distribution and Effectiveness of Larch Casebearer Parasites in Southwestern Quebec.—Weather conditions during the summer of 1967 in southwestern Quebec favored larch casebearer (*Coleophora laricella* (Hbn.)) populations which attained higher levels than in 1966. In December 1967, an attempt was made to assess population densities in general, and evaluate the distribution and abundance of *Agathis pumila* (Ratz.) and *Chrysocharis laricinellae* (Ratz.), two common parasites of the larch casebearer.

Infestation levels were determined using Webb's sampling techniques for the overwintering stage of the larch casebearer (Bi-mon. Progr. Rep., Can. Dep. Agr. 13(4):1-2. 1957). Branches about 2½ feet long were cut at breast height from casebearer-infested trees. Entire twigs of the current year's growth were examined until 200 cases were collected. The cases were opened with the aid of two watchmaker forceps on a small piece of water-soaked filter paper under a stereomicroscope. Larvae attacked by *C. laricinellae* could immediately be recognized because, as a rule, this parasite hibernates in the third instar after having consumed most of the host's body (Quednau. Ann. Entomol. Soc. Quebec 11: 200-205. 1966). Parasitism by *A. pumila,* which hibernates

as a second-instar larva in the living host (Cody. Dissertation Univ. Wisconsin. 1965), was established by dissection of the casebearer larvae which were first decapitated on a microscope slide in a droplet of water using two fine needles, and then inverted.

Host densities and percentage parasitism for 20 localities are given in Table 1. The number of cases found per 100 buds represents an average for three different trees examined.

TABLE 1

Parasite activity in larch casebearer populations in southwestern Quebec

Locality	No. of cases per 100 buds	Infestation level	Percentage Parasitism	
			Agathis	*Chrysocharis*
Southern Region (near Granby—Sherbrooke)				
Waterloo	92	sev.	67	3
Rang Racine	90	sev.	55	4
Stanstead	26	mod.	76	3
Belval	96	sev.	68	4
Ayers Cliff	4	lt.	71	0,5
Barnston	12	lt.	54	28
Central Region				
Weedon	34	mod.	69	0,5
Cookshire	12	lt.	46	0
Stornoway	16	lt.	4	2,5
Thetford Mines	40	mod.	75	5
Trois-Rivières	53	sev.	19	12
St-Louis	29	mod.	65	2
Northeastern Region (near Quebec City)				
St-Raymond	53	sev.	13	9
Grondines	17	lt.	3	3
St-Malachie	7	lt.	0	0,5
St-Alban	34	mod.	8	1
St-Étienne	105	sev.	6	0
Western Region (near Montreal)				
New Glasgow	59	sev.	48	0
St-Lin	29	mod.	59	0
Joliette	45	mod.	79	0

Sev. = severe; mod. = moderate; lt. = light

Activity of *C. laricinellae* was low in all areas investigated and this parasite must be considered as being of secondary value in the biological control of the casebearer in this part of Canada. The absence of suitable alternate hosts in larch stands and the comparatively low temperatures in late summer and autumn do not permit the build-up of a large third generation of this parasite in third-instar host larvae. For the same reason, *C. laricinellae* does not seriously compete with other parasites of the larch casebearer.

A. pumila, on the other hand, is favored by warm weather conditions during June and July, because the adult lives only about 1 month and is greatly dependent on early synchronization with first-instar casebearer larvae. If the eggs of the moth hatch late due to cool rainy periods during the season, *A. pumila* adults may die before they can find their hosts. Activity of *A. pumila* was markedly lower in the northeastern part of the area investigated. In areas with favorable weather, this parasite exhibits good searching even at light infestation levels. *A. pumila,* which was originally introduced from Europe and was liberated in Quebec from 1942 to 1947, has spread widely and is now well established in areas considerably distant from the original release points.—F. W. Quednau, Forest Research Laboratory, Quebec, P.Q.

Erratum: Vol. 24, p. 5, col. 1, seventh line should read:
Dibrom > Baytex > Thimet = Matacil = Anthio > SD 8447 >
Ciba 9491 > Cyan 47031 > Zytron > Abate > DDT

The Occurrence of Free D-Serine and D-Alanine in Spruce Budworm Larvae (*Choristoneura fumiferana* (Clem.) Free.).—One of the first reports of the occurrence of a D-amino acid in an insect was that of D-alanine in the haemolymph of the milkweed bug (Auclair and Patton. Rev. Can. Biol. 9:3-8. 1950). Recent reports of up to 75% D-serine of the total serine in blood of Lepidoptera (e.g. Corrigan and Srinivasan. Biochem. 5:1185-1190. 1966). Srinivasan et al, J. Biol. Chem. 237:3844-3845. 1962) suggested that amino acids isolated from spruce budworm larvae may contain the D-configuration. To test this hypothesis amino acids were extracted with 70% ethanol from 10 g of larvae collected on June 29 (instar VI) after all chloroform-soluble substances were removed and regurgitated matter discarded. Alcoholic extracts were dried and redissolved in 0.20 N sodium citrate buffer at pH 2.2. D-serine and D-alanine were isolated by collecting fractions from the acidic and neutral ion-exchange column of an amino acid analyzer (Beckman Instruments Model 120C) in a system set up for physiological fluids as described by Benson and Patterson (Anal. Biochem. 13:265-280. 1965). Each fraction was desalted (Drèze et al. Anal. Chim. Acta 11:554-558. 1954), chromatographed on paper in two directions (phenol, saturated with water pH 5.5; n-butanol, acetic acid, water (9:1:2.9, v/v)) and compared with synthetic standards to confirm the identity and purity of each fraction.

The isolated amino acids were assayed for the D-configuration using a Bronwill Model 30 UFL Warburg respirometer and the method of Boulanger and Osteux (*In* Methods of enzymatic analysis. H. Bergmeyer [Ed]. Academic Press. 1963. pp 367-272.). The high specificity, utility and limits of the enzymic assay have been described by Greenstein and Winitz (*In* "Chemistry of the amino acids." John Wiley and Sons, N.Y. 1961. 1748 p). Criteria for the occurrence of D-serine and D-alanine involved:

a) net oxygen uptake when the D-amino acids were reacted with hog-kidney D-amino acid oxidase (Worthington, Biochemical Corp. N.J.). One µmole of D-amino acid oxidized corresponds to 11.2 µliter or 0.5 µmole of oxygen consumed.

b) formation of colored α-keto acid products as detected by precipitation with 2, 4-dinitrophenylhydrazine (DNPH).

c) confirmation of the identity of the hydrazones with synthetic standards on paper chromatograms by location and properties of the hydrazones under ultraviolet light and color formed after spraying with NaOH in ethanol (Krupka and Towers. Can. J. Bot. 36:165-177. 1958).

d) reproducibility in triplicate of each observation.

Results indicated the presence of D-configurations for serine and alanine at levels 12.0 ± 2.13% and 3.9 ± 0.4% percent of the total amino acid isolated. This corresponded to levels of 1.28 and 1.42 µmoles of D-amino acid per larva. Hydrazones of their α-keto analogues, hydroxypyruvic acid (orange-yellow) and pyruvic acid (yellow) gave R_f values of 0.64 and 0.71 respectively for the *trans* isomer, consistant with position and properties of authentic standards when chromatographed on paper (Whatman No. 1; n-propanol, ammonia, water, (6:3:1 v/v). Hydrazones absorbed strongly under ultraviolet light and spraying chromatograms with sodium hydroxide gave a chocolate color to the *trans* isomer of pyruvic-DNPH and a light yellow-brown color for the hydroxypyruvic-DNPH.

Our finding of free D-serine and alanine in spruce budworm larvae widens the known distribution of D-amino acids in Lepidoptera. D-configurations of these amino acids have not yet been reported in higher plants (cf. Steward and Durzan, *In* Plant Physiology: A treatise. Vol. 4A. Academic Press, N.Y. Appendix I, II. 1965). Thus it seems unlikely that

the larvae obtained D-amino acids from their hosts, although levels of many free amino acids in larvae clearly reflected food source, i.e. host species (Durzan and Lopushanski *J. Insect Physiol.* In press).

Acid hydrolysis of larval protein racemizes the component amino acids and precluded a study of the occurrence of D-amino acids in protein. D. J. Durzan and S. M. Lopushanski, Petawawa Forest Experiment Station, Chalk River, Ontario.

FOREST PRODUCTS

Organization of Tension Wood Fibers in Poplar Stem.—Tension wood is a defect in hardwood trees. It causes excessive shrinkage, splitting, warping and wooliness in lumber and veneer. The element involved in these defects is the abnormal gelatinous layer developing in the libriform fibers of many hardwood species. This unusual cell wall layer is often deposited inside the secondary wall as a response to the lack of perpendicularity between the tree and the gravitational pull.

Intensive research related to the gelatinous layer organization and the fine structure in the fibers of trembling aspen (*Populus tremuloides* Michx.) has been carried out with bright-field, polarizing- and electron-microscope techniques. In one study a ½-mm sapwood cube was embedded in a mixture of epon-araldite for thin sectioning (½- to 1-micron thick) using a glass or a diamond knife. These sections mounted on standard microscope glass slides were stained with natural dyes, preferably toluidine blue O. The lignified middle lamella and the secondary walls stained blue metachromatically while the cellulose-rich gelatinous layer stained bright purple. When applied skilfully this technique gives spectacular results with almost any plant material.

In another study ultrathin sections were cut in the same manner using the same tissue blocks but were mounted on copper grids for electron microscopy. Uranyl acetate and lead citrate were used for electron dense stains for cell walls and cytoplasmic components.

Figure 1 shows the gelatinous layer as intact, coherent structure with an undulating inner margin and an outer margin attached to the secondary wall. Therefore this layer does not display a convoluted form (withdrawn from the secondary wall) as reported by Scurfield and Wardrop (Aust. J. Bot. 10. 1962). Submicroscopic studies of the gelatinous layer using uranyl and lead staining revealed a random parallel cellulose microfibrils with an angular dispersion almost parallel to the longitudinal axis of the fiber. These observations invalidate previous concepts of the gelatinous layer possessing concentric lamellae (Cote and Day. Forest Prod. J. 12. 1962) or a honeycomb organization (Sachsse, Holz Roh-Werkstoff. 22. 1964).

Further studies on the origin of fibers in the cambium to their maturation in the sapwood have been carried out with reference to the formation of the gelatinous layer. A young fiber undergoing rapid elongation possesses a large vacuole and a dense parietal cytoplasm with the usual organelles: ribosomes, mitochondria, proplastids, golgi bodies, vesicles and endoplasmic reticulum. When the deposition of the secondary wall and the gelatinous layer begin, numerous long tubular structures (approx. diameter 200A) appear in the peripheral region of the cytoplasm (Fig. 2). These cytoplasmic structures called microtubules (Ledbetter and Porter, Science 144. 1964) occur with remarkable regularity in a single row along the outer margin of the cytoplasm as shown in the longitudinal section of the fiber. (Fig. 2). A maximum of 175 microtubules were recorded in a transverse section of one complete fiber. As the microtubules appear oriented parallel to the microfibrils in the wall it is suggested that these organelles are responsible in the organization and orientation of the microfibrils—A. J. Mia, Forest Products Laboratory, Ottawa, Ont.

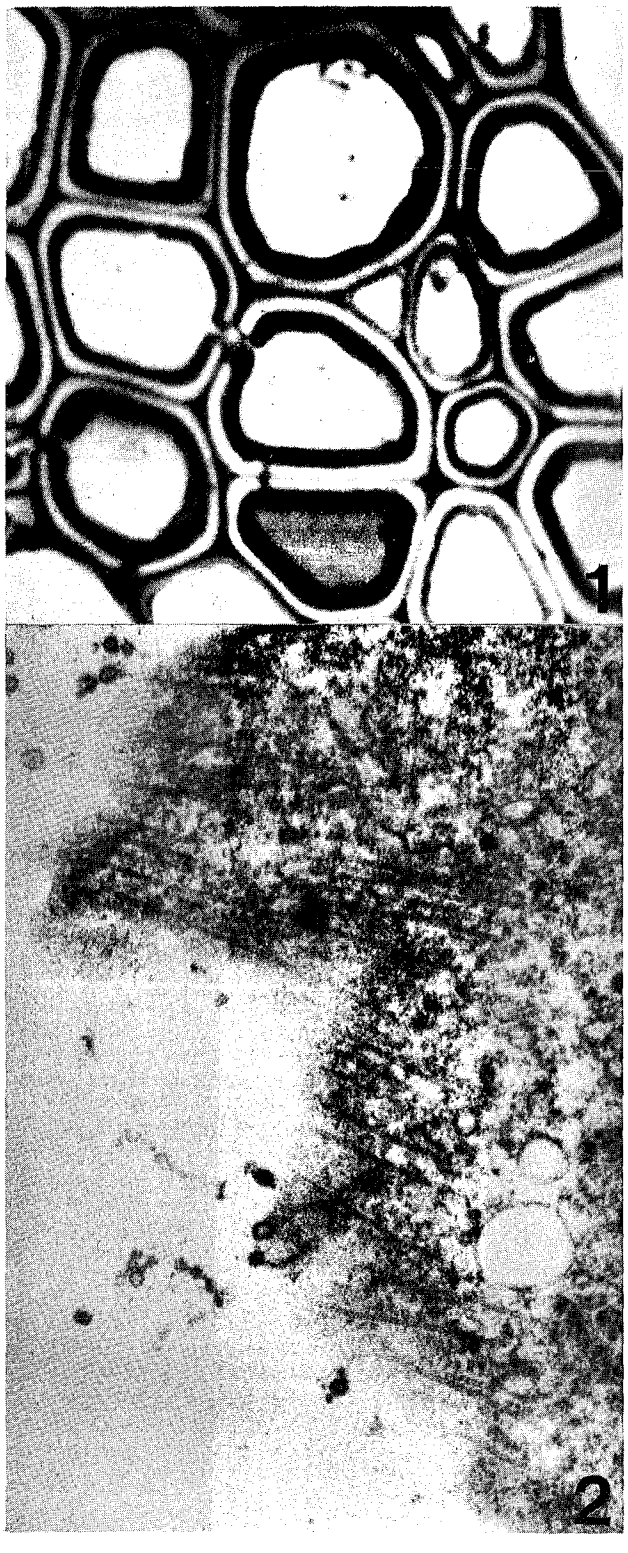

FIGURE 1. Light-microscope picture showing the gelatinous layer in a 1-micron thick transverse section of tension wood fibers embedded in epon-araldite. X 1,500.

FIGURE 2. Electron-micrograph showing the microtubules in longitudinal section of a tension wood fiber. X 27,000.

Relative Effect of Stress on Glue-Wood Bonds.—It was observed by Gillespie (Forest Prod. J. 15(9):36. 1965) that plywood bonds break down much faster upon boil-dry cycling than upon continuous boiling. The faster breakdown was attributed to swelling and shrinking forces of the glue-wood bonds. In order to obtain information on the relative importance of stress as a degrading factor, compared with hydrolysis, the following kinetic equations were used to analyze recent results of W. V. Hancock and P. L. Northcott, of the Vancouver Forest Products Laboratory, in work to be published.

$$k = C/T \qquad (1)$$

Where: k = rate constant; C = a constant; T = time taken for the plywood sample to break at 10 psi.

Equation (1) was used to calculate the hydrolysis rate constant, k_h, in the continuous water-soaking degradation systems at 70 and 100 C. In order to calculate the rate constant due to stress, k_s, for the 4-hour boil and 20-hour drying at 100 C cycle, the measured k_h values at 100 C were substituted into Equation (2). Similarly, k_s at 70 C was calculated for the 70 C-cyclic-degradation system.

$$k_{exp} = k_h/6 + k_s \qquad (2)$$

where: k_{exp} = the experimentally observed rate constant for the cyclic-degradation system;
1/6 = the factor representing the relative time the plywood samples were hydrolyzed in the cyclic-degradation system.

The temperature dependence of the rate constants k_s and k_h can be estimated by calculating k_s/k_h at 70 and 100 C. The values calculated for k_s/k_h are shown in Table 1. Results for urea formaldehyde are shown only at 70 C, since at 100 C the bonds are broken in a half day or less.

TABLE 1

Relative effect of stress compared with hydrolysis in Douglas-fir and poplar plywood bonds

Glue	Douglas-fir		Poplar	
	$\frac{k_s}{k_h}$ at 70°C	$\frac{k_s}{k_h}$ at 100C	$\frac{k_s}{k_h}$ at 70C	$\frac{k_s}{k_h}$ at 100C
Phenol formaldehyde (exterior)	6.0	7.2	2.0	2.5
Melamine formaldehyde	0.5	0.3	0.3	0.1
Melamine-urea formaldehyde	0.4	0.1	0.2	0.01
Urea formaldehyde	0.2	—	0.1	—

Upon comparing the k_s/k_h values in Table 1 for Douglas-fir and poplar for each glue, either at 70 C or 100 C, it is seen that in all cases the ratio k_s/k_h is lower for poplar than for Douglas-fir. This indicates that the factor of stress is dependent upon the tree species and is more important as a degrading factor in breaking down glue-wood bonds for Douglas-fir than for poplar plywood.

The ratio k_s/k_h is higher at the lower temperature of 70C than at 100C for the glues urea formaldehyde, melamine formaldehyde, and melamine-urea formaldehyde; whereas for phenol formaldehyde the ratio k_s/k_h does not vary appreciably. These observations indicate that the glues melamine formaldehyde and melamine-urea formaldehyde show pronounced temperature dependence toward hydrolysis, whereas phenol formaldehyde shows little temperature dependence at these temperatures. This finding is in agreement with earlier results (Troughton, Information Report VP-X-26, 1967) where phenol formaldehyde was shown to be resistant to hydrolysis, even at 100C, whereas the glues urea formaldehyde, melamine-urea formaldehyde, and melamine formaldehyde showed considerable tempereature dependence toward hydrolysis.—G. E. Troughton, Forest Products Laboratory, Vancouver, B.C.

Photo-crosslinking in Cellulose Material.—A review of the extensive literature on the photochemical degradation of cellulosic materials shows that the cellulose molecule usually is degraded with a decrease in its mechanical strength. It is also found that cellulose undergoes chain scission and its degree of polymerization rapidly decreases in the initial stage of photodegradation. However, the changes in physical properties that occur in high polymers during degradation and oxidation are the results of simultaneous reactions both of chain scission (depolymerization), further polymerization, branching, and crosslinking. The last three types of reactions have been completely overlooked in the studies on photodegradation of cellulosic materials except for an indirect reference to an increase in the mechanical strength of the cotton fibers exposed to the ultraviolet light for a very short duration (H. J. Henk, Melliand Textilber 19: 730. 1938).

The production of free radicals has been reported in the photolysis of cellulose (B. O. Phillips, O. Hinojosa, J. C. Arthur Jr., and T. Mares, Textile Res. J. 36; 822, 1966; T. N. Kleinert, Holzforschung 18: 24. 1964; T. N. Kleinert, Textil-Rundschau 20: 336. 1965). The possible recombination of some of these radicals may result in the formation of intra- or inter-molecular crosslinks, or both. Alternatively, the photo-oxidation of cellulose will be accompanied by the formation of carbonylic and carboxylic groups which may initiate crosslinking in the cellulose substrate. A mechanism based on crosslinking in the cellulose material to explain the observed increase in the wet strength of the heat-treated cellulose material was advanced by Back (Pulp and Paper Mag. Can. 68: T165. 1967).

Crosslinking reduces the swelling property of the cellulosic material in softeners such as water. Hence, measurement of the wet strength of the cellulosic material will provide a means of following the crosslinking process in the material. The wet strength was thus measured for the cellulosic material exposed to unfiltered light from a 550-watt Hanovia high-pressure mercury-vapor lamp.

Squares (4 by 4 inches) of Whatman No. 1 filter paper were exposed to the ultraviolet light in an aluminum cell specially constructed to control the specimen temperature which, in these experiments, was maintained at 40 C at 1 atmosphere pressure. The distance from the lamp to the sample was kept at 5 inches for all the experiments.

After the desired exposure time, the specimens were conditioned at 23 C and 50% relative humidity. The conditioned samples were then cut into strips (½- by 4-inch) in the machine direction and the wet tensile strength was determined on an Instron machine provided with special attachments to hold the specimen in place. For wetting the specimen, a series

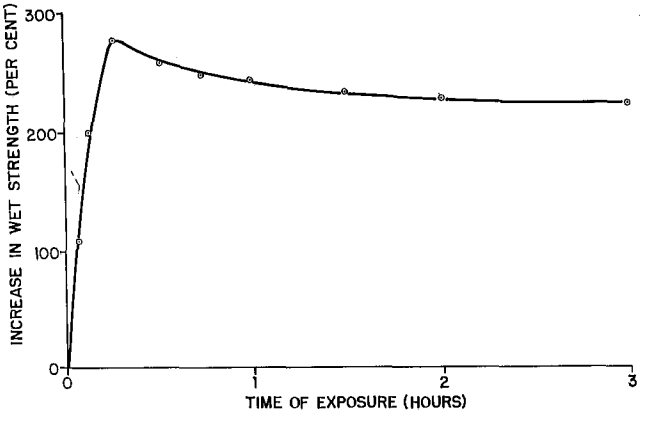

FIGURE 1. Variation of wet strength of paper against time of ultraviolet irradiation.

of trial experiments was conducted using a spraying device to obtain reproductible results; a standard procedure was adopted which consisted of spraying the sample in position twice on each side and then determining the breaking load, using rates of loading in the range specified by TAPPI. For each set of exposures at least 15 strips were tested. The wet strength of the controls was also measured under identical conditions. From the average of the wet breaking loads for the controls and the exposed test specimens, the percentage increase in wet strength was calculated and plotted against time of exposure (Fig. 1).

A substantial increase in the wet strength of the cellulose material exposed to the ultraviolet light is evident from Fig. 1. Under experimental conditions, the wet tensile strength of the material was maximum at a 15-minute exposure.

Water normally breaks the hydrogen bonds in the amorphous part of cellulose and hemicellulose material. If there are any covalent crosslinks between the cellulose chains, and between the fibers, resistance to swelling by water and consequent increase in the wet strength of the material will be recorded. The observed increase in the wet strength of the exposed cellulose material can be attributed to such a crosslinking in the substrate due to the photochemical action. Further work is in progress to determine the origin and the nature of the crosslinking resulting from the photochemical action of light on cellulose.—R. L. Desai, Forest Products Laboratory, Ottawa, Ont.

PATHOLOGY

Hardiness and Resistance to *Ceratocystis ulmi* (Buis.) C. Moreau of Hybrids and Clones of European and American Elm.—The resistance of white elm (*Ulmus americana* L.) to the Dutch elm disease (*Ceratocystis ulmi* (Buis.) C. Moreau) has been under investigation in Quebec since 1950. Clones selected since 1952 at l'Assomption, P.Q., (Ouellet and Pomerleau. Can. J. Bot. 43:85-96. 1965) were replanted in the nursery of the Forest Research Laboratory, Quebec City, in 1959. These stocks, which were propagated by cuttings during the summer, were inoculated at the base of trunk during June and July, 1967. In 1957, material for grafting from eight hybrids and clones resistant to the disease was acquired from the Willie Commelin Laboratory, Baarn, Holland. Cuttings were taken from the grafts and the number of trees under investigation was increased. In addition to a yearly examination for hardiness, their resistance to *C. Ulmi* was tested by inoculation in 1967.

Of the nine clones of white elm found to tolerate the infection at l'Assomption between 1952 and 1963, only *U.* "l'Assomption (L-235)" manifested no external symptoms of the disease. The 30 specimens of this strain, inoculated between June 9 and July 17, 1967, were free from leaf wilting throughout the summer. However cultures of the trunk, shoots and leaves, prepared according to the method suggested by Pomerleau and Pelletier (Le Natur. Can. 94:59-62. 1967) revealed that from 13 to 100% of the stem length and part of the terminal shoots had been invaded by the pathogen. Hence for at least the first 10 years of their growth, the cuttings of this particular strain were resistant to the elm disease.

Results of research undertaken in 1962 and 1963 at l'Assomption on cuttings of clone 56-L-115 yielded varying results. Ten trees of this strain were inoculated at Quebec on June 9 and June 16, 1967. Of these only one suffered severe leaf wilting (90%) whereas for five others leaf damage was slight (10% wilting or less) although the total stem length had been invaded. Furthermore, of the trees at Quebec City, transplanted 8 years previously from l'Assomption, only two manifested leaf wilting (of 10% and 50% respectively). This clone, having a normal growth rate, would thus seem to merit further study.

Despite detection of the pathogen in the top of most of the hybrids and clones of European elms grown in Quebec City, these trees have stoutly resisted the disease as is evidenced by the absence or at worst the low incidence, in the crown, of leaf wilting after inoculation. Moreover, none of the five trees of hybrid 202 (*Ulmus glabra* cv *exoniensis* x *U. wallichiana*) exhibited external symptoms of disease although in some cases the pathogen had been isolated from their shoots and leaves.

Frost damage and the loss of a significant proportion of twigs leaves little hope for the European elms under the climatic conditions at Quebec City. At best, hybrid 202 showing only some twig failure in 1958, 1959 and 1967 may merit investigation under more varied conditions. Further, this hybrid was one of the few not severely damaged nor killed by Nectria canker.

Inoculated Chinese elm (*U. parvifolia*) suffered no apparent damage apart from the withering of several branches on one individual. Nevertheless, it should be borne in mind that the pathogen is able to invade the whole trunk and a part of the branches, twigs and leaves and not provoke leaf wilting. A hybrid elm taken from the nursery at Indian Head, Sask., also showed good resistance to the elm disease; only one of the eight trees inoculated was damaged, with wilting noted in but 10% of its leaves.

In the present experiments, only the slow-growing strain of *U. americana* or *U.* "l'Assomption (L-235)" has been entirely free of external signs of the disease in the past 12 years. Another strain (56-L-115) with a normal rate of growth and apparently able to withstand the effects of the pathogen quite successfully is deserving of confirmatory studies. Although clearly resistant to the disease, the hybrids and clones of European elms lack the hardiness to survive the Quebec climate. A possible exception is hybrid 202; however its susceptibility to Nectria canker is yet to be assessed.

The definition of the resistance mechanism of these two clones of white elm is essential to the development of hybrids both resistant to the disease and hardy in North America. Hybridization would be facilitated if early flowering could be induced.—R. Pomerleau and J. Bard, Forest Research Laboratory, Quebec City, P. Q. (Translated from French by E. S. Maser).

Isolation of *Thelephora terrestris* from Soil and Hyphal Strands on Seedlings.—Until recently the importance of *Thelephora terrestris* (Ehrh.) Fr. was considered to be in its habit of occasionally strangling or smothering seedlings by its fruiting body. However, two studies suggest that it may occur as a mycorrhizal parasite on conifers (Hacskaylo. Forest Sci. 11:401-404. 1965; Zak and Marx. Forest Sci. 10: 214-222. 1964). This fungus is absent in culture collections, and the experience of the above investigators, that of Dr. M. Larsen (personal communication), and of mine, suggest that this fungus is peculiarly difficult to isolate in pure culture. In view of this, the following isolation records are of interest.

When studying soil mycoflora in experimental conifer beds at the nursery at Midhurst, Ont., in 1965, one particularly selective medium was developed. This medium allowed only a few species to grow, and it was employed for sandy rhizosphere soil gently shaken from roots of 1-year-old white spruce (*Picea glauca* (Moench) Voss). Many of the short roots seemed to have either black or brown mycorrhizae. The soil was mixed in cooled (50 C) molten agar of the following composition: distilled water 1000 cc, agar 21 g, sucrose 1 g, casein 0.5 g, yeast extract 0.5 g, tannic acid 60 mg, o-phenylphenol 12 mg, pimarican 4 mg, pentachloronitrobenzene 3 mg, novobiocin 200 mg, streptomycin 100 mg, neomycin 200 mg, aureomycin 5 mg. Among the fungi growing into this medium, *Mortierella* spp. and *Penicillium* spp. were dominant. In addition, there were a few extremely slow-growing species. Among the latter, two kinds were particularly interesting: (1) black colonies, which were identified as *Cenococcum graniforme* (Saw.) Ford. & Winge, and (2) whitish ones with fine

nodose-septate hyphae. At first the latter fungi were unidentified. Later, culturally identical fungi were isolated from brown, nodose-septate, coarse hyphae growing from *T. terrestris* fruiting bodies along roots of 2-year-old *P. glauca*. Most of approximately 100 attempts to culture the tissue of the fruiting body and the hyphal strands failed. Only a few hyphal fragments plated on cornmeal agar yielded uncontaminated cultures. Cultural properties of these isolates were compared with the descriptions given for probable *T. terrestris* in the above-noted studies. The following similarities were found. Single, bulbous nodes (clamps) at most of the numerous septa. Main hyphae rather straight, seldom intersecting. Branches often anastomosing. Fairly uniform hyphal diameter, mainly 4 μ, varying from 2 μ at the tips and in some aerial hyphae, to 5 μ, rarely 7 μ. Medium dense, slow-growing colony mat with, at first, a creamy color, which later becomes brown. The findings of three independent studies thus indicate that these cultures are *T. terrestris*. The linear growth rate at 25 C varied from 0.4 mm per day on malt agar to 1.1 on cornmeal and 1.4 on water agar. The fungus grew almost as fast at 15 C as at 25 C but not at all at 30 C.

Unexpectedly, the standard growth medium for Basidiomycetes, malt agar, did not support satisfactory growth of this fungus. This finding may explain some of the difficulties in attempts to isolate *T. terrestris*. Similarly, the medium described above did not allow fast growth of this fungus, although its selectivity may have facilitated the first isolation from soil. Efforts to develop more selective media have so far failed. Double-layered media consisting of varying amounts of cornmeal agar and malt agar (CM and MA) were also tested. The growth was correlated with the ratio CM:MA. On 1:1 mixture the growth was almost as slow as on MA alone, regardless of which component was on top. This indicates that the unsuitability of MA was not due to the lack of essential nutrients, but rather to some diffusible inhibitor in malt agar. *T. terrestris* was found to be inhibited by relatively low concentrations of many fungi-toxicants: benzoic acid, Botran, captan, chloronitropropane, Daconil, Difoltan, methyl arsine-oxide, pine oil, octachloropropene, salicylic acid, tannic acid, Terrazole, and thiram. The isolates from both soil and hyphal strands exhibited similar spectra of inhibition by toxicants and by malt agar. This further indicates that both isolates belong to one species. The isolates were also readily inhibited by other fungi and bacteria, which often appeared as aerial contaminations, particularly on malt agar.—O. Vaartaja, Forest Research Laboratory, Maple, Ont.

SILVICULTURE

Phytotoxic Effects of Aldrin on Pine Seedlings.—In several experiments for the control of white grubs, machine planted red and jack pine seedlings have been treated with 2% emulsion of aldrin prepared from commercial 20% aldrin emulsion concentrate with no apparent ill effect to seedlings (Ives and Warren. Forest. Chron. 40:505-508. 1964). In 1966, however, high mortality occurred on hand-planted red and jack pine seedlings, each treated with 10 cc of 2% aldrin emulsion (0.44 lb. active ingredients per 1000 seedlings). This phytotoxicity can probably be explained by the different methods of application: in machine planting the same formulation of insecticide was sprayed automatically along a 12-inch strip of soil, while in hand planting most of the insecticide was concentrated on or around the roots.

In 1967, an experimental plantation was set out near Hadashville, Man., to further evaluate the phytotoxic effect of aldrin and its solvent (heavy aromatic naptha) on pine seedlings and to develop a safe method of insecticidal application for hand planting. The area had been prepared for planting in 1966 by ploughing furrows at 6-ft intervals. Red and jack pine seedlings (2-1) were planted in the furrows at 6-ft intervals in adjacent plots, each 300 ft long, and treated rows were alternated with untreated buffer rows.

The formulations used for treatment were a commercially prepared 20% aldrin emulsion concentrate and a similar formulation which did not contain aldrin. The first formulation was diluted with water to prepare an emulsion containing 2% aldrin, 0.4% emulsifier and 7.7% heavy aromatic naptha solvent. The formulation which lacked aldrin differed slightly on dilution and contained 0.4% emulsifier and 9.7% solvent. One treatment consisted of unsprayed controls, the other four treatments consisted of two methods of applying 10 cc of the emulsions, with and without aldrin. In the first method, the emulsion was sprayed directly on the roots as the seedling was held in place before closing the planting hole. In the second method, the emulsion was sprayed in the planting hole prior to setting the seedling in place. Each treatment was replicated four times.

For red and jack pine, the application of both aldrin and solvent directly to the roots gave significantly greater seedling mortality than in the controls (Table 1). The addition of aldrin produced significantly higher mortality than

TABLE 1

Mortality of Red Pine and Jack Pine Seedlings Subjected to Various Treatments of Aldrin and Solvent.

Treatment	Red Pine		Jack Pine	
	Total No. Seedlings	No. Dead	Total No. Seedlings	No. Dead
Control	200	5	208	27
Solvent to soil	196	4	199	17
2% aldrin to soil	205	8	205	22
Solvent to roots	201	13**	196	47**
2% aldrin to roots	201	28**	201	85**

**Significant at 0.01 level.

the solvent alone. When applied directly to the roots, the phytotoxicity of a 2% emulsion of aldrin to red and jack pine seedlings is apparently due partly to the aldrin and partly to the solvent. There were no significant differences between the controls and soil applications of either aldrin or solvent, indicating that aldrin may be applied to the soil in the planting hole prior to placement of the seedling.—L. D. Nairn and W. G. H. Ives, Forest Research Laboratory, Winnipeg, Man.

Erratum: Vol. 24, p. 11, col. 1, l. 43, should read "while spruce (*Picea* spp.)".

(*Continued from back cover*)

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FBI -

MONTHLY RESEARCH NOTES

IN THIS ISSUE:

Vol. 24—No. 4, JULY-AUGUST 1968.

Published under the authority of The Minister Department of Fisheries of Canada Ottawa

BI-MONTHLY

RESEARCH NOTES

A selection of notes on current research conducted by the Department of Fisheries of Canada

BOTANY

Cell and Tissue Culture of White Spruce and Jack Pine.—A method to obtain large quantities of living, free cells of white spruce [*Picea glauca* (Moench) Voss] and jack pine [*Pinus banksiana Lamb.*] has been developed. The method shows promise for providing (a) an assay system using free conifer cells whereby physiologically active substances such as growth regulators or herbicides may be added to the medium and tested for their activity in terms of cell division, enlargement and other physiological and biochemical criteria; (b) the possibility of applying many of the techniques of microbiology to cells of gymnosperms, e.g. isotopically labelled substances can be administered under aseptic conditions to study metabolic pathways, or mutations may be induced and superior strains of cells selected for growth studies; (c) a system whereby metabolic products of these cells or cellular masses can be examined for their ability to produce potentially useful products similar to those obtained from micro-organisms; (d) controlled conditions to study division and enlargement of cells from superior trees, and eventually to induce the cellular masses to organize into seedlings. This approach would be of considerable aid to tree breeding and forestry in general.

Embryos germinated for 5 days are excised, surface sterilized and placed on agar or in a liquid medium similar to that described by Steward et al. (Am. J. Bot. 45:693-705. 1968). Treatments which produced the best callus growth on agar and which contained various levels of coconut milk and α-naphthalene acetic acid gave the most free cells in liquid media of the same composition. Tissue was recovered after a period of 8 weeks from 2.0 mg fresh weight of hypocotyl placed in liquid media containing 10% coconut milk, 5 ppm α-napthalene acetic acid, and either 13.5 g spruce or 1.5 g pine cells. Free cells of pine and spruce are shown in Fig. 1 and the evidence already available indicates that some organized growth can be obtained in these suspensions. Work is still in progress to elucidate factors that may allow such cells to organize into embryos.—D. J. Durzan, Petawawa Forest Experiment Station, Chalk River, Ont. and Prof. F. C. Steward, Laboratory for Cell Physiology, Growth and Development, Cornell University, Ithaca, N.Y.

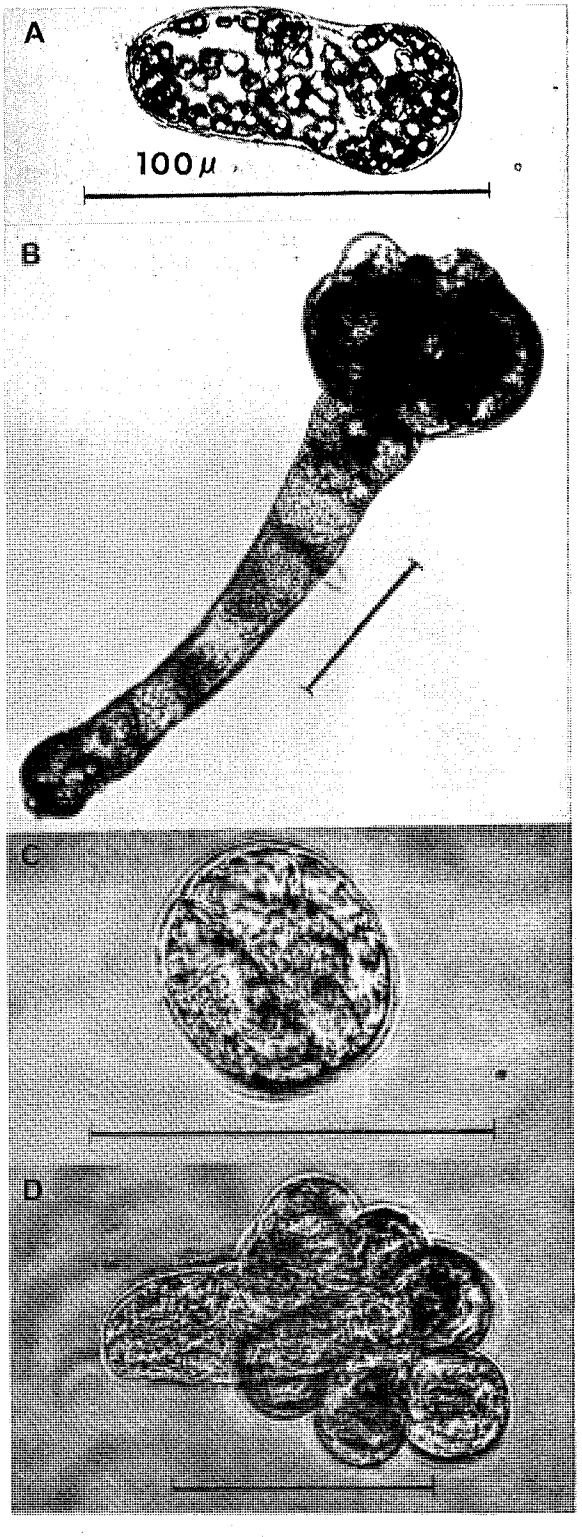

FIGURE 1. Freely-suspended, living cells of white spruce and jack pine and their organization into embryo-like structures. A) Single cell of white spruce. ×450. B) Embryo-like structure in a suspension of white spruce cells and tissue. ×288. C) Single cell of jack pine. ×720. D) Embryo-like structure obtained from a suspension of jack pine cells and tissue. ×450. Culture medium contained White's basal medium with casein hydrolysate, 10% coconut milk and 5 ppm α-napthalene acetic acid.

ENTOMOLOGY

A New Sampling Technique for Spruce Budworm Larvae.—Sampling populations of injurious insects to assess the possible need for control treatment is often a costly operation in time and manpower. This is particularly true of of the spruce budworm in New Brunswick because severe infestations during the past two decades have necessitated the examination of many thousand of samples each year to monitor the intensity and distribution of these infestations,

and to locate areas requiring chemical control. To reduce sampling cost is most desirable, and the following proposal is one method of reducing cost and increasing efficiency.

Washing foliage with a mild chemical solution is an established technique for collecting and counting arthropods (Strickland. *In* Annu. Rev. Entomol. 1961. p. 207). We found that overwintering second-instar spruce budworm larvae can be effectively extracted from balsam fir foliage with a 5% solution of NaOH. The technique consisted of clipping sample branches and immersing the twigs in the solution for 10 to 12 hr. The twigs were then agitated vigorously and the solution poured through a series of three sieves. Twigs and needles were extracted in the larger sieves, and the finest, 0.20 mm, retained the larvae and small bits of bark. The twigs and needles were then washed in water and this wash was also poured through the finest sieve. The effluent was filtered with a water-operated pump and examined microscopically. Caution was exercised in handling the solution. The same solution was used up to five times but the effect of dilution requires investigation.

Three extraction trials were conducted. Small balsam fir twigs with a total of 85 second-instar larvae in staminate flower bracts were immersed in the NaOH solution for 5 to 20 hr. In less than 5 hr the webbing of the hibernacula dissolved and 88% of the larvae dropped from the twigs. All larvae were extracted after 10 hr, and some larval deterioration occurred in 15 hr.

In the second trial, mid-crown branches were collected in October 1967 from balsam fir in the Green River area where the spruce budworm was known to be extremely scarce. These samples were stored at 25 F, and extracted in March, 1968. Counts from 132 branches were: 0.17 spruce budworm larvae per branch; 3.2 black-headed budworm eggs per branch (see Condrashoff, Can. Entomol. 99: 300-303, 1967); and 0.18 *Evagora* spp. larvae per branch. Current shoots on 1500 branches collected from the same location had been examined in the conventional manner in 1967 and 0.02 third-instar larvae were found per branch. The count of 0.17 second-instar larvae in the 1968 generation is within the density range that would be expected from a count of 0.02 third-instar larvae in the previous generation.

For the third trial six mid-crown branches from each of five trees were collected in a budworm infested area in March 1968. Three of the branches from each tree were washed in NaOH and gave the following results:

Tree	1	2	3	4	5
Total budworm:	264	249	194	279	257

The remaining three branches from each tree were suspended in a controlled light and temperature regime and living larvae were forced from hibernation. When emergence was complete the foliage from two of the five trees was washed in NaOH.

Tree	1	2	3	4	5
Larvae emerged:	113	82	57	35	24
Larvae washed :	*130*	*151*			
Total budworms:	243	208			

Forced emergence from these samples was unexpectedly low, but a comparison of the data shows close agreement in the total budworms collected from Tree 1 and Tree 3.

The washing technique was also tested against the forced emergence of larvae from hibernacula by E. G. Kettela of this laboratory. Two branches were collected from each of two trees at each of three locations approximately 1 week before emergence was expected in the field. The results were:

Location	1	2	3
Larvae emerged:	354	58	210
Larvae washed :	305	42	111

The counts from locations 1 and 2 are comparable, and it is suspected that the two-fold difference in location 3 is partly the result of tree to tree variation in density.

These preliminary tests indicate that:

(a) Washing foliage in a 5% solution of NaOH for 10-12 hr is a reliable technique for extracting almost all overwintering spruce budworm larvae.

(b) The sampling cost is relatively low. On the average a mid-crown balsam fir branch requires approximately 100 min to count budworm eggs, 45 min to count small larvae in new shoots, and 10 min to examine the NaOH filtrate.

(c) The second instar can be sampled from mid-September to mid-April; no other developmental stage is numerically stable for so long a period.

(d) The technique is especially applicable to sparse populations where large amounts of foliage must be sampled to attain accuracy and precision.—C. A. Miller and G. A. McDougall, Forest Research Laboratory, Fredericton, N. B.

Log Preference Studies on *Tetropium velutinum* LeConte—Studies were undertaken at Trinity Valley, B.C., to determine if trees felled early in the winter were as subject to attack and damage by *Tetropium velutinum* LeConte as those felled during the spring. One western larch tree [*Larix occidentalis* Nutt.], about 14 inches dbh, was felled each month from November 1966 to June 1967. In the spring of 1967, six sections, each 2 feet in length, were cut from the bole of each tree and placed at random in an east-west direction on the forest floor.

When the log sections were debarked in the fall of 1967 all *Tetropium* larvae had not yet bored into the wood; there was an average of 0.3 to 2.0 living larvae in each square foot of bark. However, woodpeckers had removed larvae disproportionately from the bolts and the significance of living larvae in or under the bark is questionable. The average number of entrance holes of *Tetropium* larvae in the wood, for each felling date, ranged from 0.2 to 8.4/ft^2 (Table 1). The largest number of entrance holes were in bolts from trees felled in May and June.

TABLE 1

Average number of larval entrance holes and depth of penetration in larch logs by November 1967

Date of felling	No. of holes per sq ft	Avg. depth mm
November 1966	0.2	—[a]
December	2.8	20.3
January 1967	4.3	23.0
February	5.4	23.5
March	1.3	20.0[b]
April	5.1	23.4
May	6.6	27.1
June	8.4	—[c]

[a]Inadequate number of galleries in bolts.

[b]Paired variate test used on February and March penetrations.

[c]Not examined.

Tetropium larvae penetrated radially into the wood and turned, generally, 90 degrees to excavate their pupal cells. In most cases, maximum radial penetration was reached at this turning point. Maximum depth of 120 completed galleries was measured, 20 for each tree felled from December 1966 to May 1967. Average depths of penetrations are shown in Table 1. A paired variate test used on penetrations into February- and March-felled logs indicated a significant difference.

Our data show that *T. velutinum* preferred logs felled in May and June. Penetration into logs cut in May was greater than in those cut in early winter. Examination of wood density showed that the tree felled in March had only one-half as many annual rings per inch as the others. This may account for the significant differences between the March logs and the February and April logs both in the number of larval entrance holes and the average depth of penetration in the wood. Since larch trees felled early in winter were less subject to damage by *T. velutinum* than those felled during the spring, damage would be minimized by giving priority in utilization to spring-felled trees.—H. Vanderwal and D. A. Ross, Forest Entomology Laboratory, Vernon, B.C.

FOREST PRODUCTS

Weight Distributions in Western Hemlock Trees.—In the complete-tree pulping research, component-weight distributions for three western hemlock trees were determined. Such information is essential for evaluating the potential gain by adding various tree components to the boles, which presently constitute the raw material for pulp.

The study trees were selected from a second-growth stand in the University of British Columbia Research Forest near Haney, B.C. Table 1 lists descriptive data for each tree. The trees were winched over and uprooted by a bulldozer when the ground was damp. Few roots were broken during this procedure, and those that did break were dug out easily. Since many of the finest roots were necessarily lost, figures for the smallest-size root class must be a slight underestimation of the true value.

TABLE 1

Characteristics of selected western hemlock trees

Tree No.	Age at stump (yr)	Dbh (in.)	Height (ft)	Total green weight (lb.)	Total dry weight (lb.)
1	59	18.0	113.9	7547.9	3338.8
2	67	14.2	120.0	4190.0	2058.1
3	92	8.5	75.0	978.3	533.8

Trees were divided into the various components listed in Table 2. The bole was defined as a 1-ft stump height and a 6-inch-diameter top. The unmerchantable top was that portion of a stem from a 6-inch to a 1-inch diameter. Measurements of various branch and root components are based on outside-bark diameter classes. A single root or branch might, therefore, have been divided into lengths falling into several diameter classes. The green weight of each component was determined and 2-inch-thick disks sawn from each for moisture-content determinations. In the case of branch and root components, disks were taken from six pieces selected randomly from each diameter class. For the smallest-diameter branch and root classes, two samples each of single whole pieces were selected for the determinations. Disks were taken from the bole and unmerchantable top at 10-ft intervals. Each stump was sampled at the 1-ft height and at the base of representative large roots.

Wood/bark ratios were determined on a green-weight basis, and the original weight of each component was adjusted to obtain the green weight of the wood alone. The dry weight of bark and wood for each component was estimated by correcting the original weight by moisture content. Table 2 shows the total dry-component weights expressed as a percentage of total dry-tree weights.

The total branch component varies from 9.8 to 16.6% of the entire weight of the trees. The greatest branch part in each case is in the component comprised of foliage and branches less than 1-inch diameter.

The root components vary from 12.1 to 14.4% of the total. In contrast to the branches, the largest part of the total root component is in the largest-diameter roots. For the three trees, a component comprised of the stump and roots greater than 3 inches diameter ranges from 11.8 to 13.2% of the total. This represents a potential increase in wood yield per tree over that of the bole segment alone of 16.7 to 21.6%.

Perhaps the most easily-handled component, the unmerchantable top, contributed a fairly low proportion of wood to the total of the trees except for Tree 3. The small diameter of this tree (8.5 inches dbh) resulted in a disproportionally high percentage of its total weight being assigned to the unmerchantable top.

The constancy of the wood/total-weight ratio between trees for the various components as shown in Table 2 is marked. This is undoubtedly attributable to classification of the components on a diameter basis and what must be a relatively uniform bark thickness from tree to tree. In general, the bole and stump are comprised of about 90% wood, while the remaining components contain 85% wood.

The moisture contents of different components vary considerably. No consistent patterns of distribution are evident; however, all trees exhibit the least moisture content in the branches, and the unmerchantable top is consistently greater in moisture content than the bole.

This latter trend is more fully illustrated in Fig. 1 which shows the distribution with height of bark-free stem density, basic specific gravity and moisture content. All parameters are expressed in the same units (g/cc of green wood), so that specific-gravity and moisture-content contributions are additive to yield the density curves. In each case, the moisture content decreases from the stump level to the lowest levels of the bole. It then increases at increasing heights in the stems, attaining greater values than at stump level. This pattern of increasing moisture content with greater height in stems is undoubtedly a result of the increasing proportions of sapwood in cross-sections. The upper curve in each part of Fig. 1

TABLE 2

Dry weight, wood/total weight ratio, moisture content and specific gravity distributions in selected western hemlock trees.

Tree Component	Distribution of total dry weight (%)			Wood/total weight ratio (dry-weight basis)			Green moisture content (%)			Specific gravity (dry-volume basis)		
	Tree 1	Tree 2	Tree 3	Tree 1	Tree 2	Tree 3	Tree 1	Tree 2	Tree 3	Tree 1	Tree 2	Tree 3
Branches												
Foliage and branches < 1" dia.	9.9	7.5	9.1	—	—	—	113.7	106.2	103.6	—	—	—
Between 1"—2" dia.	5.8	2.3	2.7	0.85	0.84	0.86	67.4	57.5	47.1	0.644	0.732	0.734
Between 2"—3" dia.	0.9	—	—	0.86	—	—	58.8	—	—	0.702	—	—
Total or weighted average	16.6	9.8	11.8	0.85	0.84	0.86	94.5	94.7	90.6	0.650	0.732	0.734
Roots												
< 1" dia.	1.8	2.3	3.5	—	—	—	127.0	112.7	134.2	—	—	—
Between 1"—2" dia.	1.4	1.2	2.2	0.72	0.78	0.79	179.3	86.4	127.4	0.383	0.506	0.449
Between 2"—3" dia.	1.9	1.5	0.6	0.79	0.81	0.82	170.1	76.5	68.4	0.407	0.526	0.517
> 3" dia.	9.3	7.1	9.9	0.87	0.88	0.88	142.6	75.2	73.5	0.386	0.460	0.478
Total or weighted average	14.4	12.1	16.2	0.84	0.86	0.86	147.8	83.6	93.7	0.388	0.475	0.474
Stump	3.9	4.9	1.9	0.90	0.90	0.91	144.6	78.9	83.1	0.387	0.460	0.468
Unmerchantable top	0.8	2.5	16.4	0.85	0.85	0.76	137.5	135.5	99.5	0.439	0.438	0.425
Bole	64.3	70.6	53.7	0.92	0.91	0.90	130.1	110.8	75.6	0.360	0.394	0.422

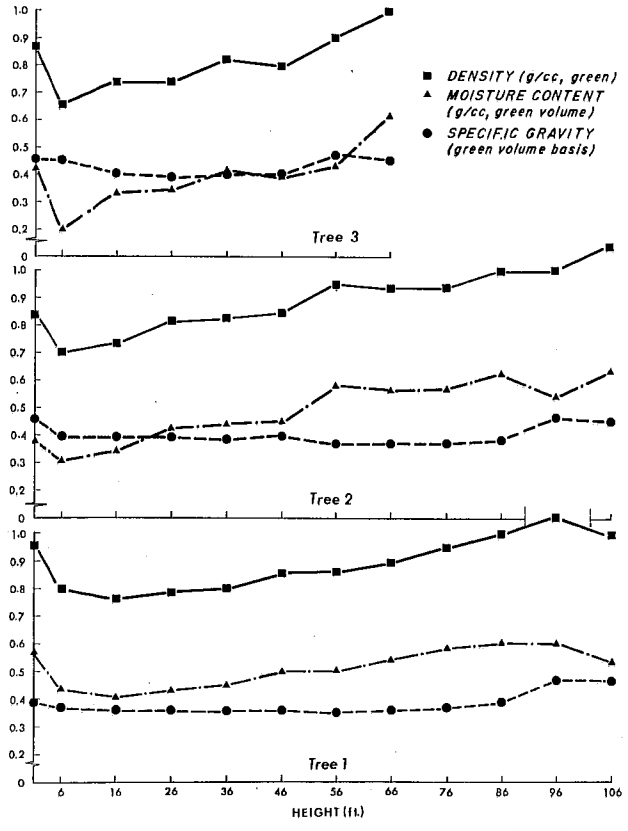

FIGURE 1. Specific gravity, moisture content and density distributions for the stems of three western hemlock trees.

illustrates the density distribution within each stem. It is clear that the pattern of stem-wood density is influenced more by moisture content variation than by wood specific gravity. The pattern of wood specific gravity with height is quite consistent for all three trees. Relatively little variation occurs over most of the stem length, but both the butt end and unmerchantable top are greater in value. The density-distribution curves point to the greater flotation problems from material either in butt sections or from the upper portions of stems.

It should be pointed out that, by design, the density distributions are for knot-free wood. In whole-stem material, increasing density with height would be accentuated by the presence of greater proportions of knot material in the upper levels of trees. The high density of knots is indicated by the specific gravity values for the branch components shown in Table 2. For each of the trees, the bole segment is the least dense component.—R. M. Kellogg and J. L. Keays, Forest Products Laboratory, Vancouver, B.C.

A simple Formula for Predicting Veneer Lathe Settings.—This preliminary study was undertaken to derive a mathematical expression for the relationship between horizontal and vertical openings as a function of veneer thickness, roller-bar diameter, knife bevel, wood species, wood-moisture content and cutting temperature.

It is assumed that the external forces acting on a veneer chip, which is positioned with two-thirds of its length over the knife face, can be resolved into a bending moment and a horizontal and vertical component. At failure, these external forces must exceed the internal resistance of chips in transverse tension and rolling shear. Thus the following function may be obtained:

$$H^3+H^2(R-2T)+HT[(T-2R)-\tfrac{1}{3}V(Z+2S(\sin K))]$$
$$+T^2[R+\tfrac{1}{3}V(Z+2S(\sin K))]=0$$

where

T = veneer thickness (in.)
R = radius of roller-bar (in.)
H = horizontal opening (in.)
V = vertical opening (in.)
K = effective bevel angle (deg.)
G = oven-dry specific gravity
S = 2Ga/b—species effect
Z = 2Gc/b—species effect
a = { rolling shear stress / longitudinal cleavage stress } (psi)
b = transverse compressive stress (psi)
c = transverse tensile stress (psi)

It is evident from the equation that all factors interact with each other. A very close relationship is indicated between horizontal opening, veneer thickness, and roller-bar diameter. These appear to be the dominant factors, together with the vertical gap. Similarly, the influence of wood species, effective bevel angle, and vertical opening are highly correlated. The role of species and bevel angle, however, seems to be underestimated by the formula.

This function implies that optimum horizontal compression should increase with decreasing veneer thickness, decreasing roller-bar diameter, increasing vertical opening, and increasing effective bevel angle for any species. When using roller-bars of large diameter, the optimum compression becomes more uniform for the different veneer thickness. The term (R—2T) may be interpreted to define the optimum relationship between roller-bar diameter and veneer thickness as presented in Table 1. The consistently low peel-quality of thick veneers in industrial production may be partially attributed to the undersized roller-bars used.

TABLE 1

Suggested Roller-Bar Diameters

Veneer thickness (in.)	Roller-bar diameter		Comment
	Minimum (in.)	Suggested (in.)	
1/20	1/5	2/8	N.A.
1/10	2/5	4/8	N.A.
1/8	1/2	4/8	N.A.
1/7	9/16	5/8	C.U.
1/6	21/32	6/8	R.U.
1/5	4/5	7/8	N.A.
1/4	8/8	8/8	N.A.

N.A. = not available; C.U. = commonly used; R.U. = rarely used.

Lathe settings were already established for Douglas-fir veneers of different thicknesses, using a $\frac{5}{8}$-inch roller-bar and a knife main-bevel angle of 21° 30′, by a trial-and-error technique (Feihl, O., H. G. M. Colbeck and V. Godin. Can. Dep. Forest. Pub. No. 1004. 31 pp. 1963). A calculated horizontal gap of 0.080 inch falls reasonably close to the recommended 0.075 inch for 1/10-inch-thick Douglas-fir heartwood veneer. This formula, however, slightly underestimates the horizontal gap for thick veneer sheets. Further testing under experimental conditions with different species has shown some correlation between predicted and published lathe settings.

The significance of this equation is that it effectively summarizes the scattered qualitative information found in the literature of rotary-cutting, by providing a fairly realistic functional relationship between the six basic factors determining veneer-peel quality.

Encouraged by the usefulness of even this simple function, more complex analytical models that promise a more accurate theoretical prediction of optimum lathe settings are currently being evaluated.—L. C. Palka, Forest Products Laboratory, Vancouver, B.C.

Electrical Conduction in Wood.—Brown, et al. (Forest Prod. J. 13(10):455. 1963) using theirs and Uyemura's results (Bull. Govt. Forest Expt. Sta. No. 119, 95. 1960. Tokyo, Jap.) explained electrical conduction in wood in the light of Hearle's dissociation hypothesis (J. Tex. Inst. 44:T177-T198. 1953).

According to this hypothesis, conductivity $\varkappa$ is related to the permittivity ε by a relationship of the form $\log \varkappa = B - (C/\varepsilon)$. Here B is a constant which involves the concentration of electrolyte in gram equivalents per cc of wood, the ionic mobility in cm per second per unit field strength in volts per cm, the degree of dissociation and the Faraday constant. C is given by $0.434(I_o/2RT)$, where I_o is the energy required to separate the ions in vacuum, and R and T are gas constant and temperature in degrees Kelvin, respectively. Brown (*loc. cit.*) tested this equation for wood over a 5-25% M.C. range and over frequencies from 2-15 MHz. Their results supported the assumption of a linear relationship between $\log \varkappa$ and $1/\varepsilon$.

In our work conductivity and permittivity measurements were made on two species of wood (densities 0.46 and 0.38 g per ml at 70 F and 65% relative humidity) over a frequency range of 100 Hz to 100 KHz and from 0-20% M.C. The dielectric parameters were measured with a General Radio conductance bridge. The dielectric cell was that designed and constructed by Nanassy (Rev. Sci. Inst. 36(6):756. 1965). The M.C. of the wood was adjusted over the range 0-20% by means of salt solutions in the cell. Analysis of the new findings showed that $\log \varkappa$ was directly proportional to $1/\varepsilon$ only at constant frequency. As the frequency changed the value of the slope C remained essentially constant, whereas the intercept B varied strongly with the frequency.

The variation of B with the frequency is nearly proportional, which suggests that the frequency dependence involves the ionic mobility u, and that this ionic mobility is in turn related to the relaxation time τ in a form $u = u_o f(\omega\tau)$ where $\omega = 2\pi$ times the frequency in Hz.

Our results suggest that Hearle's hypothesis needs further refinement to accommodate this frequency dependence.—A. Venkateswaran, Forest Products Laboratory, Ottawa, Ont.

PATHOLOGY

Stimulation of *Armillaria mellea* Rhizomorphs With Alder Extracts.—Raabe (Phytopathology. 52:364. 1962) reported that the rhizomorph production of *Armillaria mellea* (Vahl. ex Fr.) Kummer was stimulated by extracts from a number a wood species. Weinhold et al. (Phytopathology. 52: 757. 1962) suggested the stimulatory substance was indol-3-acetic acid. This report enumerates the stimulatory effects obtained with a hot water extract of red alder [*Alnus rubra* Bong.] on the development of *A. mellea* rhizomorphs.

One hundred g each of wood, bark, and wood plus bark shavings in 500 ml of distilled water were steamed for 3 hr. The decoctions were filtered through Whatman No. 4 filter paper and the filtrates brought to 500 ml with distilled water.

Nine-cm petri dishes containing approximately 30 ml of the following media were inoculated, in triplicate, with a 4 mm disc from the advancing margin of a 2-3 week-old culture of *A. mellea* isolated from *Picea glauca* (Moench) Voss.

1) Basal medium—Bacto malt extract 1.25 g; thiamine hydrochloride 0.1 mg; Bacto agar 2 g; distilled water 100 ml.

2) Basal medium with 5, 10, 15, 20, 25, 50 and 100% of the distilled water replaced with extract.

3) Basal medium plus 5 ppm indol-3-acetic acid.

4) Basal medium plus 500 ppm ethyl alcohol.

The media were autoclaved at 15 psi for 20 min, and adjusted to pH 5.5 with 0.1 *N* sulphuric acid or 0.1 *N* sodium hypochloride. Idol-3-acetic acid, ethyl alcohol and thiamine hydrochloride were added after autoclaving.

The numbers and lengths of the rhizomorphs were recorded 2 weeks after the media were inoculated.

Rhizomorphs were not produced on the basal medium but were present in all plates containing extract (Table 1). The optimum concentration of wood and wood plus bark extract was between 25 and 50%; rhizomorphs occurred at concentrations of 100% but their growth was considerably less than at optimum concentrations. The greatest number of rhizomorphs on bark extracts occurred when the concentration was 100%, but the average length was not appreciably increased at concentrations above 15%. Bark extracts at concentrations above 15% were less effective than wood and wood plus bark extracts.

TABLE 1

Armillaria mellea rhizomorph development on basal medium containing various concentrations of alder extract

conc. %	Wood		Bark		Wood + Bark	
	no. per plate[a]	avg length cm	no. per plate[a]	avg length cm	no. per plate[a]	avg length cm
0	0	—	0	—	0	—
5	3	1.3	6	0.7	6	1.5
10	10	2.8	6	0.8	11	2.3
15	15	4.5	7	1.3	11	4.4
20	22	5.5	12	1.8	19	4.8
25	30	5.4	16	1.8	24	4.9
50	25	6.0	12	1.5	21	5.3
100	15	3.2	23	1.4	25	3.7

[a]Average of three replicate plates.

The addition of indol-3-acetic acid at 5 ppm and ethanol at 500 ppm to the basic medium stimulated rhizomorph development; an average of 11 and 9 rhizomorphs, respectively, per plate were present, the average length of which were 3.6 and 3.0 cm, respectively. These results were in agreement with the optimum growth reported by Weinhold et al. (*loc. cit.*) and Weinhold (Science. 142: 1065-1066. 1963) but are well below the optimum growth obtained with alder extracts (Table 1).

A detailed biochemical analysis of alder extracts is planned to define the stimulatory substances.—P. S. Rehill, formerly Post Doctorate Fellow, Forest Research Laboratory, Victoria, British Columbia, now Forest Research Institute and Colleges, P.O. New Forest, Dehra Dun-5 (U.P.) India.

SILVICULTURE

Mortality and Height Growth of Red Pine Provenances in Manitoba.—In 1956 the Petawawa Forest Experiment Station initiated an interprovincial red pine [*Pinus resinosa* Ait.] provenance experiment.

Seed collection was undertaken by untrained collaborators and therefore proper information about the seed sources was somewhat obscured. The brief seed-source data that were recorded are shown in Table 1.

One of the trials was established near the western limit of the range of red pine (Fowler. Silvae Genet. 13:170-177. 1964) in the Sandilands Provincial Forest in southeastern Manitoba. The experimental area originally supported a natural stand of jack pine [*Pinus banksiana* Lamb.] which was clear-cut and slash piled and burned about 1950. Topography is flat; the soil is an excessively drained sand to loamy sand. The site is mesotrophic fresh minus (Müeller-Dombois. Can. J. Bot. 42:1417-1444. 1964). The lesser vegetation was characterized by a dense cover of bearberry [*Arctostaphylos uva-ursi* (L.) Spreng.] and abundant grasses.

Four-year-old, uniformly handled transplants were shipped from Petawawa, Ont. Condition was not recorded. Some replanting of failed spots has been done since 1965 using species other than red pine.

Nine provenances of red pine were planted in a randomized block design with five replications. Forty-nine seedlings were planted per plot at 4 x 4 ft spacing. Seedlings of local origin were used in two external surround and one internal dividing rows.

TABLE 1

Source, mortality and growth data for 10 red pine provenances planted in southeastern Manitoba

Code Number	Source	Lat°	Long°	Annual[a] precip. (in.)	Frost-free days	10-year mortality (%)	Height 1967 (cm)	Growth 1963/67 (cm)
	Nova Scotia							
S2045	Stanley, Hants County	45.0	63.0	42.32	158	84	116	47
	New Brunswick							
S2046	Grand Lake	46.0	66.0	39.90	93	36	120	47
	Quebec							
S2114	Kenogami Lake, Plessis Twp	48.3	71.5	38.72	107	79	130	55
	Ontario							
S1718	Pedley Twp, east of Sturgeon Falls	46.3	80.0	35.07	92	68	136	56
S1715	Thessalon,[b] S ½ Lot 4, Wells Twp	46.3	83.5	30.00	83	30	133	54
S1716	Sault Ste. Marie, Point aux Pins	46.5	84.0	30.00	83	50	130	53
S1714	Petawawa[c]	45.9	77.3	29.21	122	27	127	50
S1717	Regina Bay 40 miles SE of Kenora	49.4	94.0	25.80	128	47	142	62
	Manitoba							
96-J	Eastern sec. of Sandilands	49.2	95.0	21.59	72	18	120	57
	U.S.A.							
S1712	Raco, Mich.	46.4	85.1	30.00	83	8	140	57

[a]Climatic data were obtained from nearby weather stations.
[b]Continental area.
[c]Great Lakes—St. Lawrence Region, Middle Ottawa Section.

Mortality was assessed after the 1st, 2nd, and 10th growing seasons. Height of survivors was measured in 1963 and after the 10th growing season in 1967.

Analysis of variance was applied to assessments of mortality in 1963 and 1967. Seven dividing rows per block of the local seedlot were included in the analysis. Number of trees (49 at the time of planting) and conditions were the same for the local provenance as for the other provenances planted in square plots. Differences in mortality at the 5% level were found among the provenances. The overall mortality averaged 46% in the first growing season and no substantial change occurred in the following years. The mortality of each of the 10 seed sources was correlated at the 5% level with annual precipitation ($r = .664$) and with frost-free days ($r = .582$) in the source locality. Provenances from Stanley, N.S., Kenogami, P.Q., and Sturgeon Falls, Ont., where annual precipitation is high, showed the poorest survival when planted in Sandilands. These provenances appeared to be affected more than the westerly provenances by the drought which occurred in the late spring of 1958.

The analysis of growth data was not possible. After 10 years, the numbers of the surviving trees are highly variable in each plot. The unequal number of trees per plot precludes the use of a standard randomized complete block analysis of the growth data. However the uniform growth rate of the 10 seedlots suggests that the trees were not affected by the varying plot densities caused by the high mortality in several seedlots. The three internal blocks exhibit more rapid growth than the two external blocks located on the western and eastern sides of the experiment. The lesser rate of height growth in the external blocks may be the result of various border effects such as more weed competition and more exposure to wind, frost and radiation.

In respect to mortality and height growth, the rank of provenances shows that the poorest seed sources were from the Maritime Provinces and the best were from Raco, Michigan. The Regina Bay seed source exhibited superior height and medium mortality while the local seedlot appeared to improve its height growth with age.

Results after 10 growing seasons strongly suggest that seed source is an important factor in performance of planted red pine. The varying response to drought, at the beginning of the trial, could be the result of selection produced by the differences in ecological factors at the different seed sources. Results of the trial indicate that red pine seeds obtained from the east coast are unsuitable for planting in Manitoba.—K. J. Roller, Forest Research Laboratory, Winnipeg, Man.

(*Continued from back cover*)

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FBC - MONTHLY

RESEARCH NOTES

IN THIS ISSUE:

Vol. 24—No. 5, SEPTEMBER-OCTOBER, 1968

BI-MONTHLY

RESEARCH NOTES

A selection of notes on current research conducted by the Department of Fisheries of Canada

NOTES TO AUTHORS

Content: The title, *Bi-monthly Research Notes,* indicates the content. Bare empirical or observational data are not sufficient without some indication of their significance or implications; only essential data can be included. Notes on new techniques or apparatus, or effective adaptions of existing ones, are acceptable, but such information must not have been published elsewhere. Data should be presented in the most appropriate form (textual, tabular, graphic or photographic) but in only one form. Currently, *Bi-monthly Research Notes* is mailed to 61 countries, hence the need for jargon-free presentations.

Manuscript: Manuscripts may be in either English or French. They should be typed, double spaced with 1½ inch margins, on manuscript paper (FD-5 and FD-6) and submitted in three copies (typescript and two carbons) under cover of a manuscript routing form (FR-28). Tables and captions must be double spaced; each table must be on a separate page but several captions may be placed on a single page. Manuscripts are subject to review and acceptance or rejection at the discretion of the Program Coordinator concerned and/or referees. Manuscripts not returned for revision or rejected within 3 weeks may be considered as accepted. Authors may expect publication within 4 months.

Style: Titles are to be typed as "run-in" heads after normal indentation for a paragraph. Titles are followed by a period and a dash. Text commences immediately following the dash. References are "in text" and include author's surname, abbreviated name of publication, volume, pages, and year, e.g. (Lewis, Can. J. Bot. 48:127-140, 1968) or Lewis (Can. J. Bot. 48:127-140, 1968). A note is concluded by a period followed by a dash, author's initials and name, unit, city, and province, e.g.—A. J. Lewis, Forest Products Laboratory, Ottawa, Ont.

The *Style Manual for Biological Journals,* American Institute of Biological Sciences, 2000 P Street N.W., Washington, D.C. 20036, is used as a guide, except for references and the abbreviations for the titles of publications. For the latter, the current *American Standard for Periodical Title Abbreviations* (Z39.5-1963) is used. Both the spelling and the meaning of words follow *Webster's Third New International Dictionary.*

Text must be as concise as is compatible with clarity, and should not exceed four pages, including tables and figures. Use of jargon or colloquialisms often leads to misinterpretation and ambigious translations. Titles should be short, and footnotes avoided.

Figures: Figures are printed as either line (graphs, maps) or half-tone (photographs). They should be prepared for reduction to 3¼ inches (one column) or 6¾ inches (two columns) in width. The 3¼ inch width is preferred. Figures are acceptable only if they are essential to the exposition.

Tables: Tables that are one column in width (48 spaces including all punctuation, spaces between words, etc.) are preferred. Consideration should be given to incorporating short tables into the text; this also applies to rows or columns of a table that contain only "nil" results. Normally it is necessary to give only the results of calculations or summary tabulations; if complete calculations or tabular data are needed by the reader, he may obtain them from the author.

ENTOMOLOGY

Artificial Nesting Material Used in Propagating Ants.—An important aspect of investigations on ants as control agents of insect pests is the determination of the main factors limiting ant populations, and change or modification of these factors to increase the populations. In coniferous plantations established on abandoned farmland or pastureland, a smaller number of ants have been found than are normally present in forested areas due to lack of suitable nesting material or to the severe environment.

To encourage rapid establishment of ants in such areas, two synthetic materials commercially known as "sterospan" and "sterofoam", as well as decaying wood in the form of stumps and fallen logs, were tested in artificially established nests.

After 2½ years (three winters) three species of *Formica* (*F. sanguinea* Emery, *F. fossaceps* Buren, and *F. fusca* Linnaeus) and three species of *Camponotus* (*C. noveboracensis* (Fitch), *C. herculeanus* (Linnaeus), and *C. pennsylvanicus* (Debeer)) accepted and thrived as well in nests supplied with decaying wood as in those supplied with sterospan plastic. For unknown reasons, sterofoam was not used in any visible way by the ants, other than for shelter from drenching rains when ants grouped in small tunnels made immediately underneath the plastic. Only one nest (out of about 20) supplied with sterospan was abandoned by the ants. This was a nest of *F. fossaceps* which had been collected several hundred miles away on a completely different site.

Species of *Camponotus* (and to a lesser extent of *Formica*) made eleborate tunnels in sterospan (Fig. 1). The tunnels extended throughout the sterospan but seldom penetrated the upper surface of the plastic.

Although decaying wood was also readily accepted as nesting material by all species of ants, we considered it

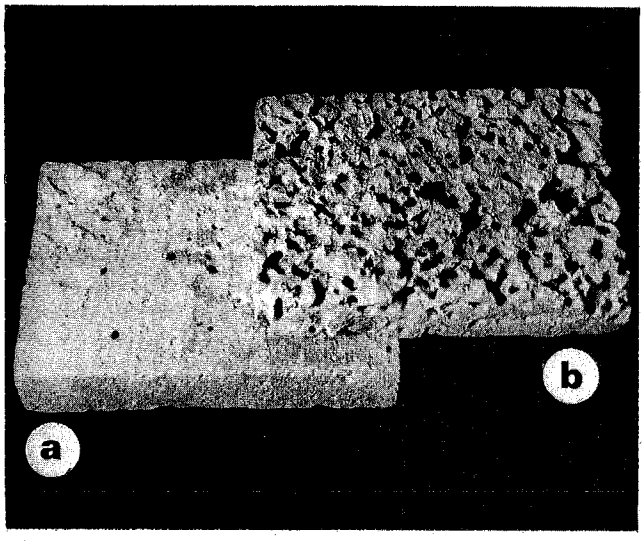


FIGURE 1. Block of sterospan showing tunnels made by *Camponotus herculeanus*; a—upper surface, b—lower surface.

inferior to the sterospan because: (a) sterospan will last much longer than wood when buried in the soil, permitting the ants to attain larger increases in numbers without having to abandon the old nest for a new site when the wood has rotted and disappeared; (b) sterospan is readily available, while suitable decaying wood is sometimes difficult to find; (c) sterospan is easily shaped into any desired form and size, is light to transport, and has good insulation properties; (d) additional pieces of sterospan can be added to established nests as required.

In Europe, where artificial propagation of ants has been studied for many years, experience has been that as much as 80% of transposed nests, using natural nesting material only, are abandoned shortly after the nests are re-established. This has proved costly and at times restricts research programs. Our experience indicates that use of sterospan would ameliorate such conditions.— R. J. Finnegan, Forest Research Laboratory, Sillery, Quebec.

Starvation Experiments with First Instar Forest Tent Caterpillar Larvae:—An extensive outbreak of the forest tent caterpillar [*Malacosoma disstria* Hbn.] in central and northern Alberta collapsed during late May 1964. A high percentage of eggs hatched, but most of the larvae disappeared during the first or second instar (Brown and Stevenson. *In* Ann. Rep. Forest Insect and Disease Surv. 1964, pp. 98-99). Collapses of tent caterpillar outbreaks during the early larval instars have also been recorded by Sippel (Can. Entomol. 94:416, 1962) and Hodson (Dep. Entomol., Univ. Minn., personal communication, 1966). Termination of these and other outbreaks (Blais et al., Can. Entomol. 87:1-8, 1955) has been attributed to either the direct effect of late spring frosts, or the indirect effect of unfavorable spring weather which may freeze new leaves or delay flushing of trembling aspen [*Populus tremuloides* Michx.] and subsequent starvation of the young larvae. Indications of starvation occurred in 1964 when hatching preceded leafing of aspen by about 8 days. Following are the results of experiments to determine how long first instar larvae can survive without food and to observe their behavior.

Forest tent caterpillar egg bands were collected in Sept. 1964 from nine locations in central Alberta where populations were at outbreak levels. The eggs were stored at 38 F until Jan.-Feb. 1965 when they were incubated at 72 F. Each experimental colony consisted of about 100 larvae less than 48 hours old from a single egg band. Treatments were performed either in a temperature and humidity controlled room (72 F, 62% R.H.), or in temperature controlled cabinets, in which moisture was supplied once daily with an atomizer.

Nine control colonies were reared on aspen foliage in the temperature and humidity controlled room. Six of these were discarded after 11 days, during which time all larvae developed to late second instar. The three remaining colonies were reared to adults. Disease was not observed in the control colonies and was not considered a factor in these experiments.

The treatments and results are summarized in Table 1. The substratum was unleafed living aspen for each treatment except 2, where it was a plywood stick, and 7 where it was fresh aspen leaves. At constant high temperatures (Treatments 1 and 2), when the metabolic rate was high for 24 hours each day, newly hatched larvae withstood a minimum of 9 days complete starvation, whereas at constant low temperatures (Treatment 5) most of the larvae lived for 30 days. Apparently these larvae did not obtain nourishment from aspen bark, because larvae lived as long on plywood sticks as on live aspen stems (Treatment 2). When temperature approximated Alberta spring temperatures (Treatment 3 and 4), larvae withstood 2 to 3 weeks of starvation. Starvation initiated after 2 days feeding did not seem to affect the length of time that larvae lived (Treatment 7 in which, after 15 days, larvae were placed in a refrigerator at 18 F). Even exposure to excessive

TABLE 1

Effect of various environmental factors on survival of first-instar forest tent caterpillar larvae

Treatment and Lighting[a]	Temp. °F	Time hours	R.H. %	Number of Colonies	Average days to— First mortality	Major mortality[b]	Last Live Larva
1 L	72	14	62	7	8	9	12
D	72	10	62				
2 L	72	14	62	1	9	10	12
D	72	10	62				
3 L	55	16	40–50	3	9	13	15
D	30	8	40–50				
4 L	72	8	75	3	19	22	28
D	38	16	75				
5 L	38	12	38	2	22	30	47
D	38	12	38				
6 L	55	16	40–50	2	9	—	—
D	30	8	40–50				
7 L	72	14	62	30	—	11	20
D	72	10	62				

[a]L Light; D Dark.
[b]At least 75% cumulative mortality.

low temperatures of short duration did not cause large scale mortality: treatment 6 in which, after 15 days, larvae were placed in a refrigerator at 18 F for 2 days and on return to 72 F they commenced feeding. In addition, one colony from each of treatments 1 and 5 was removed after 10 days; each commenced feeding and survived.

In 1964 and 1965, living colonies were found on trees which did not leaf until 10 to 16 days after the eggs had hatched. These observations and this experiment support the hypothesis that starvation is not a major cause of death when the leafing-out of aspen is delayed.

A comparison of larval behavior just prior to death of laboratory-starved colonies with that in the field at the time of the population collapse revealed the following differences: 1) Laboratory colonies died over a period of several days. The larvae lowered themselves to the floor or firmly attached themselves to the branch with silk before dying. In the field colonies disappeared abruptly. They were never observed lowering on silk. 2) When disturbed, larvae in the laboratory remained on the branches but those in the field immediately lowered *en masse*. 3) Laboratory larvae travelled very little and then towards the top of the branch whereas those in the field travelled extensively up and down the tree trunk. 4) Laboratory larvae were able to move to and feed on foliage whereas those in the field did not feed after moving onto new foliage. These differences in behavior indicate that factors other than starvation caused the large scale mortality.

We conclude that starvation may cause the death of individuals or individual colonies, but that it is highly unlikely to be the cause of the complete collapse of whole populations over large areas. However, starvation in combination with other factors such as weather, disease, or qualitative population changes may influence the mortality rate of first instar larvae.—G. J. Smith and A. G. Raske, Forestry Research Laboratory, Calgary, Alta.

Relation of Light Trap Catches of Bruce Spanworm to Infestations in Central Nova Scotia.—In recent years the operation of light traps by the Forest Insect and Disease Survey in the Maritime Provinces has provided useful information on moth activity, mass flights, changes in abundance from year to year and has helped to predict and locate outbreaks. Some evidence of this is in records of catches of adult males of the Bruce spanworm [*Operophtera bruceata* (Hulst.)] at the Forest Entomology Laboratory, Debert, Nova Scotia from 1957 to 1965. The Bruce spanworm, a native

insect known to occur in all provinces of Canada, has been collected in small numbers in the Maritimes for many years but no infestations had been recorded before 1962. From 1962 to 1965 the insect caused severe and widespread defoliation of hardwoods, mostly sugar maple [*Acer saccharum* Marsh.] and beech [*Fagus grandifolia* Ehrh.] in New Brunswick and Nova Scotia.

The light trap at Debert, unidirectional and equipped with four, 15-watt fluorescent (black light) lamps, is operated continuously each year from early spring to late fall. Males of the Bruce spanworm (females are flightless) are active from mid-October to mid-November when most other insects are inactive.

Table 1 shows the relationship between the numbers of males trapped at Debert, the extent of severely infested areas in the Cobequid Mountains of Cumberland and Colchester counties, and the numbers of adults (males and females) per 50 sq ft of soil surface at Wentworth, about 12 miles northwest of Debert.

TABLE 1

A yearly comparison of three indicators of Bruce spanworm densities in central Nova Scotia, 1957–1966

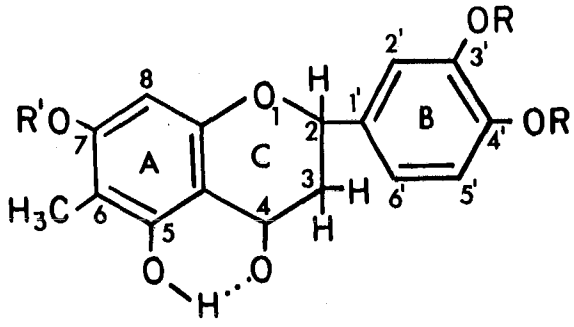
Year	Total adults trapped	Acres of severe defoliation	Adults per 50 sq ft
1957	1	0	—
1958	1	0	—
1959	0	0	—
1960	0	0	—
1961	8	0	—
1962	10	2,560	—
1963	68	330,000	239
1964	8	496,000	60
1965	3	48,000	0
1966		10	

These light trap data predicted correctly the fluctuations in the extent of severe Bruce spanworm infestations each year from 1962 to 1966, and they were related to measured adult populations in the forest. Thus it appears that, with positively phototropic lepidopteran species whose numbers fluctuate considerably over large areas, light traps offer considerable promise as a tool in predicting and monitoring insect infestations.—W. Harrington, Department of Forestry and Rural Development, P.O. Box 667, Truro, N.S.

FOREST PRODUCTS

New C-Methyl Flavanones from Douglas-fir Roots.—The present concern over the spread of root rot [*Poria weirii* Murr.] in second-growth stands of Douglas fir [*Pseudotsuga menziesii* (Mirb.) Franco] (Wallis and Reynolds, Can. J. Bot. 43:1-9, 1965) has resulted in current studies by the Vancouver Forest Products Laboratory (Barton, Can. J. Bot. 45:1545-1552, 1967) on phenolic-extractive differences between diseased and healthy roots. The first new compound to be characterized from these extractives was poriol, a C-methyl flavanone associated with diseased roots (Barton, Can. J. Chem. 45:1020-1022, 1967). A second C-methyl flavanone has now been discovered which, unlike poriol, has been isolated from healthy root bark and in high yields of up to 2.6% (by weight based on dry root bark). Limited tests to date have shown the new flavanone to be absent from diseased root bark. The structure of this new C-methyl flavanone, m.p. 255-257 C, is proposed as I (Fig. 1).

Details of its structure determination are summarized briefly as follows: a positive color test (violet) with magnesium-hydrochloric acid and a classical ABX absorption pattern of ring C protons (compound III) showed that I was a flavanone.



I R = H, R' = glucose

Ia R = R' = H

II R = CH_3, R' = H

III R = R' = CH_3

FIGURE 1. New C-methyl flavanones from Douglas-fir roots.

Mild hydrolysis gave two main fragments, glucose and aglycone Ia, as well as a smaller quantity (25% of total) of rhamnose. High resolution NMR spectroscopy I, II and III showed the main substitution pattern for rings A and B, namely: a hindered hydroxyl group, carbon 5; a single aromatic proton, presumably on ring A; a typical ABC aromatic proton pattern, presumably on ring B; and a C-methyl group on either carbon 6 or 8. Since the NMR spectrum of compound III had shown the presence of three methoxyl groups and color tests (Schroeder, J. Chromatogr. 30:537-542, 1967) indicated vicinal hydroxyl groups in compound I, it must be concluded that the sugar moiety must be attached to carbon 7. Final proof of structure was obtained by dehydrogenation of compound III to give the known derivative 6-methyl-luteolin, 3,3',4'-trimethyl-ether, m.p. 202-203 C.

The presence of rhamnose in addition to glucose in the hydrolysate of I suggested the possibility of a rhamnoside as well as a glucoside. The possibility of a rutinoside was ruled out on the basis of insufficient proton signals in the NMR spectrum of I.

Pathological testing of compound I against *P. weirii* is being done by Dr. G. W. Wallis at the Forest Research Laboratory, Victoria, B.C. Complete details of the purification and elucidation of compound I will be published elsewhere.—G. M. Barton, Forest Products Laboratory, Vancouver, B.C.

Photodegradation of Glucose and Cellobiose as Model Compounds for Cellulose.—In an earlier study, the authors found that the volatile products on photodegradation of cellulose contained several low molecular weight organic compounds such as acetaldehyde, propionaldehyde, acetone, methanol, etc. (Bi-Mon. Res. Notes. 23:37, 1967). These compounds were produced after 2 to 3 hours exposure of the cellulose material to ultraviolet light, but were not detected during the first hour of exposure. However, the presence of CO, CO_2 and H_2 in the photolyzed products of cellulose (Desai, Bi-Mon. Res. Notes 22:5, 1966) was detected even with brief 10- to 15-minute exposures. These observations suggest that the low molecular weight organic compounds may result from the secondary degradation of the exposed material.

A study of the degree of polymerization (DP) of photodegraded cellulose by the viscosity method indicated a large drop in the molecular size of the cellulose macromolecule during the first hour but, with longer exposure, the DP decreased

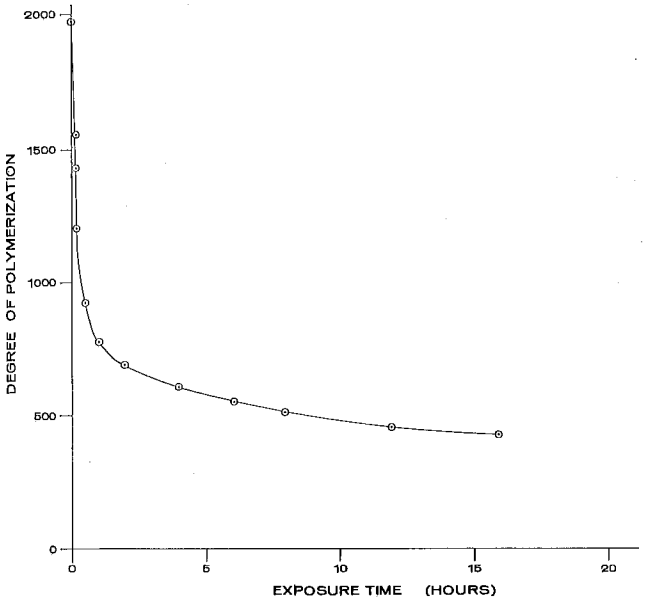


FIGURE 1. Decrease in DP of irradiated cellulose as a function of exposure time.

at a relatively slow rate (Fig. 1). The DP of the exposed material decreased by 80% at the end of a 16-hour exposure, 60% of this decrease occurring within the first hour. Furthermore, the presence of glucose, cellobiose and other oligosaccharides have been reported in the exposed material (Beelik and Hamilton, Das Papier. 13:77, 1959). It is quite possible that these latter compounds may further degrade due to the action of ultraviolet light and yield the low molecular weight organic compounds observed with photodegradation of cellulose after 2 to 3 hours exposure. Therefore, a study was undertaken to examine the volatile products of photodegradation of glucose and cellobiose as model compounds.

One gram of the material was exposed to the ultraviolet light from a 550-watt Hanovia high-pressure mercury-vapor lamp. The volatile products were then examined by gas chromatography. There is a very good agreement between the retention times of the known reference compounds and those of the components of the gaseous products of photodegradation of glucose and cellobiose (Table 1). These results indicate that the primary process in the photodegradation of cellulose probably involves mainly the chain cleavage of the macromolecule and the production of CO, CO_2 and H_2, while the other low molecular weight organic compounds, detected after longer exposures of the cellulose material, are the products of secondary degradation of the exposed material. Further studies are in progress to understand the exact mechanism of the production of the various degradation products.—R. L. Desai and J. A. Shields, Forest Products Laboratory, Ottawa, Ont.

TABLE 1

Relative retention times[a] of known compounds and unknown components

Compound	Column No. 1 25-ft Carbowax 20M on Haloport at 100 C			Column No. 2 10-ft Ucon Polar 50HB–5100 on Chromosorb at 22 C		
	Reference compounds	Glucose photolysis products	Cellobiose photolysis products	Reference compounds	Glucose photolysis products	Cellobiose photolysis products
Air	1.00	1.00	1.00	1.00	1.00	1.00
Acetaldehyde	1.92	1.92	1.92	1.865	1.865	1.87
Methyl formate	2.28	2.28	2.27	2.49	2.49	2.47
Propionaldehyde	2.66	2.67	2.67	3.11	3.11	3.08
Acetone	2.90	2.95	2.96	3.61	3.58	3.56
Methanol	3.69	3.70	3.71	5.94	5.99	6.00
Ethanol	4.38	4.41	4.44	8.06	8.12	8.14

[a]Expressed relative to air peak.

Erratum

Vol. 24, p. 32, Table 2: delete "<3″ dia" and insert ">3″ dia".

PATHOLOGY

Squirrel Feeding on Dwarf Mistletoe Infections.—A dwarf mistletoe [*Arceuthobium americanum* Nutt. ex Engelm.] infected lodgepole pine [*Pinus contorta* Dougl. var. *latifolia* Engelm.] stand was surveyed for disease intensity near Lake Louise, Alta., 25 Mar. 1968. Extensive feeding by the British Columbia red squirrel [*Tamiasciurus hudsonicus columbiensis* Howell.] was observed on the living bark tissues of dwarf mistletoe infected branches. Similar squirrel feeding was observed at Cottonwood Camp Ground, near Jasper, Alta., 15 May 1968 and in the Beaverdam Lake area, of British Columbia, 4 Jul. 1968. These widely spaced observations indicate that feeding on dwarf mistletoe infections is a general habit of this squirrel.

Small branches, about ¼ inch diameter, infected with dwarf mistletoe were cut by the squirrels and carried to caches where cones were usually husked for the seed or to trees with dense crowns. The bark of the swellings was gnawed. Old, resinous, healed wounds on the swellings were not touched. Feeding was restricted to the bark in the vicinity of the infection (Fig. 1). The fresh white color of the

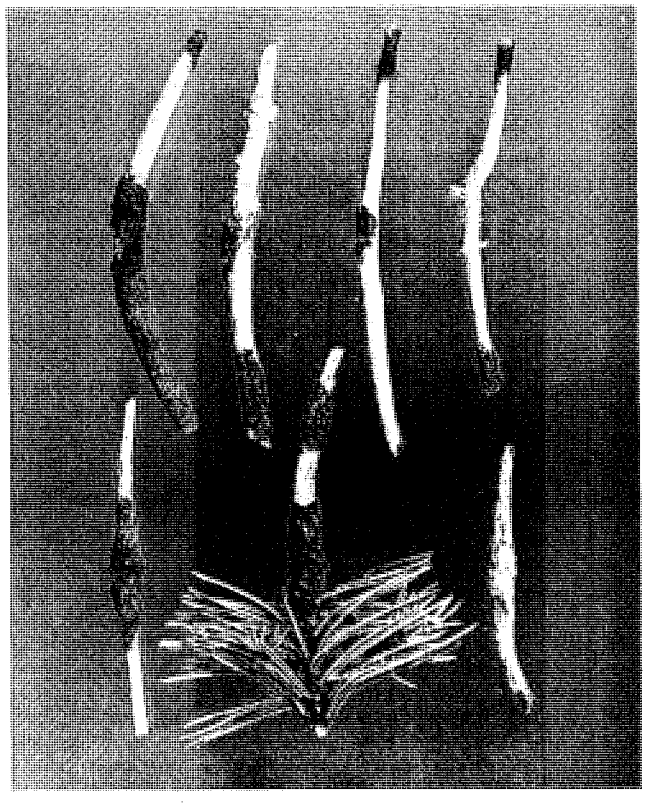


FIGURE 1. Red squirrels gnaw the thick, soft bark, which is induced by dwarf mistletoe infections.

debarked swellings in the Lake Louise area indicated that the feeding on the swellings started only a few weeks prior to the observation. The debarked twigs at Jasper and Beaverdam Lake were moldy and dried, indicating that the feeding is likely restricted to the months of March and April only.

Klugh (J. Mammal. 8:1-32, 1927) observed that red squirrels feed on the bark of some species of deciduous trees at all seasons of the year. Squirrel feeding was observed on peridermium rust infected lodgepole pine bark during late winter and early spring (Mielke, J. Forest. 54:518-521, 1956). Korstian and Long (U.S. Dep. Agri. Bull. 1112, 1922) reported that the cortex of dwarf mistletoe infected branches are frequently gnawed by porcupine and squirrels, but extensive cutting of mistletoe infected lodgepole pine branches by red squirrels has not been previously reported.—J. A.. Baranyay, Forest Research Laboratory, Calgary, Alta.

Ascospore Discharge of *Lophophacidium hyperboreum* and *Phacidium abietis*.—*L. hyperboreum* Lagerb. and *P. abietis* (Dearn.) Reid & Cain in Quebec are associated with snow blight of several species of conifers (Smerlis and Saint-Laurent, Plant Disease Rep. 50:356-357, 1966; Smerlis, Plant Disease Rep. 51: 678-679, 1967). The two fungi caused damage in natural stands, plantations and nurseries by killing foliage under the snow.

Although *L. hyperboreum* and *P. abietis* have been know for many years, ascospore maturation and period of discharge has never been definitely established. It is known only that ascospores of *L. hyperboreum* (Faull, J. Arnold Arboretum 10:3-8, 1929; Legerberg. Svensk Botanisk Tidskr. 43-420-437, 1949) and of *P. abietis* (Faull, J. Arnold Arboretum 10:3-8, 1929) mature and are disseminated in the fall. To obtain more detailed information, ascospore discharge of the two fungi was investigated. Duration of discharge and effect of relative humidity were the two aspects studied.

The duration of ascospore discharge of *P. abietis* was determined at Lake Valois (alt 2,700 ft) in Laurentide Park in 1962 and that of *L. hyperboreum* at Lake Jacques Cartier (alt 2,700 ft), 10 miles northeast of Lake Valois, in 1966. Nine spore traps were set up on balsam fir [*Abies balsamea* (L.) Mill.] at Lake Valois and eight on black spruce [*Picea mariana* (Mill.) BSP.] at Lake Jacques Cartier. The traps and method used were described previously (Smerlis, Bimon. Res. Notes. 24:10, 1968).

Ascospore discharge of *P. abietis* began in the third week of September. Increasing gradually in intensity, it reached a maximum in the second week of October. Subsequent spore discharge was light. A slight increase in intensity occurred during the last week of October. No spores were caught after the third week of November.

Ascospore discharge pattern of *L. hyperboreum* was very similar to that of *P. abietis*. The first spores of *L. hyperboreum* were caught in the third week of September. The discharge increased gradually in intensity until the maximum was reached in the second week of October. Subsequent discharge was light, with a slight increase during the fourth week of October. Ascospore discharge ceased during the third week of November.

Ascospores of both species were discharged only at 100% relative humidity.

The first snow in Laurentide Park in both 1962 and 1966 fell in mid-September. In a few days, however, all the snow was gone. The weather between the first snowfall and mid-October was relatively mild, with temperatures ranging from −8 to +18 C with frequent rain. The first major snowfall, also marking the beginning of winter in Laurentide Park, occurred in 1962 and 1966 in mid-October. Ascospore discharge of *P. abietis* and *L. hyperboreum* was most intense during the mild period, with the maximum occurring a few days before the first major snowstorm. With the onset of winter, ascospore discharge of the two fungi became relatively light. Although no ascospores of *P. abietis* were caught after the third week of November, specimens of this fungus collected at the end of November still contained some spores. However, most of the ascospores observed in the asci, had already germinated. On the other hand, apothecia of *L. hyperboreum* collected at the end of November were empty. When needles with empty fruiting bodies of *L. hyperboreum* were surface-sterilized and placed on 3% malt agar at 15 C, colonies of the fungus developed. Evidently, the mycelium of *L. hyperboreum* present in the needles was still viable. *L. hyperboreum*, therefore, spreads in the same manner as *P. abietis*, not only by wind-disseminated spores, but also by mycelium from infected to green foliage.—E. Smerlis, Forest Research Laboratory, Sillery, Quebec.

SILVICULTURE

Delayed and Limited Effect of Organic Fertilizer on Growth of White Spruce [*Picea glauca* (Moench)].—Some scientists have found that organic fertilizer applied during planting greatly affected the growth of white spruce. Cunningham (Can. Dep. Res. Develop. Bull. No. 103, 1953), following investigations in 1946, observed that such was the case in experiments at Grand'Mère, P.Q., when using stands established in 1920 on sandy former farmland on deep dry maritime deposits where cultivation had modified the profile. Others agree with Ray (personal communication, 1966) who, in the light of more recent studies and reviews, questioned the likelihood that such trees are subject to any prolonged effect of organic fertilizers. The fact that the control plot selected in 1920 extended over two sites of very different quality has seriously hindered a definitive evaluation of results; a study was consequently instituted to compare the development of a stand which was fertilized with that of a control located nearby and equally fertile at the time of planting.

To access the duration and extent of the influence of barnyard manure on tree growth the following experiment was performed. In the fall of 1966, seven trees of various diameters were chosen at random from the manured stand and were paired with seven trees from the control stand. The differences between the diameters of each pair was determined. A t-test was applied to these differences, taken as the dependent variable, thus permitting an evaluation of the homogeneity of the sample ($t = .66$ for 6 degrees of freedom). The seven manured trees were felled and their growth measured along four perpendicular radii, a total of 28 measurements being made for each growth period studied. The average value of the 28 measurements is presented in Fig. 1. The same procedure was followed for the control trees.

A statistical analysis indicated that no significant differences were observed after 20, 25, 30 or 40 years, indicating that the manure influenced growth only from 5-10 years after application. Furthermore, mean annual increment was 2.255 mm for the manured trees as compared with 2.265 mm for the controls.

The results, plotted for every fifth year, clearly demonstrate that barnyard manure exerts no apparent influence on growth during the first 5 years after application. However from the fifth to the tenth year there is an appreciable influence (Fig. 1). After the tenth year, tree growth on the fertilized plot fluctuated, being now superior, now inferior to the growth of trees on the control plot.

After 40 years, tree growth on all plots was about the same. Furthermore, although trees 5-10 years after treatment grew much faster than the control trees, a statistical analysis indicated that the two growth curves did not differ significantly when considered over the 40-year period. The rapid increase in the growth of the control trees from the thirtieth year is attributable to thinning (25%). At this time the fertilized

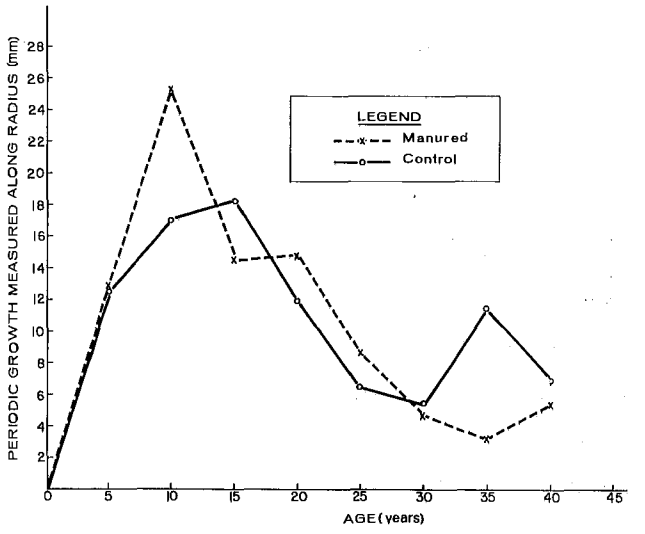


FIGURE 1. Periodic growth (as measured along four radii) of manured and control white spruce.

plots were also thinned (10%), to remove, primarily, the diseased, deformed or suppressed trees. A subsequent thinning in the fertilized plots seems to have been beneficial.

A complemetary study, comparing the physicochemical properties of organic and mineral soil horizons, the concentration of nutrient elements in current needle growth, and the volumes and mean annual increment of the trees has been initiated.—J. D. Gagnon and M. Boudoux, Forest Research Laboratory, Quebec City, Que.

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RESEARCH NOTES

IN THIS ISSUE:

Vol. 24—No. 6, NOVEMBER-DECEMBER 1968.

Published under the authority of
The Minister
Department of Fisheries and Forestry
Ottawa, Canada

BI-MONTHLY

RESEARCH NOTES

A selection of notes on current research conducted by the Forestry Branch,

Department of Fisheries and Forestry of Canada

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ENTOMOLOGY

Effect of Sumithion on the Balsam Woolly Aphid in Newfoundland.—An aerial spraying operation using Sumithion [0, 0-dimethyl 0-4-nitro-*m*-tolyl phosphorothioate] was conducted in southwestern Newfoundland in July 1968, to control an outbreak of the hemlock looper [*Lambdina fiscellaria fiscellaria* (Guen.)]. The balsam woolly aphid [*Adelges piceae* (Ratz.)] was present in part of the sprayed area, and a study was conducted to determine the effect of the insecticide on the aphid population.

Sumithion was applied twice, first on July 7 or 9 and again on July 14, at the rate of 2 oz of concentrate per acre. The sample trees in eight locations selected for collection of data on the hemlock looper were also assessed for balsam woolly aphid population levels before and after spraying. Counts of sessile aphids and egg masses were made on a maximum of six branches from each location. On each branch, four 2-year-old nodes in the apical portion were inspected for aphids.

About two-thirds of the eggs had hatched when sampling commenced. The data, summarized by stages of aphid development, are given in Table 1. The number of adults, eggs and immature stages were less after spraying. The decreases in adults and eggs were expected because of mortality from normal seasonal senescence, cessation of oviposition and eclosion. Eclosion should have led to an increase in the number of settled immature stages. However, 56% of 18 branch pairs (pre- and postspray branch samples) showed a decrease; the remaining branch pairs had equal numbers of insects. The expected decrease, calculated from counts on untreated trees in July 1966, should have been about 31% (N=36). The probability of obtaining a decrease $\geq 56\%$ is 0.028, which is non-significant ($P \leq 0.05$, two-tail test).

TABLE 1

Number of sessile aphids and egg masses before and after aerial spraying

Stage	Prespray VII/2-5	Postspray VII/19-22
1st. Generation Adults	54	7
2nd. Gen. Egg Masses		
<16 eggs/mass	50	10
>15 eggs/mass	6	0
2nd. Gen. Immatures	343	273

Crawlers may have been killed by Sumithion or lost through emigration. Emigration is prominent at high levels of population, where there is a shortage of feeding sites as on severely damaged trees, and where host tissues does not elicit a feeding response in the crawlers. In this study, high levels of aphid population were not evident and only 2 of 24 sample trees had a shortage of suitable feeding sites, that is living 2- and 3-year-old nodes and internodes with staminate buds. It appears that a feeding response was not elicited, maybe due to systemic activity of Sumithion, and the crawlers continued searching and eventually died.

There was no evidence in this test to show that sessile aphids were killed; this agrees with the results obtained by Randall, Hopewell and Nigam (Bi-Mon. Res. Notes 23: 18-19, 1967). However, the results indicate that Sumithion restricted establishment of crawlers and that a significant reduction in numbers might be obtained if the insecticide was applied before eclosion commenced.—D. G. Bryant, Forest Research Laboratory, St. John's, Newfoundland.

Notes on Insects Attacking Spruce and Fir Cones at Black Sturgeon Lake, Ontario, 1963-4.—Because of concern over the reduction in quantity and quality caused by insects to seed required for reforestation programs, surveys were conducted during 1963 and 1964 to assess insect damage to cones of white and black spruce and balsam fir in different types of stands near the field station at Black Sturgeon Lake, Ont. Information on parasites of the spruce budworm known to attack lepidopterous cone insects, particularly *Dioryctria* spp., was also sought.

Cones were sampled in September from trees in three areas: 1) spruce budworm sampling plots (mixed regeneration of physiological age from 5 to 40 years); 2) advanced open-grown regeneration of physiological age from 15 to 20 years on the field station grounds; and 3) relict trees that survived the spruce budworm outbreak in the late 1940's. Cone samples were taken throughout the cone-bearing portion of the tree crown. In 1963, a poor cone year, white spruce was sampled in areas 2 and 3; black spruce in areas 1 and 2; and balsam fir in area 2. In 1964, a good cone year, white spruce, black spruce and balsam fir were sampled in all three areas.

The cones were kept in individual containers at 42 F. from late September to January or February and were then incubated at 70 F. Following 6 weeks of incubation, insect emergence was recorded and a portion of the cones were sectioned longitudinally to permit estimation of the incidence of sound, infested and hollow seed.

Data obtained from examination of white spruce, black spruce and balsam fir cones in 1963 and 1964 are presented in Tables 1 and 2, respectively. More detailed data were taken in 1964 allowing better estimates of damage.

TABLE 1

Damage to Spruce and Balsam Fir Cones at Black Sturgeon Lake, Ont., 1963

Host species	Source*	No. trees sampled	No. cones sampled	% cones damaged by insects
White spruce	Station	8	370	98
	Relicts	10	725	99
Black spruce	Regeneration	71	1711	7
	Station	10	250	12
Balsam fir	Station	20	317	95

*Regeneration ranged in age from 10-40 years; relict trees were about 175 years old; trees at station were about 20 years of age under semi-landscaped conditions.

TABLE 2

Damage to Spruce and Balsam Fir Cones at Black Sturgeon Lake, Ont., 1964

Host species	Source*	No. trees sampled	No. cones examined	% hollow seed	% insect damaged seed
White spruce	Regeneration	50	1500	45	21
	Station	10	300	30	8
	Relicts	10	900	49	17
Black spruce	Regeneration	45	1350	52	4
	Station	15	450	62	5
	Relicts	10	900	52	3
Balsam fir	Regeneration	50	1500	0	2
	Station	10	300	0	3
	Relicts	10	900	5	6

*Regeneration ranged in age from 10-40 years; relict trees were about 175 years old; trees at station were about 20 years of age under semi-landscaped conditions.

The commonest Lepidoptera attacking white spruce cones were *Laspeyresia youngana* Kft. (1963 — 65%; 1964 — 2.4%) and *Dioryctria* spp. (1963 — 1.5%; 1964 — 1.1%). Diptera of the genus *Dasyneura* were reared only in 1963 and then from 18% of the cones. Cecidomyiids were also present in both the annual and longer diapausing forms (the latter does not emerge until the second year) but could not be associated with damage to seed. In 1963 more than 80% of the seed in white spruce cones was damaged by insects compared to 18% in 1964.

Black spruce cones contained *Dioryctria* spp. and cecidomyiids, but on the average, less than 10% of the cones were infested each year.

Dioryctria spp. emerged from 16% of the balsam fir cones from the station grounds in 1963 but from only 3% of the cones in 1964. In 1963, Lepidoptera including *Eupithecia* sp. and *Paralobesia* (*Polychrosis*) *piceana* Free. emerged from 2% of the cones and lonchaeids from an additional 2%. The seed chalcid, *Megastigmus specularis* Walley emerged from 19% of the small number of cones in 1963 and 3% of those in 1964.

The survey thus suggests that, in years of light cone crop, insect damage may result in significant loss in spruce and fir seed production. Conversely, when the cone crop is heavy, as in 1964, the high incidence of hollow seed in both white and black spruce suggests that lack of pollination is a more important factor in seed production by these species than damage by insects. The sharp decline in insect damage from 1963 to 1964 is most likely a result of the large increase in the number of cones in 1964 in relation to a relatively small absolute population of insects, although poor weather during the 1964 flight period may have contributed also to the decrease in insect attack.

A large number of parasites and hyperparasites were associated with insects damaging cones. The *Dioryctria* complex was commonly attacked by two parasites, *Bracon rhyacioniae* (Mues.) and *Pimplopterus* sp. Chalcids of the genera *Copidosoma*, *Elachertus*, *Tetrastichus*, *Hyssopus*, *Amblymerus*, *Habrocytus*, *Torymus* and *Platygaster* were reared from 48% of the white spruce cones, 3% of the black spruce and 8% of the balsam fir cones in 1963. In 1964, they were reared from only 1% of the white spruce cones. These records suggest that lepidopterous cone insects are not important as alternate hosts for spruce budworm parasites.

Grateful appreciation is expressed to the staff of the Canada Department of Agriculture, Entomology Research Institute, Ottawa, for the identification of the insects associated with the cone studies.—R. E. Fye and W. D. Wylie, Forest Research Laboratory, Sault Ste. Marie, Ont.

FOREST PRODUCTS

Effect of Outside Chip Storage on Refiner-Groundwood Pulp Brightness — In May 1968, a long-range study of effects of outside chip storage of white spruce [*Picea glauca* (Moench) Voss] and lodgepole pine [*Pinus contorta* Dougl. var. *latifolia* Engelm.] was begun at the site of the Intercontinental Pulp Co. Ltd. mill, Prince George, B.C. The objectives and experimental methods used in this study, together with the potential economic losses resulting from outside chip storage, are described by Hatton, Smith and Rogers (Pulp and Pap. Mag. Can. 69(15): 33-36, 1968). This note reports the effect of outside storage of lodgepole pine and white spruce chips on the brightness of refiner-groundwood pulps, which was part of the above-noted study.

Fresh pine and spruce chips were refined separately in a 12-inch Sprout Waldron single-disc laboratory refiner. Plates No. C2916 were set at clearances of 0.020″ and 0.001″ respectively, for the two passes required in order to obtain a pulp with a Csf of approximately 70. After screening, the pulp was made into handsheets for brightness determination according to Tappi Standard T 218 m-59. Pulp brightness was determined using a Carl Zeiss Elrepho reflectance photometer. This procedure was repeated for samples of pine and spruce chips which had been stored in the experimental pile for 3 months. The stored chips and fresh chips were both part of the same thoroughly mixed mass of chips used in the entire study.

The refiner-groundwood pulp brightnesses are shown in Table 1 and the pile positions of the refined-chip samples are numbered in Fig. 1. These results show that brightness losses in lodgepole pine refiner-groundwood pulps can be as much as 12 to 18 points Elrepho for a chip-storage period of 3 months. In a larger, commercial-size chip pile, pulp brightness losses may be significantly larger. Furthermore, there is evidence to indicate that much of this brightness loss occurs during the first month of chip storage. Whilst some brightness loss might be tolerated in practice, this would be so only if it were economically feasible to recover this loss by means of a brightening stage such as hydrosulfite or peroxide. Some preliminary experiments should be carried out to determine, (a) whether substantial brightness losses can be regained, and if so, (b) at what cost. There is some degree of correlation between the brightness losses observed for both lodgepole pine and white spruce refiner-groundwood pulps and the maximum temperatures recorded for the specific pile positions sampled. In general, the higher the temperature, the greater the brightness loss. The severe losses observed for lodge-

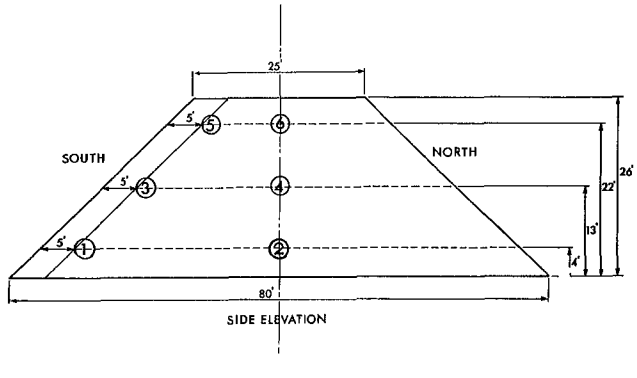

FIGURE 1. Side-elevation schematic of experimental chip pile showing location of 6 pine and 6 spruce samples in a vertical plane. The planes of the samples of the two species were 7 feet apart.

TABLE 1

Effect of 3-month outside chip storage on refiner-groundwood pulp brightness

Sample	Pile Position	Maximum Temperature in Pile (°F.)	Elrepho Brightness: Fresh Chips	Elrepho Brightness: After 3-month Storage
Pine				
3-Cp-2-R	2	123.0	59.0	41.3
3-Cp-3-R	3	90.0	59.0	47.0
3-Cp-6-R	6	145.0	59.0	42.7
Spruce				
3-Cp-2-R	2	123.5	62.8	55.5
3-Cp-6-R	6	144.5	62.8	48.0

pole pine are caused by the great incidence of staining amongst the chips. Typical of these are the ochre-orange and red stains in the heartwood-sapwood (predominantly heartwood) and the fungal hyphae giving rise to blue stain in the sapwood. Identification of these microorganisms is currently proceeding.

The loss in pulp brightness due to storage of white spruce chips appears to be severe only in the hottest part of the pile.

In view of the extreme brightness loss of refiner-groundwood pulp prepared from lodgepole pine chips stored for 3 months in an outside chip pile, there can be but little question that any mill contemplating the manufacture of mechanical pulp from lodgepole pine by the stone or refiner-groundwood processes should carry out an intensive research program to determine the feasibility of using this species. In any event, it is recommended that if lodgepole pine is processed for mechanical-pulp manufacture then the roundwood or chips used should originate from freshly-felled trees, with a minimum number of days between stump and refiner — J. V. Hatton, Forest Products Laboratory, Vancouver, B.C.

Effect of Drying Techniques on Softwood Permeability. — The permeability of softwoods is the most important factor in controlling their impregnation by substances in preservative and fire-retardant treatments, or in the production of wood-polymer combinations. It is well-known that drying sapwood from certain organic solvents results in considerably higher permeability. It has been shown that green sapwood is permeable but that in air-drying this permeability is reduced to a fraction of its original value by the aspiration of the tori of the bordered pits caused by surface tension effects of the receding air-water interface. In this phenomenon, the torus acts like a valve and is pulled to one side, closing the pit aperture. The much lower surface tension of organic liquids is generally insufficient to aspirate the torus, so that the valve is not closed in solvent drying. Consequently, the permeability of wood so dried is similar to that of green wood.

An investigation at the Vancouver Laboratory into the effect of drying techniques on wood permeability has shown that freeze-drying in a similar manner results in high permeability of the wood. It is hypothesized that in freeze-drying the tori are encased in ice, which then sublimes without the formation of an air-liquid interface. Thus the forces responsible for aspiration of the tori are not activated. This investigation is being actively pursued — G. Bramhall, Forest Products Laboratory, Vancouver, B.C.

The Occurrence of 3-Hydroxyflavanones in Aspen Branch Stubs. — Dead branches and ingrown branch knots are of special interest in aspen [*Populus tremuloides* Michx.] because of their prolonged durability and their association with stains and heartrots. Extraction of dead branches, wounds and associated stained sapwood has revealed the presence of several biologically interesting compounds (Oberg *et al.* Tappi 39: 470-471, 1956; Wall and Kuntz, Can. J. Bot. 42:969-977, 1964) none of which are known to have been identified.

Lower branches which had been dead 5 to 15 years were collected from several 30- to 50-year-old stands in Manitoba. The basal 3-inch portions were subdivided into bark, the outer two or three annual rings of wood and the inner, discolored wood. The tissues were ground in a laboratory mill and extracted with small quantities of water in a Carver hydraulic press. Precipitation with acetone for 2 to 3 hours at 0 C and filtration yielded an amber-yellow filtrate which gave a red color when treated with magnesium and HCl, indicating the presence of flavonoids. This reaction was most pronounced in extracts from the outer wood tissue. The zinc-HCl test (Pew, J. Am. Chem. Soc. 70:3031-3034. 1948) also gave a red color, suggesting that at least one of the flavonoids was a 3-hydroxyflavanone.

Exhaustive extraction of outer wood tissue with methanol in a soxhlet apparatus and silica-gel thin-layer chromatography in chloroform-methanol (7:1) revealed at least seven spots by their fluorescence under long-wave ultraviolet light: R_f 0.93 (light blue); 0.84 (light blue); 0.74 (light yellow); 0.64 (deep yellow); 0.39 (light yellow); 0.20 (light yellow), and 0.09 (light yellow). All compounds except R_f 0.93 and R_f 0.84 reacted with diazotized sulfanilic acid to give yellow colors diagnostic for phenols. Compounds of R_f 0.64 and R_f 0.09 gave the red-purple zinc-HCl reaction specific for 3-hydroxyflavanones, using the technique recently developed by Barton (J. Chromatog. 34:562. 1968). By using chloroform-methanol (7:3) similar separations were achieved with higher R_f values, e.g., the two 3-hydroxyflavanones had R_f 0.71 and R_f 0.30, respectively. Using the latter solvent in preparative thick-layer chromatography, these two substances were isolated and one of them (R_f 0.71) crystallized, melting at 237.2 C (Mettler F. P. 1). Mass spectrometry showed a molecular weight of 288. Nuclear-magnetic-resonance spectroscopy further revealed the presence of six aromatic protons of which four formed an A_2B_2 pattern, and three phenolic hydroxyl groups, one of which was hindered.

Since these data describe the well-known flavanone aromadendrin (dihydrokaempferol), this unknown's identity was confirmed by t.l.c. and by quantitative infrared spectral comparison with an authentic sample of aromadendrin. Additional confirmation was provided by preparing the known yellow derivative, kaempferol by dehydrogenation with aqueous sodium bisulfite (Hergert and Goldschmid, J. Org. Chem. 23:700-704, 1958).

The other 3-hydroxyflavanone (R_f 0.30 in chloroform-methanol, 7:3) is believed to be a glycoside of aromadendrin, since it was hydrolyzed in 2% aqueous oxalic acid to give aromadendrin. Current studies are under way to determine the type and position of the sugar moiety. Since a p-anisidine positive substance resembling glucose was detected in water extracts using silica gel t.l.c. and n-butanol-acetone-water (80:100:20) it is possible that hydrolysis of this or some other glycoside occurs during water extraction. Water extracts are acidic (pH 4 to 5) and may thus provide conditions favorable for such hydrolysis.

The discovery of these 3-hydroxyflavanones in aspen wood is important in view of their known inhibition on sulfite pulping, as well as their participation in color formation. The facile conversion of dihydrokaempferol to the intensely yellow-colored kaempferol could explain the presence of yellow stains in aspen wood. Factors causing their formation and their effects on decay fungi are of interest in future studies. — G. M. Barton, Forest Products Laboratory, Vancouver, B.C., and R. E. Wall, Forest Research Laboratory, Winnipeg, Man.

PATHOLOGY

Seasonal Variation in Infection of Douglas-Fir Logs and Stumps by Fomes annosus. — *Fomes annosus* (Fr.) Karst. is one of the most destructive root rots in immature forests in the temperate zone. The fungus becomes established in healthy stands primarily through spore infection of freshly exposed stumps but also through infection of logs left lying in the woods. The disease passes to living trees when their roots contact the fungus in these infected stump roots or logs.

To determine the frequency of log and stump infection by *F. annosus* and its subsequent threat to residual or second-growth stands, a number of Douglas-fir [*Pseudotsuga menziesii* (Mirb.) Franco], with an average diameter of 12 inches, was felled and cut into 24 to 32 ft logs each month from August 1961 to July 1962 and in November 1962 in the Lake Cowichan area of Vancouver Island. Half the logs were sampled 2 years after felling and the remainder 4 years after felling. Samples were taken from each end of the logs and at 8-foot intervals along their length. The stumps of these trees were sampled periodically 2 to 4 years after exposure.

F. annosus was isolated from logs from all periods of felling except from those of trees felled in both November 1961 and 1962 (Fig. 1). *F. annosus* was also isolated from stumps exposed during all periods of felling except from those stumps exposed during November 1961; incidence of infection in stumps was:

Year	1961								1962					
Month	A	S	O	N	D	J	F	M	A	M	J	J	N	
Percent	50	35	20	0	7	14	25	7	36	45	19	28	36	

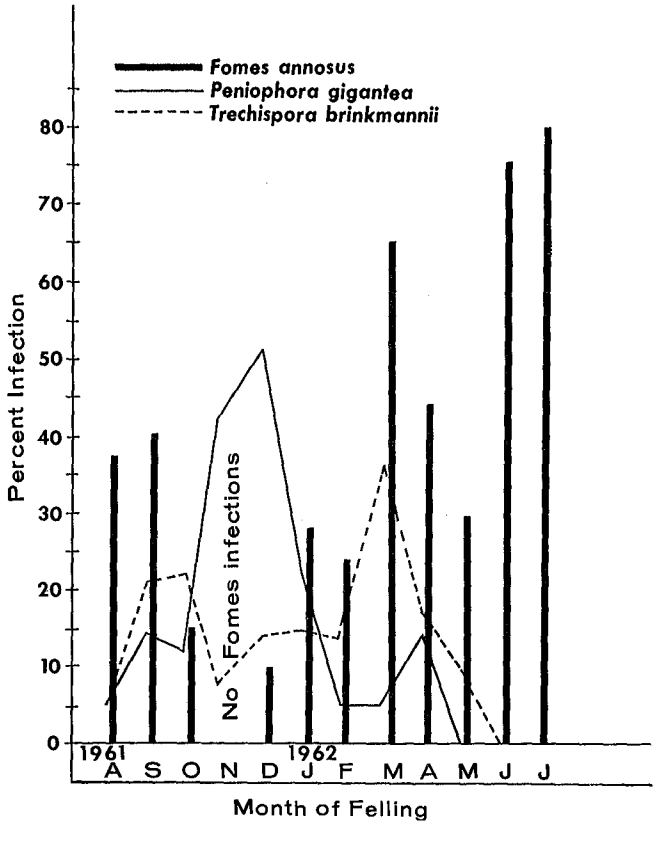

FIGURE 1. Monthly incidence of Douglas-fir log infections by three fungi.

Log and stump infection was highest from March through September, with an average of 53% of the logs and 29% of the stumps becoming infected. Log infection reached a maximum of 80% in July, and stump infection of 50% in August. The incidence of log infection was similar for both the second- and fourth-year sampling periods.

Approximately half the infected logs showed infection in the mid-portion, which could not be attributed to penetration through the ends; the fungus possibly gained entrance to the woody tissues through insect galleries or bark injuries.

Sporophores of *F. annosus*, which developed on several logs as early as 2 years after felling, could be important in increasing the air-spore population where debris accumulation is extensive.

The seasonal variation in stump and log infection generally showed a negative correlation with the variation in spore deposition shown by Reynolds and Wallis (Bi-Mon. Res. Notes, Vol. 22(4):6-7, 1966).

The incidence of *Peniophora gigantea* (Fr.) Massee and *Trechispora brinkmanii* (Bres.) Rogers & Jacks showed a strong negative correlation with that of *F. annosus* (Fig. 1). — G. Reynolds and H. M. Craig, Forest Research Laboratory, Victoria, B.C.

SILVICULTURE

Effect of Seed Wings on Germination and Establishment of Jack Pine Seed. — Regeneration of jack pine [*Pinus banksiana* Lamb.] from natural seedfall or seedfall from scattered slash may prove to be silviculturally practical in southeastern Manitoba (Cayford, Forest. Br. Dep. Forest. Rural Develop. Pub. No. 1165, 1966). Observations have suggested that the attached wing on natural seed may physically prevent the seed from establishing good contact with the seedbed. Therefore a test was carried out to obtain information on the effect of wings on the germination and establishment of jack pine seed.

Seed was obtained from the Pineland nursery operated by the Provincial Government at Hadashville, Man. Seed was extracted by standard methods and samples for testing were randomly selected from the same lot before and after de-winging. A cutting test showed the winged seed to be 85% sound and the de-winged seed 98.5% sound.

Although jack pine usually germinates well with no pretreatment, both stratified and unstratified seed was used. Seed was stratified according to recommendations of the United States Forest Service (U.S. Dep. Agri. Misc. Pub. No. 654). To simulate spot seeding, half the seeds were tamped down to make firm contact with the soil. The remaining seeds were dropped on the soil and care was taken to avoid covering or tamping them down.

Seeds were surface-sown in small waxed paper tubs, about 4½ inches in diameter and 3 inches deep, which were filled to within ½ inch of the top with medium textured sand. A 2 x 2 x 2 factorial design was used with 20 replications. A replication contained eight tubs, each sown with 50 seeds, representing the eight treatment combinations.

The test was carried out in a greenhouse using a photoperiod of 15 hours under fluorescent lamps. Maximum and minimum air temperature averaged 89 and 64 F with extremes of 100 and 56 F, respectively. Soil surfaces were kept moist by surface watering.

Germinated and established seedlings were tallied daily for 6 weeks. A seed was classified as 'germinated' when the radicle became exposed and 'established' when the seed coat separated from the cotyledons. Because of the differences in seed soundness between winged and de-winged seed, germination results were adjusted to a comparable basis by dividing results by the decimal percentage of seed soundness.

Test results are shown in Table 1.

Analysis of variance indicated that de-winging and tamping significantly increased germination and establishment at the 1% level. Stratification did not significantly affect germination and no treatment interactions were significant.

The results show that, under the ideal conditions of this experiment, wings significantly reduce germination and establishment of jack pine seed. Reasons for the reduction, other than poor contact with the seedbed (when seeds were tamped the adverse effect of the wing was nullified), are not known and further research into exact mechanical and physiological influences of the seed wing are needed.

Although germination of the winged seed was adequate under the conditions of this experiment, the adverse effect of

TABLE 1

Germination and establishment of winged and de-winged jack pine seed

Treatment	Per cent Germinated	Established
Winged, tamped, stratified	89.8	88.1
Winged, tamped, not stratified	90.7	87.6
Winged, not tamped, stratified	77.8	72.0
Winged, not tamped, not stratified	71.7	66.8
De-winged, tamped, stratified	95.1	93.2
De-winged, tamped, not stratified	94.9	92.8
De-winged, not tamped, stratified	92.1	86.3
De-winged, not tamped, not stratified	81.8	75.4
Total winged	82.5	78.6
Total de-winged	91.0	86.9
Total tamped	92.6	90.4
Total not tamped	80.8	75.1
Total stratified	88.7	84.9
Total not stratified	84.8	80.6

seed wings is likely to be greater under natural field conditions where the environment is more severe. Field trials in Manitoba have indicated that wind causes considerable movement of de-winged seed on bare, unprotected areas (unpublished data, Manitoba-Saskatchewan Region). With wing intact, movement of seed, collection of seed in depressions, and disturbance of seed with emerged radicles would be greater, resulting in poorer germination and survival. Also, lethal levels of soil moisture would be lower and soil-surface temperatures higher when seed is not in firm contact with the soil. These factors should be considered by foresters who propose to predict regeneration from a natural seed supply using results of artificial seeding trials.

Although this study does not explain physiological effects of wings on germination it does shed some light on the natural regeneration phenomenon and suggests a possible reason for the failure of some natural seeding trials of species with winged seeds. — H. P. Sims and N. G. Bruce, Forest Research Laboratory, Winnipeg, Man.

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