FBC - MONTHLY

RESEARCH NOTES

IN THIS ISSUE:

Vol. 26—No. 1, JANUARY-FEBRUARY 1970.

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 Canadian Forestry Service, Department of Fisheries and Forestry

BIOLOGY

Genetic Control of Female Flower Color, and Random Mating in White Spruce.—The purpose of this study was to find out if a single gene controls the color of white spruce [*Picea glauca* (Moench) Voss] female flowers, and if it does, to test for randomness of mating in white spruce populations using genotype frequencies. Carlisle and Teich (Can. J. Bot. In press) found that a single gene controlled male flower color in natural populations of Scots pine [*Pinus sylvestris* L.], and noted that genotypic frequencies could be used to evaluate degree of inbreeding or randomness of mating in populations. If a single gene controls flower color in white spruce it could be similarly used.

Twenty-five white spruce provenances, mainly from the central part of the Great Lakes—St. Lawrence Forest Region (Rowe, Can. Dept. North. Aff. Natur. Resources, For. Br. Bull. 123) were planted in a balanced lattice square design with six replications and 25 trees per plot, spaced 1 x 1 foot. At 6 years of age 17 trees from 11 provenances bore female flowers, but no male flowers. Flowers of a given tree were all one color: red, pink or green.

Genetic analysis was based on the Hardy-Weinberg Law which states that in a large, random-mating population, where parental genotypes are of equal fertility and offspring genotypes of equal viability up to the time of observation, both gene and genotype frequencies are constant from generation to generation in the absence of migration, mutation and selection (Falconer, Introduction to quantitative genetics, Ronald Press, New York, 1960, p. 10). In a population defined as the white spruce of the Great Lakes—St. Lawrence Forest Region a single gene, R, was assumed to control flower color, with an allele R_1 promoting red and an allele R_2 promoting green. Frequency of R_1, designated as p, was calculated by summing observed frequency of trees with red color and half of the frequency of trees with pink flowers, while the frequency of R_2, designated as q, was set equal to 1-p. Frequencies of the various genotypes and phenotypes are listed in Table 1. Chi-square with one degree of freedom was used to test significance of differences between observed and, calculated frequencies.

TABLE 1

Observed and expected frequencies of 17 trees with female inflorescence colors in a white spruce provenance experiment, where the frequency of R_1, p = .6765 and the frequency of R_2, q = .3235

Phenotype	Red	Pink	Green
Proposed genotype	R_1R_1	R_1R_2	R_2R_2
Observed frequencies	0.47	0.41	0.12
Expected frequencies	$p_2 = 0.46$	$2pq = 0.44$	$q_2 = 0.10$

$X^2 = .0601$ Deviation not significant at $p < .10, < .80$

Observed frequencies did not differ significantly from calculated frequencies ($P < 10, < 80$) even though the sample size of 17 was rather small, making observed frequencies vulnerable to fluctuation by chance. The Chi-square test is also a test of validity of assumptions, e.g., one gene with two alleles controls female flower color and random mating.

Quantitative genetic studies often use seed by wind pollination rather than controlled crosses. This requires the assumption of random mating for the data to be valid in estimation of genetic variation, heritability estimates and prediction of potential genetic improvement by selection. Data in this experiment, in addition to indicating that a single gene with two alleles controls female flower color in white spruce, also supports the assumption of random mating in white spruce populations.

I am grateful to Mr. M. J. Holst, who initiated the experiment in which the data of this study were observed.—A. H. Teich, Petawawa Forest Experiment Station, Chalk River, Ont.

ENTOMOLOGY

Toxicity of Insecticides to Sixth Instar Jack-pine Budworm Larvae Under Laboratory Conditions.—The severity of jack-pine budworm [*Choristoneura pinus* Free.] infestations have been increasing in northwestern, central and southeastern Ontario and eastern Manitoba during recent years. In 1967, about 1500 acres were sprayed in Manitoba with DDT, at the rate of ½ and ¾ lb./acre. These dosages reduced the population by 87% and 99% respectively. Subsequently, it was suggested by the Inter-departmental Committee on Forest Spraying Operations that DDT should not be used in future operations and that alternate insecticides should be tested against this pest. This note summarises the results of tests with nine insecticides in 1968, to establish contact toxicity levels against sixth instar jack-pine budworm larvae, and to determine the insecticides for field trials. The larvae were collected at Chalk River, Ont.

The experiments were conducted under laboratory conditions similar to those described by Nigam, 1968 and 1969 (Bimon. Res. Notes 24:4-5 and 25:11-12). Thirty to forty larvae per dosage were sprayed in three or four replications of 10 larvae each under a modified Potter's tower. There were six to eight dosages for each insecticide. Post-treatment observations were taken at 24, 48 and 72 hours and the LD_{50} and LD_{95} values in $\mu g/cm^2$ were calculated. The results are presented in Table 1. The insecticides are arranged in descending order of toxicity on the basis of LD_{50} values. When a regression line could not be obtained the highest mortality at the lowest dose is presented in the table.

TABLE 1

LD_{50} and LD_{95} values of insecticides against 6th instar jack-pine budworm [*Choristoneura pinus* Free]

Insecticides	Type	Formula	LD_{50} (48 hr) $\mu g/cm^2$	LD_{95} (48 hr) $\mu g/cm^{2**}$
Zectran®	C Sys.	4-dimethylamino-3,5-xylyl methylcarbamate	0.064	0.143
Matacil®	C Con.	4-dimethylamino-m-tolyl methylcarbamate	0.098	0.184
Sumithion®	O-P Sys.	0,0-dimethyl 0-(4-nitro-m-tolyl) phosphorodithioate	0.401	0.890
Sum/Phos. Mix.	O-P Sys.	Sumithion 30% Phosphamidon 20%	0.497	1.083
Imidan®	O-P	0,0-dimethyl S-phthalimido-methyl phosphorodithioate	1.799	6.355
Anthio®	O-P Sys.	S-((formylmethylcarbamoyl) = methyl) 0,0-dimethyl phosphorodithioate	2.025	4.893
Baygon®	C Sys.	o-isopropoxyphenyl methylcarbamate	3.679	7.388
Cygon®	O-P Sys.	0,0-dimethyl S-(methyl= carbamoylmethyl) phosphorodithioate	3.691	16.68
*Phosphamidon	O-P Sys.	dimethyl phosphate, ester with 2-chloro-N,N-diethyl-3-hydroxycrotonamide	100% mortality at 0.673	

* No regression line.
** 1.121 $\mu g/cm^2$ = 1% at 1 gal/acre.
C = Carbamate.
O-P = organophosphate.
Con. = Contact.
Sys. = Systemic.

The relative toxicities are rated below according to LD_{50} and LD_{95} values at 48 hours taking the LD_{50} and LD_{95} values for Sumithion as 1.

At LD_{50} level — Zectran 6.2 > Matacil 4.1 > Sumithion 1.0 > Sumithion/phosphamidon (Sum/Phos.) Mix 0.8 > Imidan 0.2 = Anthio 0.2 > Baygon 0.1 = Cygon 0.1.

At LD_{95} level — Zectran 6.2 > Matacil 4.8 > Sumithion 1.0 > Sum/Phos. Mix 0.8 > Anthio 0.2 > Imidan 0.1 = Baygon 0.1 > Cygon 0.05. The relative toxicity values of Matacil, Imidan and Cygon have changed at LD_{95} levels because their regression lines are not parallel to Sumithion, while regression lines of other insecticides are. However, the order of toxicity of the insecticides is changed only for Imidan.

Zectran is the most toxic and Matacil is second followed by phosphamidon and Sumithion. The toxicity of these four compounds is comparatively high against this pest. Zectran and Matacil are still undergoing field experimentation and phosphamidon is hazardous to birds at higher dosages.

Sumithion has been tried in field operations because of its success in controlling the spruce budworm [*Choristoneura fumiferana* (Clem.)] a very close relative of the jack-pine budworm. Sumithion gave poor control at the rate of 6 oz/acre on approximately 1200 acres of infested jack pine stands in northwestern Ontario during 1968 operations. In 1969 the population was reduced by 89% when Sumithion at the rate of 4 oz/acre was applied twice (i.e. a total of 8 oz/acre) on approximately 1200 acres in the Petawawa-Deep River area of Ontario.

The screening of new compounds will continue in search of effective insecticides from a growing list of chemical compounds synthesised each year and released for experimental studies after initial screening by chemical companies and other organizations.—P. C. Nigam, Chemical Control Research Institute, Ottawa, Ont.

Recognition of Mated Male Spruce Budworm Moths.—While studying the reproductive system of the male spruce budworm moth [*Choristoneura fumiferana* (Clem.)], it was noticed that part of the ductus ejaculatorius simplex contained a yellow secretion (Outram, Can. Entomol. 102: in press, 1970). During mating, this secretion is transferred to the female leaving the simplex translucent to white. A similar phenomenon occurs in male fall armyworm moths [*Spodoptera frugiperda* J. E. Smith] and Snow and Carlysle (Ann. Entomol. Soc. Amer., 60: 1071-1074, 1967) have described how it may be used as a reliable indicator of mating for the males of this species. Accordingly the reliability of the character as a mating indicator for male spruce budworm was tested.

The yellow secretion of the male budworm is found in a 4- to 6-mm-long section of the primary ductus ejaculatorius simplex immediately following the cuticular and the looped constrictor muscle regions of the duct. This section is easily exposed by a median dorsal incision in the abdomen, locating the silvery cuticular simplex, and pulling this outward with forceps; or, with practice, it can be located directly. Dissections were carried out in insect saline solution since the color fades rapidly and disappears within 10-30 minutes in either water or alcohol. It is also desirable to use freshly killed moths, but if this is not possible they can be kept in a freezer for at least 2 weeks without noticeable loss or change of color.

Two experiments were carried out to test: 1) whether age affects the color of the simplex in unmated males; and 2) whether the color returns after mating, as was found in *Spodoptera frugiperda* (Snow and Carlysle, *loc. cit.*).

Initially, the experiments were carried out on males that had been reared on artificial diet in the laboratory. In the first test groups of 50 or more unmated males were dissected <1, 1, 2, 4, 6, and 10 days after emergence and the presence and intensity of the yellow color in the simplex recorded (Table 1). The color takes several days to build up to maximum concentration In the newly emerged males (<1 day-old), only 52% showed strong color. Maximum coloration was not reached until the males were at least 4 days old, when all the males examined showed at least some yellow color and 94% a strong coloration.

TABLE 1
Color of the simplex in unmated males

Age of males in days	Percentage males with —		
	No yellow	Weak yellow	Strong yellow
<1	13	35	52
1	4	18	78
2	2	10	88
4	0	6	94
6	1	1	98
10	0	0	100

In the second test, groups of 50 or more 2- to 4-day-old males, in which the yellow color in the simplex would be well developed (Table 1), were mated and then held without females for <1, 1, 2, 4, 6, and 10 days before examination of the simplex. Only successfully mated males were used, mating success was checked by examining the females for spermataphores. On mating, all the yellow secretion was transferred to the female leaving the simplex translucent to white and newly mated males could be detected with 100% accuracy. However, accuracy decreased when the males were held for 2 or more days after mating, increasing numbers showing a sufficient reconcentration of yellow color to be confused with unmated males (Table 2).

TABLE 2
Color of the simplex in mated males

Days after mating	Percentage males with—		
	No yellow	Weak yellow	Strong yellow
<1	100	0	0
1	100	0	0
2	93	7	0
4	63	12	25
6	38	12	50
10	17	12	71

The tests were repeated using wild males (collected as pupae) with similar results. However, the yellow of the simplex in these males was much paler than in the laboratory reared males. Consequently the interpretation of "no yellow" versus "weak yellow" was open to a greater degree of observer error.

The tests showed that the technique cannot be used with confidence as an indicator of mating in field populations of spruce budworm, since it requires that the age of the male and time since mating be known. The method may be useful in laboratory experiments where it could be used to estimate mating success without sacrificing the females for spermatophore counts.—Ina Outram, Forest Research Laboratory, Fredericton, N.B.

FOREST PRODUCTS

Yellowing of Cellulose by Light.—Although yellowing of cellulose by light is a well-known phenomenon, very few studies deal with the effect of environmental factors on this process. In most of the earlier studies, the yellowing of cellulosic materials was attributed to impurities present in the cellulose substrate (Aribert and Bouvier, Papeterie *42*: 338, 386 (1920); Hitchins, Paper *22* (20): 11, 1918; Schoeller, Wochbl. Papier Fahr., *43*: 3222, 3408, 3489, 3673, 3963, 4148, 1912). However, even pure cellulose will discolor on exposure to ultraviolet light (Abadie-Maumert, Papeterie *77*: 593, 595, 597, 599, 1955). In the present study the effect of moisture and gases such as oxygen and nitrogen on the yellowing of cellulose by ultraviolet light has been examined.

Squares (4″ x 4″) of Whatman No. 1 filter paper were irradiated with unfiltered light from a 550-watt Hanovia high-pressure mercury-vapor lamp. The exposures were carried out

in a thermostatically controlled, specially constructed aluminum cell which was adaptable to conditions of 0 and 100% RH and was capable of maintaining a vacuum of 10 to 15 x 10^{-3} torr or an atmosphere of the desired gas. The lamp-to-sample distance was kept constant at 15 cm and all the exposures were of 2 hours duration.

The extent of yellowing of the irradiated papers was measured on a Beckman Du spectrophotometer equipped with a reflectance attachment. The light of wavelength 375 mμ from a tungsten lamp was incident on the paper at an angle of 45° and the diffused scattered light was measured by a photomultiplier situated perpendicular to the plane of the paper. All the measurements were made relative to the unirradiated paper.

The viscosity-degree of polymerization (DP) was determined by the cadoxen method. The solvent preparation and the viscosity determinations were carried out according to the procedures used by Henley (Svensk Papperstidn. *63*: 143, 1960; Arkiv Kemi *24*: 237, 1965).

The results are shown in Table 1. It is evident that the presence of moisture inhibits the yellowing of irradiated cellulose. Continuous evacuation has the most pronounced effect, while there is not much difference in the effect of either air, oxygen, or nitrogen on yellowing of the material.

TABLE 1

Reflectance and DP (in parenthesis) of samples irradiated under various conditions

Exposure Condition	Percent Reflectance at 375 mμ			
	0% R.H.		100% R.H.	
Unexposed	100.0	(1900)	100.0	(1900)
Air	81.5	(785)	96.8	(814)
Oxygen	85.0	(816)	98.8	(834)
Nitrogen	84.5	(804)	94.0	(830)
Continuous vacuum	71.9	(890)	82.0	(927)[a]

[a]Relative humidity somewhat less than 100%; the exposure cell was connected to a flask containing water while being continuously evacuated.

All the irradiated papers showed a marked decrease in the DP. However, the reduction in DP under different conditions of exposure did not show appreciable difference from one another. It seems that the presence of moisture inhibits yellowing but has very little effect on the chain scission of the cellulose macromolecule due to ultraviolet light.

It has been suggested that the initial reaction in the photodegradation of cellulose is mainly confined to the chain cleavage of the cellulose macromolecule yielding glucose, cellobiose and oligosachharides (Desai and Shields, Makromolekulare Chemie, *122*: 134, 1969). Subsequent degradation of these products resulted in the formation of low molecular weight organic compounds. It is possible that, during this latter stage, yellowing of cellulose results. The yellowing or browning action of light on glucose, cellobiose and other model compounds has already been observed (Simionescu and Rozmarin, Chem. Ind., (Apr. 9): 627, 1966). Since there is no difference in reduction of DP of the material exposed with or without moisture, it apears that the chain cleavage reaction is insensitive to the presence of moisture, while yellowing depends on the presence of moisture to a considerable extent. Further work is in progress on the mechanism of this yellowing of cellulose material and to examine the nature of the colored compounds formed.—R. L. Desai and J. K. Shields, Forest Products Laboratory, Ottawa, Ont.

Some Histological Observations on Outside-stored Softwood Chips.—Light- to dark-brown discolorations are a manifestation of degrade in pulpwood chip piles. Potentially, this degradation can result in large economic losses to the pulp and paper industry, depending upon the intensity and distribution of discolored areas within the pile. A possible cause of this type of discoloration is the heating of large pockets of chips, particularly in the upper areas of large piles where temperatures may reach at least 60 C. Indications are that brown staining is not as severe in smaller piles where more moderate temperatures (10 to 30 C) may occur. Some idea of the magnitude of this problem and its effect on pulp quality and yield has been presented previously (Shields and Unligil, Pulp Pap. Mag. Can. 69:62-67, 1968). In the current investigation certain histological aspects of the discolored wood are examined to delineate the location of the colored material in the cell wall.

Brown-stained *Abies balsamea* (L.) Mill. wood chips stored for 8 months and nonstained chips stored for about 2 months were obtained from near the top of a large mixed *A. balsamea* and *Picea* spp. pile situated at a pulp mill at Atholville, N.B. Transverse sections of brown-stained and nonstained wood were cut at 15μ thickness on a microtome. Some of these were stained in phloroglucin-hydrochloric acid to observe the lignin

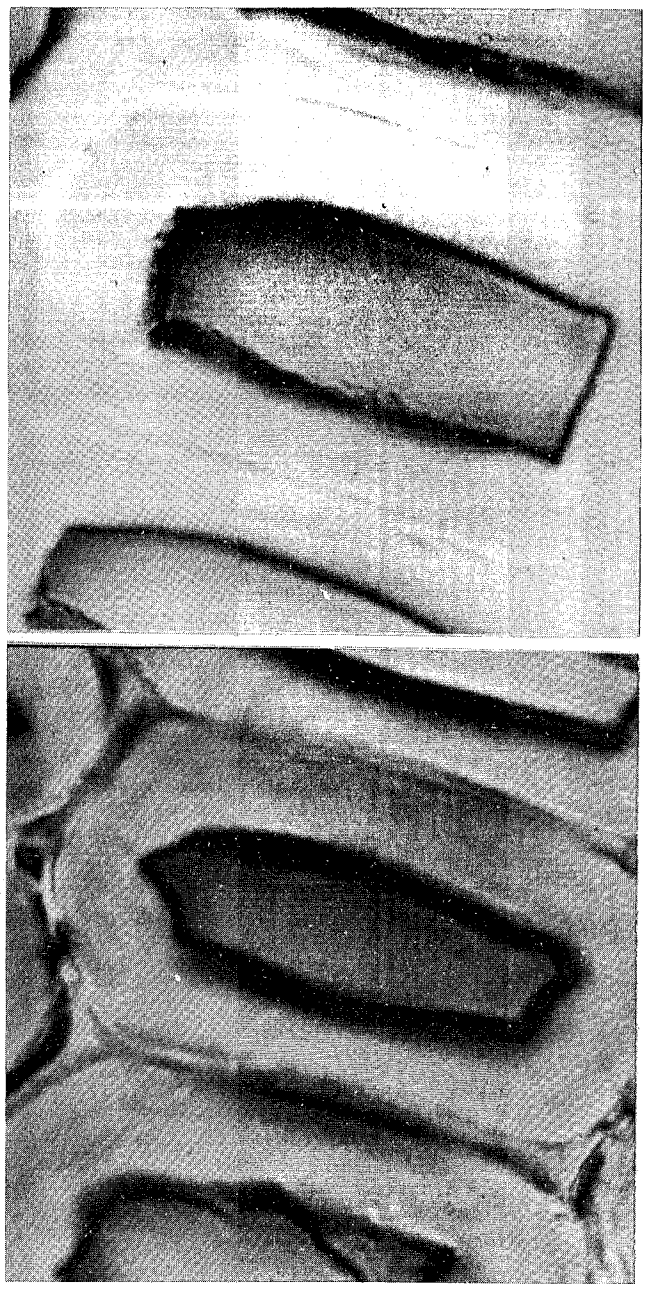


FIGURE 1. Transverse sections of *Abies balsamea* wood chips. Upper, nonstained summerwood; lower, brown-stained summerwood. Magnification approximately X2200.

color reaction in summerwood tracheids. Other sections were left unstained for microscopic examination under bright field illumination. Photographs of wood sections were made under similar exposure and development conditions.

The histochemical test for lignin resulted in a moderate pink, 10 RP 6/8 (Nat. Bur. Stand., U.S. Dep. Com. Circ. 553, 1955) reaction in secondary walls of nonstained wood chips. A moderate purplish-red, 7.5 RP 5/8, reaction occurred in the compound middle lamella. This color first developed at the corners of the tracheids, spread along the radial surface of adjoining cells and finally appeared in the middle lamella areas along the tangential plane in a way similar to results of other studies (Saleh, Lenney and Sarkanen, Holzforschung 21 (4): 116-120, 1967) where radio-autographic techniques were used. The color intensity was somewhat higher in the radial than in the tangential part of the middle lamella area as was reported for other wood species by Kato and Nakato (Bull. Kyoto Univ. For. No. 40, 1968).

Conversely, sections of brown-stained chips showed a moderate reddish-orange, 7.5 R 6/8, reaction in the secondary walls of tracheids. In this material the lignin color reaction seemed to be weaker along the tangential part of the middle lamella areas. In some sections there appeared to be structural changes which could indicate alterations in intercellular substances. The radial portion of the middle lamella gave a strong moderate red reaction, 5 R 4/8.

An examination of natural wood sections (Fig. 1) showed that the brown discoloration was more intense in the middle lamella and primary wall areas, particularly along the radial side of the tracheids. The S_1 and S_2 wall layers of tracheids were darker than those of nonstained wood chip sections. This could be an explanation for the different lignin color reaction with phloroglucin-hydrochloric acid. These observations suggest that some of the lignin or lignin-like components of the cell wall, particularly along the radial middle lamella and primary wall areas, have been modified in the brown-discolored wood chips. As this discoloration is apparently associated with hot spots in wood chip piles it is possible that moderately high temperatures existing in certain areas of the piles could contribute to the alteration of lignin or lignin-like material to brown-colored substances during the chip storage period.—J. K. Shields, Forest Products Laboratory, Ottawa, Ont.

Methylating Enzyme Specificity in Western Red Cedar.—During studies on the biosynthesis of the lignans from western red cedar [*Thuja plicata* Donn] it was decided to isolate the *O*-methyltransferase enzyme from the tree. This enzyme would be very useful in synthesis of natural products involving the introduction of specifically placed methoxyl groups.

The enzyme was isolated from western red cedar twigs using the same techniques as Finkle and Nelson (Biochem. Biophys. Acta *78*: 747, 1963) used to isolate it from apple cambium. The western red cedar enzyme, when incubated with *S*-adenosylmethionine, converted caffeic acid to ferulic acid, but did not convert either thujaplicatin or dihydroxythujaplicatin to thujaplicatin methyl ether and dihydroxythujaplicatin methyl ether, respectively. These compounds are all lignans found in relatively large abundance in western red cedar (MacLean and MacDonald, Can. J. Chem. *47*: 4495, 1969). The examination method was thin-layer chromatography on silica gel G with benzene-ethanol (9:1) as the solvent; detection was with sulphuric-nitric acids followed by heat. The product compounds themselves were run on the plates for comparison and their absence noted in the incubated substrate. Even a very small amount of conversion (50 ppm) should have been detected by the very sensititive chromatographic technique. Similar results were obtained from an enzyme isolated from rat liver.

T. Higuchi (paper presented to the International Wood Chemistry Symposium, Seattle, Wash., Sept. 3, 1969) reported a study of the enzymes active during lignification of bamboo. The *O*-methyltransferase enzyme was unable to methylate any substrate more complex than caffeic acid. It was concluded that, in the biosynthesis of the lignans of western red cedar, the methylation of one of the aromatic hydroxyl (phenolic) groups occurred before the dimerization reaction. Higuchi's work showed that the enzymes could not methylate substrates which were too complex, or perhaps foreign to the enzyme *in vivo*; this work showed that the plant's own enzyme could not methylate the substrates because they were too complex but not foreign.—Eric P. Swan, Forest Products Laboratory, Vancouver, B.C.

PATHOLOGY

Armillaria Root Rot in a Coniferous Plantation in Newfoundland.—Armillaria root rot [*Armillaria mellea* (Vahl ex Fr.) Kummer] is an important root disease of many tree species in both temperate and tropical regions of the world. Trees in all vigor classes are affected but infection is highest in trees of low vigor. The disease is spread by basidiospores, rhizomorphs and root contacts with infection of healthy trees or stumps being primarily by rhizomorphs which grow freely through soil. After the death of the host, the fungus continues to live in the wood as a saprophyte and as a source of infection to nearby trees. The infected stumps also serve as a food for the fungus (Leaphart, U.S. For. Pest Leaflet 78, 1963). In 1968 a survey was initiated to determine the impact and status of this disease in coniferous plantations in Newfoundland. This report presents results from the first plantation examined.

A total of 2400 trees of different species had been planted on an old burn near Cormack in western Newfoundland in 1958. When this plantation was examined in 1968, 1348 living and dead trees were present and 1052 trees were missing. All species except *Picea glauca* (Moench) Voss (local) were exotic to Newfoundland. Primary roots and root collars of all dead and chlorotic trees, and of some apparently healthy trees were examined for the presence of *A. mellea* and the percentage infection calculated. Most of the dead and chlorotic trees were located near infected stumps.

The infected living or dead trees exhibited characteristic symptoms of the disease including chlorosis or browning of a few branches or whole crowns, reduced growth and resinosis near the root collar. These symptoms were usually accompanied by abundant development of characteristic mycelial fans under the bark; black or dark brown, glossy to dull rhizomorphs; and honey colored fruting bodies. Early stages of infection were also evident in some apparently healthy trees indicating continuing progress of the disease in the plantation. Results of the survey are summarized in Table 1. *Picea sitchensis* (all origins) appeared to be most susceptible although all other species were attacked to some degree, especially those of low vigor.

The growth of all trees was poor, especially *Picea sitchensis*, *Pseudotsuga taxifolia* and *Larix leptolepis*. Preliminary studies suggest that suppressed growth may be ascribed to poor edaphic conditions. Although the soil was a friable, stone free, red-brown loam, samples from the top 9-inches were low in available nitrogen and phosphrous (2.03 mg/100 g of soil and 0.5 mg/100 g of soil, respectively). The pH was 4.8 which is well within the optimum range (4.0-5.5) for the growth of the fungus as well as development of the rhizomorphs (Twarowski and Twarowsha, Prace Instytutu Badawczego Lesnictwa. No. 192, pp. 3-63, 1959. English translation; Sokolov, Izadatel'Stvo "Lesnaya Promyshlennost". Moscos. pp. 1-183, 1966).

Infected, old hardwood and softwood stumps (some in an advanced stage of decay) in and near the plantation, and the fact that most of the dead trees were 6-10 years of age when they died suggests that the fungus was established early in the history of the plantation.

TABLE 1

Summary of *A. mellea* infection on coniferous species in the Cormack plantation, Newfoundland

Species and origin	Total no. of trees present	Percent healthy trees	Percent infection		
			Living (chlorotic) trees (A)	Dead trees (B)	Total (A+B)
Picea abies (Norway)	203	87	7	6	13
Picea glauca (Local)	230	80	4	16	20
Picea glauca (Sewert, Alaska)	44	86	5	9	14
Picea sitchensis (Fisk Bay, Alaska)	95	80	13	7	20
Picea sitchensis (Krozow, Alaska)	11	45	45	9	54
Picea sitchensis (Lillisnoo, Alaska)	29	66	28	7	35
Picea sitchensis (Old Sitka, Alaska)	399	57	19	24	43
Picea sitchensis (Petersburg, Alaska)	106	62	14	24	38
Picea sitchensis (Queen Charlotte Island, B.C.)	67	33	39	28	67
Picea sitchensis x *glauca* (Denmark)	13	85	8	8	16
Larix leptolepis (Holland)	66	96	0	5	5
Pseudotsuga taxifolia (Vancouver Island, B.C.)	85	69	24	7	31

The rapid development of the disease in this plantation can be attributed to a deficiency of soil nutrients, low host vigor, abundant inoculum in the soil, soil pH favorable for the development of the fungus, and abundance of infected hardwood and softwood stumps which serve as a food base as well as a source of additional inoculum. These conditions indicate that the fungus will attack the residual healthy trees and may completely destroy the plantation.—Pritam Singh, Forest Research Laboratory, St. John's, Nfld.

SILVICULTURE

Variation of Site-index and Basal Area Within the Forest Types of Newfoundland's Avalon Peninsula.—A classification and brief description of the forest types of the Avalon Forest Section (B 30) of the Boreal Forest Region in eastern Newfoundland (Rowe, Can. Dept. N. Aff. Nat. Res., For. Br., Bull. 123, 1959) has been prepared by Damman (unpublished data). This classification, which is based on floristic and edaphic characteristics, is being used in the Canada Land Inventory project in Newfoundland as one of the bases for determining and mapping forest land capability.

No completely independent check on the validity of Damman's classification for mensurational purposes has so far been carried out. However, data for such a check are now available from a quantitative site evaluation study that is presently being carried out on the Avalon Peninsula with the objective of determining those site factors that have a major influence on forest growth. During the study a total of 150 tenth-acre sample plots were established in stands of black spruce [bS; *Picea mariana* (Mill.) BSP] and balsam fir [bF; *Abies balsamea* (L.) Mill.]. These plots, each of which has been classified by Damman's system, were positioned to include a wide range of soil and topographic conditions, essentially without regard to forest type or growth rate. Consequently, each plot constitutes an entirely random sample of the forest type concerned.

All sample plots were situated in well stocked, approximately even-aged stands of ages as close to 50 years as possible. Site-index values based on dominant trees at index age 50 years have been derived from a series of site-index curves developed for eastern Newfoundland (Page, unpublished data). Basal area figures have been calculated in the usual manner from plot tallies, and refer to stems of all species with diameters of 0.6 inches or greater.

Eleven of the thirteen forest types described by Damman were sampled. Table 1 shows that stands of all the forest types were well stocked, with average number of stems per acre ranging from 1548 to 2313.

The forest types can be divided into three distinct groups on the basis of site-index (Table 2). This division of the types is in agreement with Damman's description of their productive potential. The two types showing the fastest height growth, Moist Dryopteris and Dryopteris, do not differ significantly from one another, but are different, at the 99% significance level, from all other types. The two types cannot be regarded as homogeneous, however, since there is a significant difference of more than 50 sq ft per acre between their mean basal area values (Table 1). Mean annual merchantable volume increment averages approximately 33 cu ft per acre (capability class 5) for the Moist Dryopteris type and approximately 22 cu ft per acre (capability class 6) for the Dryopteris type.

The three forest types showing the poorest height growth, Sphagnum-Taxus, Carex-Sphagnum-bS, and Sphagnum-Girgensohnii, do not differ significantly from one another but can be distinguished from all other types, at the 99% level, on the basis of both site-index and basal area. These three forest types, which are unmerchantable, with mean annual increments averaging between 3 and 5 cu ft per acre (capability class 7), can be regarded as homogeneous for mensurational purposes.

The remaining six forest types are intermediate between the two groups already described. They form a series, with gradually decreasing values of mean site-index (from 34.5 to 29.9), but can be divided into three sub-groups which differ from one another at the 95% significance level (Table 2). One of the sub-groups contains the three intermediate types with the most rapid height growth (Clintonia, Clintonia-Sphagnum-bS, and Pleurozium), while a second includes the three intermediate types with the poorest height growth (Hylocomium, Rubus-Vaccinium and Dicranum-Nemopanthus). However, not all the forest types within these two sub-groups are significantly different fron one

TABLE 1

Avalon Peninsula forest types: statistics for basal area and number of stems per acre (all species)

Forest Type and Number of Samples	Basal Area (Square Feet/Acre)					Stems/ Acre mean
	Mean Mean	Recorded max-imum	Recorded min-imum	Stan-dard error	95% Confi-dence limits at mean	
Moist Dryopteris (5)	156.8	207.9	112.9	15.39	42.7	1836
Dryopteris (9)	105.9	162.1	64.9	11.64	26.8	1973
Clintonia (15)	135.2	205.0	85.9	9.71	20.8	1812
Clintonia-Sphagnum-bS (5)	124.6	155.9	107.3	8.31	23.1	1548
Pleurozium (26)	137.5	186.1	76.6	5.57	11.5	2075
Hylocomium (15)	121.1	166.1	80.8	5.97	12.8	2313
Rubus-Vaccinium (15)	123.7	189.9	60.7	9.01	19.3	2236
Dicranum-Nemopanthus (27)	104.9	165.0	29.1	5.64	11.6	2136
Sphagnum-Taxus (11)	55.5	106.2	31.8	6.64	14.8	1937
Carex-Sphagnum-bS (11)	52.6	101.3	8.1	7.87	17.5	1705
Sphagnum-Girgensohnii (9)	60.0	114.0	28.9	8.55	19.7	2136

TABLE 2

Avalon Peninsula forest types: statistics for site-index, the index species being balsam fir or black spruce

Forest types and number of samples	Mean	Recorded maximum	Recorded minimum	Standard error	95% Confidence limit at mean
Moist Dryopteris (5)	41.2	47.0	32.2	2.53	7.0
Dryopteris (9)	39.6	46.2	30.3	1.75	4.0
Clintonia (15)	34.5	38.8	29.0	0.71	1.5
Clintonia-Sphagnum-bS (5)	33.2	37.0	27.6	1.69	4.7
Pleurozium (26)	32.4	41.5	25.2	0.91	1.9
Hylocomium (15)	31.3	40.4	22.9	1.34	2.9
Rubus-Vaccinium (15)	30.1	40.9	22.1	1.52	3.3
Dicranum-Nemopanthus (27)	29.9	36.5	17.2	0.82	1.7
Sphagnum-Taxus (11)	20.7	29.8	14.4	1.58	3.5
Carex-Sphagnum-bS (11)	20.3	27.2	11.3	1.55	3.5
Sphagnum-Girgensohnii (9)	19.9	32.1	14.1	1.92	4.4

↕ ..... Continuous lines join those forest types with non-significant differences between site-index values (determined by paired t-tests for all possible combinations of forest types).

another and a third group can be formed at the 95% level, containing the Clintonia-Sphagnum-bS, Pleurozium, Hylocomium and Rubus-Vaccinium types.

Most intermediate types show a large variation in basal area. There is no significant difference between any of the six types, with the exception of the Pleurozium and Dicarnum-Nemopanthus types which are significantly different from one another at the 95% level (Table 1). No distinct mensurational groupings can be delineated on this basis. Mean annual increment averages between 18 and 25 cu ft per acre (capability class 6) for all six types.

Five-foot site-index classes and 20 sq-ft-per-acre basal area classes are normally associated with changes in crop yield of a magnitude sufficient to be of practical importance. Only the Clintonia, Pleurozium, and Dicranum-Nemopanthus types achieve this level of accuracy for site-index. Other types have confidence limits as high as ± 7.0 ft, and differences between maximum and minimum recorded values range from 9.4 ft (Clintonia-Sphagnum-bS) to 19.3 ft (Dicranum-Nemopanthus). None of the types are within the quoted limits for basal area, and differences between maximum and minimum values range from 48.6 to 135.9 sq ft for the various types.

These results suggest that Damman's forest type classification for the Avalon Peninsula is meaningful, in broad terms, in relation to the mensurational characteristics of the stands. The types can be divided into three broad groups which correspond reasonably well to the Canada Land Inventory Capability Classes 5, 6, and 7. However, the classification system cannot, alone, achieve desirable levels of accuracy for site-index and basal area. Any system of site potential evaluation or capability classification designed for use on the Avalon Peninsula will, therefore, need to take into account other site factors, such as soil drainage and exposure, which are of importance to forest growth, in addition to those already embodied in Damman's forest type classification.—G. Page, Forest Research Laboratory, St. John's, Nfld.

(*Continued from back cover*)

Larsen, Michael J. 1969. Notes on tomentelloid fungi. II. *Tomentella bresadolae* and *T. ruttnerii*. Mycologia. LXI: 670-679.
Lindquist, O. H. and W. J. Miller. 1969. The larvae of *Pristiphora acidovalva* (Hymenoptera: Tenthredinidae) in Ontario. Can. Entomol. 101:473-475.
Lüthy, Peter and Richard S. Soper. 1969. Chalky disease, a bacterial septicemia of the cicada *Okanagana rimosa* Say. J. Invertebrate Pathol. 14:158-164.
Lyons, L. A. 1969. The use of crystal violet for determining the age of sawfly cocoons in the soil. Can. Entomol. 101:915-920.
MacLean, Harold and B. F. MacDonald. 1969. Lignans of western red cedar (*Thuja plicata* Donn). IX. Plicatinaphthalene. Can. J. Chem. 47:4495-4498.
Mahendrappa, M. K. 1969. Determination of nitrate nitrogen in soil extracts using a specific ion activity electrode. Soil Sci. 108:132-136.
McGuffin, W. C. 1969. Larval head capsule characters for specific identification in *Deilinia* and *Drepanulatrix* (Lepidoptera: Geometridae). Can. Entomol. 101:1228-1231.
McIntosh, J. A. and E. L. Kerbes. 1969. Lumber losses in tree shear felling. B. C. Lumberman. (October).
Mia, A. J. 1969. Light and electron microscope studies of crystalline substances in *Acer saccharum* mineral stain. Wood Sci. 2:120-124.
Morris, R. F. and T. Royama. 1969. Logarithmic regression as an index of responses to population density: comment on a paper by M. P. Hassell and C. B. Huffaker. Can. Entomol. 101:361-364.
Morrison, D. J. 1969. Effect of hot-water-soluble *Thuja plicata* heartwood extractives on the growth of *Thuja* and non-*Thuja* isolates of *Poria weirii*. Can. J. Bot. 47:1605-1610.
Mullick, D. B. 1969. New tests for microscale identification of anthocyanidins on thin-layer chromatograms. Phytochemistry 8:2003-2008.
Nanassy, A. J. and A. Vyas. 1969. Electron spin resonance in pyrolyzed lignin. J. Macromol. Sci. Phys. (June): 271-292.
Parker, A. K. and James Reid. 1969. The genus *Rhabdocline* Syd. Can. J. Bot. 47:1533-1545.
Quon, H. H. and Eric P. Swan. 1969. Norditerpene alcohols in the bark of *Thuja plicata* Donn. Can. J. Chem. 47:4389-4392.
Rose, A. H. 1968. Noteworthy forest insects in Ontario in 1968. Proc. Entomol. Soc. Ont. 99:7-11.
Salamon, M. and S. McIntyre. 1969. Manipulation of air velocity permits drying time savings. Can. Forest Ind. (September).
Sanders, C. J. 1969. Extrusion of the female sex pheromone gland in the eastern spruce budworm, *Choristoneura fumiferana* (Lepidoptera: Tortricidae). Can. Entomol. 101: 760-762.
Sims, H. P. and N. G. Bruce. 1969. Recovery of vegetatoin and its effects on survival of planted jack pine seedlings after a light burn on a mixed pine-hardwood cutover. Pulp Pap. Mag. Can. (February).
Smerlis, E. 1969. Pathogenicity of some species of *Godronia* occurring in Quebec. Plant Dis. Reptr. 53:807-810.
Smirnoff, W. A. and J. R. Valéro. 1969. Influence de l'infection virale (Polyèdrie nucléaire) sur la formation d'acide urique chez la larve de *Neodiprion swainei* (Hymenoptera: Tenthredinidae). Can. Entomol. 101:763-766.
Smith, R. B. 1969. Assessing dwarf mistletoe on western hemlock. Forest Sci. 15:277-285.
Sohi, S. S. 1969. Adaptation of an *Aedes aegypti* cell line to hemolymph-free culture medium. Can. J. Microbiol. 15: 1197-1200.
Sullivan, C. R. and D. R. Wallace. 1968. Reductions in fecundity associated with inclusions in *Neodiprion sertifer* (Geoff.). Proc. Entomol. Soc. Ont. 99:57-60.
Turnock, W. J. 1969. Comparative food preferences of wireworms (Coleoptera: Elateridae) from sandy soil under pine woods. Man. Entomol. 2:76-80.
Weatherston, J. and J. E. Percy. 1969. Studies of physiologically active arthropod secretions. III. Chemical, morphological, and histological studies of the defence mechanism of *Uroblaniulus canadensis* (Say) (Diplopoda: Julida). Can. J. Zool. 47:1389-1394.
Weir, L. C. 1969. Experiments in control of *Fomes annosus* root rot in Douglas-fir and western hemlock. Plant Dis. Reptr. 53:910-911.
Whitney, R. D. and W. B. G. Denyer. 1969. Resin as a barrier to infection of white spruce by heartrotting fungi. Forest Sci. 15:266-267.

Recent Publications

Ackerman, R. F. and J. R. Gorman. 1969. Effect of seed weight on the size of lodgepole pine and white spruce container-planting stock. Pulp Pap. Mag. Can. (Convention Issue).

Agnihotri, V. P. and O. Vaartaja. 1969. Stimulation of *Waitea circinata* by root exudates of *Pinus cembroides*. Can. J. Microbiol. 15:1319-1323.

Basham, J. T., H. M. Good, and L. D. Taylor. 1969. The ecological status of *Coniochaeta velutina* in a sugar maple wounds. Can. J. Bot. 47:1629-1634.

Bergin, E. G. 1969. The strength and durability of thick gluelines. Dep. Fish. Forest., Can. Forest Serv. Pub. 1260. 24 p.

Calvert, W. W. and L. G. Brace. 1969. Pruning and sawing eastern white pine. Dep. Fish. Forest., Can. Forest. Serv. Pub. 1262. 22 p.

Cserjesi, A. J. 1969. Toxicity and biodegradation of dihydroquercetin. Can. J. Microbiol. 15: 1137-1140.

Dionne, Jean-Claude. 1969. Tidal flat erosion by ice at La Pocatière, St. Lawrence estuary. J. Sediment. Petrol. 39:1174-1181.

Dobie, J. 1969. A comparison of productivity with small logs in various types of sawmills. Proc. High-speed Headrig Conf., State Univ. Coll. Forest., Nov. 12-15 (1968) Syracuse, N.Y.

Downton, W. John S. and D. A. Ross. 1969. Factors influencing pupal coloration in *Neophasia menapia*. Can. Entomol. 101:774-777.

Eidt, D. C. 1969. Orientation of spruce budworm hatchlings. Can. Entomol. 101:1005-1006.

Evans, David. 1969. *Laspeyresia pseudotsugae* n. sp. (Lepidoptera: Olethreutidae), a bark miner in Douglas-fir. Can. Entomol. 101:955-963.

Feihl, A. O. and M. N. Carroll. 1969. Rotary cutting veneer with a floating bar. Forest Prod. J. 19: (October).

Flann, I. B. 1969. Take second look for hidden value in hardwood cull logs. Can. Forest Ind. (October).

Foschi, R. O. 1969. Stress distribution in plywood stressed-skin panels with longitudinal stiffeners. Dep. Fish. Forest., Can. Forest. Serv. Pub. 1261. 74 p.

Fowler, D. P. and C. Heimburger. 1969. Geographic variation in eastern white pine, 7-year results in Ontario. Silvae Genet. 18:123-129.

Fraser, J. W. 1969. Influences of sweet-fern on germination, survival, and early growth of red pine. Can. J. Bot. 47:1681-1683.

Funk, A. 1969. A shoot-blight disease of western larch in British Columbia. Can. J. Bot. 47: 1509-1511.

Gillespie, T., H. P. Sedziak, and J. Krzyzewski. 1969. The analysis of service life experiments on wood treated with preservatives. Wood Sci. 2:73-76.

Griffiths, K. J. 1969. Development and diapause in *Pleolophus basizonus* (Hymenoptera: Ichneumondidae). Can. Entomol. 101:907-914.

— The importance of coincidence in the functional and numerical responses of two parasites of the European pine sawfly, *Neodiprion sertifer*. Can. Entomol. 101:673-713.

— **and C. S. Holling. 1969.** A competition submodel for parasites and predators. Can. Entomol. 101:785-818.

Hopewell, W. W. and D. G. Bryant. 1969. Chemical control of *Adelges piceae* (Homoptera: Adelgidae) in Newfoundland, 1967. Can. Entomol. 101:1112-1114.

Keith, C. T. 1969. Resin content of red pine wood and its effect on specific gravity determinations. Forest. Chron. 45 (October).

Kerbes, E. L. and J. A. McIntosh. 1969. Conversion of trees to finished lumber — the volume losses. Forest. Chron. 45 (October).

Krywienczyk, J. and T. A. Angus. 1969. Serological investigations of parasporal inclusion protein from *Bacillus thuringinensis* strain 562-5A. J. Invertebrate Pathol. 14:258-261.

(*Continued on page 7*)

BI-MONTHLY

RESEARCH NOTES

IN THIS ISSUE:

Vol. 26—No. 2 MARCH-APRIL 1970.

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 Canadian Forestry Service, Department of Fisheries and Forestry

BIOLOGY

Effect of Partial Defoliation on Leader Growth.—This note concerns the inter-relationships of leader growth and growth in the rest of the tree in trembling aspen [*Populus tremuloides* Michx.]. The study was carried out in a nursery at Petawawa Forest Experiment Station. Mean annual temperature is 4.2C and annual precipitation averages 78.8 cm. Nursery plots lie on a well-drained sandy till.

One-year seedlings were transplanted in spring 1968 to a five-block layout with 24 x 24 inches (61 x 61 cm) spacing between plants. Each block contained 60 plants in each of three plots. On 26 May 1969, just before bud break, trees in two plots of each block were stripped of all branches (treatment 1). On 17 June 1969, after bud break, trees in one of these two plots in each block were treated by removal of all new (1969) branches (treatment 2). Trees in the remaining plot in each block were left untreated as controls. Thus, controls carried foliage on the new (1969) developing branches, and on branches originally formed in 1968; treatment 1 trees carried foliage on the 1969 leader and 1969 branches only; treatment 2 trees carried foliage only on the 1969 leader. Branches were not formed in the first year of seedling growth (1967). Five trees were lifted from each plot at five 3-week intervals during the summer; there were, therefore, five samples of 25 trees for each treatment and control. Plants were separated into leader foliage, other foliage if any, leader stem, wood, and other wood (stem, branches, and roots). Dry weights of these components were determined; plant height, area and number of leader leaves, and area of one subsample of 50 other leaves were measured for each plot sample of five trees. Only data from the last sample have been used in statistical analyses of results (Table 1). Where relevant, seasonal trends are illustrated (Fig. 1).

Analysis of variance (Table 1) indicates that neither treatment influenced height growth and weight of leaders (Fig. 1). Partial debudding of lower stems was similarly ineffective (Maini, Can. J. Bot. 44, 1581-90, 1966). Large differences in total plant increment (Fig. 1) resulted from the large differences in total leaf area.

The increase in size and number of leader leaves in treatments 1 and 2 may have been the result of a reduced transpiration load on the treated plants. This explanation is supported by the effects of pruning on fruit trees: pruning reduces total transpiration of the plant but increases transpiration in remaining leaves (Miller, Plant Physiology, p. 454; McGraw-Hill, 1938). Higher transpiration rates are associated with low internal moisture stresses, and low stresses favor growth processes such as initiation, cell division and cell enlargement (Slatyer, Physiological aspects of crop yield, Crop Sci. Soc. Amer. 53-83, 1969).

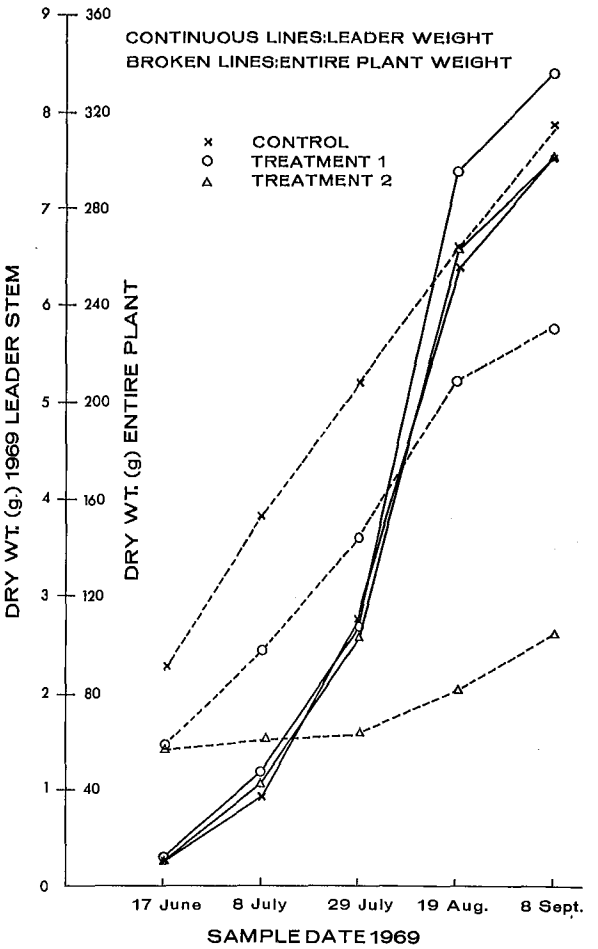
TABLE 1

Effects of defoliation treatments on growth of 3-year aspen seedlings and on characters of their current leaders.

	Treatment Mean			Variance Ratio
Variable	Control	1	2	Observed
Tree ht (cm)	174	174	171	0.20
Total tree wt (g)	314	232	105	16.9**
Leaf area (cm²)	7,063	5,479	1,268	14.5**
1969 leader:				
stem wt (g)*	7.6	8.2	7.7	0.22
leaf number	30.3	30.2	34.2	? 17**
leaf area (cm²)	787	967	1,268	7.40**
mean leaf area (cm²)	25.9	32.2	36.6	5.76**

*excluding leaves
**significant differences occur between means at P = 5%

FIGURE 1



All leaders were able to maintain usual growth, presumably because the leader has priority for its own produce. Independence of leader growth is not so evident in an evergreen conifer with determinate growth: although red pine debudded for 9 years did not show height growth different from that of controls (Berry, Forest. Chron. 38, 345-355, 1962), height growth of this species was retarded after removal of foliage below the leader (Kozlowski and Winget, Amer. J. Bot. 51, 522-29, 1964). Growth occurring in other organs in treatment 2 showed that the leader produced about five times more dry matter than was required for its own growth. It is consequently unlikely that leader growth resulted from relocation of assimilates from other parts of the tree.

Measurements of height growth are widely used in assessing results of tree breeding experiments; there is consequently good

reason for physiological studies being directed into leader extension growth. The design and interpretation of these studies would be easier if leader growth were more or less independent of growth in the rest of the plant; from data in this report, it is tentatively concluded that this is true for species showing indeterminate growth. The results suggest, so that some hardwood species could be managed to produce special purpose, knot-free boles without loss of height growth.—D. F. W. Pollard, Petawawa Forest Experiment Station, Chalk River, Ont.

Emergence Patterns of the Mountain Pine Beetle from Lodgepole Pine.—The effects of temperature and light on daily emergence and the effect of weather on the seasonal emergence of the mountain pine beetle [*Dendroctonus ponderosae* Hopk.] from lodgepole pine [*Pinus contorta* Dougl. var. *latifolia* Engelm.] have been studied by Reid (Can. Entomol., 94: 531-538, 1962) and Powell (Agr. Meteorol., 4: 189-201, 1967). Reid (*loc. cit.*) found that, in southeastern British Columbia, the pattern of daily emergence is more the result of temperature than light conditions. Emergence threshold is about 58F but most of the emergence occurs at temperature above 70F. Seasonal emergence is related to temperature since the beetles require about 8340 degree-hours above 10C in the subcortical zone of the stem to develop from egg to adult (Powell, *loc. cit.*). This paper relates the daily emergence patterns of the mountain pine beetle in southeastern British Columbia to aspect and height on the stem, tree diameter, heat units, and beetle size.

Beetles emerging from the northern and southern aspects of 6 trees in 1968, and 10 trees in 1969, were trapped at 2-foot intervals on the bottom 20 feet of the boles. The traps, consisting of ice-cream cartons 3 inches deep and 3⅞ inches in diameter with vials containing 75% alcohol attached to their lower sides to collect the beetles, were inserted into slits cut through the bark with a circular hole-saw when about 85% of the brood had matured. The traps were inspected every 2 to 3 days, between 8 and 9 AM, throughout the emergence period, and the number of emerging beetles was recorded by aspect, height, and date of emergence. Sex was determined by presence or absence of the stridulating teeth on the 7th abdominal tergite of the male (Hopkins, U.S.D.A. Bur. Entomol. Bull. 83 Part I, 1909). Pronotal width, measured on the dorsal aspect to the nearest 0.5 mm, was used as an index of beetle size. Heat units were expressed in degree-days above 58F.

Emergence in 1968 occurred between 14 July and 8 August, and in 1969 between 17 and 29 July. During these two emergence periods, 431 and 111 beetles respectively were collected in the traps; the corresponding male-to-female ratios were 1:1.9 and 1:3.3.

Emergence was directly proportional to degree-days above the 58F threshold during the emergence period in both years. The

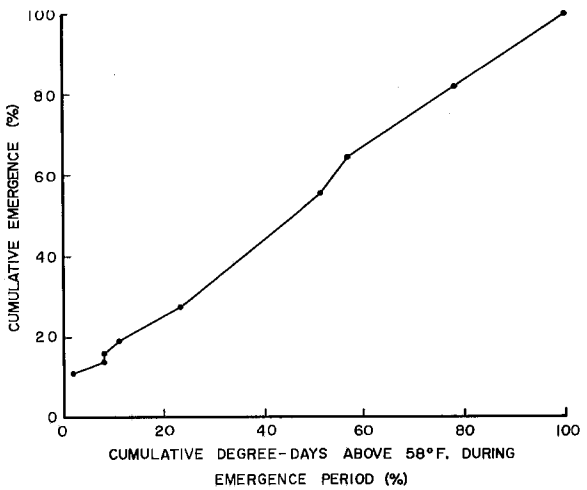


FIGURE 1. Cumulative emergence of male and female *Dendroctonus ponderosae* from the bottom 20 feet of the stem of lodgepole pine trees in relation to cumulative degree-days above 58F (1968 data).

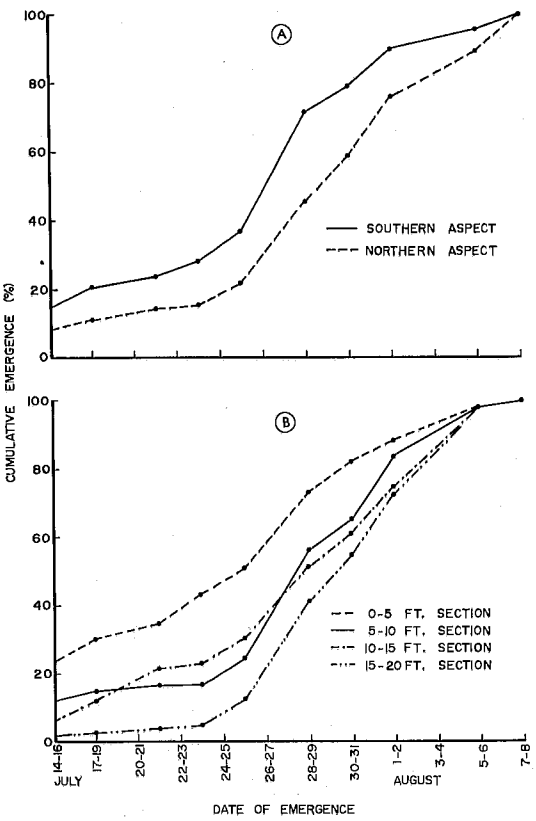


FIGURE 2. Cumulative emergence of male and female *Dendroctonus ponderosae* from the bottom 20 feet of the stems of lodgepole pine trees in relation to date of emergence in 1968. A, cumulative emergence by aspect; B, cumulative by level.

TABLE 1

Cumulative emergence of the mountain pine beetle from the bottom 20-ft section of lodgepole pine stems in relation to diameter in 1968[a].

Diameter at breast height (inches)	Cumulative emergence (%)	Date on which cum. emergence in column 2 was reached
12.2	25	July 18
	50	July 25
12.0	25	July 16
	50	July 25
11.5	25	July 26
	50	July 29
11.3	25	July 27
	50	July 29
11.1	25	July 27
	50	July 31
10.2	25	July 27
	50	July 31

[a] The 1969 data were excluded because, on the average, only 11 beetles per sample tree were trapped.

TABLE 2

Differences between average pronotal widths of mountain pine beetles emerging from the bottom 20-ft section of lodgepole pine stems during first and second halves of the emergence period.

	Average pronotal width of emerging beetles (mm)			
Year	Males		Females	
	First half of emergence period versus second half		First half of emergence period versus second half	
1968	1.92(74)[a]	1.86(73)	2.10(157)	2.04(127)*
1969	1.93(12)	1.85(14)	2.11(54)	1.99(31)*

[a] Numbers in brackets indicate sample size.
* Differences significant at the 5% probability level; entries without asterisks are not significant.

(*Continued on page 19*)

FOREST PRODUCTS

The Pyrolysis of Aspen and Black Spruce Lignins.—The search for more effective fire-retardant treatments for wood has resulted in the publication of a number of detailed studies on the pyrolysis of cellulose (MacKay, Wood Fire Behavior and Fire-Retardant Treatment. C.W.C. Nov. 1966). Relatively fewer investigations on the lignin component of wood have been made. However, because of its aromatic nature, lignin might be expected to be a major contributor to the development of the smoke associated with fire. A study was therefore initiated to investigate the basic processes involved in lignin pyrolysis and the mode of action, if any, of fire-retardants. Results of initial studies of the pyrolysis of two types of lignin are reported here.

Gas-chromatographic analysis of the flash-pyrolysis products of polymers has been used extensively to elucidate polymer structure and the mechanism of pyrolytic polymer degradation. This technique has been used by Kratzl *et al.* (Kratzl), Holz. Roh. *u.* Werkstoff 23(6):237, 1965) to characterize the pyrolysis products of Björkman spruce lignin, crude softwood sulfate lignin and crude hardwood sulfate lignin; also by Kitao and Watanabe (Kitao, J. Soc. Materials Sci. Japan 16(169):844, 1967) who studied the pyrolysis products of milled wood lignin (Björkman) from pine, beech, and rice straw.

In our studies, 0.5 mg samples of high-purity, fractionated ball-milled lignins (Brownell, Tappi 51(7):298-300, 1968) of aspen [*Populus tremuloides* Michx.] and black sprice [*Picea mariana* (Mill.) BSP.] were flash pyrolyzed at 425 C, in a stream of helium, using an F & M Model 80 Pyrolysis unit. The products were separated using an F & M Model 700 dual column, gas chromatograph, fitted with flame ionization detectors. With this arrangement the pyrolysis products were swept directly onto the column, thus minimizing secondary reactions. Copper columns, ¼ in. x 11 ft, packed with 5% Carbowax 20M on Chromosorb W (AW), operating at 177 C, afforded good resolution of the products as is shown in Fig. 1. Tentative identification of the phenolic products was made by comparing their retention times with those of expected reference model compounds (Table 1). A tentative qualification is noted since, in three instances, the retention times of single pyrolysis peaks (numbers 7, 9 and 10) correspond to those of two reference models. Improved resolution of lignin pyrolysis products was attained, as compared with earlier work.

TABLE 1

Retention times of aspen and black spruce lignin pyrolysis products

Pyrolysis product peak No.	Model reference compound	Relative retention time*
1	Guaiacol	1.00
2	4-Hydroxy-3-methoxytoluene	1.32
3	Phenol	1.48
4	4-Hydroxy-3-methoxyethylbenzene	1.67
5	*p*-Cresol	1.90
6	4-Hydroxy-3-methoxypropylbenzene	2.14
7	Eugenol 4-Ethylphenol	2.60
8	4-Hydroxy-3-methoxystyrene	2.87
9	*cis*-Isoeugenol 2,6-Dimethoxyphenol	3.61
10	*trans*-Isoeugenol 4-Hydroxy-3,5-dimethoxytoluene	4.72
11**	4-Hydroxy-3,5-dimethoxyethylbenzene	5.80
12**	4-Hydroxy-3,5-dimethoxypropylbenzene	7.35
13**	4-Hydroxy-3,5-dimethoxyallylbenzene	9.72
14	Vanillin	10.12
15	Acetovanillone	12.37

*relative to guaiacol (200 sec.).
**absent from black spruce lignin pyrogram.

Pyrolytic studies of aspen lignin or highly fractionated spruce lignin have not been reported previously. The use of high-purity lignins facilitates the characterization of the pyrolysis products by reducing the initial tailing of non-lignin products. In crude lignins, such tailing tends to swamp subsequent peaks. The presence of guaiacyl compounds among the pyrolysis products of spruce lignin and of both guaiacyl and syringyl compounds among those of aspen lignin is in agreement with the findings of others regarding the major difference in gross structure between gymnosperm and dicotyledonous-angiosperm lignins.

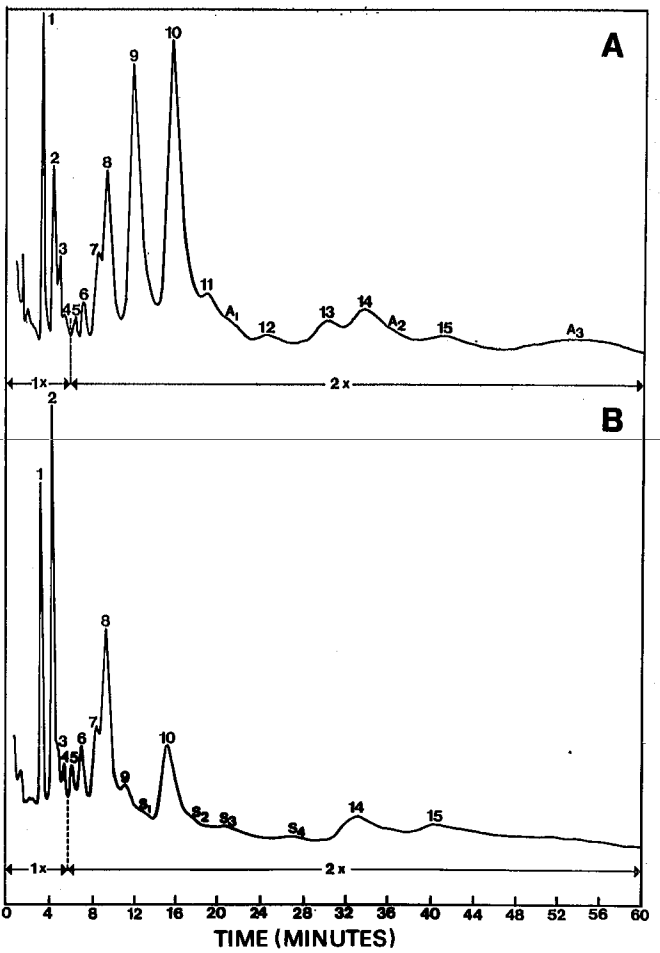


FIGURE 1. Wood lignin pyrogram: A. aspen [*Populus tremuloides* Michx.]; B. black spruce [*Picea mariana* (Mill.) BSP.].

Complete details of this work and recent findings on the effect of fire-retardants on the pyrolysis of these lignins are presently being prepared for publication.—D. P. Fung and R. A. Ripley, Forest Products Laboratory, Ottawa, Ont.

INSECT PATHOLOGY

Production of Resting Spores of Some *Entomophthora* Species on Artificial Media.—The periodic effectiveness of the genus *Entomophthora* in restricting or controlling natural populations of certain insects is well documented, but a major problem in inducing epizootics of these fungi is the development of a suitable method of introducing the fungus into the insect population. In nature, the fungus is in general propagated by conidia during the summer months and overwinters as thick-walled resting spores.

Conidia are readily produced on artificial media and germinate well, but they have a short life-span and are dependent upon high humidity for survival. Resting spores appear to offer the greatest potential for introduction of the fungus into an insect population as they are long-lived and resistant to a wide variety of weather conditions. Although they have proved difficult to germinate in the laboratory, this disadvantage may be offset by the fact that timing of applications is not as critical as it is for conidia.

Production of resting spores by *Entomophthora virulenta* was reported by Hall and Halfhill (J. Econ. Entomol. 52:30-35, 1959) when the fungus was grown on Sabouraud dextrose agar medium. These workers noted that 2-5% of these spores germinated readily when transferred to fresh medium. Gustafsson (Lantbrukshogskolans Ann. 31:103-212, 1965; *ibid.* 31: 405-457, 1965) confirmed the findings of Hall and Halfhill on *E. virulenta*, and noted the

production of resting spores in pure culture by *E. coronata*, *E. culicis* (Sabouraud dextrose medium), *E. sphaerospherma* (potato dextrose peptone medium), and *E. exitialis* (egg yolk medium).

This note concerns the production of resting spores by the following species of *Entomophthora*:

Species	Source of isolates	Obtained from
E. virulenta	*Peronea minuta*	Centraalbureau voor Schimmelcultures, Baarn.
E. tipula	Not known	Dr. J. Weiser, Prague.
E. conglomerata	Not known	Dr. J. Weiser, Prague.
E. pyriformis	*Rhopalosiphum insertum*	Mme G. Thoizon, Pasteur Institute, Paris.
E. thaxteriana	*Therioaphis maculata*	Agriculture Experiment, Station Berkeley, Calif.

These isolates grow rapidly and sporulate well on Sabouraud dextrose agar (Difco) supplemented with 0.2% yeast extract. For production of resting spores, Petri plates containing the medium were inoculated by spreading a washed mycelial suspension evenly over the surface of the medium. The mycelial suspension was obtained from a 2-3 day-old shake cultures grown in liquid medium of similar composition. The plates were incubated in an inverted position under continuous fluorescent light at room temperature (22-23 C). In all cases, conidial production generally began by the 2nd day, while resting spore formation was evident by the 4th or 5th day. The conidia were forcibly ejected from the surface of the medium by the conidiophores, and adhered to the lids of the Petri dishes.

Incubation of the plates was continued for approximately 2 weeks, by which time all growth and sporulation had ceased. The resting spores were readily obtained from the cultures by scraping the vegetative material from the agar surface with a glass microscope slide, followed by maceration a in VirTis homogenizer and repeated washing with distilled water. Very little contamination by conidia was noted.

To determine the effect of the various constituents of the medium on sporulation dextrose, peptone and yeast extract were incorporated singly and in pairs into media in amounts similar to those in the complete medium. The media were inoculated as described. Only media which included dextrose as one of the constituents supported substantial growth and the formation of conidia and resting spores. In all cases where sporulation occurred both conidia and resting spores were formed. Sporulation is therefore dependent upon the presence of a readily utilizable sugar in the growth medium. Experiments are now in progress to determine whether other sugars can replace dextrose in supporting sporulation of these isolates.

Our results are in accord with the findings of Hall and Halfhill, and Gustafsson, for *E. virulenta*, and further extend the number of *Entomophthora* species known to produce resting spores in culture. Work on the production of resting spores is now being extended to include other *Entomophthora* species available in pure culture.—David Tyrrell, Insect Pathology Research Institute, Sault Ste. Marie, Ont.

Preliminary Results of Radiation Induced Sterility of the Male Spruce Budworm.—The feasibility of employing the sterile-male technique in controlling the spruce budworm [*Choristoneura fumiferana* Clem.] is under investigation. This note presents preliminary results of the effects of gamma irriadiation on the male spruce budworm.

Male spruce budworms reared on a meridic diet (McMorran, Can. Entomol. 97: 58-62, 1965) after the method of Stehr (Can. Entomol. 86: 423-428, 1954) were irradiated with gamma rays from a Co^{60} source at the Atomic Energy of Canada laboratory in Chalk River, Ontario. The dose rate of the Co^{60} unit was 250 R/min at 49 cm from the source as determined by a dosimeter. Fourth-, fifth-, and sixth-instar larvae were each exposed to four levels of radiation, 0, 5, 10, and 30 kR. The pupae and adults were irradiated at 0, 10, 30, and 40 kR. The adults were mated at Chalk River after subjecting them to gamma rays, whereas the larvae and pupae were brought back to Sault Ste. Marie and mated after they had reached adulthood. Each male was placed in a suitable container with one virgin female and the mating success was determined by examining for the presence of sperms in the bursa copulatrix and seminal receptacle of the female. The eggs laid by the mated females and the larvae that hatched from these eggs were counted.

The irradiated larvae showed several pathological symptoms. Many of them had radiation burns (Fig. 1) and some of them had crumpled wings when they reached the adult stage. Pupation was considerably delayed and many died as pupae. Of the ones that reached the adult stage, only a few mated. Total sterilization, however, was never achieved.

FIGURE 1. Effect of gamma radiation on the sixth-instar larva of the spruce budworm. A) Control B) Received 30 kR and shows radiation burns.

The minimum sterilizing dose for pupae was 30 kR/male (Table 1). Some of the irradiated pupae developed a pair of vesicles filled with fluid instead of the wing buds, and failed to develop into adults. As the dose was increased there was a progressive increase in mating failure.

TABLE 1

Radiation sterilization of male pupae of spruce budworm.

Treatment (kR/♂)	Sample size	% mating failure	% egg hatch from ♀ that mated with irradiated ♂
0	19	5	80
10	21	57	60
30	22	86	0
40	22	95	0

The minimum sterilizing dose for the adults was also 30 kR/male (Table 2). The high incidence of mating failure was probably due to the disturbance they were subjected to while being transported to Chalk River during winter, since the untreated controls behaved as poorly as all but the most heavily irradiated ones.

These preliminary results indicate that larvae and pupae are difficult to sterilize without producing any adverse side effects. Adult males, however, can be successfully sterilized by exposing them to 30 kR/insect. Work on mating competitiveness of irradiated adult males is currently in progress.

TABLE 2

Radiation sterilization of adult male spruce budworm.

Treatment (kR/♂)	Sample size	% mating failure	% egg hatch from ♀ that mated with irradiated ♂
0	17	35	76
10	16	31	59
30	20	20	0
40	20	50	0

The author wishes to thank Dr. W. F. Baldwin, Biology and Health Physics Division, Atomic Energy of Canada Limited, Chalk River, Ontario, for laboratory facilities and setting up the Co^{60} source for irradiation. The technical assistance of Mr. John French and Mr. Christopher Rose are greatefully acknowledged. —Arthur Retnakaran, Insect Pathology Research Institute, Sault Ste. Marie, Ont.

PATHOLOGY

Infection of Engelmann Spruce by Hemlock Dwarf Mistletoe.—Evidence from nature and from artificial inoculations indicate that hemlock dwarf mistletoe [*Arceuthobium campylopodum* Engelm. f. *tsugehsis* (Rosend.) Gill] will infect about 20 conifer species and varieties included in the genera *Tsuga, Abies, Pinus, Larix* and *Picea*. Extensive damage is generally restricted to the principal hosts, western hemlock [*Tsuga heterophylla* (Raf.) Sarg.] and mountain hemlock [*T. mertensiana* (Bong.) Carr.], though pure stands of shore pine [*Pinus contorta* Dougl.] are occasionally severely attacked.

Species of spruce [*Picea*] are rarely attacked, and only when closely associated with infected western or mountain hemlock. Reports of natural infection exist for Brewer spruce [*P. breweriana* S. Wats.] in California (Hawksworth and Graham, Nthwst. Sci. 37:31-38, 1963) and Sitka spruce [*P. sitchensis* (Bong.) Carr.] in Alaska (Laurent, Plant Dis. Reptr. 50:921, 1966) and British Columbia [Molnar *et al.*, Can. Dep. For., 1967 Ann. Rpt. For. Insect Dis. Surv., 1968). Inoculation of white spruce [*P. glauca* (Moench) Voss] and Norway spruce [*P. abies* (L.) Karst.] showed these species were also susceptible to hemlock mistletoe (Smith, Can. Dep. For., Bi-m. Progr. Rpt. 21(6):3-4, 1965). In September 1969, F. G. Hawksworth (Rocky Mtn. For. and Range Exp. Sta., Ft. Collins, Colorado, Pers. comm. 1969), found a suppressed Engelmann spruce [*P. engelmannii* Parry] with several mistletoe-caused brooms near Santiam Pass, Oregon. No aerial shoots were visible but basal cups were present. Because the spruce occurred among western hemlock trees heavily infected by hemlock dwarf mistletoe, the mistletoe on it was assumed to be the same. This note presents information on the susceptibility of Engelmann spruce to hemlock dwarf mistletoe gained from artificial inoculations.

Inoculations were carried out near Victoria on plantation-grown Engelmann spruce from two provenances, Montana and southeastern British Columbia. The test trees were thrifty, growing almost 12 inches per year during the past 5 years. Seeds were collected and stored and inoculations effected, but only at the axils of needles, as previously described (Smith, Bi-Mon. Res. Notes, 2:—, 1970). Each year from 1963-1966, 10 mistletoe seeds from each original host were planted on each of four trees of the two provenances. A total of 640 seeds were used during the 4-year period.

Sixty-three infections were obtained; 28 swellings appeared within 1.5 years of inoculation, while a few were not apparent until after 3 years. Swellings were more globose (length: width = 2.7:1) than those resulting from normal parasitism of western hemlock trees (5.7:1) growing in the same plantation. Aerial shoots appeared irregularly, as early as 1.5 years after inoculation in a few infections, but more commonly not for 2 years or more. By August 1969 (3-6 years after inoculation) more than half of the infections still lacked shoots, contrasting with infections on western hemlock in which all swellings produced aerial shoots within 3 years of inoculation. After emergence, aerial shoots on Engelmann spruce developed normally; the longest measured was 79 mm. Flowers developed on 13 of the infections and anthesis proceeded regularly. A few female flowers were observed in 1968 but failed to develop into fruit in 1969. More female flowers appeared in 1969 and they seemed to be developing normally at the last examination.

Because of the earlier success with white and Norway spruce, infection of Engelmann spruce was not entirely unexpected. However, the high rate of infection was surprising. In particular, 44 infections developed from 160 seeds planted in 1965, an infection rate of 28%. This included 16 infections on southeastern British Columbia Engelmann spruce from 40 seeds collected from shore pine. Other than the latter particularly successful combination, there were no overall differences in the susceptibility of Montana and British Columbia spruce, or in the infectiveness of hemlock mistletoe from hemlock and shore pine.

Considering the relatively high frequency of infection produced in this study, natural infection of Engelmann spruce can be expected to occur wherever it is exposed to hemlock mistletoe. The Santiam Pass report noted earlier is the first observation of this in nature. In this case, the absence of living shoots prevented verification of the mistletoe species, but the presence of only hemlock mistletoe in the area and the demonstrated susceptibility of Engelmann spruce indicate that hemlock mistletoe was likely the casual agent. As range maps suggests that Engelmann spruce and hemlock mistletoe are probably sympatric in other areas of the Cascade Mountains in Oregon, Washington and British Columbia, other instances of this host-parasite combination undoubtedly exist. Hemlock mistletoe on Engelmann spruce may not be extensive or particularly damaging, but forest managers concerned with mistletoe control should be aware of this potential source of dwarf mistletoe inoculum.—R. B. Smith, Forest Research Laboratory, Victoria, B.C.

Development of Corky Root Disease in Douglas-fir Transplants.—Corky root, a stunting disease of Douglas-fir seedlings (Bloomberg, Can. Dep. For., Bi-Mon. Res. Notes 24:8, 1968), was probably introduced into the Duncan, B.C., forest nursery in fill-soil containing large populations of the nematode *Xiphinema bakeri* Williams 1961 (Sutherland and Dunn, Plant Dis. Reptr. In press). Consequently, the disease is present in well-defined areas.

In 1967, 1-0 Douglas-fir of a single seedlot from an uninfected nursery were transplanted into the area containing the nematode-infested soil and also into an area containing the original nursery soil. Two years later, the transplants in small patches of the imported soil area were severely stunted but elsewhere stunting was absent. For sampling purposes, the area was divided into "stunted" and "unstunted" plots. Five transplants were removed from each plot by carefully digging out as much of the root system as possible, together with surrounding soil. The plants and soil were placed immediately in polyethylene bags. For comparison, six transplants plus surrounding soil, in an adjoining area containing the original nursery soil, were dug from eight points about 20 feet apart.

Shoot and root growth of each seedling were measured. Lateral roots, and new root tips were counted. Disease severity in roots was rated by degree of swelling, lack of root hairs and clubbing of root tips.

The number of *X. bakeri* on seedling roots were determined by carefully removing the roots, with adhering rhizosphere soil, and quickly submerging them in a bucket half-filled with water. The roots were then washed with a stream of water, and the nematodes extracted by a modified (final screen of 325 mesh) Christie and Perry method (Proc. Helminthol. Soc. Wash. 18:106-108, 1951). To determine the populations of *X. bakeri* in the soil, each sample was thoroughly mixed and the nematodes extracted, by the same procedure from a 500 g (wet wt) aliquot. Nematode counts were expressed on an oven-dry weight of soil basis.

TABLE 1

Growth, disease severity, nematode populations and fungus infection in Douglas-fir transplants

Area	Plant Condition	Shoot growth after transplanting: 1st year % annual increase in length[c]	Shoot growth after transplanting: 2nd year % annual increase in length[c]	Shoot growth after transplanting: Total length (mm) at end of 2nd yr.	Root Growth: Tap root (mm)	Root Growth: % with >10 laterals	Root Growth: Disease severity[d]	Root Growth: No. new tips	No. *X. bakeri*: on roots	No. *X. bakeri*: in soil[e]	% Infection by *C. destructans*
Original soil distant[a]	Healthy	71	106	240	242	100	0.0	3.0	1.1	2.5	3
Original soil adjacent[b]	Healthy	58	131	244	273	100	0.4	5.5	22	61	7
Imported soil	Unstunted	61	85	186	253	100	1.1	8.7	411	433	15
Imported soil	Stunted	45	14	88	157	57	2.6	2.2	86	92	60

[a]Samples furthest from imported soil area. [b]Samples nearest to imported soil area. [c]% of shoot length at end of previous growing season. [d]0 = nil, 1 — light, 2 = moderate, 3 = severe. [e]Basis, 500 g O.D. soil.

Fungi were isolated from roots by submerging 10-mm root segments in an ultrasonic cleaner containing "Cavicide" (Mettler Electronics) for 10 minutes, rinsing with water and then aseptically transferring the central 5 mm of each segment to 2% malt extract agar containing 100 ppm steptomycin sulphate and 100 ppm penicillin G. Root segments were taken from swollen "corky" regions, if present; otherwise, they were taken from the mid-region of the taproot.

Table 1 presents a summary of our observations. During the first year after transplanting, there was little difference in the percentage of shoot-length increase between unstunted and adjacent plots. Therefore soil factors were not likely the cause of reduced shoot-length increase (45%) in the stunted plots. Also, the numbers of *X. bakeri* were much higher in soil and roots samples from the imported soil than from the original soil, and the root disease symptoms were characteristic of damage by *Xiphinema* spp. on other hosts (DiSanzo and Rhode, Phyto pathology 59:279-284, 1969; Davis, Phytopathology 49:523, 1959; Schindler and Braun, Nematologica 2:91-93, 1957). The symptoms and their localization in small patches of the imported soil were typical of corky root disease elsewhere (Bloomberg, *loc. cit.*).

Paradoxically, at the end of the second year after transplanting within the imported soil area, plots with the highest disease ratings had lower *X. bakeri* populations than plots with less disease. This may have resulted from initially high local populations damaging the roots so severely in the first year that height-growth was reduced but the available food became limited and the population declined. By the same reasoning, initially low populations may not have increased appreciably until the second year after transplanting when feeding had just begun to reduce height-growth but had not yet produced severe root disease symptoms.

Why the transplants growing in the unstunted plots of the imported soil and the adjacent plots of the original soil developed the most new root tips is not clear. These roots also had more nematodes than roots with fewer tips and it is possible that feeding stimulated the development of new tips.

The incidence of the fungus *Cylindrocarpon destructans* (Zinssm.) Scholten (= *C. radicicola* Wr.) increased with increased disease severity, adding to the evidence (Bloomberg, *loc. cit.*) that the fungus plays a role in the disease. However, the fungus is a very weak parasite of other tree hosts (Peace, Pathology of Trees and Shrubs, Clarendon Press, Oxford, 1962) so it may only infect roots that have already been damaged by the nematode. The fungus appears to persist in the roots but it is not known whether it prevents their recovery.

Corky foot disease had previously been observed only on Douglas-fir seedlings. The fact that it can also occur on transplants increases the importance of the disease. W. J. Bloomberg, Jack R. Sutherland, W. Lock and T. G. Dunn, Forest Research Laboratory, Victoria, B.C.

Seed Disease of Douglas Fir During Cone Storage. — An earlier report (Bloomberg, Forest Sci. 15: 176-181, 1969) dealt with the effects of cone characteristics, seed condition and fungus growth on disease and germinability of Douglas fir [*Pseudotsuga menziesii* (Mirb.) Franco] seeds during 125-225 days of cone storage. In 1968, the importance of these factors was investigated immediately after the cones were picked and during 90 days subsequent storage.

Four to six sacks (ca. 6-10 bu) of cones were picked from each of three stands (lots) of Douglas fir, 20 to 100 miles apart, on southern Vancouver Island. Picking took place 1-12 Sept. Operational picking, storage and seed extraction methods of the British Columbia Forest Service were used. Sampling design and methods of cone, seed and fungus assessment were the same as in the previous study. An unheated garage served as a temporary collection depot, the cone sacks being placed upright on the concrete floor with 1-ft spaces between them. After 30 days, the sacks were transferred to the cone sheds at the British Columbia Forest Service Seed Centre, Duncan, B.C. Air temperatures and relative humidity in each location were as follows:

	Collection Depot	Storage Shed
Air Temp (C)		
Range	5.5–16.6	−3.2–27.1
Avg weekly min	7.7	0
Avg weekly max	13.3	20.0
Relative humidity %		
Range	66–97	32–100
Avg weekly min	74	39
Avg weekly max	93	100
Avg no. hr 90%	2	13

Samples of cones were drawn from three sacks of each lot immediately after picking, and again after 7, 30, 60 and 90 days in storage. In each sample, cone, seed and fungus characteristics (see Table 1) were microscopically examined in 20 dissected cones, and cone moisture content (per cent oven dry weight) was determined from 200 cones. Seeds were extracted (except at 7 days' storage) from about 500 cones, cleaned in a Dakota blower, stratified, then tested for germination in four replicates of 100 seeds by standard procedures (Baldwin, FAO Forest. Development Paper 4, 1955).

Cone Characteristics. The cones of the three lots varied greatly in moisture content and scale closure (Table 1). At picking, the cones in lot A were drier and almost completely open, where those in lot B were almost completely closed. Insects, mainly *Contarinia washingtoniensis*, occurred in 25 to 90% of the cones examined and did not vary greatly among lots or storage periods.

Fungus growth. Mycelial growth on the cone surface, inside the scales and around the seeds was sparse or absent at the time of picking. Thereafter growth increased rapidly, completely covering cones in lots B and C after 30 days. Mycelial growth inside the cones also increased but attained maximal development later than the external growth. Growth occurred earlier around empty seeds than around filled ones. Fungus genera most commonly found on the cones included: *Papulospora, Penicillium, Trichoderma, Phoma, Trichothecium* and *Gliocladium* in that order.

Seed Condition. Less than 1% of the seeds examined in the cone were diseased, i.e., had lesions, or were discolored or decayed, but in germination tests after extraction, up to 27% of the filled seeds became diseased, accounting for 85% of the germination failures. In lot B, disease incidence during germination decreased with cone storage and in lot C, incidence increased temporarily after

TABLE 1. Relationship of cone storage period, cone characteristics, mycelial growth and seed condition in Douglas fir.

	Cone Characteristics				Mycelial Growth			Seed Condition	
					Mycelial Density[2]				
Lot	Cone storage period	Moisture content % oven dry wt	Scale Closure[1]	Cone surface covered	On inner scale	Around empty seeds	Around filled seeds	Germinable[3]	Diseased[3]
	(days)		index	%	index	index	index	%	%
A	0	50	1.2	14				87	
	7	—	—	40				—	
	30	41	1.0	65				89	
	60	25	1.0	—				87	
	90	26	1.0	—				87	
B	0	140	4.9	0	0	0.2	0	66	27
	7	—	—	12	1.0	0.5	0	—	—
	30	126	2.2	99	2.7	2.6	2.6	74	19
	60	92	1.5	100	5.5	4.2	3.2	80	17
	90	62	1.3	100	6.3	5.5	4.1	80	13
C	0	134	3.7	2	0.7	0.6	0	82	12
	7	—	—	45	2.9	2.5	2.0	—	—
	30	118	2.5	90	3.3	2.9	2.7	72	21
	60	78	1.4	98	4.3	4.4	3.9	87	11
	90	46	1.1	100	6.2	4.9	3.3	86	11

Note: Within the same lot, means followed by a bar are not significantly different ($p < .05$) by Duncan's multiple range test.
[1] Rated from 1 = fully open to 5 = tightly closed.
[2] Rated from 0 = nil to 10 = very heavy.
[3] Per cent of filled seeds: Other categories of seed condition (not shown) account for the balance of 100%.

the first 30 days in storage, then decreased. Fungus genera associated with disease included: *Penicillium, Gliocladium, Papulospora* and *Cephalosporium.*

Germinability (per cent filled seeds germinating) in all lots exceeded 80% after 90 days in storage. In lots A and C, germinability after 90 days in storage was the same as at the time of picking, whereas germinability of lot B increased.

The above results support indications from the previous study that, under local operational conditions, cone storage for at least 90 days does not reduce the germinability of Douglas-fir seeds, but may increase it; also that fungi are non-injurious to seeds while in the cones but are associated with disease during germination. As in the previous investigation, and in partial disagreement with other reports (Rediske and Shea, Forest Sci. 11: 463-472, 1965; Shea, Weyerhaeuser Co. Forest Res. Note 31, 1960), no other factors examined had any relationship to disease or germinability. Nor did insect damage, negligible in the previous investigation but severe in the present one, bear any relationship to disease or germinability — W. J. Bloomberg, Forest Research Laboratory, Victoria, B.C.

Infection of Western Larch by Hemlock Dwarf Mistletoe.— Since it was first described (Rosendahl, Minn. Bot. Studies 3: 271-273, 1903), hemlock dwarf mistletoe [*Arceuthobium campylopodum* Engelm. forma *tsugensis* (Rosend.) Gill] has been considered distinct from larch dwarf mistletoe [*A. campylopodum* forma *laricis* (Piper) Gill] (Piper, Contr. U.S. Nat. Herb. 11: 222-223, 1906). In a monograph of the genus (Gill, Trans. Conn. Acad. Arts and Sci. 32:111-245, 1935), the two were differentiated as forms mainly on the basis of principal hosts, western hemlock [*Tsuga heterophylla* (Raf.) Sarg.] for hemlock mistletoe and western larch [*Larix occidentalis* Nutt.] for larch mistletoe. The lack of evidence of cross-infection was considered justification for taxonomic separation even in the absence of demonstrated morphological differences. However, a report of natural infection of plantation-grown European larch [*Larix decidua* Mill.] by hemlock dwarf mistletoe on Vancouver Island (Kuijt, Madrono 17:254-256, 1964) suggested that physiological differences in the two forms were less pronounced than hitherto believed. The latter combination produced distinct swellings but no aerial shoots. Wicker (Ph.D thesis, Wash. State Univ., 1965) obtained a single infection of hemlock mistletoe on western larch by using an inoculation technique involving an artificial incision on the host branch.

To further the knowledge of host ranges, a series of inoculations employing several dwarf mistletoe and conifer species were conducted in a plantation near Victoria, B.C. Results pertinent to the taxonomy of larch and hemlock dwarf mistletoes are reported here.

Hemlock mistletoe seeds were collected in early October on Vancouver Island from western hemlock, the primary host, and from shore pine [*Pinus contorta* Dougl.], an occasional host. Larch mistletoe seeds were collected in September from western larch growing in southeastern British Columbia. All seeds were stored at 5C before inoculation in late October and early November. To effect adhesion to the branch surface, the seeds were briefly wetted and then placed mainly on 1- and 2-year-old branches at the axils of needles or at the bases of buds. Inoculations were repeated for 4 years from 1963 to 1966.

Twenty-nine of the 160 hemlock mistletoe seeds collected from shore pine and placed on western larch produced swellings, normally the first indication of infection; however, by 27 Aug. 1969, none bore aerial shoots even though swellings reached to 100 mm in length. Ten of the 160 seeds collected from western hemlock caused swellings on larch and one of these produced aerial shoots. The production of aerial shoots by this host-parasite combination is apparently rare. The inoculation was made in early November 1965, and a swelling with aerial shoots was first observed in October 1966. By 1968, five shoots were present. The largest (48 mm in length) bore staminate flowers in 1968. Anthesis occurred normally. Pollen recovered from the

flowers was examined by F. G. Hawksworth (U.S.F.S., Ft. Collins, Colorado) who classified it with the hemlock dwarf mistletoe type. By early 1969, all aerial shoots had died and no new shoots have appeared since.

It is instructive to compare the response of western larch to hemlock mistletoe with that of western larch to larch mistletoe. Of 144 larch mistletoe seeds planted on larch, 39 caused swellings. All swellings bore aerial shoots and new shoots are continually appearing. A comparison of the size of swellings caused by the two dwarf mistletoes indicates that the endophytic system of larch mistletoe is more vigorous than hemlock mistletoe when both are parasitizing western larch (Fig. 1).

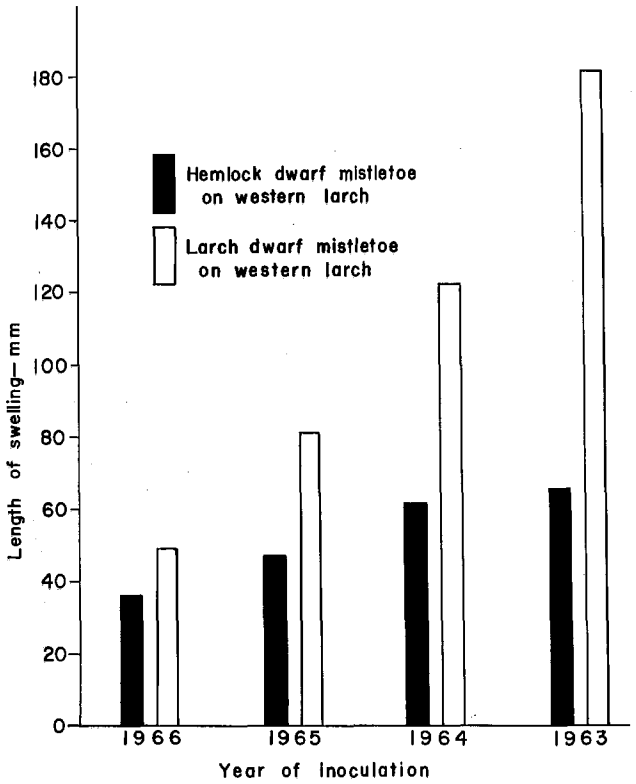


FIGURE 1. A comparison of the length of swellings on western larch caused by larch and hemlock dwarf mistletoes. Measurements were made 27 August 1969. Basis: 39 infections for each type.

No larch mistletoe infections were obtained on western hemlock.

Evidently, hemlock dwarf mistletoe can establish fairly readily on western larch. However, the slow growth it exhibits and the rarity of aerial shoot production shows that larch is a relatively incompatible host. Results also suggest that western hemlock is immune to larch mistletoe under artificial conditions, substantiating observations made in nature (Kuijt, Nat. Mus. Can, Bull. 186:134-148, 1963). These differences in the responses of western larch and western hemlock to larch and hemlock dwarf mistletoes, indicate that taxonomic separation of the two mistletoes, at least on a physiological basis, is justified.—R. B. Smith, Forest Research Laboratory, Victoria, B.C.

Butt Decay in Balsam Fir Defoliated by the Spruce Budworm.—The 1949-1959 outbreak of the spruce budworm [*Choristoneura fumiferana* (Clem.)] caused varying degrees of defoliation, top-killing, and tree mortality in dense stands of balsam fir [*Abies balsamea* (L.) Mill.] in northern New Brunswick (Baskerville, Forest. Chron. 36: 342-345, 1960). The surviving trees constitute the pulpwood forest of the future and the possibility of a high incidence of butt decay associated with the budworm stress is of vital interest. Rankin (Phytopathology 10: 314-315, 1920) and McCallum (Can. Dep. Agr. Bull. 104, 1928) reported no correlation between the amount of cull and previous budworm injury; however, Stillwell (Forest Sci. 2: 174-180, 1956) found a higher incidence of stem decay was commonly associated with buried leaders which had been killed by severe budworm defoliation. Similar information on the incidence of butt decay is lacking, although Redmond (Forest Sci. 4: 15-21, 1957) reported that the presence of butt decay could not be exclusively related to rootlet mortality resulting from budworm defoliation. However, existing infections may spread more quickly because of the reduction in tree growth and vigor.

In 1967, 368 trees greater than 4.5 inches dbh. were felled in two stands which had not been sprayed with insecticide during the 1949-1959 outbreak of spruce budworm: 191 trees were from the Kedgwick watershed in northwestern New Brunswick and 117 were from the Charlo watershed in north central New Brunswick. Both stands were released by the 1912-1920 outbreak and are predominantly balsam fir. The Kedgwick and Charlo stands were subjected to 9 and 7 years respectively of moderate to severe defoliation.

The volume of butt decay was determined for each tree. If no decay was visible in the stump, all main roots were cut about 1 foot from the root collar and examined. Decay fungi were cultured on 2% malt agar slants. A disk, marked on the north side, was taken from each tree about 2 feet from ground level and the dates and number of suppression rings were determined.

Of the isolation attempts on the two study areas, 54% yielded basidiomycetes. Six basidiomycetes were commonly isolated from both areas with nearly the same relative frequency (Table 1). Of the 122 basidiomycete isolates, 38% were *Scytinostroma galactina* which did not appear to be associated with any particular suppression group. *Armillaria mellea*, previously isolated with low frequency from balsam fir, constituted 30% of the isolates and was associated with trees of the higher suppression classes, conforming with the established pattern of *A. mellea* progressing rapidly in weakened trees (Boyce, Forest Pathology, McGraw Hill, 1961). *Coniophora puteana* comprised 22% of the isolates and was isolated with about equal frequency from all suppression classes.

TABLE 1

Frequency of isolation of basidiomycetes from butt decay in the Kedgwick and Charlo stands

Fungus	Kedgwick	Charlo
	Number of times isolated	
Scytinostroma galactina (Fr.) Donk	25	22
Armillaria mellea (Vahl ex Fr.) Kummer	21	15
Coniophora puteana (Schum. ex Fr.) Karst.	17	10
Odontia bicolor (Alb. & Schw. ex Fr.) Quel.	1	2
Polyporus balsameus Peck	2	2
Xeromphalina campanella (Batsch ex Fr.) Kuehn. & Maire	4	1
TOTAL	70	52
	122	

Radial growth of balsam fir is reduced 1 to 3 years after the first severe defoliation (Mott, Nairn, and Cook, Forest Sci. 3: 286-304, 1957). In the present study, all suppression rings initiated during the known period of the budworm infestation were assumed to be the result of defoliation. The few stems with more than seven suppression rings appeared to be suppressed by factors in addition to defoliation and were discarded.

The percentage of trees with butt decay in each suppression class is shown in Figure 1. Repression analysis of the data resulted in r^2 values of 0.67 and 0.79 for the Kedgwick and Charlo stands respectively, and the slopes of both regression lines were significant at the 5% level. Trees in the Charlo stand that suffered little or no suppression had an appreciably higher incidence of decay than trees of the same group in the Kedgwick stand. This suggests that factors in addition to budworm defoliation, such as site and stand history, are responsible for the overall higher incidence of decay in the Charlo stand.

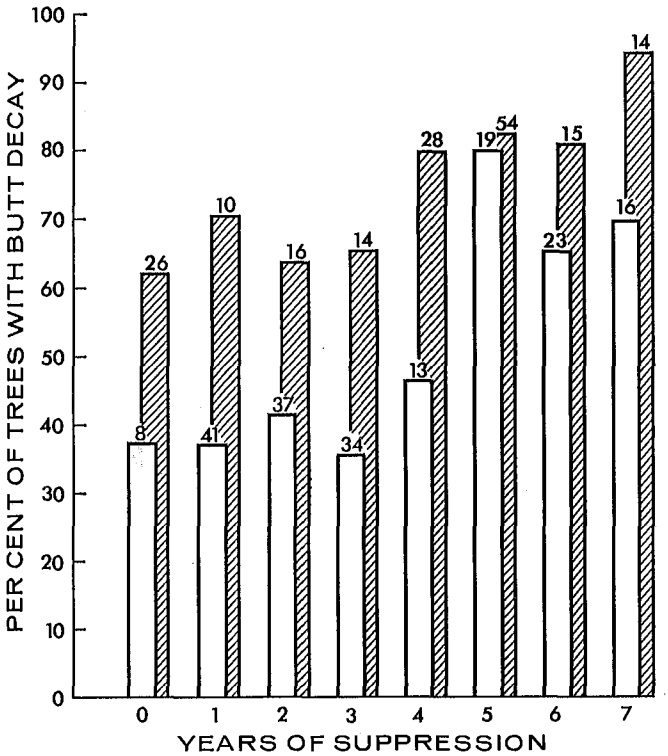


FIGURE 1. Percentage of trees containing butt decay in each suppression class. Numbers at top of bars indicate the total number of trees in each suppression class. Open – Kedgwick, hatched – Charlo.

The majority of the decay volumes were small and no relationship was apparent in either area between volume of decay and severity of suppression. Only 23% of the decayed trees from the Kedgwick stand had decay pockets more than 1 inch in diameter and only 27% of the decay pockets extended more than 6 inches above ground level. Decay volumes were somewhat higher in the Charlo stand where the values were 43 and 49%. As similarly defoliated trees age, however, they may contain higher volumes of butt decay which would tend to make them more susceptible to windthrow than trees that had not been defoliated. Consequently, this aspect of "budworm damage" should also be assessed so that a more precise prediction of the stands' future could be made.—T. E. Sterner, Forest Research Laboratory, Fredericton, N.B.

Pathogenicity of *Aleurodiscus amorphus*.—*Aleurodiscus amorphus* (Pers. ex Purt.) Schroet., a basidiomycete reported on Douglas fir [*Pseudotsuga menziesii* (Mirb.) Franco], true firs [*Abies* spp.], mountain hemlock [*Tsuga mertensiana* (Bong.) Carr.], Bishop pine [*Pinus muricata* D. Don], and spruces [*Picea* spp.] (Lemke, Can. J. Botany 42: 213-282, 1964), occurs in Quebec on balsam fir [*A. balsamea* (L.) Mill.]. In Quebec, the fungus is usually encountered on dead, lower branches of its host. Occasionally, it is also found on cankers of living branches of suppressed trees. *A. amorphus* has been associated with cankers of stems of lowland white fir [*A. grandis* Lindl.] and of branches of southern balsam fir [*A. fraseri* (Pursh) Poir.] in the United States by Hansbrough (Hansbrough, J. Forest. 32:452-458, 1934). Pathogenicity of the fungus, however, has not been demonstrated.

To investigate the pathogenicity of *A. amorphus*, a number of vigorously growing conifers were inoculated in 1968 in Quebec (Table 1). In addition, young, suppressed balsam fir in the understory of a coniferous stand in Laurentide Park were inoculated in 1966.

A total of 170 inoculations and 170 controls were made. An equal number of suppressed and vigorous balsam fir (20 trees each) were inoculated. All inoculations were done in the fall. The method of inoculation has previously been described (Smerlis, Can. J. Botany 47: 213-214, 1969). Two monospore isolates were used as inocula, one in 1966 and the other in 1968. Both isolates, grown on 3% malt agar at 15 C, originated from balsam fir. Inoculations on eastern white cedar, eastern hemlock, jack, lodgepole, red, Scots, and white pine, and Norway and red spruce were done on internodes of branches and stems ranging in age from 3 to 6 years. The other conifers were inoculated on leaders on 3-to-6-year-old internodes of branches or stems.

Results are presented in Table 1. *A. amorphus* was pathogenic on eastern hemlock, balsam fir, and the species of pines and spruces tested. Inoculations on eastern white cedar and the larches, trees on which *A. amorphus* has not been reported, were negative. The fungus was reisolated from all infected tree species although not from all infections. Controls were not infected. Infections on leaders of balsam fir caused either cankers or dying above the point of inoculation. Successful inoculations on internodes of branches and stems of balsam fir and the other tree species resulted in formation of cankers. The infections were more numerous and the cankers larger on vigorously growing balsam fir than on suppressed trees of the same species. The balsam fir, which were inoculated in 1968 but not sampled for the presence of *A. amorphus* in the spring of 1969 were reexamined in mid-July, 1969. Fruiting bodies of *A. amorphus* on the infections of these trees were not observed. The other tree species and also the balsam fir inoculated in 1966 were not reexamined after isolations had been made and presence or absence of fruiting bodies of *A. amorphus* was not established. E. Smerlis, Forest Research Laboratory, Ste. Foy, Quebec.

TABLE 1

Results of inoculations with *Aleurodiscus amorphus*.

	Inoculations				Controls	
Tree species	Total	Symptoms observed	Sampled	*A. amorphus* reisolated	Total	Symptoms observed
Abies balsamea (L.) Mill.[a,b] (balsam fir)	40	31	13	6	40	0
Larix decidua Mill.[c] (European larch)	10	0	0	0	10	0
L. laricina (Du Roi) K. Koch[a] (tamarack)	10	0	0	0	10	0
Picea abies (L.) Karst.[a] (Norway spruce)	10	7	3	1	10	0
P. glauca (Moench) Voss[a] (white spruce)	10	9	4	3	10	0
P. mariana (Mill.) BSP.[a] (black spruce)	10	7	3	2	10	0
P. rubens Sarg.[a] (red spruce)	10	8	3	1	10	0
Pinus banksiana Lamb.[a] (jack pine)	10	6	4	1	10	0
P. contorta Dougl.[a] (lodgepole pine)	10	4	3	1	10	0
P. resinosa Ait.[a] (red pine)	10	9	3	2	10	0
P. sylvestris L.[a] (Scots pine)	10	9	3	2	10	0
P. strobus L.[a] (white pine)	10	4	4	1	10	0
Thuja occidentalis L.[d] (eastern white cedar)	10	0	0	0	10	0
Tsuga canadensis (L.) Carr.[d] (eastern hemlock)	10	8	3	2	10	0

Locations: a = Valcartier; b = Laurentide Park; c = Saint-Etienne-de-Lauzon; d = Saint-Louis-de-Blandford.

SILVICULTURE

Effect of Scarification on a Non-regenerating Burn.—The ability of fire to create a suitable seedbed on upland black spruce [*Picea mariana* (Mill.) BSP.] sites is largely dependent upon moisture conditions at the time of burning. A dry-season fire will frequently consume most of the raw humus and leave only a thin layer of organic residue with some exposed mineral soil (Chrossciewicz, Forest. Br. Dep. Forest. Rural. Develop. Pub. No. 1181, 1967); this condition is favorable for the regeneration of spruce. A fire occurring during a period of low drought index often destroys only the surface litter leaving a thick layer of surface-charred humus which is detrimental to the establishment and survival of spruce seedlings. This latter condition results in poorer

seedbeds than before burning and accounts for some of the extensive areas of understocked spruce sites in Newfoundland.

An opportunity to test the effect of scarification to improve seedbed conditions on a non-regenerating burn was presented in August 1965 when a wildfire swept through a portion of 1964 cutover on the Gander watershed of central Newfoundland. The burn was located on moraine material, derived from fine granites, along the south side of the Northwest Gander River valley at an elevation of 300 ft A.M.S.L. The soil is a fresh sandy loam overlain by 3-5 inches of organic material which, prior to burning, supported a moss and ericaceous shrub vegetation. After cutting, in the absence of fire, this condition would not normally prohibit adequate spruce regeneration. However, the late season fire did not burn deeply and created a typical problem area.

Site treatment was applied in August 1966, 1 year after burning, using an SFI scarifier. This is a mechanical device, with scalping arms, which produce scalps at 6-ft. intervals (Wilton & Salter, Dep. Fish. Forest, Br. Info. Rep. N-X-32, 1969). These spaced scalps are patches, each about 2.5 square feet in size, on which the mineral and organic soils have been loosened and intermixed. The treatment was applied to an area of approximately 10 acres. Seeding to Sitka spruce [*Picea sitchensis* (Bong.) Carr.] was conducted on a portion of the area in November 1967; the remainder of the scarified section was left unseeded. Seeding consisted of depositing, by hand, 10 viable seeeds on or near a scarrified patch. The design permitted testing of all combinations of scarification and seeding treatments; in addition an adjoining unburned cutover block was used as a control.

The area was examined in the fall of 1969, approximately 2 years after establishment. Assessment was based upon examination of contiguous milacre quadrats in each of the treatment categories. It is obvious (Table 1) that the area would have regenerated adequately, after clearfelling, in the absence of fire. However, the table also indicates that scarification and seeding is required for successful regeneration of lightly burned cutovers.

Table 2 shows an analysis of seedling occurrence, on the scarified area, classified according to seedbed categories. This is based upon the detailed mapping of individual milacre quadrats. Relative seedbed receptivity, in Table 2, refers to the seedling numbers per unit area.

TABLE 1

Regeneration Results from Combinations of Treatments

Treatment	Samples (Milacre Quadrats)	Percent Quadrats Stocked	Average Seedlings Per Stocked Quad.
Burned, scarified, seeded	100	89	6.9
Burned, scarified, unseeded	100	14	1.1
Burned, unscarified, unseeded	50	16	1.2
Burned, unscarified, seeded	50	8	1.0
Unburned, unscarified, unseeded	50	52	6.0

TABLE 2

Seedling Frequency for Various Seedbed Media Occurring on a One-Acre Scarified and Seeded Block

Seedbed Type	Percent of Total Area	Number of Seedlings			Relative Seedbed Receptivity (Sitka Spruce)
		Sitka Spruce	Black Spruce	White Birch	
Mineral Soil	7.3	3010	—	1010	37
Mixed mineral and organic soil	4.1	2550	10	400	56
Charred organic material	85.7	530	—	480	1
Live mosses	1.1	10	—	80	1
Other	1.8	100	—	100	5

It is noteworthy that natural seedlings occur on these seedbeds in approximately the same ratio as seeded specimens. The study has demonstrated that a surface-charred thick organic layer does not constitute a good spruce seedbed and, in the absence of additional site treatments, such areas are likely to degenerate to open stands of hardwood species.—W. C. Wilton and E. Salter, Forest Research Laboratory, St. John's, Newfoundland.

(*Continued from page 11*)

relationship between cumulative percentage emergence and cumulative percentage degree-days for the 1968 data is shown in Fig. 1. Males and females emerged at the same relative rate in both years. Beetles emerged at a greater relative rate from the southern aspect of trees than from the northern aspect (Fig. 2A) possibly because subcortical temperatures are usually higher on the southern aspect (Powell, *loc. cit.*). Furthermore, the relative rate of emergence from the stem generally decreased with height from the ground (Fig. 2B). The rates of emergence in relation to aspect and height on the stem were about the same in both years. Beetles generally emerged at a faster rate from trees with large diameters than from trees with small diameters (Table 1).

The average pronotal width of females emerging in the first half of the emergence period was significantly greater (at the 5% level) than that of females emerging in the second half in 1968 and 1969 (Table 2). Although the average size of the males was also greater in the first half of the emergence period than in the other half in both years, the differences in these averages were not statistically significant.

These results suggest that the emergence pattern of the mountain pine beetle from lodgepole pine is related to host characteristics associated with height on the stem and tree diameter, in addition to subcortical temperatures before emergence.—L. Safranyik and R. Jahren, Forest Research Laboratory, Calgary, Alta.

(*Continued from back cover*)

MacGillivray, H. G. 1969. Larches for reforestation and tree improvement in eastern Canada. Forest. Chron. 45:440-444.

MacHattie, L. B. 1969. Modern meteorological services and forest fire control. Pulp Paper Mag. Can. 70(16)87-89.

Manley, S. A. M. and D. P. Fowler. 1969. Spruce budworm defoliation in relation to introgression in red and black spruce. Forest Sci. 15:365-366.

Mansingh, A., T. S. Sahota, and D. A. Shaw. 1970. Juvenile hormone activity in the wood and bark extracts of some forest trees. Can. Entomol. 102:49-53.

McIntosh, J. A. and D. M. Wright. 1970. Haul roads in the sky. Can. Forest Ind. 90(1):46-51.

Morgenstern, E. K. and D. P. Fowler. 1969. Genetics and breeding of black spruce and red spruce. Forest. Chron. 45:408-412

Place, I. C. M. 1969. Tree breeding in Canada. Forest Chron. 45:375-377.

Roche, L., M. J. Holst, and A. H. Teich. 1969. Genetic variation and its exploitation in white and Engelmann spruce. Forest. Chron. 45:445-448.

Sayn-Wittgenstein, L. and A. H. Aldred. 1969. A forest inventory by large-scale aerial photography. Pulp Paper Mag. Can. 70(17):92-95.

Smerlis, E. 1969. Pathogenicity tests of four Pyrenomycetes in Quebec. Plant Disease Reptr. 53:979-981.

Smirnoff, W. A. and O. Eichhorn. 1970. Diseases affecting predators of *Adelges* spp. on fir trees in Germany, Switzerland, and Turkey. J. Invertebrate Pathol. 15:6-9.

— **and J. M. Loiselle. 1969.** Influence of a virus infection on the formation of uric acid in the fat body of *Galleria mellonella*. J. Invertebrate Pathol. 14:421-422.

Sutton, B. C. 1969. Forest microfungi. III. The heterogeneity of *Pestalotia* de Not. section Sexloculatae Klebahn sensu Guba. Can. J. Botany 47:2083-2094.

— **1969.** *Minimidochium setosum* n. gen., n. sp. and *Dinemasporium aberrans* n. sp. from West Africa. Can. J. Botany 45:2095-2100.

Taylor, L. David. 1970. *Coniochaeta velutina* and its synonyms. Can. J. Botany 48:81-83.

Turnock, W. J. 1969. Comparative food preferences of wireworms (Coleoptera: Elateridae) from sandy soil under pine woods. Man. Entomol. 2:76-80.

Tyrrell, D. 1969. Biochemical systematics and fungi. Botan. Rev. 35:305-316.

Venkateswaran, A. 1969. X-ray studies of cellophane. J. Appl. Polym. Sci. 13:2459-2468.

Recent Publications

Bird, F. T. 1969. Infection and mortality of spruce budworm, *Chloristoneura fumiferana*, and forest tent caterpillar, *Malacosoma disstria*, caused by nuclear and cytoplasmic polyhedrosis viruses. Can. Entomol. 101:1269-1285.

Bonga, J. M. 1969. The morphology and anatomy of holdfasts and branching radicles of *Arceuthobium pusillum* cultured in vitro. Can. J. Botany 47:1935-1938.

Calvert, W. W. and L. G. Brace. 1969. Pruning and sawing eastern white pine. Dep. Fish. Forest. Can. Forest. Serv. Pub. 1262. 22 pp.

Chapman, J. A. 1969. Winged ants return after removal from a summit swarming site. Ann. Entomol. Soc. Amer. 62:1256-1259.

Clements, John R. 1970. Shoot responses of young red pine to watering applied over two seasons. Can. J. Botany 48:75-80.

Ebell, L. F. 1969. Revised circuitry for a variable speed, motorized burette. Laboratory Practice 18:1073.

Eidt, D. C. and J. O. Nichols. 1970. An outbreak of a sawfly, *Pamphilius phyllisae* (Hymenoptera: Pamphiliidae), on northern red oak, with notes on larval morphology. Can. Entomol. 102:53-63.

Eis, S. 1970. Reproduction and reproductive irregularities of *Abies lasiocarpa* and *A. grandis*. Can. J. Botany 48:141-143.

Foschi, R. O. 1969. Buckling of the compressed skin of a plywood stressed-skin panel with longitudinal stiffeners. Dep. Fish. Forest. Can. Forest. Serv. Pub. 1265. 50 pp.

— **Ricardo O. 1970.** Point-matching of curved timber beams. J. Struct. Div., Proc. Amer. Soc. Civil Eng. 96:35-48.

Fowler, D. P. and C. C. Heimburger. 1969. Genetic improvement of red pine and eastern white pine. Forest. Chron. 45:414-419.

Gardiner, L. M. 1970. Rearing wood-boring beetles (Cerambycidae) on artificial diet. Can. Entomol. 102:113-117.

Garlicki, A.M. and W. W. Calvert. 1969. A comparison of power requirements for full-length versus tree-length skidding. Pulp Paper Mag. Can. 70(14)83-86.

Ghent, A. W. 1969. Studies on regeneration in forest stands devastated by the spruce budworm. IV. Problems of stocked-quadrat sampling. Forest Sci. 15:417-429.

Hedlin, A. F. and D. S. Ruth. 1970. A Douglas-fir twig mining beetle, *Pityophthorus orarius* (Coleoptera: Scolytidae). Can. Entomol. 102:105-108.

Hoedemaker, E. and E. G. Bergin, 1969. A disc-shear technique for evaluating assembly glue bonds in plywood-lumber composites. Dep. Fish. Forest. Can. Forest. Serv. Pub. 1266. 9 pp.

Holst, M. J. and C. C. Heimburger. 1969. Tree breeding and genetics of exotic conifers in Canada. Forest. Chron. 45:434-440.

Jurdant, Michael. 1969. The ecological survey: The biophysical basis of forest land management. Pulp Paper Mag. Can. 70(9):89-92.

King, B. and R. O. Foschi. 1969. Crossed-ring dynamometer for direct force resolution into three orthogonal components. Int. J. Mach. Tool Des. Res. 9:345-356.

Krywienczyk J. and T. A. Augus. 1969. Serological investigations of parasporal inclusion protein from *Bacillus thuringiensis* strain 562-5A. J. Invertebrate Pathol. 14, 258-261.

Lindquist, O. H. and A. A. Harnden. 1970. A study of the biology of the web-spinning sawfly *Pamphilius ochreipes* (Hymenoptera: Pamphiliidae) in Ontario. Can. Entomol. 102:95-97.

— **and M. J. Thomson. 1970.** The biology of a birch leaf miner, *Messa nana* (Hymenoptera: Tenthredinidae), new to Canada. Can. Entomol. 102:108-111.

Little, C. H. A., 1970. Apical dominance in long shoots of white pine (*Pinus strobus*). Can. J. Botany 48:239-253.

Lyons, L. A. 1970. Some population features of reproductive capacity in *Neodiprion swainei* (Hymenoptera: Diprionidae). Can. Entomol. 102:68-84.

(*Continued on page 19*)

O.H.M.S.

DEPARTMENT OF FISHERIES AND FORESTRY OF CANADA

FBI - MONTHLY

RESEARCH NOTES

IN THIS ISSUE:

Vol. 26—No. 3, MAY-JUNE 1970.

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 Canadian Forestry Service, Department of Fisheries and Forestry

ENTOMOLOGY

Avian Predators of Eastern Hemlock Looper in Newfoundland.—Several outbreaks of the eastern hemlock looper [*Lambdina fiscellaria fiscellaria* (Guenée)] have been recorded in Newfoundland since 1912. During the current outbreak, a preliminary study was made to obtain information on avian predation on this insect.

Birds were collected between July 30 and September 18 in a partially cut balsam fir stand near Corner Brook in western Newfoundland. The stand was moderately defoliated and beating samples from 10 trees averaged 148 larvae per tree. The stomachs of 60 birds representing 22 species and 9 families were removed and stored in 70% ethanol. Contents of the stomachs were examined under a microscope and the food material was classified.

No loopers were found in the stomach of the hairy woodpecker (2 specimens), downy woodpecker (2), black-backed three-toed woodpecker (1), red-breasted nuthatch (2), American robin (2), and the ruby-crowned kinglet (1). Remains of looper eggs, larvae, pupae and adults were estimated in the other birds as a percentage of the area occupied by the entire food content of the stomach (Table 1).

TABLE 1

List of the avian predators of the eastern hemlock looper with the percentage of looper in the diet relative to total area of food mass.

Species	No stom. exam.	Looper Stages in Diet—% Egg	Larva	Pupa	Adult	Total Area Occup. by All Food Particles (in mm²)
Tyrannidae						
Empidonax flaviventrix (Baird and Baird) (Yellow-bellied) flycatcher)	3	trace (1)*	25(3)	—	—	939
Corvidae						
Perisoreus canadensis (Linnaeus) (Gray jay)	4	—	5(1)	—	—	3,136
Paridae						
Parus atricapillus Linnaeus (Black-capped chickadee)	8	2(4)	23(5)	27(7)	1(1)	1,903
Parus hudsonicus Forster (Boreal chickadee)	1	10(1)	—	2(1)	—	102
Turdidae						
Hylocichla guttata (Pallas) (Hermit thrush)	2	16(2)	—	43(2)	—	751
Parulidae						
Mniotilta varia (Linnaeus) (Black-and-white warbler)	2	5(1)	30(1)	23(1)	5(1)	609
Vermivora peregrina (Wilson) (Tennessee warbler)	1	—	7(1)	77(1)	—	375
Dendroica coronata (Linnaeus) (Myrtle warbler)	2	trace (1)	—	—	—	900
Dendroica virens (Gmelin) (Black-throated green warbler)	3	5(2)	42(3)	36(3)	4(1)	792
Dendroica striata (Forster) (Blackpoll warbler)	1	4(1)	30(1)	32(1)	14(1)	496
Seiurus noveboracensis (Gmelin) (Northern waterthrush)	1	—	2(1)	—	—	50
Oporornis philadelphia (Wilson) (Mourning warbler)	1	—	—	30(1)	—	253
Geothlypis trichas (Linnaeus) (Common yellowthroat)	1	1(1)	—	7(1)	—	151
Fringillidae						
Carpodacus purpureus (Gmelin) (Purple finch)	2	trace (1)	—	46(2)	—	420
Pinicola enucleator (Linnaeus) (Pine grosbeak)	11	6(7)	20(7)	39(9)	—	8,541
Zonotricia albicollis (Gmelin) (White-throated sparrow)	7	trace (1)	9(3)	—	—	3,166
Total	50	(23)	(26)	(29)	(4)	

*Figures in parentheses indicate number of stomachs in which the food was found. Percentages are rounded off to nearest percent.

The avian predators were ranked in the order of importance on the basis of the amount of looper material found in the stomachs. The more important species, in decreasing order, are: pine grosbeak, blackpoll warbler, black-and-white warbler, Tennessee warbler, black-throated green warbler and black-capped chickadee. One pine grosbeak stomach contained remnants of 50 pupae, another 32 pupae. The stomach of one black-capped chickadee had 12 larvae and 20 pupae.

Hemlock looper larvae and pupae made up 84.0, 77.2, 61.6 and 52.9% of the diet of the Tennessee, black-throated green, blackpoll, and black-and-white warblers. In addition, looper moth remnants and eggs were found in the stomachs of these warblers. It is presumed that most looper eggs came from moths macerated in the stomach rather than being picked individually and eaten. About one-half of the diet of the pine grosbeak and the black-capped chickadee was composed of looper larvae and pupae. Chickadees were observed picking resting looper moths from tree trunks and branches, and capturing some in flight. It was also noted that chickadees clip the wings from moths before swallowing the body. Only a single specimen of each of the mourning warbler, hermit thrush and purple finch was examined. Looper remains found in the stomachs of these species were composed solely of pupae.

Results of this study provide only a preliminary list of birds feeding on the eastern hemlock looper and an indication of the extent of this predation. No attempt was made to census the bird population or to determine its control value. However, the results presented provide additional evidence of the potential importance of birds as predators of forest insects as suggested by others (Buckner, Annu. Rev. Entomol. 11: 449-470, 1966) and warrant further investigation. Studies will be continued and intensified in the coming field season.—Imre S. Otvos and Mary E. Taylor, Forest Research Laboratory, St. John's, Nfld.

FOREST PRODUCTS

An Improved Technique for Determining the Green-volume Specific Gravity of Small Wood Samples.—The green volume-oven dry weight specific gravity of small wood samples can be calculated by the following formula:

$$\text{Sp. gr.} = \left[\frac{W_d}{W_a - W_1}\right] d_1$$

where W_a is the oven-dry weight, W_1 is the saturated weight in water, and d_1 is the density of the water (Browning. Methods of Wood Chemistry. Vol. I. Interscience Publ., N.Y. 1965). When

the measurement is in grams, the value of d_1 for water at room temperature is usually taken as 1.0. Accurate determination of W_1 is the critical step in obtaining the correct specific gravity values. The usual method for the determination of W_1 requires the use of an analytical balance with a weighted pin suspended from the balance pan hook, and a reservoir filled with water.

The risk of error is high with this method because of the number of weighings and weighing checks that must be made and the subtraction steps that must be carried out for each sample. Also, the time required to obtain the W_1 value for a single sample is 2-5 minutes depending on the ability of the operator to estimate the volume of water required to correct the water level in the reservoir. Adjusting the water level with a dropping pipet is tedious, but must be made to ensure constant hydrostatic pressure.

With the new technique, a semi-micro analytical balance that has a tare range covering the entire weighing capacity of the balance is used. A weighted-pin assembly is substituted for the balance pan (Fig. 1) and after adjusting the reservoir water-level, the balance is adjusted to zero.

The tediousness of adjusting the reservoir water-level is eliminated by the use of a reservoir coupled with a 30-ml syringe (Fig. 2). The syringe needle is soldered to a piece of brass which has been machined to accept 3/16″ I.D. tygon tubing. The syringe is mounted in an aluminum holder which consists of two syringe supports, a thumb screw, and a thumb screw support. The thumb screw has 20 threads per inch and is equipped with a 1.5-inch-diameter handle for accurate adjustment of the syringe plunger, which transfers small volumes of water into or out of the reservoir. A plexiglass tray is placed under the reservoir to prevent water from entering the weighing mechanism of the balance.

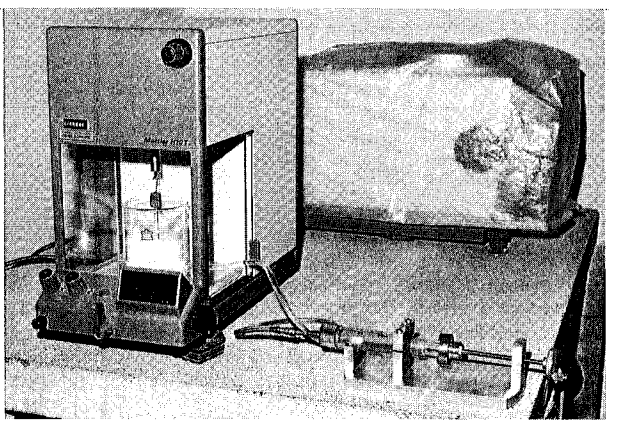


FIGURE 1. Weighing system for green-volume determination of small wood-samples.

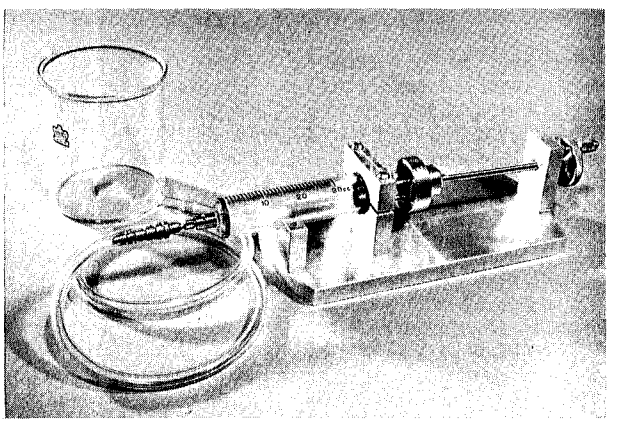


FIGURE 2. Syringe and reservoir system for green-volume determination.

The modifications provide several procedural advantages: (1) the weight of the sample in water is read directly, which eliminates the possibility of error when the weight of the weighted pin is subtracted; (2) the water level is corrected directly and almost instantly; (3) the weight of the pin assembly is checked very rapidly by the zero check of the balance; (4) removal of the balance pan clears the area where the sample is suspended, which gives more room and faster access to the sample.

This equipment has the advantage of providing very accurate and rapid adjustment of water level. It, therefore, provides a rapid measure of volume of small wood samples, with a resulting reduction in operator fatigue and error.—J. B. Kasper, Forest Research Laboratory, Calgary, Alt.

***Trichoderma viride* Enzymic Degradation of Wood Structure.**—The attainment of cell-free enzymic decay of wood could facilitate study of natural wood decay and wood structure chemistry. Recently Jutte (Bull. No. 141, Bot. Lab. State Univ. Leiden, Holland, 1969) demonstrated cell-free enzymic breakdown on tension wood fibers of beech [*Fagus* sp.] and ash [*Fraxinus* sp.] using cellulases from both snails and fungi. Normal wood was not affected. This note reports exploratory tests with cellulase of *Trichoderma viride* Pers. ex Fr. reacted with modified wood and cellulose fractions, as well as with aspen [*Populus* sp.] whole wood.

Crude enzyme consisted of the clear culture filtrate obtained from an 8-day growth of *T. viride* (FPLO,D47) in shake flasks, using a mineral salt medium with 1% Whatman cellulose as the carbon source. The filtrate was kept as a freeze-dried powder. Its enzyme activity against various substrates is shown in Table 1. This was measured in the following manner. Substrate (120 mg) was suspended in 3 ml 0.2 M sodium acetate buffer, 15 mg enzyme powder added, the volume adjusted to 10 ml with water and the whole incubated for 16 hr at 50 C. The reducing sugar produced (corrected for inactivated controls) was indicative of enzyme action. Chromatographic separation of the sugars released showed that glucose, cellobiose and trace amounts of xylose and sylobiose were formed from breakdown of 20-mesh wood, whereas higher concentrations of these sugars plus xylotriose and mixed higher molecular weight oligosaccharides were formed from the breakdown of holocellulose.

TABLE 1

Breakdown of various substrates by *T. viride* enzyme

Substrate	Reducing sugar as glucose (mg/10 ml)	Conversion of substrate (%)
ASPEN (*Populus* sp.)		
— 10 mesh (washed)	1.0	0.8
— 20 mesh (washed)	2.4	2.0
— holocellulose	12.3	10.3
— holocellulose (ball-milled)	27.8	23.2
— hemicellulose (after Timmell)	29.6	24.7
— wood (ball-millled)	15.6	13.0
COTTON		
— 40 mesh	4.6	3.8
— ball-milled	26.3	21.9
WHATMAN No. 1		
— swollen with H_3PO_4	28.3	23.6

The *T. viride* enzymic preparation was also reacted against 10-μ-thick transverse sections cut from green aspen wood. These sections were placed into the sealed end of a tubular glass vial. Enzyme which had been fractionated on G-75 Sephadex and concentrated approximately 10 fold was added to the vial in dry powder form (a few mg). Enzyme and section were wetted with 0.1 M sodium acetate buffer, the open end of the vial sealed off in a flame and the whole with suitable controls incubated at 50 C for 5 days. Vials were then opened, the sections removed, the liquid content rinsed out and the reducing sugar content determined. Sections stained with safranin-fast green showed no microscopic difference from controls, but a significant titer for reducing sugar was observed, demonstrating that 0.08 mg had been produced. Under the same conditions with 20-mesh aspen holocellulose as substrate 0.14 mg reducing sugar was produced.

The *T. viride* enzymic preparation was complemented with lignases and other wood-rot enzyme systems, and then reacted with 20-mesh wood. The lignase preparation was obtained from

culture filtrate of wood-grown *Polyporus versicolor* L. ex Fr. Suspected wall-bound wood-rot enzymes were obtained by acetone drying of *P. versicolor* mycelium grown on glucose (gl) and wood (w). The conditions for reaction were the same as those listed previously. Where wood-rot material was added, 50 mg per reaction tube was used. The mixtures tried and the results obtained (control results omitted for brevity) are shown in Table 2.

These data demonstrate that extensive enzymic breakdown of whole wood is difficult to attain. Modified cellulose and wood are much more amenable to enzyme attack. However, some degradation of intact whole wood (10-20 mesh and sections) was indicated. To obtain gross enzymic breakdown of untreated wood, apparently some enzymic or physico-chemical system natural to wood-rot fungi but seemingly not present in any of the prepared enzymic materials tested, is required. This unknown factor could possibly be a swelling or decrystallizing agent. The *T. viride* preparation used was known to contain cellulase and xylanase since glucano- and xylano-fractions were produced by enzyme action.

TABLE 2

Breakdown of cellular wood (washed 20-mesh aspen) with mixed enzymes

Enzymic preparations added to wood and *T. viride* mixture	Reducing sugar as glucose (mg/10 ml)	Enzymic conversion (%)
P. versicolor mycelium (gl) and *P. versicolor* supernatant	5.4	4.5
P. versicolor mycelium (gl)	4.6	3.8
Nil	4.3	3.6
P. versicolor mycelium (w) and *P. versicolor* supernatant	0.0	0.0
P. versicolor mycelium (w)	0.0	0.0

Complementing this preparation with lignases and wall-bound enzymes from the wood-rotting basidiomycete, *P. versicolor*, did not extend the ability of the *T. viride* preparation to degrade whole wood. Possibly because of some adsorptive phenomenon, wood-grown *P. versicolor* mycelial preparation actually reduced the total enzyme activity to zero. The breakdown products from enzymic degradation of whole wood (20-mesh aspen) were predominately glucose and cellobiose, indicating that just the cellulose of the wood was attacked. This observation could lend support to the concept that hemicellulose in whole wood is tightly bound, for example, as a hemicellulose-polyuronide-lignin complex (Dadswell, Proc. Spec. Field Inst. in Forest Biol., North Carolina State College, Raleigh, 1960) and the bonding disallows xylanase activity. This, our first observations of cell-free enzymic breakdown of whole wood, was accomplished with enzymes derived from *T. viride* which is not a true wood-rotting fungus but which nevertheless produces appropriate enzymes when grown on modified wood.—D. W. Stranks, Forest Products Laboratory, Ottawa, Ont.

Oxathiins to Prevent Wood Decay.—Oxathiin derivatives have been used very successfully as systemic fungicides to control diseases in cereals, tea, beans and other crops, where they show no phytotoxic effects. Edgington, Walton and Miller (Science 153:307-308, 1966) made the interesting observation that 2,3-dihydro-5-carboxanilido-6-methyl-1, 4-oxathiin (DCMO) when incorporated into agar showed strong specificity in controlling the growth of Basidiomycetes. They also showed that DCMO had greater fungitoxicity than the dioxide derivative, 2,3-dihydro-5-carboxanilido-6-methyl-1, 4-oxathiin-4, 4-dioxide (DCMOD). Edgington and Barron in subsequent studies (Phytopath. 57:1256-1257, 1967) confirmed that DCMO was highly toxic to Basidiomycetes, including one wood-decaying fungus. They also showed that the ortho-phenyl derivative showed fungicidal "preference" for Basidiomycetes, *Porosporae* and *Aspergillus* sp.

Because of the observed fungicidal efficacy and specificity of DCMO and DCMOD against Basidiomycetes, these compounds could be effective wood preservatives and, therefore, were tested using the standard soil-block culture technique (ASTM D-1413-61) with slight modifications. These modifications included the use of larger (16 oz) soil jars, thinner (1/16 inch) feeder blocks and an ethylene oxide gaseous sterilization technique (Smith, Trans. Brit. Mycol. Soc. 48:341-347, 1965). Lodgepole pine [*Pinus contorta* Dougl. var. *latifolia* Engelm.] test blocks were impregnated under vacuum with various concentrations of DCMO and DCMOD dissolved in methanol and then, in replicates of six blocks, decayed by one of the following brown-rot fungi: *Lenzites trabea* (FPLV no. 47B), *Poria monticola* (FPLV no. 120D), *Coniophora puteana* (FPLV no. 9F) and *Lentinus lepideus* (FPLV no. 44C). The same two chemicals also were tested against the white-rot fungus *Polyporus versicolor* (FPLV no. 105C) using red alder [*Alnus rubra* Bong.] test blocks.

After a decay period of 12 weeks, the percentage oven-dry weight losses of all the test blocks were calculated, and from these values the threshhold retentions for DCMO and DCMOD were determined. These results (Table 1) show that *P. versicolor* is more resistant than any of the four brown-rot fungi to DCMO and DCMOD. The reasons for this resistance are not known, but they could involve lack of penetration of the fungal cell walls and plasma membranes by the oxathiin, or they may relate to their ability to bind to ribosomes, thereby affecting protein synthesis (Mathie, Phytopath. 58:1464-1469, 1968). It is even possible that *P. versicolor* is able to degrade both DCMO and DCMOD, as has been shown for *Rhizopus japonicus* (Wallnoeffer, Arch. Mikrobiol. 64:319-326, 1969).

TABLE 1

Threshold retentions for oxathiins DCMO and DCMOD, determined by ASTM D-1413-61 soil-block test.

Fungus	Wood	Threshold Retentions kg/m³	
		DCMO	DCMOD
L. trabea	Lodgepole pine	1.10	0.37
P. monticola	Lodgepole pine	1.10	3.29
C. puteana	Lodgepole pine	1.10	1.10
L. lepideus	Lodgepole pine	1.10	3.29
P. versicolor	Red alder	9.29	9.23

The threshold retentions obtained with the four brown-rot fungi, for both compounds, are approximately equivalent to those values obtained in this laboratory with either pentachlorophenol or copper-chrome-arsenate wood preservatives. However, the very low mammalian toxicity of the oxathiins (2 to 3g/kg) compared with pentachlorophenol (50 to 100 mg/kg) and copper-chrome-arsenate wood preservatives would be an attractive advantage for oxathiins in this era of increased interest in pollution. The oxathiins, particularly DCMO, are relatively insoluble in water and have a low vapor pressure. Good retention in a wood substrate therefore could be expected and, if necessary, verified by standard weathering tests (ASTM D-1413-61). Further development of these chemicals as wood preservatives is possible, but would depend upon critical cost evaluations in conjunction with chemical stability studies.—R. S. Smith, Forest Products Laboratory, Vancouver, B. C.

INSECT PATHOLOGY

Persistence of the Nuclear Polyhedrosis Virus of the Eastern Hemlock Looper on Balsam Foliage.—The eastern hemlock looper [*Lambdina fiscellaria fiscellaria* (Guen.)] is a major forest pest in Newfoundland (Carroll, Can. Entomol. 88:587-599, 1956). This report is part of a study to evaluate the possibilities of controlling this insect with a nuclear polyhedrosis virus. Nuclear polyhedrosis viruses sprayed on foliage in the field are rapidly inactivated by ultraviolet radiation (Cantwell, J. Invertebrate Pathol. 9:138-140, 1967; Jaques, Can. Entomol. 99:785-794, 1967; David, Gardiner and Woolner, J. Invertebrate Pathol. 11:496-501, 1968).

A small scale experiment was set up at Pasadena, Newfoundland, to investigate the persistence of the hemlock looper virus. Several branches of a 12-foot balsam fir in an exposed situation were sprayed to drip point with a purified virus suspension containing 10^7 polyhedra per ml. Samples of sprayed foliage were cut 1, 3, 5, 10 and 15 days after spraying and taken to the laboratory. During the 2 weeks the virus was exposed on the foliage in early July the hours of sunshine were normal for that time of year,

although no records were kept. In the laboratory the contaminated foliage was populated with second-instar field-collected larvae. They were allowed to feed for 4 days on the contaminated foliage and then placed on fresh balsam foliage. Dead larvae were removed daily and examined for virus infection using a phase contrast microscope. Each batch of larvae was kept for 26 days and the experiment then terminated. The results are summarized as follows:

Days after spraying	1	3	5	10	15
Number of larvae	15	18	17	14	18
Killed by virus (%)	93.3	100	76.5	57.1	0
Mean time to death (days)	12.9	13.5	15.1	19.5	—

The virus was found to persist well for 3 days after spraying, started declining in pathogenicity after 5 days and was completely inactivated 15 days after spraying. The length of time to kill larvae with virus is normally inversely proportional to the concentration of the virus. It can be seen that the mean length of time from ingestion to death increased with increasing time of exposure of the virus on the foliage, indicating that the infectivity of the virus had decreased. No virus deaths were found in control larvae.

It is desirable to find methods of increasing the persistence of biological insecticides (David, J. Invertebrate Pathol. 14:1-3, 1969). It is hoped to mass-produce the virus and conduct larger scale field trials this summer.

I wish to thank Mr. G. L. Warren, Canadian Forestry Service, St. John's, Nfld. for his advice and co-operation and Mr. L. Smith for excellent technical assistance.—John C. Cunningham, Insect Pathology Research Institute, Sault Ste. Marie, Ont.

MENSURATION

The Influence of Plot Size on Estimates from Aerial Photographs.—In forest inventories it is common practice to estimate forest variables by classifying sample plots on aerial photographs. However, it is often not realized that the size of sample plots affects the results. This effect was demonstrated in the following study.

Fifty 1.0-acre plots were systematically located on 1:15,840 aerial photographs of an area near the Petawawa Forest Experiment Station, Ontario. On each plot photo interpreters estimated the mean height by 20-foot classes, canopy density by 20% classes, and forest type as "pure" (pure hardwood or pure softwood), "mixed", or "non-forested". The experiment was first performed considering only dominant and codominant trees (Test 1) and then considering all trees over 20 feet in height (Test 2). All estimates were then repeated, reducing plot size to 0.5-acres and then to 0.2-acres. The results are summarized in Table 1.

TABLE 1
Mean height class (HC), mean canopy density class (DC) and percentage of pure (P), mixed (M) and non-forested land (NF)

Plot size (acres)	Test 1					Test 2				
	HC	DC	P	M	NF	HC	DC	P	M	NF
1.0	5.1	4.3	46	49	5	4.8	4.4	60	37	3
0.5	5.0	4.2	49	46	5	4.8	4.3	62	35	3
0.2	4.3	3.9	53	39	8	4.3	4.1	67	24	9

Mean estimated height generally decreased with plot size. One reason is the increasing percentage of plots on non-forested land. Another reason, valid for Test 1 only, is the decreased probability that a small plot will include tall trees, although this is counteracted to some extent by the fact that one tall tree on a small plot may be used for the characteristic height for that plot, while the same tree will not appear as indicative for a larger plot. Various tendencies to clumping could change the direction and rate of the trends in both tests.

Normally there should be no change in canopy density with changing plot size, and the trend observed here is probably spurious.

The proportion of "pure" stands and of "non-forested" land increases with decreasing plot size; a small plot is more likely than a large one to include only one category of trees or to fall entirely in a clearing.

TABLE 2
Coefficients of variation (%)

Plot size (acres)	Test 1		Test 2	
	H	DC	H	DC
1.0	30	32	34	39
0.5	30	37	35	42
0.2	42	44	52	57

The coefficients of variation (Table 2) were used in an attempt to evaluate the change in consistency of the interpreter's estimates with the change in plot size. This computation was done by depressing each interpreter's estimate on a plot as a percentage of the average estimate of all interpreters for that plot. The coefficients of variation of the values resulting for all plots were then calculated. Consistency evidently deteriorates significantly with decreasing plot size; perhaps interpreters encounter greater difficulties in defining the boundaries of small plots.—U. Nielsen, Forest Management Institute, Ottawa, Ont.

PATHOLOGY

***Graphium penicillioides* on American Elm in Manitoba and Saskatchewan.**—Accounts of an American elm disease syndrome in Manitoba and Saskatchewan reveal several possible causes (Annu. Rep. Forest Insect Dis. Surv., Man.-Sask. Region, 1960, 1966, 1967). Dieback, wilting and decline have been attributed to *Dothiorella ulmi* Verrall and May, *Verticillium dahliae* Kleb. and environmental or physical disturbances. *V. dahliae* and *V. albo-atrum* Reinke & Berth. were isolated from stained sapwood of six wilted trees and a *Graphium* was reported in *Hylurgopinus rufipes* galleries in dead or dying trees (ibid. 1968). The fungus is widespread throughout the range of the bark beetle in Manitoba and Saskatchewan reaching the northern (Cumberland House, Sask., 54°N) and the western limits (Outlook, Sask., 107°W) of native elm in Canada. The *Graphium* was rarely absent from samples of elm bark with beetle galleries, and it appeared restricted to this habitat. The presence of Dutch elm disease in Minnesota, South Dakota, and North Dakota (Schreiber & Wilson, Plant Dis. Rptr. 53: 994, 1969), and the discovery of a *Graphium* in Manitoba and Saskatchewan in association with a known vector of the disease, prompted a detailed comparison between *Graphium ulmi*, *G. penicillioides* and the unnamed *Graphium*.

Elm bark with galleries was incubated for 2-14 days at 25 C in humidity chambers; pure cultures were initiated from streaked conidium suspensions derived from conidium droplets of the synnemata. Colonies on oatmeal agar were typified by a well-developed, colorless, immersed mycelium developing evenly from the inoculation point, with a distinct margin; aerial hyphae sparse. Synnemata developing readily throughout the cultures from dark knots of hyphae, dark brown, erect, single sometimes branched up to 4 times from the base, progressively light brown, expanding and looser towards the apex, 110-200 μ long, width variable; conidium droplets gray. On bark synnemata dark brown to black, compact, erect, frequently branched from the base and the upper parts of the synnemata, light brown, looser, and with limited expansion at the apex, up to 650 μ long, width variable. Conidiogenous cells mainly annellidic, intermixed with sterile hyphae, hyaline, filiform, formed from the septate branched synnematal hyphae, up to 40 μ long x 2 μ wide, with several closely or widely spaced inconspicious annellations, forming chains of holoblastic conidia, occasionally developing sympodially (Fig. 1, E). Conidia clavate with a flattened base and marginal frill, smooth-walled, continuous, distinctly curved, hyaline to olivaceous, aseptate, 3.5-5(4.2) x 1.5 μ (Fig. 1, C-D). These features agree well with those of the type collection of *Graphium penicillioides* Cda., a microscope slide preparation of which is deposited in the IMI Herbarium, Kew, England (IMI 145452). In the type, conidiogenous cells were only up to 20 μ long and the mean conidium length was 4.6 μ. Range in conidium size however was identical.

Synnemata of *G. ulmi* were formed on incubated sterile elm twigs from cultures of *C. ulmi* isolated in the Netherlands (IMI 101223—101230). Synnemata honey yellow to dark brown, erect

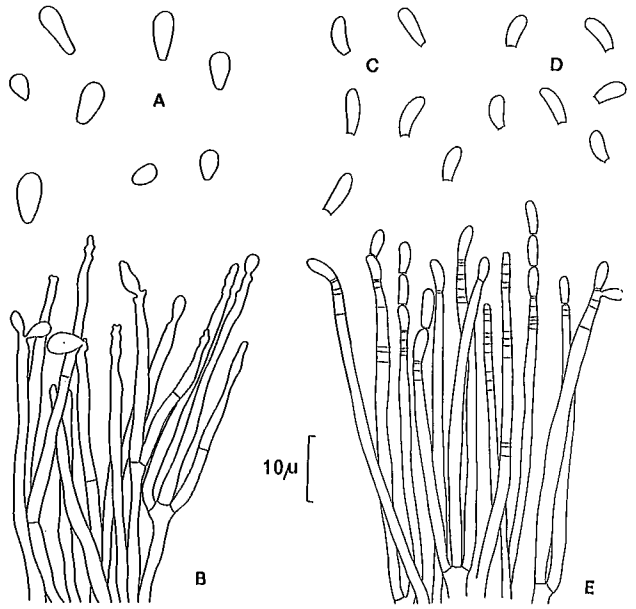


FIGURE 1. *Graphium ulmi*, A. *conidia;* B. *conidiogenous* cells: *Graphium penicillioides*, C. *conidia* from type; *D-E.*. conidia and conidiogenous cells from *Ulmus americana*.

or lax, single or extensively branched from the base to the upper parts of the synnemata, light brown, looser and expanding towards the apex, up to 1300 μ long, width variable; conidium mass colorless to very pale yellow. Conidiogenous cells hyaline, filiform, up to 30 μ long x 1.5-2 μ wide, formed from septate branched synnematal hyphae, irregularly nodulose at the apex indicating repeated sympodial development of holoblastic conidia (Fig. 1, B). Conidia cuneate, obovate or turbinate with a flattened to rounded base, smooth-walled, continuous, hyaline, aseptate, 4-5.5 (4.8) x 2-2.5 μ (Fig. 1, A). Although no type or authenticated material of *G. ulmi* is extant this description fits well with the original diagnosis and figures.

G. penicillioides differs from *G. ulmi* in its restricted annellidic, occasionally sympodial holoblastic conidium ontogeny (characteristic also of *G. cuneiferum* (Berk. & Br.) Mason & Ellis and *G. calicioides* (Fr.) Cke & Mass.), and in the narrower, clavate, curved conidia with flattened bases. Conidia in *G. ulmi* are cuneate to turbinate and probably sympodially holoblastic.

G. penicillioides was considered to be the conidial state of *Ceratostomella piceae* Münch (Melin & Nannfeldt, Skogsfor. Tidskr. 3: 397-613, 1934), a common species with a wide host range, particularly in the Coniferae. It is doubtful that the *Graphium* obtained from ascospores of *C. piceae* was ever compared with Corda's material of *G. penicillioides*. Neither descriptions nor figures satisfactorily agree with Corda's diagnosis and figure. The majority of subsequent workers (e. g., Bakshi, Trans. Br. Mycol. Soc. 33:111-120, 1950) accepted this correlation. This broad concept of the species cannot be reconciled with the absence of a perfect state, and the restricted host range and ecological niche shown by *G. penicillioides* in Manitoba and Saskatchewan. It is worthwhile noting that *G. penicillioides* was amongst the several saprophytic fungi isolated from diseased elms in the Netherlands (Spierenburg, Tijdschr. Pl. Ziekt. 27: 53-60, 1931).—B. C. Sutton and J. G. Laut, Forest Research Laboratory, Winnipeg, Man.

Effect of Nursery Soil and Soil Amendment Extracts on Growth of Damping-off Fungi and Conifer Seed Germination.—Preparation and maintenance of seedbeds are important parts of nursery practice and much consideration has been given to soil management (Stoeckeler and Jones, USDA Agr. Handbook 110, 1957; Stoeckeler and Slabaugh, USDA Agr. Handbook 279, 1965; Mullin, Forest. Chron. 41: 454-465; Armson and Carman, Ont. Dep. Lands Forests, 1961). The common amendments to a seedbed are peat or other organic mulches and in some cases sawdust (Allison and Anderson, USDA Agr. Circ. 891, 1951; Bloomberg, Bi-m. Progr. Rep., Dep. Forest. 19(6): 4, 1963). These amendments are used to improve the structure of the soil, to prevent frost heaving, to increase fertility, and in the case of sawdust to aid in weed control. In some cases the amendments have introduced damping-off pathogens into the soil (Bloomberg, *loc. cit.*). It is important to know what effect these amendments have on the growth of damping-off fungi and the effect on the germination of conifer seed.

Two species of fungi (*Rhizoctonia* sp and *Pythium* sp) and seed of two conifer species, jack pine [*Pinus banksiana*] Lamb. and white spruce [*Picea glauca* (Moench) Voss] were tested for growth and germination respectively on extracts of nursery soils and soil amendments. Extracts were made from Birds Hill nursery soil (previously sandy grassland); sandy forest soil of the A_1 horizon from a jack pine stand; peat from baled stock in the greenhouse; mixed jack pine and poplar sawdust (weathered for about 1 year in a pile); and Pineland nursery soil that had previously been in jack pine seedlings. Nursery and forest soils were screened to remove large plant root residues. Five hundred grams of each soil material were soaked in 1 liter of distilled water overnight at room temperature, screened, and filtered through No. 1 Whatman filter paper under vacuum. The filtrate was brought to 1700 ml volume and stored at 2 C for 3 days to allow settling of fine organic particles. The sediment was discarded and the supernatant was steam sterilized for 20 min. Melted Bacto agar, 30 g, was added to each liter of extract with a resultant mixture being 1.5% agar. The agar was poured into plates and inoculated with *Pythium* sp and *Rhizoctonia* sp. Jack pine and white spruce seeds were placed on fungus-free agar for germination tests. Fungal growth was measured after 2 days and seed germination after 10 days. The pH of the media ranged from 6.8 to 7.1. Data are given as means of 12 replicates. Duncan's Multiple Range Test was used for mean comparisons.

The extract from sawdust significantly inhibited the growth of the *Pythium* sp. and slightly inhibited the growth of the *Rhizoctonia* sp (Table 1). Slight, but non-significant inhibition of *Pythium* was noticed in Birds Hill soil extracts. The growth of *Rhizoctonia* on extracts of Birds Hill soil and Pineland peat was significantly greater than on the Bacto-water agar. Other extracts had no appreciable effects on fungal growth.

TABLE 1

Effect of nursery soil and soil amendment extracts on growth of damping-off fungi and conifer seed germination

Soil or amendment extract	Fungal Growth Diameter in mm		Seed Germination Per cent	
	Pythium sp	*Rhizoctonia* sp	Jack pine	White spruce
Birds Hill soil	65.7 bc*	56.9 ab	90.0 a	38.6 a
Forest soil	73.5 ab	48.5 c	89.0 a	35.8 a
Sawdust	59.9 c	40.9 d	89.8 a	38.2 a
Pineland peat	68.6 ab	62.0 a	91.6 a	45.4 a
Pineland soil	74.2 a	49.2 c	90.6 a	40.6 a
Baled peat	71.7 ab	51.2 bc	90.2 a	45.6 a
Bacto-water agar	71.4 ab	46.0 cd	91.6 a	36.4 a

*Values with same letter not significantly different at the 5% level.

None of the extracts had any significant effect on the germination of either jack pine or white spruce seed. However, there is an indication that extracts from both Pineland peat and baled peat stimulate the germination of white spruce seed.

The addition of sawdust to the soil may be an aid in controlling damping-off due to *Pythium*, while the addition of nursery peat may enhance development of *Rhizoctonia*. *Pythium ultimum* Trow has been shown to be inhibited by extracts from a variety of soil types and stimulated by extracts from peat (Vaartaja, Dep. Fish. Forest., Bi-m. Res. Notes 25: 25-26). Further information on the population of *Pythium* and *Rhizoctonia* from the individual nursery soils in combination with the above-mentioned amendments is needed to determine the extent that additives affect the fungal populations in soil.—L. W. Carlson and J. Belcher, Forest Research Laboratory, Winnipeg, Man.

Effect of Ultrasonic Root Cleaning on Subsequent Growth of Caragana Seedlings.—In nursery disease investigations, observations of seedling root rot or root lesions usually result in the destruction of the seedling. It would be desirable to study the development of root diseases by removing the seedlings from the soil, making observations, then planting the same seedlings back into the soil for further disease development studies. Washing does not remove all the fine soil particles that may interfere with the disease observations; however, roots cleaned ultrasonically were totally free from fine soil particles. There was concern that the action of the ultrasonic treatment would disrupt root hairs and root cells, thus affecting subsequent survival and growth. The following study was conducted to determine the effect of ultrasonic cleaning on the growth and survival of caragana seedlings.

Healthy caragana seedlings grown in the greenhouse for 2 months were removed from the soil and cleaned by the following methods: (1) soaking in tap water for 10 min, (2) washing in running tap water for 30 min; (3) cleaning ultrasonically for 5, 10, 20 and 30 min in distilled water. A seventh treatment (control) had no root cleaning. The ultrasonically cleaned seedlings were placed in distilled water in a stainless-steel tank that was connected to an ultrasonic generator. The generator output was 80 kc/sec. After cleaning, the seedlings were transplanted into individual pots and growth measurements taken 32 and 76 days later. A total of 20 seedlings were used for each treatment. The data are presented as the mean height of the seedlings at 0, 32 and 76 days after transplanting.

TABLE 1

Effect of ultrasonic cleaning of Caragana seedling roots on subsequent growth

Cleaning treatment	Mean height in cm after transplanting 0 days	32 days	76 days
(1) Soaked, tap water	9.76	14.45	56.13
(2) Washed, tap water	6.87	13.26	48.18
(3) Ultrasonic, 5 min	9.29	15.10	48.13
(4) Ultrasonic, 10 min	7.47	14.12	51.77
(5) Ultrasonic, 20 min	8.86	13.85	50.25
(6) Ultrasonic, 30 min	8.31	15.03	55.37
(7) Control, no cleaning	6.62	13.14	51.93

The results indicate that the ultrasonic cleaning process was neither detrimental nor beneficial to the growth of the caragana seedlings (Table 1). Only 3 seedlings used in the entire experiment died; two in the ultrasonic treatment for 30 min, and one in the soaking in tap water treatment. The ultrasonic cleaner can be considered a practical tool in the study of caragana seedling root disease development. Further studies should be carried out to determine the effect of ultrasonic cleaning on seedlings of different species.—L. W. Carlson and J. Belcher, Forest Research Laboratory, Winnipeg, Man.

Effects of Field Inoculation with Myocorrhizae of *Cenococcum graniforme* on Basswood Growth.—Few hardwood seedlings planted to reforest fields in southern Ontario survive and any that do survive grow very slowly. As the absence of mycorrhizal fungi was the suspected cause, an experiment was designed to compare the effect of *C. graniforme* inoculum from different substrates and different methods of application on the growth rate of seedlings. Basswood [*Tilia americana* L.] was chosen for the experiments because its ectotrophic mycorrhizae are most readily observed.

Cenococcum graniforme (Sow.) Ferd. & Winge was found to be commonly associated with normal basswood seedlings and was, therefore, chosen as the test fungus. *C. graniforme* was isolated from basswood growing in southern Ontario by introducing sterilized mycorrhizal short roots into test tubes containing sterile Hagem agar medium which were then stored at 23 C in darkness. Wheat grain spawn of *C. graniforme* was prepared as described by Park (Can. J. Bot. In press). The autoclaved flasks were inoculated with the master culture and incubated at 25 C.

Two-year-old basswood seedlings were obtained from the Ontario Provincial Nursery, Orono, Ont. A total of 400 seedlings were divided at random into four lots, 89, 90, 87, and 134, for inoculation with pure cultures of *C. graniforme*, with wheat grain spawns 1 and 2, and as noninoculated control seedlings, respectively.

Before planting in the field, the fresh weight and height of each seedling were recorded, and the roots were examined under the stereo-microscope to verify that no *Cenococcum* mycorrhizal infection was present. The average fresh weight of the seedlings was 50 g.

The planting site was deforested agricultural land at Sylvan, Middlesex County, where planted hardwoods had previously failed. The soil was Fox sandy loam, with an average of 3.35 ppm NO_3-N, 3.17 NH_4-N, 0.1 % total N, 0.08 % of K, a trace of P, and a pH of 6.5.

The inoculations were performed in the early part of April 1969. For inoculation by spawn, six grains of *Cenococcum* spawn were mixed with soil in a planting hole 8 inches in diameter and 8 inches deep. For pure culture inoculations, a fungal colony (20 mm in diameter) was peeled off the surface of the agar and rubbed on the surface of the root system before planting. Inoculated and noninoculated seedlings were planted directly in the field at a spacing of 4 x 4 feet. With wheat grain spawn 1, mycorrhizal hyphae completely covered the surface of individual grains, whereas with spawn 2 the hyphae were only partially developed.

At the end of September 1969, 10 seedlings from each treatment and the control were chosen at random, excavated, and the percentage of short roots infected by mycorrhizae calculated. The degree of mycorrhizal infection was assessed by counting the number of typical *Cenococcum* mycorrhizal short roots from a piece of tertiary root (4-5 cm) and by expressing this as a percentage of the total number of short roots on the tertiary root. The fungus from the mycorrhizal roots was isolated and verified to be *C. graniforme*.

In late September the total length of new shoot growth on each seedling was measured because a simple measurement of height would not include new growth on the terminal part of each branch. A comparison of growth response was made for each treatment on the basis of new seedling growth per plot. Analyses of variance were carried out and the significance of treatment differences was evaluated according to Duncan's Multiple Range Test (Steel and Torrie. 1960. Principles and Procedures of Statistics. McGraw-Hill Book Company, Inc. p. 107-109).

The experimental results are presented in Tables 1 and 2.

In general, we cannot expect inoculation to have much effect in the first year. However, some differences between inoculated and control plants are already evident. (1) Inoculation with

TABLE 1

Percentage of short roots of basswood seedlings infected by *Cenococcum* mycorrhizae

Replication	Treatment: Control	Wheat grain spawn 1	Wheat grain spawn 2	Pure culture
1	20.1	35.2	0	35.2
2	0*	18.1	0	50.1
3	0	32.2	0	10.0
4	0	10.5	0	45.1
5	20.2	28.6	0	40.2
6	20.2	42.6	0	5.3
7	0	30.5	0	10.1
8	0	45.5	0	40.1
9	0	13.2	0	45.0
10	0	15.4	0	31.2
Mean	6.3	27.2	0	31.3

*0 = no infected short root found.

TABLE 2

Effect of mycorrhizal inoculation on average length of shoot growth per tree

Treatment	Mean growth per plant* cm
Pure culture	26.17
Wheat grain spawn 1	25.05
Control	17.34
Wheat grain spawn 2	13.85

*The means joined by straight lines are not significantly different from each other at the 5 % level.

spawn 2 proved to be ineffective since no mycorrhiza developed on the plants so treated. The insignificant effect of spawn 2 was probably due to the attraction of rhizosphere organisms to the grain where the mycorrhizal hyphae were undeveloped (Tables 1 and 2). (2) All plants inoculated with either pure culture or spawn 1 were found to be infected with mycorrhizae, whereas only 3 out of 10 of the control plants were infected. Infection in the control was probably from the natural inoculum of *C. graniforme* in the soil (Table 1). (3) On the average, plants inoculated with either pure culture or spawn 1 gained significantly more new growth than the control plants; there was no significant difference between these treatments (Table 2). (4) There was no significant difference in the percentage of mycorrhizal short roots produced by spawn 1 or by pure culture inoculation (Table 1).

Pure culture inoculation on a large scale would have been almost impossible to prepare and handle in the field. On the other hand, wheat grain spawn covered fully with mycorrhizal hyphae on all grains in the amount of only 1 or 2 litres per acre of land would suffice, and would be much more economical to prepare.—J. Y. Park, Forest Research Laboratory, Sault Ste. Marie, Ont.

Thermal Image of Dutch Elm Disease.—It has been noted that transpiration along with radiation and convection are major factors affecting the energy exchange in a plant canopy and that the ability to transpire made a substantial difference in leaf temperature (Gates, Annu. Rev. Plant Physiol. 19:211-238, 1968), that the temperature of leaves subjected to a decreased transpiration rate increases (Farmer, Forest Sci. 15:151-153, 1969) and that the use of transpiration suppressants caused an increase in leaf temperature by as much as 9 C (Slatyer and Bierhuizer, Austral. J. Biol. Sci. 17:131-146, 1964). Since Dutch elm disease [*Ceratocystis ulmi* (Buism.) C. Moreau] affects an elm by restricting water movement and hence its transpirational ability, it was suspected that it might be possible to locate diseased elms on thermal imagery before the leaves had wilted. This was tested in the spring and summer of 1969 during a preliminary evaluation of the qualitative and quantitative information available on thermal imagery.

A Reconofax IV infrared line scanner was used to obtain thermal imagery (approximate center line scale, 1:12,000) five times during a 24-hr period; starting on May 28, 1969 at 13:58 hr, the coverage was repeated at 19:56 hr, at 01:50 hr on May 29, at 07:18 hr and at 13:31 hr. Imagery was also obtained in July, August and September of the test area along Highway 17, 20 miles west of Ottawa. Operated by the Flight Research Section National Aeronautical Establishment, National Research Council, the scanner, filtered for the 3 to 5 micron infrared atmospheric window, senses temperature differences of less than one degree Centigrade. By means of pulses from a glow-tube that result from variations in an electrical current which originate at the detector head, the relative temperature differences are recorded on photographic film. On the thermal image the warm areas are represented by light grey to white whereas cool areas are dark. Since the scanner has a set range to which the detector is sensitive, there are upper and lower temperature limits, with all objects above a given temperature range appearing white (hot) and all objects below a certain temperature appearing black (cold).

As the scanner is operating in the 3 to 5 micron infrared atmospheric window, the detector that senses the varying temperature emission from the surface of an object is essentially unaffected by the intervening air temperature.

None of the day-time flights produced a thermal image that might indicate a diseased tree. All trees appeared dark since their overall temperatures were related to a warm background which was imaged bright. Large numbers of contained thermal shadows within the crowns of trees added to this effect. The upper part of Figure 1 depicts the dark ("cool") appearance of the trees on day-time imagery. The middle image in Figure 1, which was taken shortly before sundown, illustrates the effect caused by a cool background. Here the trees appear brighter (warmer) than they did during the day-time; however, the foliage itself has probably cooled down, and the illusion of warmer trees has been

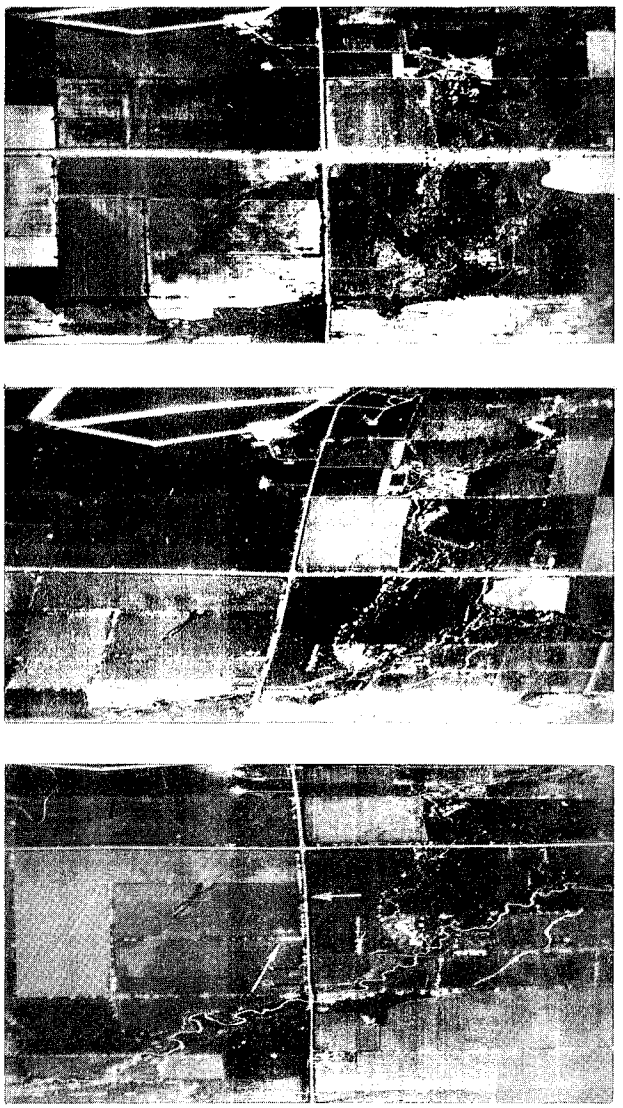


FIGURE 1. Top; Day-time, May 29, 1969, 13:31 hr. Bare soil and roads appear warm, whereas vegetation appears cool. Middle; Evening, May 28, 1969, 19:56 hr. The trees appear warmer than the cool background. Bottom; Night, May 29, 1969, 01:50 hr. Trees appear warmest in this image and also appear as warm as the highway (left to right across image) and the creek. Water in the creek appears as warm as the road, whereas in the day-time (top) it appears to be the coolest. Suspect Dutch elm disease trees are indicated by arrows and on the original print appeared brighter than smaller healthy elms. Two healthy elms are located in the cultivated field close to the middle diseased elm.

created by the cool background. At this time too, no Dutch elm disease suspect trees were located on the imagery.

The bottom image was taken shortly after midnight, and this time Dutch elm disease suspect trees were located. A ground check in August revealed that at least three of the trees (indicated by arrows on the image) had typical symptoms of Dutch elm disease; partially defoliated top, yellowing foliage. Color aerial photography on May 28, shows the suspect trees as having an apparently normal complement of green foliage. The two elms along the road below the tree indicated by the arrow also showed yellowed foliage and dead branches in August, and in the bottom image (Fig. 1) also have bright images.

Conifers and healthy, densely foliated elms and other hardwoods also appeared quite bright on the night-time thermal

imagery, with the conifers appearing brighter than most hardwoods. Moen (Ecology 49: 145-147, 1968) reported slightly higher thermal radiation from a white spruce [*Picea glauca* (Moench) Voss] than from a white birch [*Betula papyrifera* Marsh] and apparently the same sort of relationship is maintained among other conifers and hardwood. However, the net effect is to place an additional confusing factor in the interpretation of thermal imagery. In fact a lot of trees appear bright on night-time imagery including healthy conifers and densely foliated hardwoods, as well as diseased trees. Efforts will be continued to test thermal imagery as an aid in disease evaluation work.—P. A. Murtha, Forest Management Institute, Ottawa, Ont.

SILVICULTURE

Dissemination and Viability of Seed from Upland Black Spruce in Central Newfoundland.—Black spruce [*Picea mariana* (Mill.) BSP.] stands growing on well-drained, orterde podzols of the Northwest and Southwest Gander river drainages originated after fire in 1867. These stands provide more than 100,000 cords of high quality pulpwood annually. However, as the logged areas do not always regenerate adequately, strip-cutting experiments were initiated by Bowaters Newfoundland Limited in 1954 in an attempt to improve conditions for regeneration. This paper presents information on the quantity and quality of seed collected from July 1961 to June 1965 from a selected clear-cut strip.

In 1961, seven ¼-milacre, wire screen seed traps were placed in each of seven rows across a 330-foot wide clear-cut strip. The traps were 66 ft apart and the rows were separated by 132 ft. Adjacent uncut stands averaged 25 cords of pulpwood per acre. Trees averaged 3,000 stems per acre, 38 ft in height and 3.3 inches dbh. Strips were oriented in an east-west direction on a westerly slope. Seeds were collected monthly from June through November and the winter seedfall was collected in May; seed viability was determined by germination tests for each collection.

The average annual seedfall under the stand was about 635,000 seeds of which 250,000 were viable. Yearly seedfall during the 4-year period varied between 1,110,000 and 199,000 seeds per acre under the uncut stand and varied between 68,000 and 17,000 seeds per acre in the center of the uncut strip. Seedfall was highest in 1961 and lowest in 1964. Fifty-two percent of the annual seedfall occurred during June, July and August. More seed fell each year on the southern half of the cutover (Fig. 1) presumably because of the direction of the prevailing winds. Weather records, 18 miles from the study area, show that prevailing winds are south-westerly from May through October and averaged 12 mph; westerly winds prevail during the winter months and averaged 14 mph.

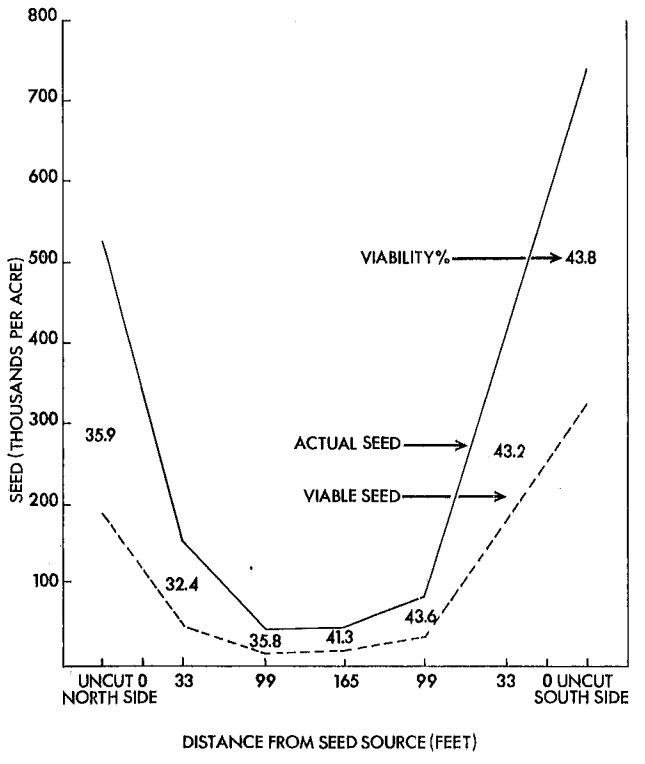


FIGURE 1. Average annual per acre seedfall and viability related to source, July '61–June '65.

The average viability of the seed for the period was 40.5% and varied annually from 34% to 49%. The number of viable seeds were highest in 1964 and lowest in 1962. Seed collected during June, July and August showed 10 to 15% higher viability than seed collected during the remaining period of the year. Viability improved from the center of the cutover to the south side of the strip and viability decreased or remained unchanged across the northern half of the cutover. The higher percentage of viable seed on the south side of the cutover was probably caused by the prevailing wind carrying the lighter non-viable seed away from this area.

The results of the experiment indicate that about 15,000 viable seed per acre are dispersed annually in the center of the 330-foot wide clear-cut strip. This number of seedlings would be more than adequate for restocking the cutover; therefore, it is evident that inadequate regeneration on similar cutover strips is associated with seedbed conditions and not seed supply. The study is continuing to determine seedling survival and to indicate a suitable silvicultural method for managing these black spruce forests. —E. W. Howard, Forest Research Laboratory, St. John's, Nfld.

Effect of Tube Dimension on Root Density of Seedlings.—Reforestation by planting tubelings is becoming an increasingly important technique. However, as failures have been encountered that may be attributable to insufficiently developed root system, an experiment was designed to measure the effect of height and diameter of the tube on the seedlings root system. Black spruce [*Picea mariana* (Mill.) BSP.] was choosen because of its importance in the forests of Quebec. Because tubes commercially available did not cover a suitable range of sizes, tubes with the following characteristics were constructed in the laboratory: (1) comparatively low production cost; (2) retains shape in humid conditions; (3) disintegrate naturally in soil; (4) range of heights and diameters easily controlled during construction.

Rectangles, with lengths and widths corresponding to the desired heights and diameters of tubes, were cut from 1.588 mm thick rotary-cut poplar veneer. The rectangles were treated with hydrochloric acid and washed profusely with distilled water to induce flexibility. They were then wound on an aluminum spindle of suitable diameter and dried. At the end of the drying operation, the spindle was removed and the tubes thus formed immersed in a polyvinyl resin solution (20% acetone, 80% polyvinyl resin) to cover all surfaces with a thin polyvinyl film.

The experimental design included 22 sizes of tubes in the following factorial combinations: 1, 2, 3, 4 cm in diameter by 7, 10, 13 cm in height; 5, 6 cm in diameter by 7, 10, 13, 20, 25 cm in height. Each combination was replicated 50 times. Each tube was filled with a sterilized soil-peat moss-sand mixture (ratio 5:1:1), seeded with one seed and then placed in a growth chamber (75F; relative humidity 75%; luminosity .3 cal.g/cm^2. min). After 10 weeks the plants were dried and their roots weighed and measured.

To determine the root system density of each plant, the ratio $Y = P/H$ (gr / cm) was used where P = root system's dry weight, and H = height of the tube. Obviously, when the root's main axis increases with increases in the height of the tube a dense root system is not necessarily achieved. On the other hand, the ratio Y, while considering substratum dimensions, represents a sound means of evaluating root development.

Correlation between Y and the tube dimensions was determined and the following regression equation was obtained

$$\hat{Y} = a_1X_1 + a_2X_2$$

where X_1 = the diameter and X_2 = the height of the tube, or

$$\hat{Y} = .2750\ X_1 - .0256\ X_2\ (R^2 = .345).$$ (Fig. 1).

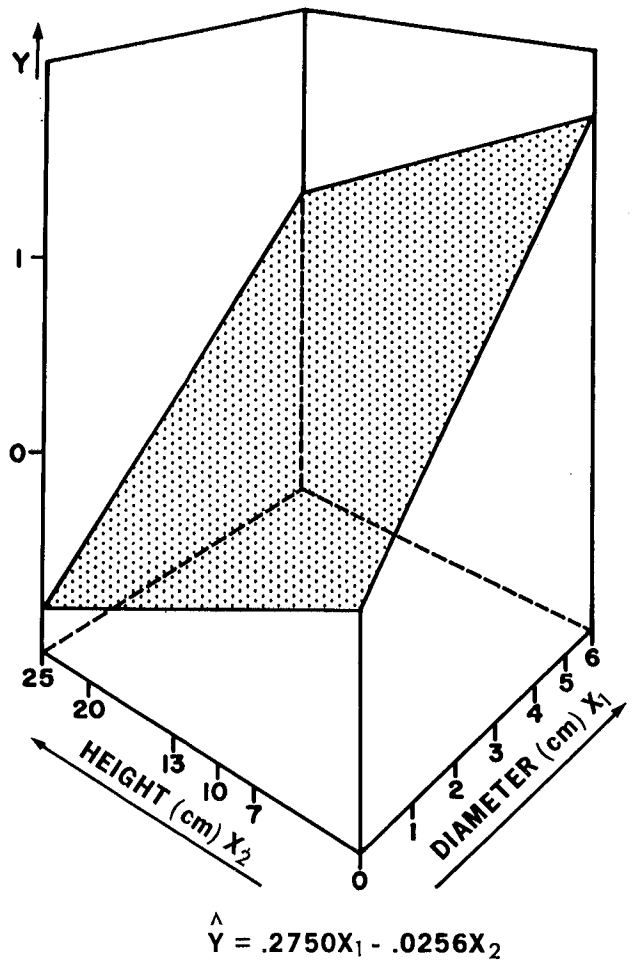


FIGURE 1. Relation between root system density (Y) and tube dimensions (X_1 and X_2).

Coefficients a_1 and a_2 being of significant importance, the equation of the plan YX_1X_2 shows that a positive increment of X_1 (favorable factor) corresponds to an increment of Y, while a reduction of Y corresponds to an increment of X_2 (unfavorable factor).

One may conclude that, to improve the density of the plant's root system, the diameter of the tube rather than its height should be increased. On the other hand, it is evident that root system density alone is insufficient to determine the optimum dimensions of the tube.

Other parameters such as water holding coefficient, vertical root growth, and stem/root ratio must be considered. These factors are under detailed study.—Michel E. Boudoux, Forest Research Laboratory, Quebec, P.Q.

Correction: Vol. 26, No. 1, page 7, table 2.

In place of long arrow joining Clintonia (15) to Dicranum-Nemopanthus (27) insert two arrows, one joining Clintonia (15) to Pleurozium (26), and the other joining Hylocomium (15) to Dicranum-Nemopanthus (27).

SOILS

Nitrogen Losses by Volatilization From Urea Applied to Forest Soils.—All nitrogen in fertilizers is not taken up by plants; some is consumed by soil microorganisms; some is fixed by the soil; some is lost by run-off and leaching; and some is lost to the atmosphere by volatilization. Research has shown that the recovery of nitrogen from urea when applied to agricultural soils is often less than that from other nitrogenous fertilizers (Gasser, Soils Fert. 27: 175-180, 1964). This lower recovery has been partly attributed to the formation of large amounts of volatile ammonia during urea hydrolysis.

Urea is an important forest fertilizer and is being used extensively in the forest fertilization research program being developed in Newfoundland. However, little is yet known about the fate of the nitrogen formed from this fertilizer when applied to forest soils; as part of that work a study was started in 1968 to determine whether there might be a significant nitrogen loss to the atmosphere. This report summarizes the results.

Surface soil samples, including the organic horizons, were collected from a number of locations in a balsam fir [*Abies balsamea* (L.) Mill.] stand near Deer Lake, a black spruce [*Picea mariana* (Mill.) BSP.] stand near Badger, a white birch [*Betula* sp.] stand near Grand Falls and a black spruce stand near Gambo. Soil textures varied from loam at Grand Falls to sandy loam at Deer Lake and Badger and to loamy sand at Gambo. Cation exchange capacity was greatest for Grand Falls (16.07 me/100 g), intermediate at Deer Lake and Badger (9.82 and 8.93 me/100 g) and least for Gambo (6.25 me/100 g). Carbon-nitrogen ratio for Grand Falls was 14.3, for Gambo 16.3, for Deer Lake 18.7 and for Badger 19.4.

Samples from each of the four stands were air-dried, mixed and passed through a 2-mm sieve. Four-hundred-gram lots (oven-dry basis) were placed in eight amber bottles. Urea in aqueous solution was thoroughly mixed with the soil in four of the bottles. Rate of application was equivalent to 600 lb. of nitrogen per acre. The other four samples served as controls. Enough distilled water was added to each bottle to bring the samples to field capacity. Bottles were attached to an aspirator and water-saturated air was passed over each sample. Exhaust air and gases were passed through individual flasks containing a 4% boric acid solution and a few drops of mixed indicator to absorb ammonia. Air flow was maintained at approximately 10 ml/min and temperature was maintained at 70F throughout the experiment. At 14-day intervals the boric acid solution in each flask was titrated against a standard acid to determine the amount of nitrogen present.

Prior to treatment pH values varied from 4.5 to 5.1. After 84 days the pH of all samples had increased probably because of the hydrolysis of urea to ammonia. The increase was greater in the treated samples (0.4 to 0.5 of a unit) than the untreated samples (0.1 to 0.2 of a unit). Differences were significant at P = 0.001 (t-test). These results are similar to those obtained by other workers (e.g. Roberge and Knowles, Soil Sci. Soc. Amer. Proc. 30: 201-204, 1966; Overrein and Moe, Soil Sci. Soc. Amer. Proc. 31: 57-61, 1967).

The loss of nitrogen by volatilization from all treated and untreated samples was small (Table 1). For the Grand Falls and Gambo samples, losses were greater from the treated samples than from the controls (significant at P = 0.05); the reverse was true for the Deer Lake and Badger samples (significant at

TABLE 1

Loss of nitrogen by volatilization from urea applied to forest soils after different times of incubation.

Treatment	Nitrogen lost (pounds per acre) Days of incubation 14	28	42	56	70	84	Total N loss after 84 days
Deer Lake — balsam fir site							
Control	0.95	0.41	0.40	0.22	0.17	0.17	2.32
Urea	0.17	0.17	0.15	0.08	0.07	0.06	0.70
Badger — black spruce site							
Control	0.24	0.15	0.13	0.11	0.11	0.10	0.84
Urea	0.22	0.14	0.08	0.10	0.07	0.08	0.69
Grand Falls — white birch site							
Control	0.32	0.29	0.31	0.18	0.15	0.18	1.48
Urea	0.34	0.30	0.33	0.27	0.21	0.21	1.65
Gambo — black spruce site							
Control	0.19	0.08	0.09	0.11	0.10	0.08	0.65
Urea	0.42	0.19	0.13	0.16	0.15	0.15	1.20

P = 0.02). The greater nitrogen loss from the controls of the two latter areas may be attributed to the higher organic matter content and C/N ratios. When urea is added to soils with high organic matter content much of the nitrogen may become fixed in the form of stable organic complexes.

Mahendrappa et al. (unpublished report) reported losses of nitrogen by volatilization of between 15 and 35% when urea was applied to the surface of 3-inch-thick sods of sphagnum and feather moss in the laboratory. However, final pH values of the moss samples were, in most cases, between 6.0 and 9.0; greater nitrogen losses through volatilization are to be expected under alkaline conditions. Under field conditions Overrein (Soil Sci. 106 (4): 280-290, 1968) recorded losses of nitrogen to the atmosphere of up to 3.5% when urea nitrogen was applied at the rate of 446 lb./acre to the surface of an acid forest soil. These latter figures are a little higher than those obtained from this study under laboratory conditions, but in both cases the actual losses were small. Further work is necessary to determine whether nitrogen losses are similar under field conditions. If losses are similar, then it does not appear that a serious loss of nitrogen will occur through volatilization when urea fertilizer is applied to acid forest soils in Newfoundland.—N. D. Bhure, Forest Research Laboratory, St. John's, Nfld.

(*Continued from back cover*)

Mullick, D. B. 1969. Thin layer chromatography of anthocyanidins. I. Techniques and solvents for two-dimensional chromatography. J. Chromatog. 39:291-301.

Muraro, S. J. 1970. Slash fuel inventories from 70-mm low-level photography. Dep. Fish. Forest., Can. Forest. Serv. Pub. 1268. 12 pp.

Nordin, V. J. Forest protection. *In* Sixth World Forestry Congress, 1966. Comercial y Artes Gráficas, S.A. Barcelona. 1968. p 1847-1856.

Pollard, D. F. W. 1970. The effect of rapidly changing light on the rate of photosynthesis in largetooth aspen (*Populus grandidentata.*) Can. J. Bot. 48-823-829.

Powell, J. M. and Y. Hiratsuka. 1969. Nuclear condition and germination characteristics of the aeciospores of *Cronartium comandrae* and *C. comptoniae.* Can. J. Bot. 47:1961-1963.

Rogers, I. H. and L. R. Rozon. 1970. Neutral terpenes from the bark of Sitka spruce [*Picea stichensis* (Bong.) Carr.]. Can. J. Chem. 48: 1021-1025.

Sims, H. P. and G. D. Campbell. 1970. Red pine seedfall in a southeastern Manitoba stand. Dep. Fish. Forest., Can. Forest. Serv. Pub. 1267. 8 pp.

Sutton, B. C. 1970. Forest microfungi. IV. A leaf spot of *Populus* caused by *Cladosporium subsessile.* Can. J. Bot. 48: 471-477.

Van Wagner, C. E. Calculation on forest fire spread by flame radiation. *In* Sixth World Forestry Congress, 1966. Comercial y Artes Gráficas, S. A. Barcelona, 1968. p 1975-1980.

Venkateswaran, A. 1969. A comparison of the dielectric method with density, moisture regain, and x-ray diffraction methods of determinating fine structure. J. Appl. Polym. Sci. 13: 2469-2481.

Wang, B. S. P. and O. Sziklai. 1969. A review of forest tree seed certification. Forest. Chron. 45:378-385.

Whitney, H. S. and S. H. Farris. 1970. Maxillary mycangium in the mountain pine beetle. Science 167:54-55.

Williams, D. E. 1969. Economics of forest fire control. Pulp Paper Mag. Can. 70(17):97-98.

Wilson, A. L. and A. W. Douglas. 1969. A note on non-linear curve fitting. Amer. Statist. (October issue).

Wong, Horne R. 1969. *Pristiphora acidovalva,* a new sawfly on willow (Hymenoptera: Tenthredinidae). Can. Entomol. 101: 970-972.

Yamvrias, C. and T. A. Angus. 1970. The comparative pathogenicity of some *Bacillus thuringiensis* varieties for larvæ of the spruce budworm, *Choristoneura fumiferana.* J. Invertebrate Pathol. 15:92-99.

Yamvrais, C. and T. A. Angus. 1969. Toxicity of *Bacillus thuringiensis* for larvae of the clothes moth, *Tineola bisselliella.* J. Invertebrate Pathol. 14:423-424.

Yeatman, C. W. and A. H. Teich. 1969. Genetics and breeding of jack and lodgepole pines in Canada. Forest. Chron. 45: 428-433.

Recent Publications

Bernier, B., D. Carrier and W. A. Smirnoff. 1970. Preliminary observations on nitrogen losses through ammonia volatilization following urea fertilization of soil in a jack pine forest. Natur. Can. 96:251-255.

Carlson, L. W. and J. Belcher. 1969. Seed treatment fungicides for control of conifer damping-off: laboratory and greenhouse tests, 1967-68. Can. Plant Dis. Surv. 49(2):38-42.

Carroll, M. N. 1970. Relationship between driving torque and screwholding strength in particleboard and plywood. Forest Prod. J. 20(3):24-29.

Cech, M. Y. and D. R. Huffman. 1970. Dynamic transverse compression treatment of spruce to improve intake of preservatives. Forest Prod. J. 20(3):47-52.

Clermont, L. P. 1970. Study of lignin from stone cells of aspen poplar inner bark. Tappi 53(1):52-57.

Dobie, James. 1970. Advantages of log sorting for chipper headrigs. Forest Prod. J. 20(1):19-24.

Dionne, Jean-Claude. 1969. Bibliographie annotée du glacial aspects morpho-sédimentologiques. Rev. Géogr. Montr. XXIII(3):339-349.

Gage, S. H., C. A. Miller and L. J. Mook. 1970. The feeding response of some forest birds to the black-headed budworm. Can. J. Zool. 48:359-366.

Gillespie, T. and M. A. Hulme. 1970. Kinetics of growth of filamentous fungi with particular reference to wood decay. Nature 225:102-103.

Hedlin, A. F. and D. S. Ruth. 1970. A Douglas-fir twig mining beetle, *Pityophthorus orarius* (Coleoptera: Scolytidae). Can. Entomol. 102:105-108.

Heimberger, C. C. and D. P. Fowler. 1969. Precocious flowering in some pines of the *Lariciones* group. Silvae Genetica. 18:146-150.

Hiratsuka, Y. 1970. Identification and morphology of the aecial state of *Pucciniastrum sparsum* in northwestern Canada. Can. J. Bot. 48:433-435.

Krywienczyk, Janina and Y. Hayashi. 1970. Serological comparison of ribosomal and viral components. J. Invertebrate Pathol. 15:165-172.

Lachance, D. 1970. Growth of *Odontia bicolor* in vitro. Can. J. Bot. 48:447-452.

Loman, A. A. 1970. The effect of heartwood fungi of *Pinus contorta* var. *latifolia* on pinosylvin, pinosylvinmonomethyl ether, pinobanksin, and pinocembrin. Can. J. Bot. 48:737-747.

MacLean, Harold. 1970. Influences of basic chemical research on western red cedar utilization. Forest Prod. J. 20(2):48-51.

Macleod, J. C. Detection and control of forest fires: recent developments in techniques and research. *In* Sixth. World Forestry Congress, 1966. Comercial y Artes Gráficas, S.A. Barcelona. 1968. p 1857-1864.

Mansingh, A., T. S. Sahota and D. A. Shaw. 1970. Juvenile hormone activity in the wood and bark extracts of some forest trees. Can. Entomol. 102:49-53.

Morgenstern, E. K. 1969. Genetic variation in seedlings of *Picea mariana* (Mill.) BSP. II. Variation patterns. Silvae Genetica 18:161-167.

Mullick, D. B. 1969. New tests for microscale identification of anthocyanidins on thin-layer chromatograms. Phytochemistry 8:2003-2008.

Mullick, D. B. 1969. Reddish purple pigments in the secondary periderm tissues of western north American conifers. Phytochemistry 8:2205-2211.

Mullick, D. B. 1969. Studies on periderm. II. Anthocyanidins in secondary periderm tissue of amabilis fir, grand fir, western hemlock, and western red cedar. Can. J. Bot. 47:1419-1422.

(*Continued on page 31*)

BI - MONTHLY

RESEARCH NOTES

IN THIS ISSUE:

Vol. ~~20~~ 26—No. 4 JULY-AUGUST 1970.

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 Canadian Forestry Service, Department of Fisheries and Forestry

BOTANY

Effect of Light Intensity on Growth of Western Hemlock and Douglas-fir Seedlings.—There is currently much interest in improving planting procedures and success through development of a system for producing high-quality container stock in as short a time as possible. The need for better knowledge of seedling growth has increased accordingly. This report describes first-year growth response of western hemlock [*Tsuga heterophylla* (Raf.) Sarg.] and Douglas-fir [*Pseudotsuga menziesii* (Mirb.) Franco] seedlings when maintained under six light intensity regimes and in two soil types.

For both species, 20 plants were grown in each of the 12 treatment combinations comprising six light regimes, ranging from 10 to 100% of full natural light and two soil types. One soil was a clay-loam; the other, a mixture of equal volumes of peat moss and coarse sand supplemented with a balanced liquid fertilizer at weekly intervals. This growing-medium is commonly used for growth of tree seedlings in containers.

Green polyvinyl chloride fabric (saran cloth), woven to different densities, was used for light screens. This fabric provides a uniform diffused light. The commonly used "half shade", made from 1-inch slat tied together with wire at 1-inch spacing (snowfence), was included as a treatment. Plants under this shade are subjected to alternating low and full light (designated L/100%).

Seeds were germinated and the plants were transplanted (9 June) in the cotyledon stage into 7-inch plastic pots, five plants to a pot, then kept under 50% of full light for 1 week. Light effect on seed germination was not included in the study. On 17 June, screens giving the desired degrees of shading were placed about 12 inches above different groups of seedlings. However, the 50% screen was kept over the full-light treatment until 28 June. Although plants for the full-light treatment were shaded (50%) for about 3 weeks following germination, survival and growth following shade removal was poor, especially for western hemlock. As a substitute, some surplus plants under 50% light were moved to full light on 14 July, about 5 weeks after germination. Survival for this group was good and they were used for the full-light treatment.

The experiment was terminated 16 Sept. for Douglas-fir and 8 Oct. for hemlock, i.e., 14 and 17 weeks after germination, respectively. Soil was washed gently from the roots and the data presented in Table 1 recorded. The oven dry weight (105 C for 24 hr) was determined (Fig. 1). Only growth of the plants in the peat moss and sand mixture is given. The response to light was similar for the other soil type although growth was considerably less.

Fifty and seventy per cent light were clearly the most favorable for dry matter production of hemlock (Fig.1). There was no statistically significant difference between these two treatments except for dry matter of roots, which was greatest with 70% light. Light also affected extension growth of hemlock and 50% light provided the best condition (Table 1). For Douglas-fir, total dry matter production increased with increase in light up to 50%. Further increase to full light did not affect total production significantly, but it decreased dry weight of leaves and of stem plus branches and increased root dry weight (Fig. 1). Fifty per cent light was optimum for stem, branch and leaf elongation and production of branches of Douglas-fir, as it was for hemlock. Growth in stem diameter was not affected by light regimes be-

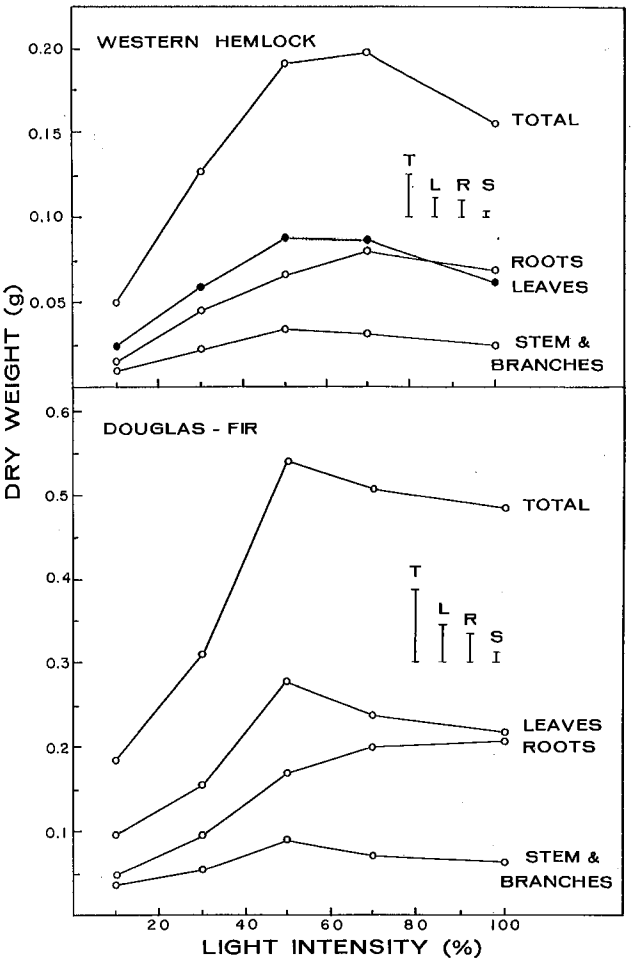


FIGURE 1. Light effect on dry matter production of leaves, roots, stem plus branches and total plant for western hemlock and Douglas-fir seedlings. Bars indicate statistically significant differences (5% level) for the different curves.

TABLE 1
Size (mm) of plant organs and number of branches of western hemlock and Douglas-fir seedlings grown under different light intensities

Light %	Stem Length	Stem Diameter	Root (longest)	Leaf Length	Leaf Width	Branch Length (longest)	Branch Numbers
W. Hemlock							
10	41	0.7	187	11.8	1.14	4	2.2
30	56	0.9	217	13.6	1.31	16	3.7
50	67	1.2	251	14.6	1.48	23	4.7
70	55	1.1	230	13.4	1.51	19	4.3
100	42	1.0	249	12.2	1.29	11	3.8
L/100	63	1.1	246	14.0	1.41	20	4.4
Douglas-fir							
10	90	1.0	282	29.0	—	9	1.9
30	91	1.2	489	31.2	—	18	4.6
50	101	1.5	350	32.2	—	29	7.1
70	81	1.6	346	29.6	—	21	6.4
100	65	1.5	350	27.3	—	15	5.8
L/100	94	1.4	361	31.5	—	23	6.0

tween 50% and full light, and root elongation was greatest at 30% light (Table 1). However, a study of root elongation may be of limited significance in experiments when pots restrict root extension.

Total dry matter production for plants under fluctuating light (L/100%) was 0.17 g for hemlock and 0.457 for Douglas-fir. This is significantly lower than weights of plants grown under 50% light from shadecloth. Stem length and diameter and number and length of branches were also slightly smaller (Table 1).

In the study area (Victoria, B.C.), where skies are mostly clear during the summer, growth was best during the first season for both species under 50 to 70% of full light. Full light should not be given until 5 weeks after germination or after mid-July, since poor survival and growth would result, especially in hemlock. Even with full light after this time, as was the case with the full-light treatment in this study, some reduction in growth will result for both species. But whether this light condition will produce seedlings better adapted to high light intensity in the field remains to be studied.—H. Brix, Forest Research Laboratory, Victoria, B.C.

ENTOMOLOGY

Susceptibility of Spruce Budworm to Pure Nuclear Polyhedrosis Virus (NPV) Sprays.—The spruce budworm [*Choristoneura fumiferana* Clem.] has been shown to be more susceptible to pure NPV than to NPV mixed with a cytoplasmic polyhedrosis virus (Bird, Can. Entomol. 101: 1269-1285, 1969). This paper presents preliminary results of a study to determine effective viral concentrations of suspensions, the larval stage or stages most susceptible to viral sprays, and whether or not sprays can be effectively applied as the larvae are emerging from overwintering hibernacula (second instar).

Based on quantitative laboratory studies, suspension containing 1 g of pulverized, freeze-dried, virus-infected larvae (about 80 sixth-instar larvae) in 1,000, 10,000 and 100,000 ml of water were selected for field trials. Freeze-dried larvae were chosen because such material is very easily processed and may be stored for several months at room temperatures without serious degradation.

The test site was 5 acres of white spruce [*Picea glassca* (Moench) Voss] 6-12 ft high, near Iron Bridge, Ont. The trees were heavily infested. The budworm population showed no evidence of viral disease but about 2% were infected with microsporidia. About 10% of the larvae and up to 60% of the pupae were parasitized. Predaceous insects, particularly ants, appeared to be numerous. The possibility of viral transmission by parasites and predators, therefore, appeared to be good.

Spraying commenced on May 9, soon after the first larvae were observed emerging from hibernacula, and continued every second or third day thereafter until June 16, about 1 week before pupation commenced. Each tree received only one application. Samples consisting of 20-30 larvae were taken periodically. From each larva smears were prepared and examined under the phase-contrast light microscope for symptoms of disease. A single infected cell was accepted as proof of virus infection.

Figure 1 shows the results obtained on second-instar larvae. Disease appeared 20-29 days after the trees were sprayed. Figure 1C shows two peaks of infection: the first (40% infection) occurring after 32 days, the second (66% infection) about 22 days later. The first was due to virus sprayed on the foliage (primary infection), the second is attributed to transmission of virus from diseased to healthy larvae (secondary infection). Thus it appears that 40% primary infection is sufficient to initiate an epizootic, whereas primary infection of 20% (Fig. 1B) was not.

Primary infections of similar magnitudes were obtained from sprays applied until June 9. At this time, about 50% of the larvae were in the third instar, 40% in the fourth and 10% in the fifth instar. Incubation periods decreased quite consistently from the 20-29 days required for sprays on May 9 to 11 days for sprays on June 9. This was due mostly to a gradual increase in temperature. (The maximal/minimal temperatures on May 9 were 53° and

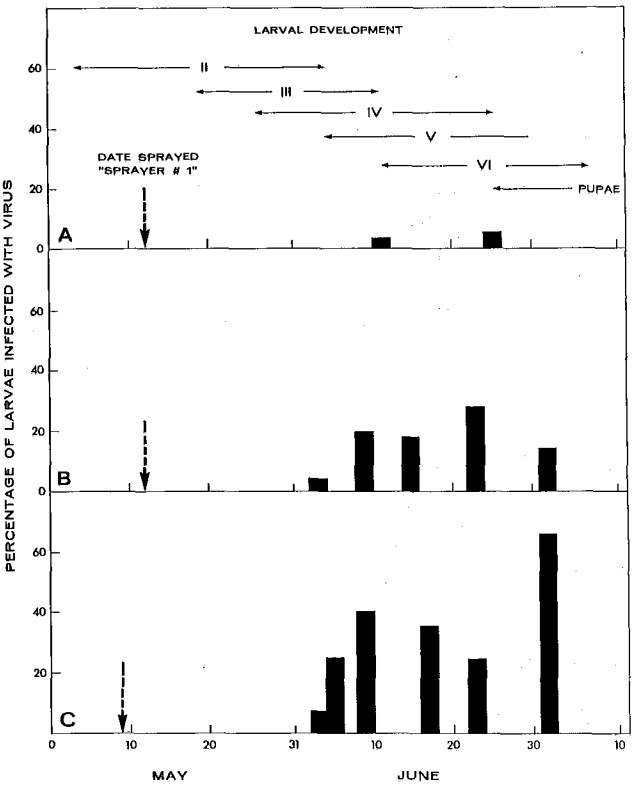


FIGURE 1. Virus infection resulting from the dissemination of NPV in water suspension: (A) 1 g/100,000 ml; (B) 1 g/10,000 ml; and (C) 1 g/1,000 ml sprayed at the rate of 50-100 ml per 6-12 ft. tree.

37°F and on June 9, 70° and 46°F). It was also due to some extent to adjusting the sprayer to yield larger spray droplets which increased percentages of infection to 75% from sprays with 1 gm of virus material in 1000 ml of water and to 54% from sprays with 1 gm of virus material in 10,000 ml of water.

These results suggest that epizootics can be induced by viral sprays applied when budworm populations are emerging from hibernacula. At this time, a primary infection of 40% would be sufficient to initiate a secondary infection of epizootic proportions through natural transmission of the virus.—F. T. Bird and J. R. McPhee, Insect Pathology Research Institute, Sault Ste. Marie, Ont.

Host Characteristics, Brood Density and Size of Mountain Pine Beetles Emerging from Lodgepole Pine.—Fecundity and rate of oviposition of the mountain pine beetle *Dendroctonus ponderosae* Hopk. are strongly related to female size (Reid, Can. Entomol., 94:605-613, 1962). This paper reports the relationship of tree diameter, height and aspect on the stem, bark thickness, moisture content of the outer sapwood, and brood density to the size of mountain pine beetles emerging from lodgepole pine *Pinus contorta* Dougl. var. *latifolia* Engelm. in southeastern British Columbia. The relationship between height on the stem and the size of attacking beetles was also investigated.

Adult beetles were collected from the bottom 20-ft sections of 22 infested lodgepole pine trees in 1967, 1968 and 1969. Three trees were sampled in 1967, 9 in 1968, and 10 in 1969; all trees were located in the same experimental area. From all of the 1967 and three of the 1968 sample trees, the beetles were hand-collected from beneath circumferential strips of bark about 10-inches wide, which were removed at 2-ft intervals on the stem starting from 2 ft above the ground up to 20 ft. Sampling commenced when about 95% of the beetles had matured. From the remaining 16 trees, emerging beetles were collected in special traps (Safranyik and Jahren, Bi-mon. Res. Notes, 26:10-11, 19, 1970) attached to

TABLE 1

Average pronotal widths of mountain pine beetles emerged from lodgepole pine trees[a]

Sample height on stem (ft)	Average width of pronotum (mm), sample size[b], and $s_{\bar{x}}$: 1967 Females	1967 Males	1968 Females	1968 Males	1969 Females	1969 Males
2	2.02(83)± .018	1.88(38)± .006	2.19(104)± .025	1.94(49)± .030	1.94(11)± .063	1.90(6)± .045
4	2.10(96)± .013	1.88(43)± .005	2.08(113)± .018	1.90(65)± .024	2.07(23)± .042	1.95(6)± .074
6	2.11(86)± .015	1.92(40)± .006	2.09(105)± .018	1.85(68)± .021	2.24(14)± .038	1.85(7)± .070
8	2.07(58)± .014	1.86(35)± .007	1.98(101)± .017	1.84(72)± .018	—	—
10	2.09(66)± .012	1.86(41)± .007	2.03(91)± .018	1.85(71)± .020	2.08(6)± .075	1.87(5)± .080
12	2.04(57)± .024	1.87(33)± .010	1.98(85)± .017	1.81(57)± .016	2.08(7)± .051	—
14	2.07(33)± .021	1.84(19)± .016	1.98(105)± .018	1.82(52)± .020	2.02(11)± .071	—
16	2.01(32)± .036	1.87(18)± .014	1.97(80)± .019	1.78(50)± .019	2.03(6)± .073	1.85(2)± .230
18	1.95(21)± .053	1.80(13)± .020	1.97(87)± .019	1.81(52)± .019	—	—
20	1.95(23)± .076	1.68(13)± .019	1.99(78)± .019	1.78(43)± .016	1.95(7)± .034	—
Grand averages	2.06(555)± .006	1.86(293)± .007	2.03(949)± .006	1.84(579)± .006	2.06(85)± .023	1.88(26)± .032

a) Emerged beetles include those caught in emergence traps and those collected as teneral under bark strips.
b) Numbers in brackets indicate sample size.

the northern and southern aspects of stems at 2-ft intervals from 2 ft above the ground up to 20 ft when about 85% of the beetles had matured. The attacking beetles were caught in window traps (Chapman and Kinghorn, Can. Entomol., 87:46-47, 1965) attached, at 2-ft intervals, to the northern aspects of the bottom 20-ft sections of seven green trees.

In 1968, beetles caught in emergence traps were separated by height and by the date of emergence. In 1969, the beetles were separated by height and aspect on the stem. Sex was ascertained by the presence or absence of stridulating teeth. Pronotal width, measured on the dorsal aspect to the nearest 0.05 mm, was taken as an index of beetle size. Moisture content of the outer sapwood was measured on sample blocks (1.75 x 0.5 x 0.25 inch) taken from the northern and southern aspects of 2-ft intervals in the lower 20-ft sections of the stems of three trees in 1968 and 10 in 1969. Bark thickness and brood density were measured only on trees having emergence traps. Brood density was expressed as total number of emerging beetles per trap and bark thickness was measured (to the nearest 0.03125 inch) beneath the trap.

In general, the average pronotal widths of emerging males and females were inversely related to height on the stem (Table 1). In 1967 and 1969, these averages reached a maximum at a height of 4 to 6 ft; in 1968, they declined with increasing height on the stem. There was no relationship between the average pronotal width of attacking male or female beetles and height on the stem. Nor was there significant difference between the northern and southern aspects of the stem in the average pronotal width of emerging female beetles although on the northern aspect the average size of both sexes was about 3% larger than those from the southern aspect.

The correlation coefficients of beetle size with some physical tree characteristics and brood density are given in Table 2. Size of both sexes was significantly correlated (at the 1% level) with tree diameter in 1968 and 1969 and with height on the stem in 1967 and 1968. Similarly, bark thickness and moisture content of the outer sapwood were significantly correlated with beetle size in 1968 but neither of these correlations were statistically significant in 1969. In 1969, the lack of statistically significant correlations between beetle size and the specified host characteristics probably resulted from small sample sizes. Brood density was not correlated with beetle size in either of the 2 years investigated.

TABLE 2

Simple correlation coefficients of the size of male and female mountain pine beetles emerging from lodgepole pine with brood density and some physical tree characteristics in the bottom 20-ft of the stem

Sex	Correlation coefficients[a]: DBH	Height on the stem	Bark thickness	Moisture cont. of outer sapwood[b]	Brood density
			1967 data		
Female size[b]	—	—0.14(555)**	—	—	—
Male size	—	—0.23(293)**	—	—	—
			1968 data		
Female size	0.40(949)**	—0.28(949)**	0.23(232)**	0.22(663)**	0.08(286)
Male size	0.35(579)**	—0.24(579)**	0.14(123)*	0.12(432)*	0.08(147)
			1969 data		
Female size	0.36(85)**	—0.18(85)	0.03(85)	0.17(85)	0.15(85)
Male size	0.52(26)**	—0.10(26)	0.29(26)	0.11(26)	0.14(26)

a) Values in brackets indicate sample size.
b) Moisture content was expressed as percentage of oven-dry weight.
* and ** Significant at the 5% and 1% probability level, respectively; entries without asterisks are not significant.

Our results indicated that certain physical characteristics of the host have considerable effect on the size of mountain pine beetles emerging from lodgepole pine trees. Consequently, relationships between beetle size and host characteristics must be considered in attempts to use beetle size as an index of the potential of the beetle population to increase in a given environment. L. Safranyik and R. Jahren, Forest Research Laboratory, Calgary, Alta.

Biological Control of the Satin Moth in Newfoundland.— The satin moth [*Stilpnotia salicis* (L.)], a native of Europe and western Asia, was introduced to North America in 1920 and first recorded in Newfoundland at St. John's in 1934 (Reeks and Smith, 1956, Can. Entomol. 88:565-579). It was discovered near St. George's in western Newfoundland in 1936 and in central Newfoundland in 1951; it has never been recorded from the Northern Peninsula. The chronological pattern of initial outbreaks suggests separate introductions to eastern and western Newfoundland. (Several species of poplars were imported from both Europe and North America without plant inspection prior to 1950).

Records of the Forest Insect and Disease Survey indicate that infestations of the satin moth have occurred at intervals of 2 to 4 years and persisted for 6 to 10 years. Continuous outbreaks were recorded on exotic poplars between 1952 and 1963 at Deer Lake, between 1950 and 1957 at Grand Falls, and between 1951 and 1958 at St. John's. Defoliation ranged from 40% to 100% in the outbreak at Deer Lake and branch and tree mortality was severe. Some branch and tree mortality was recorded during the outbreak at Grand Falls but many trees survived, presumably because of an application of D D T in 1953. Since 1953, there have been many outbreaks in natural stands of trembling aspen [*Populus tremuloides* Michx.] but no tree mortality has been recorded.

This insect was recognized as a pest of poplars and willows and two species of braconid parasites were introduced as control agents. (McGugan and Coppel, 1962, Tech. Commun. 2, Commonw. Inst. Biol. Contr.). *Meteorus versicolor* (Wesm.) was released at St. George's in 1942 but no recoveries were made. *Apanteles solitarius* (Ratz.) was released at St. John's in 1936, at various locations around Conception Bay in 1940, and near St. George's in 1942. Recoveries of this species were made at St. George's in 1942, at Conception Bay in 1946, and at Grand Falls in 1953, about 200 miles from the nearest release point. Insectary rearings from 1952 to 1961 show an average parasitism of 6% and a range from 1% to 15%. From 1962 to 1966 parasitism averaged 38% and ranged from 31% to 48%. Large numbers of *A. solitarius* cocoons have also been observed on the bark of trees defoliated by the host, an indication that parasitism was probably much higher than recorded. Native parasites have not been important; only one individual has been reared from each of five

species. Diseased satin moth larvae have been observed in the insectary but not in field populations.

It appears that the parasite, *A. solitarius*, has been the major factor in reducing the duration of satin moth outbreaks and subsequent tree mortality in recent years.—L. J. Clarke and K. E. Pardy, Forest Research Laboratory, St. John's, Nfld.

FOREST PRODUCTS

A Novel Qualitative Test for Iron.—Most wood species under optimum conditions of moisture will react with iron. This was clearly seen in the development of "transit" stain (Dep. Forest. Can., Research News 7(4):3, 1964) on white spruce [*Picea glauca* (Moench) Voss] and lodgepole pine [*Pinus contorta* Dougl. var. *latifolia* Engelm.] during railway shipment from the interior of British Columbia to the coast. It was found that contamination from iron particles caused by brake-shoe wear settled on uncovered wet lumber and reacted with the natural polyphenols of the wood to give an unsightly black-weathered stain. As long as a shipment did not encounter rain, the lumber remained clean. Moisture accounts for the sudden appearance of the stain. In many cases of stained wood in which neither fungal nor bacterial attack are factors, iron contamination often is involved. These iron stains range in color from red to black and are caused by chemical reactions between iron and the phenolic constituents in the wood. Some wood species, such as western red cedar [*Thuja plicata* Donn], are particularly susceptible to iron staining due to a high water-soluble phenolic content (Barton, Pulp Pap. Mag. Can., 55(10):132, 1954; MacLean and Gardner, Forest Prod. J. 6(12):510, 1956; Gardner, Dep. Forest. Can. Pub. No. 1023, 1963.). The Vancouver Forest Products Laboratory was called upon for a solution to the staining problem. As a result of these and other investigations, a rapid sensitive test for iron was required.

The proposed test is derived from our chromatographic-detecting reagent for phenols (Barton, Evans and Gardner, Nature 170:249, 1952) in which aqueous solutions of ferric chloride and potassium ferricyanide are sprayed on papergrams or thin-layer plates to give an intense blue color with most phenolic substances. The apparent reduction of iron to the +2 valence state is due to complexing with phenolic substances to give [Fe(OR)]++ (where R is a phenol) (Broumand and Smith, J. Am. Chem. Soc. 74:1013, 1952). In order to modify this reagent to test for iron, an aqueous 0.2% solution of any suitable phenol, such as catechin, and a 1% aqueous solution of potassium ferricyanide are mixed in a 1:1 proportion and added drop-wise to a cold or hot dilute nitric acid solution of an extract containing iron. A blue color constitutes a positive test. Alternatively, the mixed solution can be sprayed on paper spotted with the extract suspected of containing iron. The test is sensitive to 1γ of ferric iron. Unlike the potassium thiocyanate test, the reagents are not sensitive to hot dilute nitric acid and will detect either ferrous or ferric iron.—G. M. Barton, Forest Products Laboratory, Vancouver, B.C.

MENSURATION

Bole Weight to Volume Ratio: a Constant for Open-grown Balsam Fir.—The relationship between the oven-dry weight and volume in open-grown balsam fir [*Abies balsamea* (L.) Mill.]. has been studied at the Petawawa Forest Experiment Station, Chalk River, Ont., as part of an investigation into their weight/dimensional relationships.

Forty trees ranging in height from 6 to 63 feet and in diameter from 1 to 16 inches were selected, felled and sectioned, leaving a stump height of 0.5 feet. Trees of 3 inches dbh and greater were sectioned into 4-foot bolts and smaller trees into 2-foot sections. The large and small end diameters inside and outside bark, as well as bolt lengths, were measured. Following removal of the branch material, the fresh weight of each 4-foot bolt was recorded to the nearest 0.5 lb., and the smaller bolts were weighed to the nearest 5 g. A sample disk approximately 1.5 inches in thickness, was removed from the mid-portion of each bolt, and they were then transported to the laboratory in polyethylene bags for determination of dry weight. Both the fresh and oven-dry weights of the samples were recorded to the nearest 0.1 g. They were dried at 104°C, for a period of 24 to 48 hours or until no change in sample weight was noted.

The volume of each bolt was computed using Smalian's formula.

The oven-dry weight of each bolt of wood was computed from equation(1)

weight o.d. = A x B/C

where: A = fresh section weight (wood plus bark)
B = dry sample weight of wood
C = fresh sample weight of wood plus bark.

Bole volume (cu ft) and bole weight (lb.) were determined by summing the individual bolt values.

The volume and weight/dimensional relationships were expressed in the form:

$\log_e$ bole volume $= b_o + b_1 \log_e \text{dbh} + b_2 \log_e H$ (2)

$\log_e$ bole weight o.d. $= b_o' + b_1' \log_e \text{dbh} + b_2' \log_e H$ (3)

where dbh is the diameter at breast height and H is the total tree height. The results were then subjected to an analysis of covariance; no significant differences in the b_1, b_1', b_2 and b_2' coefficients were found. The differences in level were highly significant as expected.

The final equations were:

$\log_e$ bole volume $= -5.1684 + 1.6271 \log_e \text{dbh} + 0.9340 \log_e H$

$\log_e$ bole weight o.d. $= -2.1440 + 1.6271 \log_e \text{dbh} + 0.9340 \log_e H$.

These results indicate that a constant weight/volume relationship exists for open-grown balsam fir. By computing the exponents of the b_o and b_o' constants, the relationship is:

$$e^{(-5.1684)} = .0056937$$

$$e^{(-2.1440)} = .117185$$

$$\text{pounds per cubic foot} = \frac{.117185}{.0056937} = 20.58$$

The specific gravity of balsam fir has been tabulated (Kennedy, Jessome and Petro. 1968. Specific Gravity Survey of Eastern Canadian Woods, Dep. Fish. Forest. Pub. 1221.) as .333± .054, and thus the upper, average and lower values are:

upper limit = .387 x 62.4 = 24.1 lb./cu ft
average = .333 x 62.4 = 20.8 lb./cu ft
lower limit = .279 x 62.4 = 17.4 lb./cu ft

where 62.4 is the weight of one cubic foot of water.

Thus, the average specific gravity used in conjunction with bole volumes, provides accurate dry-weight estimates for open-grown balsam fir trees.—T. G. Honer, Forest Management Institute, Ottawa, Ont.

PATHOLOGY

Differential Phytotoxicity Complicates Selection of Conifer Seed-Treatment Chemicals—During the past 3 years we have tested 187 chemicals for their fungitoxic activity against *Pythium* sp., *Rhizoctonia* sp., and *Fusarium* sp., and for phytotosicity on three conifer species, jack pine [*Pinus banksiana* Lamb.], lodgepole pine [*Pinus contorta* Dougl. var. *latifolia* Engelm.], and white spruce [*Picea* glauca (Moench) Voss] (Belcher and Carlson, Can. Plant Dis. Surv. 48:47-52, 1968; Carlson and Belcher, Can. Plant Dis. Surv. 49:38-42, 1969). Attempts to find a chemical (or chemicals) with a wide spectrum of fungitoxicity and little or no phytotoxicity have not been successful due to the differential response of the conifers.

Of the 187 chemicals tested in a laboratory seed-germinator only 23 showed no phytotoxicity to all three species of conifer (Table 1) and 108 were toxic to all three. A total of 134 chemicals were phytotoxic to jack pine, 143 to lodgepole pine, and 135 to white spruce. Six were phytotoxic to jack pine alone, while 11 and 7 were toxic to lodgepole pine and white spruce alone respectively.

The intensity of phytotoxicity was striking in many cases (Table 1). Throughout the testing phytotoxicity on jack pine appears less severe than on lodgepole pine and white spruce. Of the 134 chemicals phytotoxic to jack pine only 66 reduced germination to less than 50% of the control. However, 96 of 143 for

Table 1
Seed treatment chemicals inhibiting conifer seed germination under laboratory conditions.

Conifer	Number of chemicals	Chemical	Examples[1] % germination jack pine	lodgepole pine	white spruce
Jack pine, alone	6	Sulfur 95%	56*	72	83
Jack pine + lodgepole pine	12	SWF 970	30*	24*	73
Jack pine + white spruce	8	FV-XI-131A	50*	69	48*
Jack pine + lodgepole pine + white spruce	108	dodine 65%	2*	0*	3*
		Captan 50WP	76*	52*	55*
		thiram 75WP	78*	34*	50*
Lodgepole pine, alone	11	SWF 580	86	23*	68
Lodgepole pine + white spruce	12	dichlone 50%	88	3*	11*
White spruce, alone	7	D-735 10%	92	65	15*
No phytotoxicity	23	THC 324	92	81	74
Check	—	No treatment	95	76	69

*Significantly different from the check at the 5% level of confidence.
[1] Seed treated at 0.33 g. chemical/g. of seed.

lodgepole pine and 100 of 135 for white spruce reduced germination by 50% or more.

The phytotoxicity of some chemicals is altered when formulated differently, either by an increase or decrease in percentage of active ingredient or by combination with other chemicals. The percentages of germination for jack pine, lodgepole pine and white spruce seeds, treated with different formulations of metiram and captan, are shown in Table 2. The reduction in phytotoxicity of metiram appears related to a decrease in the amount of active ingredient in the formulation. For captan, a formulation with 90% active ingredient is far less phytotoxic than a 50% formulation; phytotoxicity appears to increase with the increase in amount of "inert" ingredients.

TABLE 2
Alteration of phytotoxicity of two chemicals in relation to formulation

Chemical	percent formulation	Germination % jack pine	lodgepole pine	white spruce
Metiram	80%	67*	39*	40*
Metiram seed protectant	53.3%	79*	63*	79
Metiram	53.3%	87	74	45*
Metiram + lindane	10% & 75%	78*	67	70
Captan	90%	87	79	84
Captan	50%	76*	52*	55*
Captan + Daconil	35% & 35%	77*	62*	49*
Captan + lindane	10% & 75%	93	84	75
Captan + lindane	5% & 37.5%	85	26*	53*
Check—no treatment		95	76	69

*Significantly different from the check at the 5% level of confidence.

The problem of selection of seed-treatment chemicals is not only confounded by the differences between chemicals, but also by possible differences in the amount and quality of inert carriers used in the formulations. Further research is needed on the possible phytotoxic effects of inert ingredients before continuing with a program of screening seed-treatment chemicals.—L. W. Carlson, Forest Research Laboratory, Winnipeg, Man.

Mycelial Strand Formation by Antagonism in *Odontia bicolor*.—Very few studies (Menzies, *Botan. Rev.* 29:79-122, 1963) have dealt with the behavior of wood-rotting fungi in the soil and particularly with *Odontia bicolor*. Recently we have found that *O. bicolor* (Alb. & Schw. ex Fr.) Quél., a fungus responsible for a white butt rot in several tree species, could develop in the soil by forming mycelial strands (Lachance, *Can. J. Bot.* 48:447-452, 1970). This type of growth by the fungus seems to be the result of a response to competition from other micro-organisms in the soil. These mycelial strands appear to give *O. bicolor* a competitive advantage over the micro-organisms in the soil, more capability of colonizing a new area, and perhaps greater inoculum potential.

Formation of strands has been lately obtained *in vitro* when *O. bicolor* was grown in face of *Polyporus balsameus* Pk. (Fig. 1A), a fungus that causes a brown rot in *Abies* spp. The medium used was 2% agar-agar enriched with 2.5% malt extract, and inoculum discs were cut from cultures grown on a similar medium.

We found that *O. bicolor* started forming mycelial strands just at the meeting point of both fungi growth margins, and grew over its competitor from that time forth. This suggests that, in competition with *P. balsameus*, *O. bicolor* abruptly shifted from an open hyphae-growth type (normal growth in sterile medium)

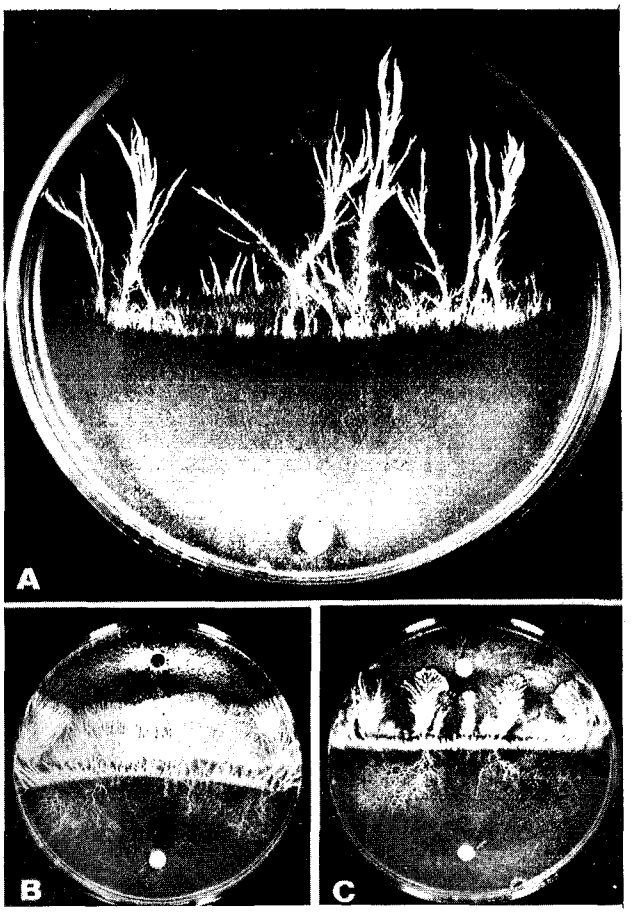


FIGURE 1. Antagonistic response, in agar medium of *Odontia bicolor* with A) *Polyporus balsameus*, B) *Amylostereum chailletii* (Pers. ex Fr.) Fr., and C) *P. abietinus* Dicks ex Fr.

to one of hyphal strands. We also noticed that funicles grew faster than unclustered hyphae. *O. bicolor* strands obtained *in vitro* were similar to those observed in a natural humus soil inoculated with a fir wood cube previously infected with this fungus.

This ability to form mycelial strands when confronted by another organism appears to be very strong in *O. bicolor*. As a matter of fact, various kinds of hyphal clusters were obtained on agar medium when this fungus was grown with other decay fungi. Such reaction was often manifested by the formation of numerous and thin twists (Fig. 1B), or by small fan-like growths (Fig. 1C). In most tests *O. bicolor* exhibited a strong tendency to grow over the mycelium of the antagonist.

As antagonistic reaction similar to that observed in the soil was obtained *in vitro* with only two organisms involved, our technique should simplify the study of factors related to this phenomenon.—D. Lachance, Forest Research Laboratory, Quebec 10, Quebec.

Butt Decay in Balsam Fir Defoliated by the Spruce Budworm.—The 1949-1959 outbreak of the spruce budworm [*Choristoneura fumiferana* (Clem.)] caused varying degrees of defoliation, top-killing, and tree mortality in dense stands of balsam fir [*Abies balsamea* (L.) Mill.] in northern New Brunswick (Baskerville, Forest. Chron. 36: 342-345, 1960). The surviving trees constitute the pulpwood forest of the future and the possibility of a high incidence of butt decay associated with the budworm stress is of vital interest. Rankin (Phytopathology 10:314-315, 1920) and McCallum (Can. Dep. Agr. Bull. 104, 1928) reported no correlation between the amount of cull and previous budworm injury; however, Stillwell (Forest Sci. 2:174-180, 1956) found a higher incidence of stem decay was commonly associated with buried leaders which had been killed by severe budworm defolia-

tion. Similar information on the incidence of butt decay is lacking, although Redmond (Forest Sci. 4:15-21, 1957) reported that the presence of butt decay could not be exclusively related to rootlet mortality resulting from budworm defoliation. However, existing infections may spread more quickly because of the reduction in tree growth and vigor.

In 1967, 368 trees greater than 4.5 inches dbh. were felled in two stands which had not been sprayed with insecticide during the 1949-1959 outbreak of spruce budworm: 191 trees were from the Kedgwick watershed in northwestern New Brunswick and 177 were from the Charlo watershed in north central New Brunswick. Both stands were released by the 1912-1920 outbreak and are predominantly balsam fir. The Kedgwick and Charlo stands were subjected to 9 and 7 years respectively of moderate to severe defoliation.

The volume of butt decay was determined for each tree. If no decay was visible in the stump, all main roots were cut about 1 foot from the root collar and examined. Decay fungi were cultured on 2% malt agar slants. A disk, marked on the north side, was taken from each tree about 2 feet from ground level and the dates and number of suppression rings were determined.

Of the isolation attempts on the two study areas, 54% yielded basidiomycetes. Six basidiomycetes were commonly isolated from both areas with nearly the same relative frequency (Table 1). Of the 122 basidiomycete isolates, 38% were *Scytinostroma galactina* which did not appear to be associated with any particular suppression group. *Armillaria mellea*, previously isolated with low frequency from balsam fir, constituted 30% of the isolates and was associated with trees of the higher suppression classes; conforming with the established pattern of *A. mellea* progressing rapidly in weakened trees (Boyce, Forest Pathology, McGraw Hill, 1961). *Coniophora puteana* comprised 22% of the isolates and was isolated with about equal frequency from all suppression classes.

TABLE 1
Frequency of isolation of basidiomycetes from butt decay in the Kedgwick and Charlo stands

Fungus	Kedgwick	Charlo
	Number of times isolated	
Scytinostroma galactina (Fr.) Donk	25	22
Armillaria mellea (Vahl ex Fr.) Kummer	21	15
Coniophora puteana (Schum. ex Fr.) Karst	17	10
Odontia bicolor (Alb. & Schw. ex Fr.) Quel	1	2
Polyporus balsameus Peck	2	2
Xeromphalina campanella (Batsch ex Fr.) Kuehn. & Maire	4	1
Total	70	52
	122	

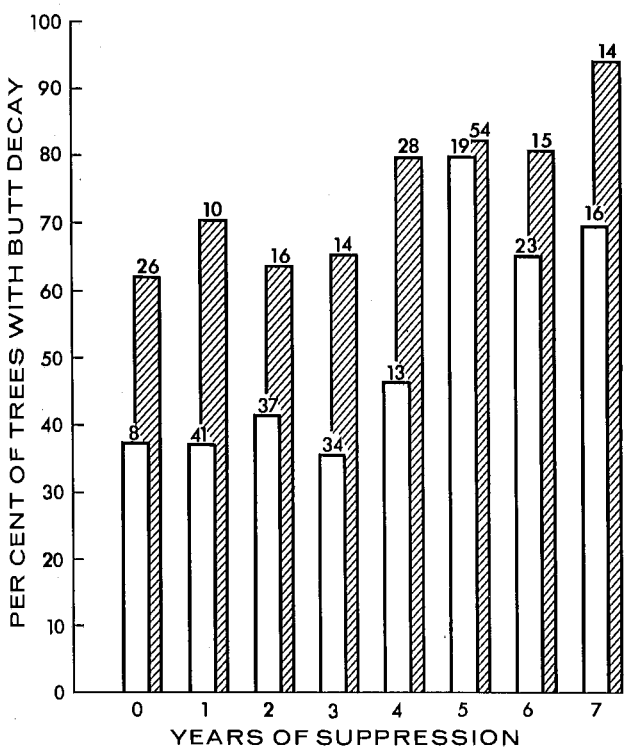


FIGURE 1. Percentage of trees containing butt decay in each suppression class. Numbers at top of bars indicate the total number of trees in each suppression class. Open — Kedgwick; hatched — Charlo.

Radial growth of balsam fir is reduced 1 to 3 years after the first severe defoliation (Mott, Nairn, and Cook, Forest Sci. 3:286-304, 1957). In the present study, all suppression rings initiated during the known period of the budworm infestation were assumed to be the result of defoliation. The few stems with more than seven suppression rings appeared to be suppressed by factors in addition to defoliation and were discarded.

The percentage of trees with butt decay in each suppression class is shown in Figure 1. Regression analysis of the data resulted in r^2 values of 0.67 and 0.79 for the Kedgwick and Charlo stands respectively, and the slopes of both regression lines were significant at the 5% level. Trees in the Charlo stand that suffered little or no suppression had an appreciably higher incidence of decay than trees of the same group in the Kedgwick stand. This suggests that factors in addition to budworm defoliation, such as site and stand history, are responsible for the overall higher incidence of decay in the Charlo stand.

The majority of the decay volumes were small and no relationship was apparent in either area between volume of decay and severity of suppression. Only 23% of the decayed trees from the Kedgwick stand had decay pockets more than 1 inch in diameter and only 27% of the decay pockets extended more than 6 inches above ground level. Decay volumes were somewhat higher in the Charlo stand where the values were 43 and 49%. As similarly defoliated trees age, however, they may contain higher volumes of butt decay which would tend to make them more susceptible to windthrow than trees that had not been defoliated. Consequently, this aspect of "budworm damage" should also be assessed so that a more precise prediction of the stands' future could be made.—T. E. Sterner, Forest Research Laboratory, Fredericton, N.B.

Preliminary Results of a Study to Control Poria Root Rot of Douglas Fir—Poria root rot of Douglas fir (*Pseudotsuga menziesii* (Mirb) Franco), caused by *Poria weirii* Murr., infects most commercially important conifers in British Columbia and the northwestern United States, and is responsible for large annual losses in immature Douglas fir. Initial tree infection arises through contact between living roots and infected stumps and large roots left from the preceding stand. It spreads among living trees via root contact and grafts. Viable mycelium of the fungus may persist for as long as 50 years in the infected residue.

In 1968, an experiment was established to test the feasibility of control of the root rot through mechanical removal (scarification) of the larger sources of inoculum in the soil, and the planting of mixed susceptible and resistant species. This report gives preliminary results of the effects of scarification.

A block, 9 chains square (8.1 acres), was marked in a stand infected with root rot near Salmon Arm, B.C. All trees in the area were tallied and mapped with respect to species, diameter, condition (alive or dead) and exact position. The study area, 8 chains square (6.4 acres), was staked out in the center of the block and divided equally into a treated and an untreated plot. A buffer strip, 0.5 chains wide (1.7 acres), surrounded the study area to prevent encroachment of the fungus from the adjacent stand and to provide sample areas for assessing the immediate effects of scarification. Trees in the untreated plot were felled conventionally and removed by tractor. As an aid to scarification, trees in the treated plot and in the buffer strip were pushed over and removed with attached roots. The ground was then scarified with a land-clearing blade to a depth of 18 inches.

Both plots were divided into 32 subplots, each 1 chain square. These were planted in random design, incorporating three replications each of pure and mixed species of susceptible

and resistant trees in each plot. Two subplots in each of the treated and untreated areas, left after completion of the design, were planted to pure stands of incidental species.

After 5 months, an assessment was made of the size and condition of residual roots in the treated and untreated areas. Pits were excavated in both areas to a depth of 2 feet, in one-foot levels. Roots were screened from the soil, recorded as to size and soil level, and examined for the presence of fungi. *Armillaria mellea* (Vahl ex Fr.) Kumm. and non-pathogenic fungi were noted, in addition to *Poria weirii.*

The data (Table 1) showed that while treatment resulted in a greater number of residual roots in the upper level of soil, the

TABLE I

Number and volume of infected residual roots per cubic foot of soil.

Root condition	Level of sample (ft)	Number of roots		Volume of roots (cm^3)	
		Untreated	Treated	Untreated	Treated
Infected with *P. weirii*	0—1	0.9	4.2	137.8	13.9
	1—2	1.4	0.7	19.8	1.4
		2.3	4.9	157.6	15.3
Infected with *A. mellea*	0—1	0.9	2.3	40.7	5.3
	1—2	1.3	0.4	5.5	0.6
		2.2	2.7	46.2	5.9
Infected with other fungi	0—1	0.9	5.9	51.9	48.8
	1—2	3.3	1.1	13.7	3.0
		4.2	7.0	65.6	51.8
Apparently healthy	0—1	3.3	15.8	30.8	56.2
	1—2	19.3	2.0	34.7	12.9
		22.6	17.8	65.5	69.1
Total of all roots	0—1	6.0	28.2	261.2	124.2
	1—2	25.3	4.2	73.7	17.9
		31.3	32.4	334.9	142.1

volume of inoculum had been reduced by approximately 70%. Over 95% of the roots in the upper level of treated soil were 1.0 cm or less in diameter, which accounts for the small volume of infected roots. The preponderance of small roots in the upper level undoubtedly resulted from breakage and physical shifting of level during the treatment. As expected, small numbers of large roots were found in the upper level of untreated soil.

Although small infected roots were not removed by the treatment, they are not likely to retain viable mycelium of the root rot for an extended period of time. The breaking of roots during treatment should enhance their susceptibility to secondary saprophytic wood-destroying organisms and thus shorten the period of viability. The data suggest that control through scarification is possible. The survival of *P. weirii* will be studied from periodic sampling of buried roots, and its ability to infect living roots will be ascertained through assessment of disease development in planted species.—L. C. Weir and A. L. S. Johnson, Forest Research Laboratory, Victoria, B.C.

Arceuthobium americanum in Ontario.—In 1955, Hord and Quirke (*In* Annu. Rep. Forest Insect and Dis. Surv., Forest Biol. Div., Can. Dep. Agr. p. 56-69, 1955) reported the occurrence of the dwarf mistletoe [*Arceuthobium americanum* Nutt. ex Engelm.] on jack pine [*Pinus banksiana* Lamb.] in northwestern Ontario. However, as reported by Sippel *et al.* (*In* Annu. Rep. Forest Insect and Dis. Surv., Can. Dep. Forest. Rural Develop., Forest, Br. p. 51-75, 1967), subsequent examination of the specimen upon which the record was based [SSMF Herbarium, Can. Dep. Fish. Forest., Sault Ste. Marie, Ont.) 4240, Fig. 1] revealed that the mistletoe associated with jack pine in that instance was *Arceuthobium pusillum* Pk. This was confirmed by Laut (Plant Dis. Reptr. 51:899-900, 1967); and to date the occurrence of *A. americanum* east of Manitoba is unknown.

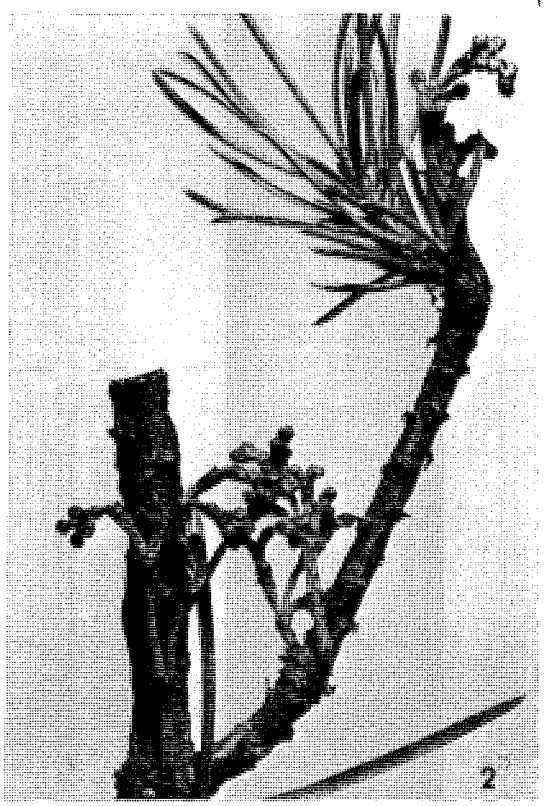


FIGURE 1. *Arceuthobium pusillum* on jack pine (x 2.28).
FIGURE 2. *Arceuthobium americanum* on jack pine (x 2.28).

The purpose of this communication is mainly to report the occurrence of *A. americanum* on jack pine in northwestern Ontario. Specimens (Fig. 2) were submitted to the Insect and Disease Survey Unit, Ontario Region, Canadian Forestry Service, by M. K. Irazawa, District Forester, Ontario Department of Lands and Forests, in early November, 1969, from the Scout Bay area of Lac Seul, north of Dryden. The occurrence is the first authenticated Ontario record (SSMF 695-5008) and constitutes an eastern extension of almost 100 miles in the range of this organism.

The specimens had been taken from a mixed stand of jack pine and black spruce [*Picea mariana* (Mill.) BSP.], approximately 50 to 80 years old. In June, 1970 an evaluation of the disease was made and the area affected is confined to some 800 acres. Tree mortality was lacking but the severe brooming of jack pine was apparently sufficient to discourage cutting since the forests surrounding the damaged stands had been clear cut several years previous.

Dr. J. Kuijt, University of Lethbridge, Alberta, kindly confirmed the identification of *A. americanum*.—M. J. Larsen and H. L. Gross, Forest Research Laboratory, Sault Ste. Marie, Ontario.

SILVICULTURE

Vegetative Propagation of Spruce—*Picea* has long been known as a genus difficult to root from stem cuttings. Differences in rooting capacity due to species were first mentioned in 1939 by Farrar (Forest Chronicle 15: 152-153). Apparently he was familiar with some of Grace's then unpublished work, performed during the early part of 1938, which showed Norway spruce [*Picea abies* (L.) Karst.] to be easier to root from cuttings than black spruce [*Picea mariana* (Mill.) BSP]. Grace's data (Grace and Farrar, Canadian Journal of Research 18C: 401-414, 1940) must be accepted with some reservation, since the trees used in the experiment differed in age and origin: some of the trees were from natural stands while others were from plantations. The present report reveals differences in the rooting ability of cuttings, from seedlings, due to differences in species and length of cuttings.

In late May 1967, 2-2 seedlings of black spruce, Norway spruce, red spruce [*Picea rubens* Sarg.], and white spruce [*Picea glauca* (Moench) Voss] were obtained from a nursery at the Forest Experiment Station, Valcartier, Quebec. Shoot extension had begun in all species except *P. rubens*. The plants were moistened and stored overnight in a cool room. Cuttings 2 and 4 inches in length were made with a straight cut and with needles intact at the base. Each cutting had the terminal and lateral shoots from the last season's growth in the approximate ratio of one terminal to three laterals. The experiment was a 4 x 2 factorial in a completely randomized design. Each of the eight treatments was represented by five blocks of 20 cuttings. The cuttings were placed at random, five blocks per wooden flat (23 x 15 x 4 inches). The rooting medium was perlite and the flats were placed on a greenhouse bench. An overhead intermittent mist system operating 10 seconds every 10 minutes between 8:00 a.m. and 5:00 p.m. provided the cuttings with moisture. The air temperature ranged between a daytime high of 98 F. and a nightime low of 66 F. Pesticides were not used. The cuttings were examined after 7 and 11 weeks in the propagation medium to determine the number rooted and the number of roots per rooted cutting.

An analysis of variance of rooting percentages showed significantly better rooting of the short cuttings (at the 5% level) for *P. glauca* and *P. mariana* after 7 weeks, and for all species after 11 weeks (Table 1). Significant differences due to species were quite evident in the short cuttings with the best rooting in *P. abies* and the worst in *P. rubens*. In the long cutting group, differences between *P. glauca*, *P. mariana* and *P. rubens* were nil, but each of these species was significantly different from *P. abies*. There was a significant species-cutting length interaction.

An analysis of the mean number of roots formed per rooted cutting (Table 1) indicated differences due to cutting length for *P. abies* and *P. mariana* after 7 weeks, and no differences after 11 weeks. Observations for the seventh week showed several variations due to species, but then at the end of 11 weeks both cutting size groups were similar for *P. glauca*, *P. mariana* and *P. rubens*. However, the difference between each of these three species and *P. abies* was significant. A species-cutting length interaction was responsible for the decrease in the number of significant differences with time.

TABLE 1

Percent rooting of stem cuttings of *Picea* and mean number of roots formed per rooted cutting, as affected by cutting length and species, after 7 and 11 weeks in the propagation medium

Cutting length (in.)	Species				
	P. Abies	*P. glauca*	*P. mariana*	*P. rubens*	Mean
		Per cent rooting of cuttings[a]			
		After 7 weeks			
2	63.0c	41.3b	50.9bc	17.2a	43.1
4	56.0c	8.0a	10.0a	10.4a	21.1
Mean	59.5	24.7	30.5	13.8	32.1
		After 11 weeks			
2	99.0e	91.9d	79.3bc	75.0b	86.3
4	86.8cd	51.0a	53.0a	44.2a	58.8
Mean	92.9	71.5	66.2	59.6	72.6
		Mean number of roots formed per rooted cutting[a]			
		After 7 weeks			
2	4.6d	3.7bcd	4.0cd	2.4ab	3.7
4	7.1e	2.5abc	2.5ab	1.6a	3.5
Mean	5.9	3.2	3.3	2.0	3.6
		After 11 weeks			
2	10.2b	5.6a	5.6a	4.2a	6.4
4	8.9b	5.2a	4.5a	4.7a	5.8
Mean	9.6	5.4	5.1	4.5	6.1

[a]At any one date, means followed by different letters are significantly different at the 5% level by Tukey's Multiple Range Test.

Throughout the experiment red spruce was one of the most difficult species to root from cuttings, while Norway spruce was always the easiest. In general, the short cuttings rooted more easily than the long ones; the length of the cuttings did not influence the number of roots formed per rooted cutting.—R. M. Girouard, Forest Research Laboratory, P.O. Box 3800, Quebec 10, Quebec.

Germination Tests on White Spruce and Douglas-fir Seed From Cones Treated With Systemic Insecticides.—In tree seed orchards, damage due to cone and seed insects can be prevented or reduced, by using insecticides with systemic properties (Johnson and Hedlin, Dep. Forest., Forest. Pub. 1168, 1967).

An experiment was conducted in 1968 to determine whether systemic insecticides used in this way might have phytotoxic effects on seeds. Cone-bearing Douglas-fir [*Pseudotsuga menziesii* (Mirb.) Franco] in the Greater Victoria Watershed and white spruce, [*Picea glauca* (Moench) Voss] in the Morice Forest, Houston, B.C., were treated as outlined by Johnson and Hedlin for prevention of damage by insects. The insecticides used were oxydemetonmethyl 1.0% and 0.5% active ingredient by weight in water, dimethoate 1.0% and 0.5% and Bidrin 0.5%. Young cones and foliage of Douglas fir were sprayed in May and white spruce in early June with a compression-type garden sprayer. Each concentration was applied to cone-bearing branches on the upper portion of three trees. Before spraying, one cone-bearing branch on each tree was enclosed in a polyethylene bag to protect

it from spray to provide untreated cones as a control. Mature cones were collected in September, and seed from each tree was extracted separately. Effective translocation of insecticide between treated and untreated branches did not occur in spruce because 50% of the cones examined from untreated branches were infested by insects; cones from treated branches were uninfested. It has also been demonstrated that effective translocation of systemic insecticides does not occur from treated to untreated branches in Douglas fir (Johnson and Zingg, J. Econ. Entomol. 60:575-8, 1967). Seed was stored at 40F for 3 months, then stratified on moist filter paper in Petri dishes at 35F for 3 weeks. After stratification, seeds were rinsed in 70% ethyl alcohol, treated with 0.1% mercuric chloride, as a fungicide, for 3 minutes and rinsed in three consecutive baths of sterile distilled water. Germination was carried out in a growth chamber at 77F, and seeds were examined daily. When radicle length equalled seed length, seeds were recorded as healthy germinants. There were a few abnormalities in seeds from both treated and untreated trees, and most occurred when the radicle was apparently unable to penetrate the outer covering of the endosperm. Germination tests were conducted on seed from individual trees and data were combined.

TABLE I
Germination of white spruce and Douglas-fir seed from cones treated with systemic insecticides (avg of two or three trees)

No. Trees	Treatment	Treated		Not treated	
		Filled Seed[a]	% Germinated	Filled Seed[a]	% Germinated
	white spruce				
2[b]	Dimethoate (1%)	92	81	80	27
2[b]	Dimethoate (0.5%)	108	46	158	1
3	Oxydemetonmethyl (1.0%)	184	37	212	43
3	Oxydemetonmethyl (0.5%)	210	12	221	12
3	Bidrin (0.5%)	194	14	189	31
	douglas-fir				
3	Dimethoate (1.0%)	230	90	241	84
3	Oxydemetonmethyl (1.0%)	230	87	249	76
2[b]	Bidrin (0.5%)	136	93	127	92

[a] Total seed tested.
[b] Insufficient seed from third tree for testing.

Table 1 shows that germination was variable. However, there is no evidence of phytotoxicity to seeds from cones treated with these systemic insecticides.—D. S. Ruth and A. F. Hedlin, Forest Research Laboratory, Victoria, B.C.

Temperature gradients in duff and soil during prescribed fires.—During a prescribed burning experiment in 80-year-old red and white pine (Van Wagner, Dep. Forest. Pub. 1020, 1965), temperatures below the duff surface were measured on several plots with temperature-sensitive paints (Templac). Strips of paint for eight temperatures ranging from 175 to 450 F were applied to thin sheets of mica; these were inserted into the ground with paint strips oriented vertically and upper edge flush with the duff surface. The fires were relatively gentle, burning with flames 1 to 4 ft. high and intensities of 40 to 200 BTU/sec-ft.

The results were difficult to interpret and quite variable, mainly due to the intricate small-scale pattern of smoldering after the fire passed. Of 384 strips on 48 mica indicators, only 167 were usable. From these data the average depth to which each temperature penetrated was calculated separately for areas where mineral soil was bared and areas where some duff remained. Figure 1 shows the results as depth versus temperature to convey the impression of a profile. Zero depth is mineral soil surface and duff surface respectively for the two kinds of area. No usable values were obtained for the 450F temperature in mineral soil.

In spite of the difficulty of interpretation, it is fairly clear that each curve can be taken as a straight line and average temperature gradients calculated. These are: for bared mineral soil 45F per 0.1 inch, and for duff 125F per 0.1 inch. These values imply that duff is about three times as good an insulator as mineral soil, and that very little temperature rise occurs within mineral soil when 0.5 inch or more of duff remains unburned. During these fires the moisture content of the duff layer varied from 30 to 60%, a fairly dry condition. The temperature gradient would be even steeper at higher moisture content, owing to the latent heat required to evaporate the moisture as the 212F wave proceeds downwards. Temperatures in bared mineral soil may of course be much higher in intense forest fires.—C. E. Van Wagner, Petawawa Forest Experiment Station, Chalk River, Ont.

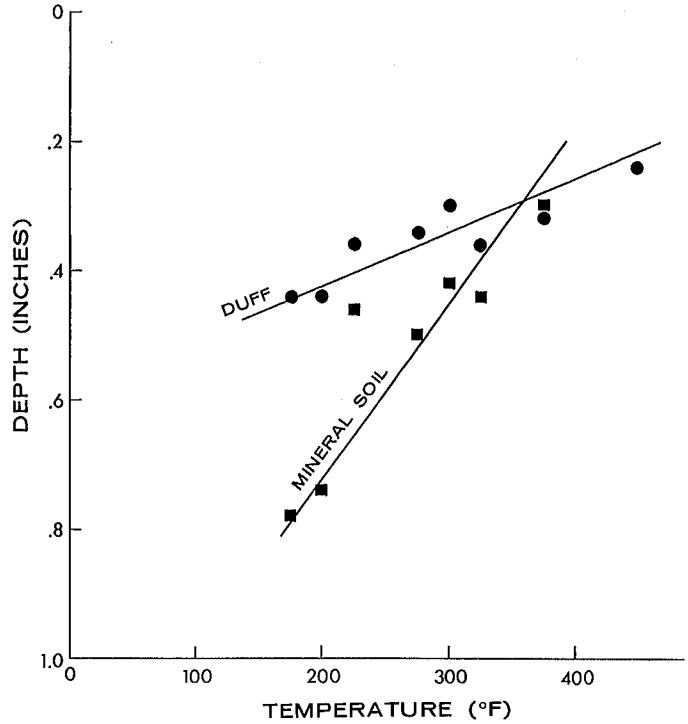


FIGURE 1. Average depth of penetration for eight temperatures in bared mineral soil and duff during prescribed fire.

SOILS

Nitrogen losses by volatilization from urea applied to forest soils.—All nitrogen in fertilizers is not taken up by plants; some is consumed by soil microorganisms; some is fixed by the soil; some is lost by run-off and leaching; and some is lost to the atmosphere by volatilization. Research has shown that the recovery of nitrogen from urea when applied to agricultural soils is often less than that from other nitrogenous fertilizers (Gasser, Soils Fert. 27:175-180, 1964). This lower recovery has been partly attributed to the formation of large amounts of volatile ammonia during urea hydrolysis.

Urea is an important forest fertilizer and is being used extensively in the forest fertilization research program being developed in Newfoundland. However, little is yet known about the fate of the nitrogen formed from this fertilizer when applied to forest soils; as part of that work a study was started in 1968 to determine whether there might be a significant nitrogen loss to the atmosphere. This report summarizes the results.

Surface soil samples, including the organic horizons, were collected from a number of locations in a balsam fir (*Abies balsamea* (L.) Mill.) stand near Deer Lake, a black spruce (*Picea mariana* (Mill.) B.S.P.) stand near Badger, a white birch stand near Grand Falls and a black spruce stand near Gambo. Soil textures varied from loam at Grand Falls to sandy loam at Deer Lake and Badger and to loamy sand at Gambo. Cation exchange capacity was greatest for Grand Falls (16.07 meq/100 g), intermediate at Deer Lake and Badger (9.82 and 8.93 meq/100 g) and least for Gambo (6.25 meq/100 g). Carbon-nitrogen ratio for Grand Falls was 14.3, for Gambo 16.3, for Deer Lake 18.7 and for Badger 19.4.

Samples from each of the four stands were air-dried, mixed and passed through a 2 mm sieve. Four-hundred-gram lots (oven-dry basis) were placed in eight amber bottles. Urea in aqueous solution was thoroughly mixed with the soil in four of the bottles. Rate of application was equivalent to 600 lb. of nitrogen per acre. The other four samples served as controls. Enough distilled water was added to each bottle to bring the samples to field capacity. Bot-

tles were attached to an aspirator and water saturated air was passed over each sample. Exhaust air and gases were passed through individual flasks containing a 4% boric acid solution and a few drops of mixed indicator to absorb ammonia. Air flow was maintained at approximately 10 ml per minute and temperature was maintained at 70°F throughout the experiment. At 14-day intervals the boric acid solution in each flask was titrated against a standard acid to determine the amount of nitrogen present.

Prior to treatment pH values varied from 4.5 to 5.1. After 84 days the pH of all samples had increased probably because of the hydrolysis of urea to ammonia. The increase was greater in the treated samples (0.4 to 0.5 of a unit) than the untreated samples (0.1 to 0.2 of a unit). Differences were significant at $P = 0.001$ (t-test). These results are similar to those obtained by other workers (e.g. Roberge and Knowles, Soil Sci. Soc. Amer. Proc. 30:201-204, 1966; Overrein and Moe, Soil Sci. Soc. Amer. Proc. 31:57-61, 1967).

The loss of nitrogen by volatilization from all treated and untreated samples was small (Table 1). For the Grand Falls and Gambo samples, losses were greater from the treated samples than from the controls (significant at $P = 0.05$, t-test); the reverse was true for the Deer Lake and Badger samples (significant at $P = 0.02$, t-test). The greater nitrogen loss from the controls of the two latter areas may be attributed to the higher organic matter contents and C/N ratios. When urea is added to soils with high organic matter content much of the nitrogen may become fixed in the form of stable organic complexes.

Mahendrappa et al. (unpublished report) reported losses of nitrogen by volatilization of between 15 and 35% when urea was applied to the surface of 3-inch-thick sods of sphagnum and feather moss in the laboratory. However, final pH values of the moss samples were, in most cases, between 6.0 and 9.0; greater nitrogen losses through volatilization are to be expected under alkaline conditions. Under field conditions Overrein (Soil Sci. 106 (4):280-290, 1968) recorded losses of nitrogen to the atmosphere of up to 3.5% when urea nitrogen was applied at the rate of 446 lb. per acre to the surface of an acid forest soil. These latter figures are a little higher than those obtained from this study under laboratory conditions, but in both cases the actual losses were small. Further work is necessary to determine whether nitrogen losses are similar under field conditions and in the laboratory. If losses are similar, then it does not appear that a serious loss of nitrogen will occur through volatilization when urea fertilizer is applied to acid forest soils in Newfoundland.—N. D. Bhure, Forest Research Laboratory, St. John's, Nfld.

TABLE 1
Loss of nitrogen by volatilization from urea applied to forest soils after different times of incubation

	Nitrogen lost (pounds per acre)						
	Days of incubation						Total N loss after 84 days
Treatment	14	28	42	56	70	84	
Deer Lake—balsam fir site							
Control	0.95	0.41	0.40	0.22	0.17	0.17	2.32
Urea	0.17	0.17	0.15	0.08	0.07	0.06	0.70
Badger—black spruce site							
Control	0.24	0.15	0.13	0.11	0.11	0.10	0.84
Urea	0.22	0.14	0.08	0.10	0.07	0.08	0.69
Grand Falls—white birch site							
Control	0.32	0.29	0.31	0.18	0.15	0.18	1.48
Urea	0.34	0.30	0.33	0.27	0.21	0.21	1.65
Gambo—black spruce site							
Control	0.19	0.08	0.09	0.11	0.10	0.08	0.65
Urea	0.42	0.19	0.13	0.16	0.15	0.15	1.20

(*Continued from back cover*)

McGuffin, W. C. 1970. The immature stages of *Scopula ancellata* (Hulst) (Geometridae). J. Lepidopterists' Soc. 24(1):54-55.

McLeod, J. M. 1970. The epidemiology of the Swaine jack-pine sawfly, *Neodiprion swainei* Midd. Forest. Chron. 46(2).

Mitchell, Kenneth J. 1969. Simulation of the growth of even-aged stands of white spruce. Yale Univ. Sch. Forest. Bul. No. 75. Yale University, New Haven. 48 p.

Nigam, P. C. 1970. Toxicity of insecticides against sawfly larvae. 1. Contact toxicity of organophosphates and carbamates to *Neodiprion pratti banksianae, N. swainei* and *Pristiphora erichsonni*. J. Econ. Entomol. 63:620-624.

Outram, I. 1970. Morphology and history of the reproductive system of the male spruce budworm, *Choristoneura fumiferana*. Can. Entomol. 102:404-414.

Parker, A. K. 1970. Growth of *Wallrothiella arceuthobii* on artificial media. Can. J. Bot. 48:837-838.

Parmelee, J. A. and Y. Hiratsuka. 1970. *Phaeoseptoria contortae* sp. nov. on *Pinus contorta* from Alberta. Can. J. Bot. 48:1002-1004.

Price, Peter W. 1970. A loosestrife sawfly, *Monostegia abdominalis* (Hymenoptera: Tenthredinidae). Can. Entomol. 102:491-495.

Retnakaran, Arthur. 1970. The male reproductive system of the spruce budworm, *Choristoneura fumiferana* (Lepidoptera: Tortricidae). I. Spermatogenesis. Ann. Entomol. Soc. Amer. 63:851-859.

Retnakaran, Arthur and Dail Grisdale. 1970. The ovicidal effect of hydrochlorination reaction mixture on the spruce budworm, *Choristoneura fumiferana* (Lepidoptera: Tortricidae). Ann. Entomol. Soc. Amer. 63:907-909.

Richards, W. C. 1970. Disruption of cytoplasmic-polyhedrosis virus by ethanol. J. Invertebr. Pathol. 15:457-458.

Roche, Laurence. 1970. The silvicultural significance of geographic variation in the white Englemann spruce complex in British Columbia. Forest. Chron. 46(2).

Ross, D. A. and D. D. Pothecary. 1970. Notes on adults, eggs, and first-instar larvae of *Priacma serrata* (Coleoptera: Cupedidae). Can. Entomol. 102:346-348.

Salamon, M. 1970. More kiln capacity. B.C. Lumberman: (February).

Shields, J. K. 1970. Brown-stain development in stored chips of spruce and balsam fir. Tappi 53:455-457.

Shields, J. K. 1969. Microflora of eastern Canadian wood chip piles. Mycologia LXI:1165-1168.

Smirnoff, W. A. and J. R. Valero. 1970. Comportement de la larvae saine ou virosée de *Neodiprion swainei* en atmosphère d'oxygène d'anhydride carbonique, d'azote ou d'argon. Natur. Can. 97:67-71.

Stiell, W. M. 1970. Thinning 35-year-old white spruce plantations from below; 10-year results. Dep. Fish. Forest., Can. Forest. Serv. Pub. 1258. 16 p.

Sutton, B. C. and T. Kabayashi. 1969. *Strasseriopsis* gen. nov. based on *Phellostroma tsugae*. Mycologia LXI:1066-1071.

Thomas, J. B. and Donald E. Bright. 1970. A new species of *Dendroctonus* (Coleoptera:Scolytidae) from Mexico. Can. Entomol. 102:479-483.

Turner, J. A. 1970. Hours of sunshine and fire season severity over the Vancouver forest district. Forest. Chron. 46(2).

Underwood, G. R. 1970. An infestation of *Neodiprion virginianus* complex (Hymenoptera:Diprionidae) in northeastern New Brunswick. Can. Entomol. 102:471-473.

Von Althen, F. W. 1970. Methods for successful afforestation of a weed infested clay soil. Forest. Chron. 46(2).

Wilton, W. C. 1970. Plowing trials for afforestation in Newfoundland. Forest. Chron. 46(2).

Yule, W. N. 1970. DDT residues in forest soils. Bul. Environ. Contamin. Toxicol. 5(2):139-144.

Recent Publications

Agnihotri, V. P. and O. Vaartaja. 1970. Effect of seed exudates of *Pinus resinosa* on the germination of sporangia and on the population of *Pythium irregulare* in the soil. Plant Soil (The Hague) 32:246-249.

Bachelor, F. W., A. A. Loman and L. R. Snowdon. 1970. Synthesis of pinosylvin and related heartwood stilbenes. Can. J. Chem. 48:1554-1557.

Bender, F., D. P. Heaney and A. Bowder. 1970. Potential of steamed wood as a feed for ruminants. Forest Prod. J. 20(4):36-41.

Brace, L. G. 1970. A radical tree-locator for use in a computer mapping system. Dep. Fish. Forest., Can. Forest. Serv. Pub. 1269. 12 p.

Bramhall, G. 1970. Moisture distribution illustrated by contour chart. Forest Prod. J. 20(4):50.

Brown, C. E. 1970. A cartographic representation of spruce budworm, *Choristoneura fumiferana* (Clem.) infestations in eastern Canada, 1909-1966. Dep. Fish. Forest., Can. Forest. Serv. Pub. 1263, 4 p. (English and French text).

Carlisle, A. and A. H. Teich. 1970. The Hardy-Weinberg law used to study inheritance of male inflorescence color in a natural Scots pine population. Can. J. Bot. 48:997-998.

Cserjesi, A. J. and J. W. Roff. 1970. Accelerated laboratory test for evaluating the toxicity of fungicides for lumber. Mater. Res. Stand. 10(3):18-20.

Etheridge, D. E. 1970. *Ascocoryne sarcoides* (Jacq. ex. Gray) Groves and Wilson and its association with decay of conifers. *In* Bul. No. 13: interaction of organisms in the process of decay of forest trees. L'Université Laval, Quebec, P.Q.

Fowler, D. P. 1970. Maternal effects in red pines, *Pinus resinosa* Ait., and their implications to provenance and progeny testing. *In* Proc. Int. Union Forest Res. Organ., Sec. 22, Working Group Meeting. Varparanta, Finland. 11 p.

Fowler, D. P. and D. T. Lester. 1970. The genetics of red pine. U.S. Dep. Agri., Forest Serv. Res. Pap. WO-8. 13 p.

Hatton, J. V. 1970. Precise studies on the effect of outside chip storage on fiber yield: white spruce and lodgepole pine. Tappi 53:627-638.

Jaegar, T. A. 1970. Increment borer damage and its control: A review of the literature. Dep. Fish. Forest., Can. Forest. Serv. Pub. 1270. 18 p.

Kayll, A. J. 1968. Heat tolerance of tree seedlings. *In* Proc. Annu. Tall Timbers Fire Ecol. March 14-15. pp. 89-105.

Larsen, Michael J. 1970. On species, subspecies, varieties, and forms of *Tomentella* named and described by Bourdot and Galzin I. Mycologia LXII:133-151.

Lavallée, André. Observations on inoculations of hardwood species with *Pholiota aurivella* (Batsch ex. Fr.) Kummer. *In* Bul. No. 13: interaction of organisms in the process of decay of forest trees. L'Université Laval, Quebec, P.Q.

Loman, A. A. 1970. The effect of heartwood fungi of lodgepole pine on its phenolic heartwood extractives. *In* Bul. No. 33: interaction of organisms in the process of decay of forest trees. L'Université Laval, Quebec, P.Q.

MacLeod, Donald M. and Müller-Közler, Erwin. 1970. Insect pathogens: species originally described from their resting spores mostly as *Tarichium* species (Entomophthorales: Entomophthoraceae). Mycologia LXII:33-66.

(*Continued on page 43*)

BI-MONTHLY

RESEARCH NOTES

IN THIS ISSUE:

Vol. 26—No. 5, SEPTEMBER-OCTOBER, 1970

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 Canadian Forestry Service, Department of Fisheries and Forestry

ENTOMOLOGY

Extended life cycle of Douglas-fir beetle in interior British Columbia.—The Douglas-fir beetle overwinters predominantly in the young adult stage, although varying numbers of larvae are usually present. Generally, the life cycle lasts 1 year, each brood spending only one winter in its original host material (Bedard, U.S. Dep. Agr. Circ. 817, 1950; Walters, Can. Dep. Agr., Forest. Biol. Div. Publ. 975, 1956). Variations in the numbers of larvae overwintering may be attributed to weather conditions during development and the time parents attack (McMullen and Atkins, Can. Ent. 94:1309-1325, 1962). Delay in establishment or development could result in brood overwintering a second time, extending the cycle to 2 years. Although such a possibility has been recognized (Chamberlin, OSC Monographs Studies in Ent. 2, OSC Press, Corvallis, Oregon, 1958; Keen, U.S. Dep. Agr. Misc. Publ. 273, 1952), Furniss (J. Econ. Ent. 58:440-442, 1965) first provided specific evidence of this behavior in southern Utah.

Two similar instances of an extended life cycle in the interior of British Columbia are reported here. In August 1963, at Lac la Hache, two trees attacked the previous year still contained young adults. The following April, only 42% of 122 adults were still alive in 11.8 sq ft of bark. Nearby, 89.5% of 2846 normal 1-year brood beetles survived in 120 sq ft of bark. In April 1965, near 100 Mile House, brood established in 1964 comprised only second-and third-instar larvae. Although the majority of the larvae transformed to adults by July 1965, they did not emerge until the following year, 1966.

Furniss attributed the occurrence of an extended life cycle to weather effects on brood development and flight. Weather, as indicated by temperature (Table 1), was the most likely causal factor in the cases reported here. Temperatures at the 100 Mile House site, 20 miles south and at a similar elevation, would not be expected to differ significantly.

TABLE 1

Average Monthly Mean Temperatures and Deviation (°F), 1962 to 1965, Lac la Hache, B.C.

Month	Avg Monthly Mean	Departure From Avg Monthly Mean			
		1962	1963	1964	1965
May	47.3	−1.3	2.0	−2.1	1.3
June	55.4	−1.0	0.5	0.2	0.2
July	60.1	−1.4	−1.0	0.6	1.9
August	59.5	−2.4	2.5	−2.5	1.3

In 1962 and 1964, years in which the broods with the retarded development were established, May temperatures were low and flight requirements (about 65F) occurred on 3 days in 1962 and on 2 days prior to 26 May 1964. Attack would be late in these years, and larval would develop slowly due to low temperatures during July and August. The young adults present in July and August of the year following brood establishment did not emerge at that time, although temperatures were suitable for flight. Some requirement, perhaps cold rest or diapause (Ryan, Can. Ent. 91:520-525, 1959) was not satisfied.

Before emergence in both 1964 and 1966, four 2-ft sections from trees containing adults of the 2-year brood and four similar sections from trees containing adults of normal 1-year brood were caged individually with 2.5-ft sections of freshly felled Douglas-fir. The freshly felled sections were examined in June for number of attacks, gallery length, number of eggs and presence of parents (Table 2). Two of the 1964 cages containing 1-year brood material were damaged and are not included in the summary.

TABLE 2

Comparison of the activity of two types of Douglas-fir beetle populations on caged Douglas-fir bolts

Type of Development	Surface Area Examined (sq ft)	Galleries			Eggs	
		Number	Percent with live parents	Avg length (in.)	Per gallery	Per inch of gallery
Dates	cage 24/4/64	examined 15/6/64				
Development						
Normal	14.3	77	87.5	3.1	9.5	3.1
Extended	23.7	72	90.9	3.6	19.7	5.5
Dates	cage 10/4/66	examined 6/6/64				
Development						
Normal	25.7	175	78.9	4.5	16.1	3.7
Extended	25.6	57	86.4	4.2	17.7	4.0

The beetles which had undergone extended development were as productive as those from the normal brood. The apparent greater productivity of the former in the 1964 experiment may be due to earlier emergence allowing more gallery construction and oviposition prior to examination. The beetles of the 2-year brood would have been ready to emerge at the first opportunity, whereas those of the 1-year brood may have been delayed. Gallery construction and oviposition was not completed at the time of examination, as living adults were present. Nevertheless, the 2-year-brood beetles were capable of emergence, attack, gallery construction and oviposition.

Extension of the life cycle to 2 years would tend to reduce populations through increased preemergent mortality, such as occurred in southern Utah. Since surviving beetles established galleries, they could maintain a population, at least in fresh slash or windfall. Although such extreme extension of brood development has seldom been recorded, these data, along with that of Furniss, indicate it may not be uncommon.—L. H. McMullen, Forest Research Laboratory, Victoria, B.C.

Pretreatment of spruce budworm eggs for counting.— Decisions on whether to apply controls for spruce budworm [*Choristoneura fumiferana* Clemens] are made largely on the basis of egg-mass surveys. Periodically the number of eggs per mass is checked and the proportion of parasitized eggs is determined. Also, in laboratory experiments, eggs must frequently be counted and fertility and fecundity determined.

Spruce budworm eggs are laid in masses on the needles of the host, in Eastern Canada usually balsam fir [*Abies balsamea* (L.) Mill.]. Masses typically consist of 20 eggs in three overlapping rows in which the eggs are approximately lenticular. Counting the eggs is difficult whether they are hatched or not, and almost impossible if the masses are two-layered or desiccated. Pretreatment by the staining method of Jennings and Addy (J. Econ. Entomol. 61:1766, 1969) gives excellent results with hatched masses, but is not satisfactory with unhatched masses.

Before counting eggs in unhatched masses we poach them in water over a double boiler for about 3 min. The masses fall off the needles and swell so that each egg becomes oval, like a rugby ball (Fig. 1). The eggs can be counted easily, even in two-layered masses, because they are forced apart but do not separate. Desiccated and shrivelled masses are easier to treat than fresh ones because the poaching time is less, about 2 min., and the results are as good. It is thus possible to postpone egg counts.

Hatched eggs cannot be counted in poached masses because the chorions become flaccid and formless. In masses with both hatched and unhatched eggs, hatched eggs may be counted first

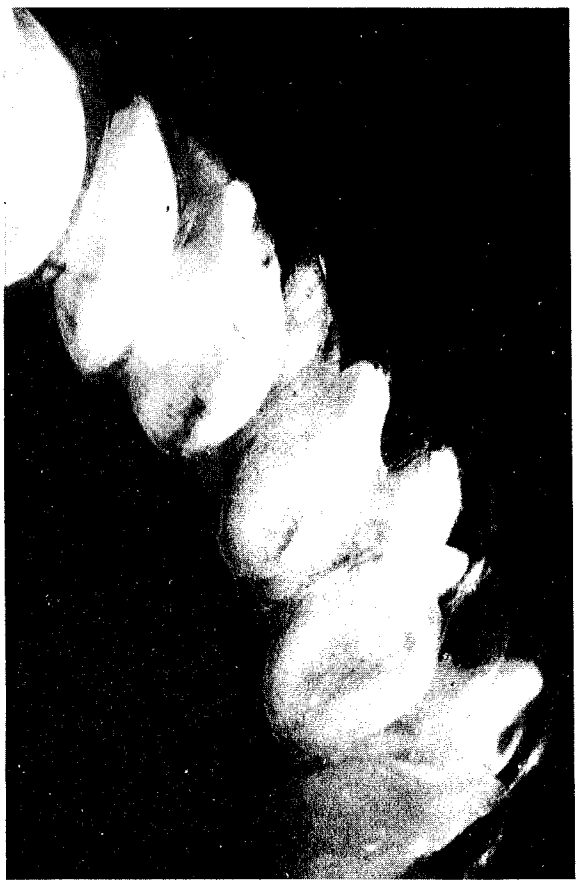


FIGURE 1. Desiccated spruce budworn eggs after poaching.

by the staining method, after which the masses may be poached and the unhatched eggs counted—D. C. Eidt and Margaret D. Cameron, Forest Research Laboratory, Fredericton N.B.

Lindane as a control for *Ips pini* (Say) in red pine plantation. —Thinnings of pine plantations in Ontario are conducted throughout the year, particularly in southern Ontario. Piles of unbarked pulpwood that are frequently left on the site during part of the summer provides extra breeding material for potentially injurious bark beetles. The most notable of these, *Ips pini* (Say), has been known to kill living trees under stress from drought, nutrient deficiency, etc. Barking or removing the wood lessens the risk of abnormally high beetle populations. Harvesting methods that reduce the size of the tops would further reduce the beetle population, although such measures are unlikely to be economical at the present time. If wood must be left unbarked in the plantation, chemical control of the beetles may be advisable to reduce the threat to the remaining stand.

BHC (benzene hexachloride) and its refined gamma isomer (lindane) have been used effectively in bark beetle control. Becker (J. Econ. Entomol. 48:163-167, 1955) obtained 87-100% protection of cordwood-sized pine logs in Massachusetts by using a 0.4% gamma isomer spray in water, and almost as good protection with a 0.2% spray. The following year Becker et al. (J. Econ. Entomol. 49:664-666,1956) repeated the tests on pine sawlogs with 0.4, 0.2, and 0.1% gamma isomer sprays and obtained 98-100, 87-100, and 85-99% protection, respectively. Stark and Borden (J. Econ. Entomol. 58:994-996, 1965) used a 3.1% concentration of lindane in water to determine the effect against *Ips confusus* (Lec.) already in ponderosa [*Pinus ponderosa* Laws.] and sugar pine [*P. lambertiana* Dougl.] logs. Treatment was applied before attack, 2 days and 2 weeks following attacks, and 2 weeks before emergence of the brood adults. Uninfested logs were completely protected for at least 53 days, development of an active attack was inhibited, and the number of adults emerging from previously infested logs was decreased. Lyon and Swain (U.S. Forest Serv. Res. Note PSW-176, 1968) conducted further tests of lindane at 1.5 and 1.0% concentration in oil against *Dendroctonus brevicomis* Lec. overwintering in ponderosa pine. Logs were sprayed in November, December, January, and February before normal emergence in April. Mortality of the brood averaged 94.8 and 83.6% at concentrations of 1.5 and 1.0%, respectively.

Thinning operations begun in 1968 in red pine [*P. resinosa* Ait.] plantations on the Kirkwood Management Unit, 60 miles east of Sault Ste. Marie, presented an opportunity to test the effectiveness of lindane against *I. pini*. Bolts 24-36 inches long and 3-5 inches in diameter were cut from tops left after a 40-year-old red pine stand had been thinned during the fall and winter of 1968-69. The first sprays were applied before any bark beetle attack, others at intervals after the beetles emerged from hibernation. A 0.5% water solution of lindane was prepared from a 20% emulsifiable concentrate, and applied to the run-off point on all surfaces with a hand-operated pressure sprayer. Unsprayed control bolts were cut from the slash at each test period.

The first test was to determine the effectiveness of lindane in preventing attack. Ten treated and 10 control bolts were supported a few inches off the ground on two hardwood logs and covered lightly by slash to prevent excessive heating and desiccation. The bolts were sprayed on May 15, approximately 1 week before the beetles emerged from overwintering sites, and were left in the plantation until September 3 when they were barked. The insecticide prevented all but four attacks compared with 103 in the control bolts (Table 1). Three of the four attacks on the treated bolts were entrance holes only. The fourth had a short gallery with one dead parent beetle and two living callow adults. There were no exit holes. Attacks on the control bolts had continued until July 3, and many living adults were under the bark on September 3 in addition to a large number of exit holes.

TABLE 1
Effect of lindane applied prior to attack by bark beetles

Date	Treatment	No. of bolts	Area of bark ft²	No. of attacks		Adult emergence
				Total	Per ft²	
15-5	0.5%	10	23.1	4	0.2	0
15-5	0 (control)	10	24.1	103	4.3	numerous

The second objective was to determine if effective control could be obtained after attack as reported by Stark and Borden (*ibid.*), and Lyon and Swain (*ibid.*) for other species of bark beetles in California. Regular examination of the slash revealed the following seasonal history. Overwintering adults began emerging on May 22 and egg galleries several inches long with some eggs hatched were common by June 4. The first brood was in the larval stage, and parent beetles were emerging and reattacking the slash by June 17. Most of the first brood was in the late larval, prepupal, and pupal stages with a few callow adults by July 3. Second brood attacks by the original parent beetles were in the egg and larval stages. By July 24, the majority of the first brood had reached the young adult stage, but very little emergence had occurred.

Bolts were cut and treated on June 4 and 17, July 3 and 24. The treated bolts and controls cut at the same periods were placed in individual screened cages outside the laboratory in Sault Ste. Marie to permit more frequent observations. Before emergence of the first brood adults was due, the bolts were transferred to sealed cartons in the laboratory, and collecting vials were fastened to the cartons.

Periodic examinations of the sprayed bolts during the summer and the final barking of all bolts in September revealed the effectiveness of lindane. Within 1 hour of spray being applied on June 4 and 17, some of the parent beetles emerged and fell to the bottom of the cage where they crawled about for a time and died. Lindane apparently penetrates the thin bark of red pine rapidly because development in most cases did not proceed

beyond that at the time of spraying. Parent beetles died in uncompleted galleries; hatching took place, but the larvae died without mining away from the egg niches. Dissection of a number of these larvae indicated, however, that they had ingested some food. All stages of the beetles in the sample of July 24 were dead under the bark. Most of the callow adults were still in the pupal cells; very few had begun feeding beyond these areas. No boring dust accumulated around the bolts as it did around the controls, a further indication that the adults died quickly. A few adults had emerged and died in the bottom of the cartons, but no beetles came to the collecting vials in contrast to the hundreds that emerged from the cartons housing control bolts.

Lindane at 0.5% concentration in water reduced the number of beetles expected to emerge by 98-99% under the experimental conditions (Table 2).

TABLE 2
Effects of lindane applied after attack by bark beetles

Date	Treatment	No. of bolts	No. of attacks per ft²	Actual emergence per ft²	Expected emergence per ft²	% control achieved
4-6	0.5%	9	12.3	0.8	225.7*	99.6**
17-6	0.5%	9	8.3	2.6	152.3	98.3
3-7	0.5%	7	8.9	3.3	163.3	98.0
24-7	0.5%	4	9.3	0.7	170.6	99.6
	Control	5	10.4	190.8	—	—

*Calculated on the basis that emergence would have equalled that of controls if no treatment was made.

$$\frac{225.7 - 0.8}{225.7} \times 100 = 99.6\%$$

Mortality might not be so high in piles of pulpwood or sawlogs because complete coverage of the bark surface could not be achieved. Nevertheless, a significant reduction in population is possible. Of major importance is the extended period during which effective control measures can be taken, and an accurate emergence date for *I. pini* is no longer necessary in order to get the spray on before attack in the spring. Development of the beetle during the season can be checked easily; this affords much more flexibility in integrating chemical control, if indicated, with other operational schedules.—J. B. Thomas, Forest Research Laboratory, Sault Ste. Marie, Ont.

FOREST PATHOLOGY

Storing of agar slants and cultures.—In fungal studies there is often a need to store agar slants and cultures for varying lengths of time. Since evaporation of water from the media is inevitable, especially at room temperature (RT), a means of slowing the action is desirable.

In 1965, we began using plastic foam plugs (diSPo plugs—T.M. S/P, div. AHSC purchased from Canlab; or Identi-Plugs from Fisher Scientific) for slants in the Victoria Laboratory. Then, on a trial basis, plexiglas (an acrylic polymer purchased commercially under this name) containers were fabricated to accomodate slants (Fig. 1). Slants with foam plugs were put into the plexiglas containers; the containers were stacked on top of each other in convenient handling heights and the stacks inserted into large plastic bags. They were stored at 5C until required, or at RT (avg 25 C) after the slants were inoculated.

During the 3-week period usually allowed for cultures to become established, no visible contamination was observed on the plugs or containers. There was no sour-musty "contamination" odor, a major complaint with the previous method, and dehydration of the agar was minimal. The combination of foam plugs, plexiglas trays and poly bags is now used routinely.

The advantages of storing cultures in this way are: 1. No apparent harm to the inoculated cultures. 2. No contamination of plugs or containers. 3. Minimal dehydration of agar. 4. Simplified storage and handling. 5. Easier control of mites. 6. Trays may be labelled with grease pencils or felt pens.

The minimizing of contamination in the containers is the most important advantage of the procedure, and additional precautions may be taken to ensure this result. Any agar spilled on the outside of the tubes should be wiped off before insertion into plastic bags. Prolific growers (e.g. *Polyporus versicolor*, *Poria cocos*) in this enclosed atmosphere grow along the tube and

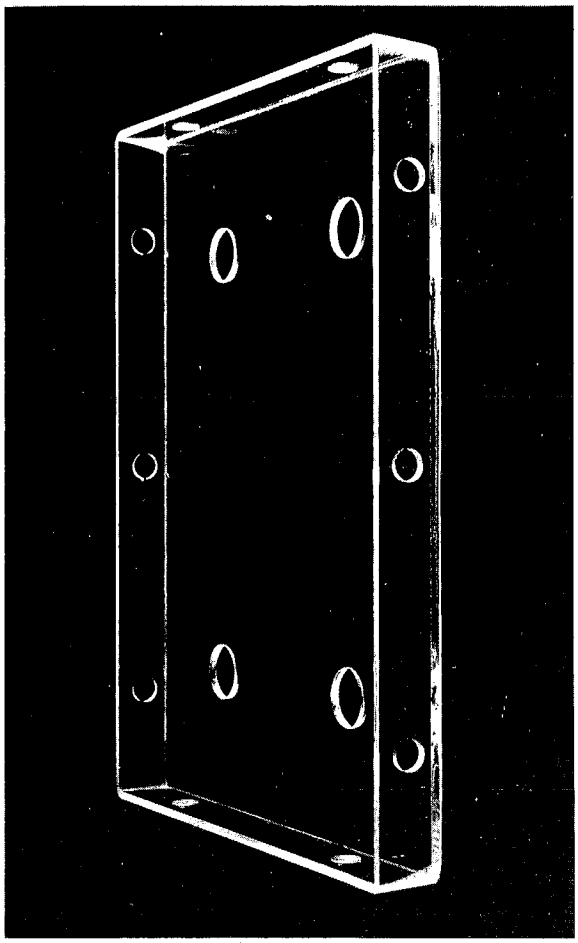


FIGURE 1. 9⅞"L x 7⅜"W x ⅞"D o.d., ⅛"-thick plexiglas trays to accommodate 16 x 125 and 16 x 150 mm tubes.

eat into the foam plugs. Storing cultures at a lower temperature minimizes this action. Inoculated slants left at RT should be examined about once a month. Agar slants should be stored away from drafts at about 5 C. Any contamination that appears can be safely wiped off with an alcohol-soaked cloth as long as the plugs in the cultures are intact. The insertion of paper labels in the plastic bags should be avoided as paper sometimes harbors and encourages the growth of contaminants.—D. Chu, Forest Research Laboratory, Victoria, B.C.

Frost heaving of forest nursery seedlings damaged by the nematode *Xiphinema bakeri*.—Frost heaving (Schram, Proc. Am. Phil. Soc. 102 (4):333-350, 1958) frequently causes considerable loss of forest nursery seedlings. It usually occurs in late winter and spring preceding the second growing season. The amount of damage depends primarily upon the nature of the frosts, soil characteristics, and seedling size at the end of the first growing season. Any factor that reduces the seedling size, especially the root system size, should increase frost heaving losss. This spring, I had the opportunity to determine the effect of nematode damage caused by *Xiphinema bakeri*, on the severity of frost heaving of seedling of the coastal and interior forms of Douglas-fir [*Pseudotsuga menziesii* (Mirb.) Franco], Sitka [*Picea sitchensis* (Bong.) Carr.], white spruce [*P. glauca* (Moench) Voss] and western hemlock [*Tsuga heterophylla* (Raf.) Sarg.] in plots established to study the effect of the various seedlings on the development of *X. bakeri* populations.

Xiphinema bakeri infested soil (sandy loam) from the Green Timbers nursery was thoroughly mixed and placed in wooden seedbed frames at Victoria. Each treatment (tree species) was

replicated three times in a completely random design, each replicate occupying half (8 ft x 3 ft x 18 inches) a seedbed. Seeds were sown in May 1969 in drills 5 inches apart, and all seedbeds received partial shade. Seedling growth had been below optimum because of high nematode populations and low soil fertility. On 4 March and 7 April 1970, partially and completely heaved seedlings were collected, counted, and the nematode damage on each seedling rated as none (healthy), moderate, or severe. Criteria used included foliage discoloration, presence or absence of old lateral roots, and development of new laterals, e.g., severely damaged seedlings had distinct foliage discoloration (chlorosis or purpling), few or no lateral roots and new laterals. On 7 April, the seedling which had not heaved were rated according to shoot size and foliage discoloration as either damaged (none were severely damaged) or healthy. Because the damage ratings were broad and the symptoms distinct, no difficulty occurred in rating seedlings.

Although 21% of the 451 coastal form and 29% of the 438 interior form of Douglas-fir showed evidence of *X. bakeri* damage, none of the seedlings heaved, probably because the severely damaged fir had fairly large root systems. White and Sitka spruce and western hemlock heaved severely and more than 95% of the heaved seedlings showed moderate to severe nematode damage (Table 1). Numerous non-heaved seedlings exhibiting

TABLE 1

Relationship between *Xiphinema bakeri* damage and seedling frost heaving

Tree species[a]	Numbers and percentages of heaved and non-heaved seedling and disease ratings									
	Heaved seedlings						Non-heaved seedlings[b]			
	Healthy		Moderate damage		Severe damage		Healthy		Moderate damage	
	No.	%	No.	%	No.	%	No.	%	No.	%
White spruce	16	6	129	46	137	49	488	66	253	34
Sitka spruce	8	2	134	39	201	59	413	55	341	45
Western hemlock	5	1	138	35	251	64	377	58	269	42

[a]No Douglas-fir were frost heaved.
[b]None of the seedlings were severely damaged.

stunting and damage symptoms (chlorosis and or purpling) were examined but all had well-developed root systems, indicating no more than moderate nematode damage. These preliminary data show that when white and Sitka spruce and western hemlock seedlings are damaged by *X. bakeri* they are more susceptible to frost heaving than healthy seedlings. More work is needed to correlate degree of damage with amount of heaving. This is the first time that nematodes have been considered as a factor contributing to heaving. Nematodes other than *X. bakeri* could play a similar role, as could other pathogens that damage seedling roots. —Jack R. Sutherland, Forest Research Laboratory Victoria, B.C.

Dwarf mistletoe spread in young lodgepole pine stands in relation to density of infection sources.—Dwarf mistletoe [*Arceuthobium americanum* Nutt. ex Engelm.] spreads into young stands of lodgepole pine [*Pinus contorta* Dougl. var. *latifolia* Engelm.] by seeds dispersed from residual infected trees that remain after logging or forest fire. In Montana, Wyoming, and Colorado, Hawksworth and Graham (J. Forest. 61:587-591, 1963) found that dwarf mistletoe spreads to an average distance of 26 ft from the margins of residual stands into adjacent young stands (age 5 to 28 years). Previous observations (Hedgcock, Wash. Acad. Sci. J. 3:265-266, 1913; Parker, Can. Dep. Mines and Resources, Land, Parks and Forest Br., Silvicult. Leafl. 15, 1942) and results from a study in a young forest 50 miles southwest of Calgary, Alberta, suggested that dwarf mistletoe spreads farther from single infected trees or trees in small groups than from the more uniform margins of continuous stands.

The present study area is situated in the Subalpine Forest Region (Rowe, Can. Dep. N. Aff. Nat. Resources, Forest Br. Bull. 123, 1959) of the Rocky Mountains and was burned by wild fire in 1939. Single residual trees 200 ft or more from any other possible infection source and stands of residual trees occupying an area of, minimum, 200 by 200 ft were selected. The distance of spread of dwarf mistletoe was measured perpendicular to stand margins and not closer than 100 ft from any major irregularity or change in exposure of margins. Spread from single residual trees was measured similarly to the north, south, east, and west of each residual tree.

The average distance of spread from nine residual stands was 28 ft (range 14 to 52 ft), which is comparable to that observed by Hawksworth and Graham. The average spread from 15 single residual trees was 45 ft (range 20 to 74 ft). The difference between the averages was highly significant (probability error less than 1%). Where stand margins had been disrupted by fire or logging, spread was comparable to that from single residual trees.

These results indicate that single, residual, infected trees should be removed first and uniform stand margins should be maintained during control operations where the objective is to minimize the extent of infection of young stands. Research is underway to determine whether the observed difference in spread is associated with distance of seed dispersal or rate of spread within the newly infected stands.—John A. Muir, Forest Research Laboratory, Edmonton Alta.

SILVICULTURE

Variation of site-index and basal area within the forest types of western Newfoundland.—The forest types of the Corner Brook Section (B28b) of the Boreal Forest Region in western Newfoundland (Rowe, Can. Dep. North. Aff. Natural Resources, Forest. Br., Bull. 123, 1959) have been classified and described by Damman (Ph.D. Thesis, Univ. of Michigan, 1967) on the basis of their floristic and edaphic characteristics. The mensurational characteristics of typical, mature stands of five or the most productive of these forest types have been described by Bajzak, Bouzane and Page (unpublished data).

Mensurational data are presented in this report for an additional 11 types as well as for the five described by Bajzak *et al.* Plots, randomly located with respect to forest type, were established in well-stocked stands (Table 1) of balsam fir (bF) [*Abies balsamea* (L.) Mill.] and black spruce (bS) [*Picea mariana* (Mill) BSP]. Study methods were the same as reported earlier for the Avalon Peninsula (Page, Bi-Monthly Res. Notes 26:6-7, 1970).

The Dryopteris-bF, Dryopteris-Rhytidiadelphus-bF, and Rubus-bF (typical variant) types show the most rapid height growth (Table 2) and do not differ significantly from each other in terms of site-index. However, the Dryopteris-bF type has basal area values significantly greater than those of each of the other two types. Its mean annual merchantable volume increment averages 48 ft^3/acre and the merchantable softwood volume in mature and semi-mature stands averages 3,500 ft^3/acre. The Dryopteris-Rhytidiadelphus-bF and Rubus-bF (typical variant) types have similar basal area values but their mean annual increments, of 44 and 35 ft^3/acre, and their merchantable softwood volumes, of 3,200 and 2,800 ft^3/acre, are noticeably different. It therefore appears that each one of these three types constitutes a distinct mensurational unit.

The Dryopteris-Hylocomium-bF is distinct on the basis of site-index from all other types with the exception of the Pleurozium-bF type. However, it is a much more productive type than the Pleurozium-bF, with an average mean annual increment of 35 ft^3/acre and an average merchantable volume of 2,500 ft^3/acre as compared to 24 and 1,650 for the Pleurozium-bF.

The Pleurozium-bF, Hylocomium-bF, Taxus-bF (typical and Epigaea variants), and Gaultheria-bF types form an intermediate series with mean site-index values between 29.9 and 39.0 and mean basal area values between 110 and 140 ft^3/acre. They appear to represent a definite sequence of productivity but are not clearly distinct from one another in terms of site-index or basal area. Their annual increments range from 13 to 24 ft^3/acre and merchantable softwood volumes average between 1550 and 1950 ft^3/acre.

The Sphagnum-Robustum-bS (Nemopanthus variant), Nemopanthus-Kalmia-bS, Osmunda-bS, and Carex-bS types form a group with similar site-index and basal area values. Stands of these types are normally unmerchantable, with average mean annual increments between 5 and 8 cubic feet per acre and average merchantable softwood volumes in mature stands between 650 and 900 ft^3/acre.

TABLE 1

Western Newfoundland forest types: statistics for basal area, number of stems per acre, and mean annual increment

Forest Type and Number of Samples	Avg number of stems per acre (all species)	Avg mean annual increment (ft^3/acre)	Basal Area (square feet per acre). All species				
			Mean	Maximum recorded	Minimum recorded	Standard error	95% confidence limits at mean
Dryopteris-bF (8)	1299	47.8	202.4a	252.1	170.3	9.72	23.0
Dryopteris-Rhytidiadelphus-bF (11)	1248	44.4	171.6b	214.4	126.8	8.29	18.5
Rubus-bF (typical variant) (10)	1329	34.8	162.4b	218.0	84.9	12.30	27.8
Dryopteris-Hylocomium-bF (20)	1752	34.5	165.7b	224.9	106.6	7.15	15.0
Pleurozium-bF (15)	1953	23.6	131.4c	162.5	100.3	4.79	10.3
Hylocomium-bF (11)	1839	23.5	139.7c	181.1	74.1	10.11	22.5
Taxus-bF (typical variant) (5)	1786	19.6	129.6cd	160.1	86.7	15.81	43.9
Gaultheria-bF (9)	1294	13.2	108.0d	158.8	82.5	9.42	21.7
Taxus-bF (Epigaea variant) (11)	1415	14.3	110.4d	138.1	58.9	7.12	15.9
Sphagnum-Robustum-bS (Nemopanthus variant) (4)	1384	6.3	73.7e	84.1	64.0	4.76	15.1
Nemopanthus-Kalmia-bS (7)	1393	7.6	76.5e	115.9	42.0	10.00	24.5
Osmunda-bS (14)	1546	7.8	80.1e	108.9	50.2	4.06	8.8
Carex-bS (4)	1330	5.8	60.5e	104.5	20.5	18.84	59.9
bS-moss forest on sand (13)	2192	24.9	141.1	225.7	95.5	11.76	25.6

Similar letters denote those forest types with non-significant differences at the 95% level between their basal area values (determined by paired T-tests for all possible combinations of forest types).

TABLE 2

Western Newfoundland forest types: statistics for site-index

Forest Type and Number of Samples	Site-index (feet). Index species: bF or bS				
	Mean	Maximum recorded	Minimum recorded	Standard error	95% confidence limits at mean
Dryopteris-bF (8)	51.0a	56.7	44.8	1.29	3.1
Dryopteris-Rhytidiadelphus-bF (11)	47.4a	56.3	36.5	2.17	4.8
Rubus-bF (typical variant) (10)	46.7a	55.9	40.0	1.66	3.8
Dryopteris-Hylocomium-bF(20)	41.5b	51.2	30.2	1.33	2.8
Pleurozium-bF (15)	39.0bc	48.7	31.6	1.30	2.8
Hylocomium-bF (11)	35.8cd	45.0	18.7	2.24	5.0
Taxus-bF (typical variant) (5)	34.5cd	40.8	27.5	2.27	6.3
Gaultheria-bF (9)	32.9de	43.0	22.5	2.25	5.2
Taxus-bF (Epigaea variant) (11)	29.9e	35.3	25.6	0.88	2.0
Sphagnum-Robustum-bS (Nemopanthus variant) (4)	26.6ef	31.1	23.3	1.63	5.2
Nemopanthus-Kalmia-bS (7)	26.4ef	33.7	18.5	2.05	5.0
Osmunda-bS (14)	25.2f	31.0	20.8	0.84	1.8
Carex-bS (4)	25.0f	28.6	18.1	2.34	7.5
bS-moss forest on sand (13)	41.9	56.5	25.5	2.78	6.1

Similar letters denote those forest types with non-significant differences at the 95% level between their site-index values (determined by paired t-tests for all possible combinations of forest types).

The bS-moss forests on sand include a greater range of crop conditions than any of the other types. For example, the difference of 31 feet between observed maximum and minimum values of site-index is greater than that for any of the other forest types. This type does not differ significantly, in terms of site-index and basal area, from the Dryopteris-Rhytidiadelphus,bF, Rubus-bF (typical variant), Dryopteris-Hylocomium-bF, Pleurozium-bF, Hylocomium-bF, and Taxus-bF (typical variant) types, and also, in terms of basal area only, from the Gaultheria-bF type. Its mean annual increment averages 25 ft^3/acre and the average merchant able softwood volume of mature and semi-mature stands is 1400ft^3/acre.

These data indicate that most of the Damman forest types for western Newfoundland are meaningful in mensurational, as well as floristic and edaphic, terms. However, the bS-moss forests on sand do not appear to be a meaningful mensurational unit, and a number of the intermediate and poorer forest types, while reflecting a sequence of productivity, are not clearly distinct from one another in mensurational terms. In addition, most of the forest types include a relatively wide range of site-index and basal area values (Tables 1 and 2), and further information on site factors associated with variation in forest growth appears necessary for the development of a fully satisfactory system of capability classification for western Newfoundland.—G. Page, Forest Research Laboratory, St. John's, Nfld.

Spacing of red pine affects upper stem and crown growth. —Tree dimensions (with the exception of height) vary directly with the available growing space; that is, the wider the spacing between trees the greater will be the diameter at breast height, total stem volume, crown length, and crown width of the individual trees. It has been assumed, however, that the development of the upper part of the tree growing in full light and not in contact with its neighbours (here defined as the "free growing" top) would be independent of spacing (Farrar. Forest. Chron. 37:323-330, 349, 1961). A study was undertaken in 1969 at the Petawawa Forest Experiment Station to determine if, in young plantation red pine [*Pinus resinosa* Ait.], spacing did actually influence the development of the "free growing" top.

Ten trees from each of five spacing classes were selected from a red pine plantation established in 1953. Each tree selected was in the dominant or codominant crown class, and had four major competitors present at the specified spacing. The four competitors were those adjacent to the selected tree along the row and at right angles to it. The spacings from which the trees were selected were 4 x 4 feet, 6 x 6 feet, 8 x 8 feet, 10 x 10 feet, and 14 x 14 feet. Observations of diameter at breast height, total height, diameter at mid-point of each internode, crown width for each whorl of branches, and the number of whorls free from contact with neighboring trees, were made for each sample tree.

The average height of all trees was about 28 feet and was not related to spacing. The average dbh increased from 5.1 inches for the trees at the 4-foot spacing to 7.5 inches for the trees at the 14-foot spacing; a gain in diameter of 47% attributed to increased spacing.

The internode diameters and crown widths were summarized (Table 1, page 51). The free growing top consisted of the first three whorls for trees at the 4-foot spacing and increased to seven whorls at the 10-foot spacing. Most of the trees at the 14-foot spacing were not touching their neighbors, but for comparison purposes the data for the first eight whorls only are presented.

The results show a definite tendency for the more closely spaced trees to have smaller stem diameters and narrower crowns in the free growing top than occur in corresponding whorls of trees at wider spacings. For exemple, in the third whorl of the trees at the 4-foot spacing stem diameters are 8% smaller and crowns are 16% narrower than in the third whorl of trees at the 14-foot spacing. Even leader diameters are affected. It appears, therefore, that where contact has been made with neighboring crowns, radial growth is reduced throughout the full length of the tree, although the reduction is less in the part above the point of contact than in the part below. Since real growth differences related to spacing do occur in the free growing top, this aspect of tree development should be taken into consideration in growth prediction studies and other research projects where size of upper crown or stem is a factor. — A. B. Berry, Petawawa Forest Experiment Station, Chalk River, Ont.

TABLE 1

Upper stem and crown dimensions by spacing class

Whorl[1] No.	Stem diameter—inches					Crown width—feet				
	4′ x 4′	6′ x 6′	8′ x 8′	10′ x 10′	14′ x 14′	4′ x 4′	6′ x 6′	8′ x 8′	10′ x 10′	14′ x 14′
1	.69a[2]	.68a	.76b	.76b	.77b	1.6a	1.5a	1.5a	1.6a	1.5a
2	1.11a	1.10a	1.15abc	1.22c	1.18bc	2.7a	2.9a	3.1a	3.1a	3.2a
3	1.65a	1.66a	1.72ab	1.81b	1.80b	4.2a	4.8b	5.0b	5.0b	5.0b
4	2.27a	2.27a	2.36ab	2.50b	2.46b	5.6a	6.5b	6.8b	6.8b	6.9b
5	2.74a	2.77a	2.94b	3.12c	3.08c	7.1a	7.9b	8.3b	8.6bc	9.2c
6	3.15a	3.25a	3.58b	3.82c	3.85c	8.5a	9.5b	10.4c	10.6c	10.8c
7	3.58a	3.73a	4.15b	4.47c	4.60c	8.7a	9.1a	11.2b	12.0bc	12.4c
8	3.93a	4.13a	4.64b	5.05c	5.32d	—[3]	—[3]	11.5a	12.7b	13.7c

[1]The solid heavy line indicates the whorl where the branches first touch the branches of the neighboring trees. Whorls above this line make up the free growing top
[2]For the same whorl number, values for either diameter or crown width followed by a common alphabetic character are not significantly different at the 5% leve (Duncan's multiple range test).
[3]Some dead branches present; not considered a fully live crown.

Correction Volume 26, No. 3

page 22 column 2 3rd last line should read: "... where W_d is the oven-dry weight, W_a is the saturated weight in air, W_l is the saturated weight is water, ..."

page 23 column 1 line 14 should read: "... hydrostatic pressure and measured volume of the weighted pin."

(*Continued from back cover*)

Loman, A. A. 1969. Bioassays of fungi icolated from *Pinus contorta* var. *latifolia* with pinosylvin, pinosylvinmonomethyl ether, pinobanksin, and pinocembrin. Can. J. Bot. 48:1303-1308.

Marten, G. G. 1970. A regression method for mark-recapture estimation of population size with unequal catchability. Ecology 51:291-295.

Mia, A. J. 1970. Fine structure of active, dormant, and aging cambial cells in *Tilia americana*. Wood Sci. 3:35-42.

Miller, D. G. and Tardif, Y. 1970. A video technique for measuring the solid volume of stacked pulpwood. Pulp Pap. Mag. Can. (April).

Morris, R. F. and Fulton, W. C. 1970. Models for the development and survival of *Hyphantria cunea* in relation to temperature and humidity. Mem. Entomol. Soc. Can. No. 70. pp 60.

Morrison, D. J. and Johnson, A. L. S. 1970. Seasonal variation of stump infection by *Fomes annosus* in coastal British Columbia. Forest. Chron. 46(3).

Park, J. Y. 1970. A change in color of aging mycorrhizal roots of *Tilia americana* formed by *Cenococcum graniforme*. Can. J. Bot. 48:1339-1341.

Post, J. L. 1970. Dry-matter production of mountain maple and balsam fir in northwestern New Brunswick. Ecology: 51:548-550.

Price, P. W. 1970. Characteristics permitting coexistence among parasitoids of a sawfly in Quebec. Ecology 51:445-454.

Ramiah, M. V. 1970. Thermogravimetric and differential thermal analysis of cellulose, hemicellulose, and lignin. J. Appl. Polymer Sci. 14:1323-1337.

Richardson, J. 1970. Broadcast seeding black spruce on a burned cutover. Dep. Fish. Forest., Can. Forest. Serv. Pub. No. 1272. pp. 14.

Salamon, M. and McIntyre, S. 1970. Combination schedule improves drying of western white spruce lumber. Forest Prod. J. 20(7):41-42.

Shen, K. C. and Carroll, M. N. 1970. Measurement of layer-strength distribution in particleboard. Forest Prod. J. 20(6):53-55.

Sims, H. P. and Campbell, G. D. 1970. Red pine seedfall in a southeastern Manitoba stand. Dep. Fish. Forest., Can. Forest. Serv. Pub. No. 1267, pp 8.

Smirnoff, W. A. and Chu, W. H. 1970. The bacterial flora associated with aqueous virus suspensions of *Neodiprion swainei*. J. Invertebr. Pathol. 16:139-141.

Smith, R. B. and Craig, H. M. 1970. Decay in advanced alpine fir regeneration in the Kamloops District of British Columbia. Forest Chron. 46(3).

Smith, S. G. and Takenouchi, Y. 1969. Chromosomal polymorphism in *Pissodes* weevils: further on incompatibility in *P. Terminalis*. Can. J. Genet. Cytol. XI:761-782.

St-Laurent, A. 1970. Effects of sawtooth edge defects on cutting forces and sawing accuracy. Forest Prod. J. 20:33-39.

Stocks, B. J. 1970. Moisture in the forest floor—its distribution and movement. Dep. Fish. Forest., Can. Forest. Serv. Pub. No. 1271. pp 20.

Sutherland, J. R., Dunn, T. G. and Cousens, N. Bruce F. 1970. Morphometric and morphological characteristics for identifying the life stages of *Xiphinema bakeri* Williams, 1961 (Nematoda: Longidorinae). Can. J. Zool. 48:771-773.

Swan, E. P. and Jiang, K. D. 1970. Formation of heartwood extractives in western red cedar. Tappi 53:844-846.

Wallis, G. W. and Reynolds, G. 1970. *Fomes annosus* root and butt rot: A threat in managed stands in coastal British Columbia. Forest. Chron. 46(3).

Whitney, R. D. and Denyer W. B. G. 1970. Inoculations with *Stereum sanguinolentum* and *Fomes pini* in black spruce and balsam fir. Forest Sci. 16:160-164.

Yeatman, C. W. 1970. Co_2 enriched air increased growth of conifer seedlings. Forest Chron. 46(3).

Ziller, W. G. 1970. Studies of western tree rusts. VII. Inoculation experiments with pine stem rusts (*Cronartium* and *Endocronartium*). Can. J. Bot. 48:1313-1319.

Recent Publications

Bloomberg, W. J. and Trelawny, J. 1970. Effect of Thiram on germination of Douglas-fir seed. Phytopathology 60:1111-1116.

Carroll, M. N. and Wrangham, B. 1970. The measurement of surface strength in particleboard. Forest Prod. J. 20(7):28-33.

Desai, R. L. 1970. Accelerated weathering of coatings on wood substrates. Paint Technol. 42:352-358.

Dionne, J. C. 1969. Nouvelles observations de fentes de gel fossiles sur la côte sud du Saint-Laurent. Rev. Géogr. Montr. XXIII:307-316.

Dionne, J. C. 1969. Bibliographie annotée du glaciel aspects morphosédimentologiques. Rev. Géogr. Montr. XXIII:339-349.

Feihl, O. and Godin, V. 1970. Peeling defects in veneer their causes and control. Dep. Fish. Forest., Can. Forest. Serv. Pub. 1280. pp 18.

Fox, S. P. 1970. Experimental verification of a stress analysis method for the double-tapered pitched glued-laminated beam. Dep. Fish. Forest., Can. Forest Serv. Pub. No. 1277. pp 48.

Funk, A. 1970. Taxonomy of *Phomopsis boycei* and its relationship to *Potebniamyces balsamicola*. Can. J. Bot. 48:1023-1025.

Gagnon, J. D. 1970. Productivité de plantations d'épinette blanche sur le sol sablonneux à Grand'-Mère, P.Q. Forest. Chron. 46(3).

Gaudert, P. C. L. 1970. An identation-resistance test for flush doors. Dep. Fish. Forest., Can. Forest. Serv. Pub. No. 1278. pp 13.

George, P. and Miller, D. G. 1970. Detection of roughness in moving douglas-fir veneer. Forest Prod. J. 20(7):53-59.

Ginns, James H. 1970. The genus *Merulius III.* Species of *Merulius* and *Phlebia* proposed by Schweinitz and Peck. Mycologia LXIII:238-255.

Girouard, Ronald M. 1970. Rooting plain and heel cuttings of spruce. Plant Propagator 16(1):7-12.

Gray, D. E. 1969. *Lenzites trabea*—invaded wood lure used as a subterranean termite survey tool in Ontario. B. W. P. A. Termite Symposium pp 117-126.

Hall, J. P. 1970. Ten-year development of planted conifers in western Newfoundland. Dep. Fish. Forest. Serv. Pub. No. 1273. pp 9.

Hallett, R. M. and Flann, I. B. 1970. Wasted fibre from hardwood edging: transform it into substantial profit. Can. Forest Ind. (May).

Hayashi, Y. and Retnakaran, A. 1970. The site of RNA synthesis of a cytoplasmic-polyhedrosis virus (CPV) in *Malacosoma disstria*. J. Invertebr. Pathol. 16:150-151.

Hulme, M. A. and Stranks, D. W. 1970. Induction and the regulation of production of cellulase by fungi. Nature. 226:469-470.

Jeffrey, W. G., Brown, C. S., Jurdant, M., Novakowski, N. S. and Spilsbury, R. H. 1970. Foresters and the challenge of integrated resource management. Forest. Chron. 46(3).

Krywienczyk, J. and Cunningham, J. C. 1970. Comparative effectiveness of different media in serological tests of insect pathogens. J. Invertebr. Pathol. 15:288-290.

Lanier, G. N. 1970. Sex pheromones: abolition of specificity in hybrid bark beetles. Science 169:71-72.

Larsen, M. J. 1970. *Tomentella* and related genera in North America VI. Some synonymy and additional new records. Mycologia LXII:256-271.

Lees, J. C. 1970. Natural regeneration of white spruce under Spruce-aspen Shelterwood, B-18a Forest Section, Alberta. Dep. Fish. Forest., Can. Forest. Serv. Pub. No. 1274. pp 14.

Little, C. H. A. and Eidt, D. C. 1970. Relationship between transpiration and cambial activity in *Abies balsamea*. Can. J. Bot. 48:1027-1028.

(Continued on page 51)

BI-MONTHLY

RESEARCH NOTES

IN THIS ISSUE:

Vol. 26—No. 6, NOVEMBER-DECEMBER, 1970

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 Canadian Forestry Service, Department of Fisheries and Forestry

CONTENTS OF VOLUME 26 (1970)

ENTOMOLOGY

Hylobius Weevils and Armillaria Root Rot in a Coniferous Plantation in Newfoundland.—The root weevils, *Hylobius warreni* Wood and *H. pinicola* Couper, and the root rot fungus, *Armillaria mellea* (Vahl ex Fr.) Kummer, are all common root parasites of coniferous trees throughout the boreal forests of North America. Surveys have shown that these organisms have caused extensive tree mortality in pine and spruce plantations in Newfoundland but this is the first report describing the combined weevil and root-rot damage on the Island. The report also provides evidence of a relationship between the injury caused by the weevils and the incidence of the root rot.

Trees infested by the weevils exhibit characteristic symptoms of injury. Weevil larvae feed on the inner bark and cambium of the roots and root collars producing tunnels of resin and frass, frequently girdling and killing infested trees. The foliage of severely damaged trees becomes chlorotic and ultimately turns red. Trees under 1-inch stump diameter are seldom attacked and those over 8 inches, although attacked, tend to survive girdling, but become susceptible to wind-throw. Symptoms of armillaria root rot include chlorosis or browning of a few branches or whole crowns, reduced growth, and resinosis. The pathogen is recognized by mycelial fans under the bark of the infected roots, black or dark brown rhizomorphs and honey-colored fruiting bodies at or near the base of infected trees.

In 1955, a total of 6,263 seedlings of red pine [*Pinus resinosa* Ait.]; Norway spruce [*Picea abies* (L.) Karst.]; and Sitka spruce [*Picea sitchensis* (Bong.) Carr.]; were acquired from the Provincial nursery at Salmonier and planted in 64 twentieth-acre plots on a moist to wet heathland site near St. John's. Only 4,620 living and dead trees were present when the plantation was examined in 1969. Living trees were about 6 ft in height. Primary roots and root collars of all chlorotic (119), dead (103) and 452 apparently healthy trees were examined for evidence of damage by the weevils and the root rot. The percent of trees infested by the weevils or infected by the root rot was calculated from total trees examined.

Results of the survey (Table 1) show that the weevil infestation is highest in Sitka spruce (58%) and lowest in red pine (33%). However, *A. mellea* infection was highest in Norway spruce (5%) and lowest in red pine (3%). Incidence of the disease increased in trees injured by the weevils, particularly Sitka spruce, where infection was 15%, followed by 7% in Norway spruce and only 1% in red pine. Whitney (Forest. Chron., 37:401-411, 1961) found that wounds caused by these two weevils provide more infection courts for the entry of root-rotting and staining fungi than any other wound type in white spruce [*Picea glauca* (Moench) Voss]. Smerlis (Forest. Chron., 37(2):108, 1961) recorded a similar role for *H. pinicola* in balsam fir [*Abies balsamea* (L.) Mill.]. The present study indicates that the weevil injury did not contribute to the entry of *A. mellea* in the pines examined.

TABLE 1

Percent trees damaged by hylobius weevils and armillaria root rot in the Beauline Line plantation

Damaged trees	Tree Species (number of trees examined are shown in brackets)			
	Pinus resinosa (337)	*Picea abies* (222)	*Picea sitchensis* (115)	*Pinus sylvestris** (38)
Weevil only				
Apparently healthy	31	17	17	53
Chlorotic	1	12	23	3
Dead	1	8	19	11
Total	33	37	58	66
Root rot only				
Apparently healthy	1	0	0	0
Chlorotic	0	1	1	0
Dead	1	5	3	0
Total	3	5	4	0
Weevils and root rot in the same tree				
Apparently healthy	<1	0	0	0
Chlorotic	0	<1	2	0
Dead	<1	6	13	0
Total	1	7	15	0
Total trees damaged				
Apparently healthy	32	17	17	53
Chlorotic	1	14	25	3
Dead	3	18	36	11
Total	36	49	77	66

* *Pinus sylvestris* examined are not included in the total number of trees examined in the plantation (4,620) because these were not within the limits of the 64 plots.

Weevil infestation in all trees was higher than infection by *A. mellea*, particularly in living trees. However, the impact of damage in the plantation cannot be fully evaluated without considering the combined effect of the weevils and the fungus. Damage to Sitka spruce approached 80%, Norway spruce 50% and less than 40% in red pine. Obviously Sitka spruce is the most vulnerable of the species examined when the weevils and the root rot occur simultaneously. Recent damage was also evident in numerous apparently healthy trees, indicating the continuing progress of the problem in the plantation.

Examination of planted Scots pine [*Pinus sylvestris* L.] and natural growing white spruce adjacent to the plantation showed high population levels and abundant old damage by hylobius weevils. The initial attack by the weevils in the plantation is attributed to invasion from the infested white spruce trees. The infestation may have been accelerated by the presence of the highly susceptible Scots pine and the wet site. The incidence of *A. mellea* infection is lower in this plantation than in those examined elsewhere on the Island, possibly because of the lower proportion of spruce, the wet site, and the unusual paucity of decayed stumps. It should be pointed out that damage by the weevils and the root rot has been observed in all plantations examined regardless of tree species or site conditions and the most severe damage has always occurred on exotic species.—G. L. Warren and Pritam Singh, Forest Research Laboratory, St. John's, Nfld.

Cutworm Damage to Summer-planted White Spruce Tubelings.—Fire destroyed about 5800 acres of mixed-wood forest near Chapleau, Ont., in early June of 1967. Foliage and smaller branches were consumed in the crown fire and the litter was partially burned. From July 10 to 31 the Ontario Department of Lands and Forests planted 160 acres of the burn with white spruce [*Picea glauca* (Moench) Voss] tubelings at a rate of 1200 per acre. In August, cutworms destroyed up to 40% of the tubelings in parts of the planting. D. Ropke, Forest Insect and Disease Survey, reported that, initially, the insects fed on sucker growth of white birch [*Betula papyrifera* Marsh.], trembling aspen [*Populus tremuloides* Michx.], maple [*Acer* spp.], mountain ash [*Sorbus americana* Marsh.], pin cherry [*Prunus pensylvanica* L. f.], and honeysuckle [*Diervilla lonicera* Mill.], as well as on aster [*Aster*], bindweed [*Polygonum*], bracken fern [*Pteridium*], interrupted fern [*Osmunda*], sarsaparilla [*Aralia*], and geranium [*Geranium*]. The white spruce seedlings were apparently eaten mainly where other foliage was sparse or where large numbers of cutworms occurred.

Two species of cutworm were involved, *Pyrrhia exprimens* Wlk. and *Mamestra curialis* Sm., in a ratio of 2:1. The robust, full-grown larvae of *P. exprimens* are about 1.3 inches long and highly variable in color, ranging from pale cream with scattered dark markings to grey-black with a network of fine white lines; some specimens have a trace of orange laterally; the head is yellow on pale larvae, brownish with heavy dark markings on dark specimens. The larvae of *M. curialis* are also variable, green to brown, with a fine, interrupted, dark-edged dorsal line, and with black-ringed spiracles set in a white or pale yellow lateral stripe.

Large-scale infestations were indicated for the following year (1968) since overwintering pupae of the two species averaged 2.5 per square foot in the ground and the incidence of parasitism was very low. Flights of adults of *P. exprimens* did occur in June and July; however, the expected hordes of cutworms did not materialize and no further injury to tubelings occurred. Tiensuu (Ann. Entomol. Fennici 11:34-38, 1945), mentions abrupt fluctuations in numbers of larvae in successive years. He attributes these fluctuations to the climatic requirements of the species in Finland and to the occurrence of a variable and sometimes prolonged diapause in the pupal stage.

Records of the Forest Insect and Disease Survey show that *P. exprimens* occurs widely across Ontario except in the south. The species was rarely collected in the 1940's and 1950's but appeared in much larger numbers from 1964-67. The common host plant is balsam poplar [*Populus balsamifera* L.] on which the larvae feed on foliage at the tips of young unshaded trees; other host plants, listed rarely, are aspen, birch, willow [*Salix* sp.], cherry [*Prunus* sp.], and wild rose [*Rosa* sp.]. In Finland the species is reported abundant on monkshood [*Aconitum*] during years of low rainfall (Tiensuu, *loc. cit.*).

The less common species in the burn, *M. curialis*, has been recorded only once previously by the Forest Insect and Disease Survey, on dogbane [*Apocynum*] near Marathon, Ont., in 1966. Specimens in the Canadian National Collection, Ottawa, are from Alberta, Ontario, Quebec, and Nova Scotia.

The origin of the 1967 infestation of cutworms is uncertain but the burned-over area may have harbored a population of pupae in prolonged diapause which emerged following the burn, or egg-laden moths from an outside source were attracted to the site of the burn. More information is required on the two cutworms, particularly with respect to the occurrence of diapause and the behavior of moths, before any recommendations can be made concerning the best planting time for tubelings relative to fire history. However, it appears that in northern Ontario summer plantings of white spruce tubelings following a spring burn are susceptible to injury by these two cutworms.—O. H. Lindquist, Forest Research Laboratory, Sault Ste. Marie, Ont.

Successful Parasitism of Spruce Budworm in Canada by a Parasite from Japan—There have already been two major attempts, both unsuccessful, to establish exotic parasites in spruce budworm populations in eastern Canada. In one attempt, parasitic flies and wasps reared from the spruce budworm [*Choristoneura fumiferana* (Clem.)] in British Columbia were released in large numbers in Ontario, Quebec, and the Atlantic Region in the late 1940's; in the other, 12 species collected from *Choristoneura murinana* (Hbn.) and *Cacoeciae histrionana* Froel. in Europe were released in northwestern Ontario in the early 1950's. We now describe the preliminary experiments in a further attempt to reinforce the biocontrols on the budworm. The initial idea was generated by Zwolfer's reference (Z. Angew. 61(4):448-452, 1968) to a species of *Glypta* in Japan attacking a coniferous defoliator closely related to the spruce budworm.

The junior author reported in December 1969 that:

(a) Japanese Todo-fir [*Abies sachalinensis* Mast.] is attacked by two tortricid defoliators, *Choristoneura coniferana* Issiki and *C. diversana* Hübner;

(b) An outbreak of *C. diversana*, the more abundant defoliator, began in 1965 and defoliation was severe in 1969;

(c) *C. diversana* has a life history similar to the spruce budworm except that it overwinters as a first- rather than as a second-instar larva;

(d) *Cephaloglypta laricis* Momoi is a common parasite of *C. diversana*. It is a univoltine species whose life history is very similar to the North American budworm parasite *Glypta fumiferanae* (Vier.); and

(e) A larch tortricid [*Ptycholomoides aeriferana* H.-S.], similar in life history to *C. diversana*, is also attacked by *C. laricis* and 50% parasitism has been recorded among some host populations on larch.

On the basis of the above information, a decision was made to import an experimental shipment of *C. laricis*. The aims were: to become acquainted with the difficulties and feasibility of shipping live material from Japan; and to conduct mating and oviposition experiments under laboratory conditions.

On 9-11 June, the junior author collected ultimate-instar larvae of *C. diversana* in a 40-year-old, heavily infested plantation of *A. sachalinensis* near Asahikawa, Hokkaido. The collections were made from the upper and midcrowns of about 30 trees. The *C. diversana* larvae were reared in the laboratory and produced about 170 *C. laricis* cocoons. These cocoons were air-expressed in two lots (21 and 28 June) to the Research Institute, Canada Department of Agriculture, Belleville, Ont. The adults were screened and 116 healthy specimens were forwarded in four lots (2, 6, 9, and 14 July) to the Green River Laboratory, New Brunswick. All but 5 of the 47 females and 69 males survived the shipment.

All 43 surviving females were used in laboratory experiments to determine mating and oviposition success. Host material consisted of first- and second-instar spruce budworm larvae in hibernacula in old staminate flower cups on cut balsam fir shoots. The arrival of the Japanese parasites coincided remarkably well with the appropriate stage of larval development at Green River. One-pint mason jars were used as experimental cages, with an aqueous sugar solution as food, and strands of excelsior for resting sites. In each cage, a male and a female were provided with about 100 spun-up budworm larvae and observations were made on adult life-span and on the searching, oviposition, and resting behavior of some females. To date, results appear encouraging; of 18 lots dissected in September, 16 contained parasitized larvae, with living first-instar *C. laricis;* parasitism varied among lots from 12 to 94% (average, 52%).

Some host material from the remaining 25 experimental lots will be dissected to determine the extent of oviposition and the rest will be set outdoors to determine overwintering survival. Success in reaching maturity will be assessed next spring.

Research will be continued in 1971 if *C. laricis* can be obtained from Japan: to determine oviposition success in the field using caged trees as experimental units; and to obtain an index of the potential competition between native *G. fumiferanae* and introduced *C. laricis*, since their attack times on spruce budworm presumably coincide.—T. R. Renault, Forest Research Laboratory, Fredericton, N.B. and K. Kamijo, Hokkaido Forest Experiment Station, Japan.

FOREST PRODUCTS

Chemical Composition of Clear and Mineral-Stained Maple. —Although the chemical composition of the clear wood of sugar maple (*Acer saccharum* Marsh.) has been reported (Clermont and Schwartz, Pulp Pap. Mag. Can. 53:142-143, 1952; Berzins, Pulp Pap. Res. Inst. Can. Res. Note 61, 1966; Freeman and Peterson, Ind. Eng. Chem. 13:803-805, 1941) there is no similar information on mineral-stained wood of this species. The only study of the chemical composition of mineral-stained maple dealt primarily with the inorganic constituents (Good, Murray and Dale, Can. J. Bot. 33:31-41, 1955).

In an attempt to relate chemical composition to cause and mechanism of mineral stain formation in maple, samples of clear and stained wood were analyzed. The samples used for analyses were of: (1) clear sapwood; (2) "heartwood" (in maple considered to be a form of protection wood); (3) lightly-stained wood from the sapwood zone; and (4) heavily-stained wood occurring in either the sapwood or "heartwood" zone. The latter was the typical green mineral-stained wood which causes considerable financial loss to industry. Table 1 gives the analyses.

Conditions for oxidation of polyphenols under alkaline conditions may exist in stained wood. The pH of the green-stained wood was 7.0 as compared with 5.4 for clear sapwood. According to Good *et al.* (Can. J. Bot. 33:31-41, 1955) the pH of stained maple increased to as much as 8.5 or 9.0 as the stain became darker or more pronounced. These high pH values were reported to be due to large amounts of potassium or calcium carbonate. They reported that, as the intensity of the stain increased, the ash content also increased; ash contents as high as 2.5 to 4.0% were not uncommon in highly-stained wood. In our work, the green-stained wood was found to contain almost five times as much ash as the clear sapwood. Extraction with water did not remove the ash from the stained wood, whereas about half of the ash was removed by water from clear sapwood. Thus, either the minerals in the stained wood were attached to the polyphenols, or they were of different composition than the minerals in clear sapwood.

Although the amounts of water extractives from clear sapwood and green-stained wood were almost the same, the extracted material from the latter was much darker in color and evidently different in chemical composition. A considerable amount of water solubles of sapwood was also soluble in acetone or alcohol-benzene whereas the material from green-stained wood was insoluble in organic solvents. Paper chromatography verified the presence of different materials in the water extractives of these wood samples and showed the presence of certain materials in water extractives of the green-stained wood; these were present only in traces in the "heartwood" and lightly-stained wood and entirely absent in sapwood. These materials could be glycosides which after hydrolysis and oxidation eventually became the staining material in the wood.—N. Levitin, Forest Products Laboratory, Ottawa.

TABLE 1
Chemical Analyses of Clear and Stained Maple

Types of Wood	Klason lignin (%)	Holo-cellulose (%)	Acetone solubles (%)	Alcohol-benzene solubles (%)	Cold water solubles (%)	Hot water solubles (%)	Hot water solubles after solvent extraction (%)	Ash (%)	Ash after hot water extraction (%)
Clear Sapwood	21.8	84.8	1.7	0.50	1.4	3.9	1.7	0.39	0.19
"Heartwood"	23.1	82.8	2.2	0.31	0.86	2.5	2.2	0.64	
Lightly stained wood	22.6	81.2	2.4	0.40	1.5	4.1	1.7	0.72	
Heavily stained wood	23.2	78.4	4.8	0.54	1.7	4.2	4.1	1.8	1.6

Acidified sodium chlorite treatments as described for holocellulose determinations (Wise, Murphy and D'Addieco, Pap. Trade J. 122:35-43, 1946) removed all of the color from the four types of wood. However, the yield of holocellulose decreased as the color intensity of the samples increased. On the other hand, the Klason lignin values varied little. Although identical treatments were used, the total of lignin and holocellulose increased to well over 100% as the color intensity of the wood decreased. It appeared to be more difficult to remove all the lignin from the clear sapwood than from the darker wood. The evidence from these analyses indicated that the more highly-colored wood contained materials which were soluble in both the acid solution of the Klason lignin determination and the acidified chlorite solution. Most probably, these materials were highly-colored polyphenolic substances.

There is further evidence that the darker color of stained wood and "heartwood" is caused by insoluble polyphenolic materials which are formed by oxidation of simpler phenolic products. Although the color of the green-stained wood was not reduced visibly by acetone extraction, the yield of extractives removed was 4.8% as compared with 1.7% from clear sapwood. The other types of wood gave intermediate values. About 70% of each of the acetone extracts was a brown solid which appeared to be a mixture of soluble lignin and a high-molecular-weight polyphenolic material. This brown material made up 3.3% of the dry weight of the green-stained wood but only 1.3% of the clear sapwood. It is suggested that this material, or part of it, is a precursor of the insoluble material which is responsible for the dark color of the stained wood.

Several white polyphenolic substances were also isolated from the green-stained wood extractives. These were present only in traces in "heartwood" extractives and were absent in sapwood. When gently heated in alkaline solution in the presence of air the white material became brown. The process was irreversible. These products are now being studied in detail, but it is suggested that the white solids may eventually oxidize to highly-colored insoluble material in the stained wood.

Erosion of Wood by Enzymes of Wood-rotting Basidiomycetes —Theoretical considerations of molecular sizes of enzymes causing wood decay indicate that, on *a priori* grounds, enzymatic degradation of wood appears to be confined to outside surfaces or gross capillaries (Cowling and Brown, Advan. in Chem. Ser. 95:152-188, 1969). Although direct experimental evidence is lacking for this pattern of wood degradation by isolated enzymes, we have data from studies with ball-milled wood that support the proposed mechanism.

Previously, enzymatic degradation of cellulosic substrates has been measured as the amount of material made water-soluble or the amount of specific reducing sugars formed. The average molecular size of the insoluble residue has been determined by viscometry although, with wood, the residue has been delignified prior to assay to allow solubilization in suitable solvents. We found, however, that sawdust ball-milled with Burundum cylinders for at least 2 weeks was readily soluble in cadoxen, a cellulose solvent prepared according to Henley (Svensk Papperstidn. 63:143-146, 1960) and that the changes in the molecular size of the combined wood constituents could then be followed by viscometry. Water-soluble material amounting to 14 to 18% of the oven-dry weight of the ball-milled wood was removed by stirring with cold water for 1 hour since this material would be too readily accessible to enzymatic degradation. Combustion analysis showed that ash residue, largely from the Burundum cylinders, weighed 1.5% of the oven-dry weight of the washed ball-milled wood. This same percentage of material was insoluble

in cadoxen and was routinely removed by centrifuging the solution before taking viscometric measurements. Standard cadoxen solutions with solute concentrations up to 1% were prepared by prewetting the wood with water (0.4 ml) for 15 minutes to prevent gel formation, followed by addition of cadoxen (10 ml) with vigorous agitation. After 30 minutes, specific viscosities were determined in a No. 1 Ubbelöhde viscometer at 30 C, and hence the intrinsic viscosity [η], which is directly related to the molecular size of the solute, was calculated. Huggins' constant was 0.32, a value close to that obtained for solutions of soft-coiled molecules in good solvents; this value allowed further intrinsic viscosities to be determined from a single measurement of specific viscosity (Gillespie and Hulme, J. Appl. Polym. Sci. 13:2031-2032, 1969).

Test enzymes were obtained by growing the typical brown rot fungus *Lenzites trabea* Pers. ex Fr. in shake culture at 28 C in an 80-ml suspension of 1% yeast extract (Difco), 0.1% glucose, and 1% 200-mesh aspen wood. Centrifuged culture supernatant was harvested after 7 days and used directly as the enzyme preparation

In a typical assay of enzyme action, washed ball-milled aspen wood (100 mg) in pH 5.5 acetate buffer (8 ml, 0.075 M) was incubated at 50 C for a minimum of 18 hours with culture supernatant (2 ml). Incubations were terminated in an autoclave at 121 C for 20 minutes, and the wood residues were washed with water (3 x 10 ml), dried, and weighed. Intrinsic viscosities were then determined (Table 1). Reducing sugar analysis (Somogyi, J. Biol. Chem. 195:19-23, 1952) and paper chromatography of the supernatant from the incubations showed that the soluble material was mostly glucose and xylose with some cellobiose and xylobiose and traces of mannose, cellotriose and xylotriose. The depolymerases were thus both cellulase and hemicellulase.

TABLE 1
Degradation of ball-milled aspen wood by enzymes of *L. trabea*

Incubation time	Ash-free wood made water soluble	Percentage decrease in
(hr)	(%)	(η)
18	18.2	13.9
18[1]	17.9	14.2
24	25.2	20.3
72	38.1	30.6
Control[2]	4.6	—3.1

[1]Included to show agreement between duplicates.
[2]Wood incubated with autoclaved enzyme. Values were similar for all incubation periods.

A plot of the percentage decrease in [η] during incubation against the percentage of wood made water-soluble is linear and passes through the origin. Such a relationship is only possible for an endwise mechanism of depolymerization. Similar results were obtained with enzymes of *Polyporus versicolor* L. ex Fr., a white rot fungus.

Sharply contrasting results have been published demonstrating a random mechanism of depolymerization: when native or swollen cellulose was incubated with cellulase of *Myrothecium verrucaria* (Selby, Biochem. J. 79:562-566, 1961; Whitaker, Can. J. Biochem. Physiol. 35:733-742, 1957) or of an unidentified Basidiomycete (Rinaudo, Barnoud and Merle, J. Polym. Sci. C 28:197-207, 1969) the average molecular size decreased rapidly compared to the small increase in water solubility. The endwise attack observed in the present work thus suggests that lignin in the cell wall confines depolymerase activity to the ends of cellulose molecules by rendering the sides of the cellulose microfibrils inaccessible to the enzyme.—M. A. Hulme and J. F. Thomas, Forest Products Laboratory, Ottawa, Ont.

Effect of Solutions of Nitrogen Dioxide in N-N-Dimethylformamide on Cellulose.—When a solution of NO_2 in anhydrous N-N-dimethylformamide (DMF) was added to cellulose in the form of cotton batting in a weight ratio of 2.5-3 parts NO_2 per part of cellulose and the suspension shaken at room temperature, the cellulose gradually dissolved and a clear viscous solution was obtained in about 1 hr. In the case of fluffed bleached sulfite pulp, solution was complete in about 15 min at room temperature. Similar observations were also made by Schweiger (Schweiger, Chem. Ind. (London) 10:296, 1969) using N_2O_4 or NOCl in DMF or dimethylacetamide. The dissolved cellulose may be recovered by precipitating in either methanol or water. It was also observed that if the cotton cellulose was soaked in pure DMF for 3 to 4 hr prior to adding the solution of NO_2 in DMF, the cellulose dissolved completely in 3 to 5 min. Such a cellulose solution was allowed to stand at constant temperature (25C) and aliquots were taken at intervals. The recovered cellulose samples were analyzed for nitrogen, carboxyl and carbonyl groups. Infrared spectra were also run. Table 1 shows the results of these analyses. The viscosity of the cellulose solution decreased with time of standing (Fig. 1).

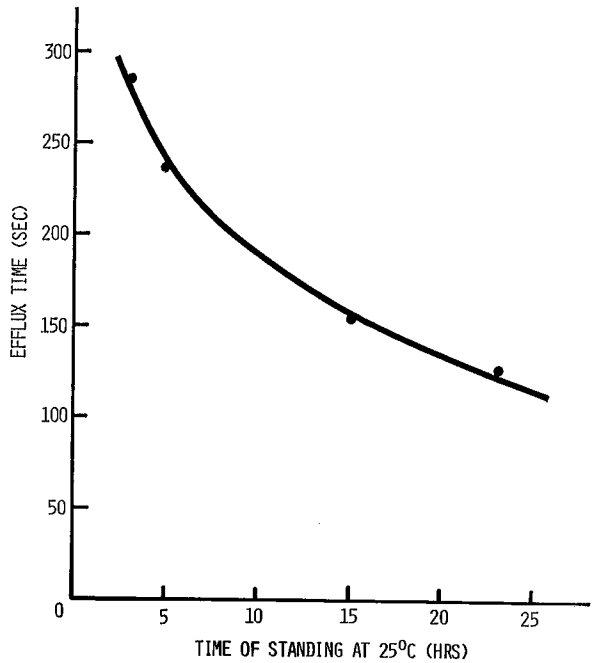


FIGURE 1. Decrease in the viscosity of a solution of cellulose in NO_2-DMF with time.

The nitrogen content of the regenerated samples increased from 0.03% after a 5-min reaction time to 1.03% after 22 hr. Infrared spectroscopy revealed the presence of a strong absorption band at 1680 cm^{-1} in all samples, increasing in intensity with nitrogen content. Upon treatment of the samples with dilute alkali at room temperature, the band decreased in intensity. On the basis of this evidence, the nitrogen content was attributed tentatively to the formation of nitrite ester groups which are known to absorb very strongly in the 1680–1650 cm^{-1} region.

Table 1 shows that no oxidation of alcoholic hydroxyl groups to carboxyl groups took place in this system. The small decrease in carboxyl groups is probably due to the solubilization of acidic impurities. The total carbonyl content increased slightly from 14.7, for untreated cotton, to 18.0 m-equiv/kg after 22 hr of treatment. This increase in total carbonyl groups is due to the formation of reducing end groups resulting from chain cleavage.

Infrared spectra of the regenerated cellulose samples were similar to the original cellulose in the 3600–2800 cm^{-1} region. In the 1500–1000 cm^{-2} region, absorption bands of the regenerated cellulose samples were more diffuse in character.

TABLE 1
Analyses of regenerated cellulose from solutions of NO_2 in DMF

Sample	Time of treatment (hr)	N (%)	Carboxyl (m-equiv/kg)	Carbonyl (m-equiv/kg)
Untreated Cotton	...	...	9.8	14.7
A	0.08	0.03	8.5	12.3
B	1.00	0.25	..	..
C	5.00	0.40	..	..
D	22.00	1.03	8.3	18.0

The results indicate that for short treatment times at room temperature, little or no chemical modification of the cellulose takes place in this system. It appears likely that solution takes place through solvation of the hydroxyl groups of cellulose by NO_2-DMF adducts, stable in highly polar solvents.—L. P. Clermont, Forest Products Laboratory, Ottawa, Ont.

Chemical Analysis of Atropellis Canker-Infected Lodgepole Pine.—The fungus, *Atropellis piniphila* (Weir) Lohm. and Cash, causes a canker on lodgepole pine [*Pinus contorta* Dougl. var. *latifolia* Engelm.] growing in the southern foothills of Alberta and eastern B.C. This perennial canker causes a distortion of growth with a resinous blue-black staining of both sapwood and heartwood. During the course of a literature survey on pulping of this species, it became apparent that no chemical analysis data existed for this infected wood. This note reports analytical findings that were obtained as part of the pulping studies.

Table 1 shows the chemical analyses of healthy and infected lodgepole pine. The sugar contents were determined by complete acid hydrolysis of the extracted wood, followed by reduction of the neutralized hydrolyzate and then gas-chromatographic evaluation of the acetates of these reduced sugars.

On a percentage weight basis, the infected wood contained lesser amounts of all the constituent sugars, especially glucose and mannose, while the uronic acid anhydride content (CO_2-producing material) increased almost two-fold. The increase probably results from the presence of acidic degradation products of the fungus, which are capable of liberating carbon dioxide during the uronic anhydride analysis. The sugar analyses indicate that some glucomannan and some cellulose are the main components lost, while the tree produces abnormally large amounts of resin in an attempt to resist the fungus.

The slightly smaller amount of lignin determined for the infected wood may result from higher resin production or may be just a consequence of positional difference within or between trees.

The very high extractives content of the infected wood is important for any area where these materials are being utilized. The results obtained in this laboratory by I. H. Rogers show a crude resin acid content of 62% of the total acetone extractives, no fatty acids being detected. Turpentine yield amounted to 16.63 U.S. gallons per o.d. short ton of wood.

On an extractive-free wood basis, the carbohydrate content of the infected wood does not differ greatly from that of healthy wood. The density of the infected wood is considerably greater and, therefore, on a volume basis the pulp yield of infected wood would be expected to be normal or slightly higher than normal. Since the lignin contents of the woods are close in value, their cooking rates should be similar; however the increased acid content (sugar acids and resin acids) would mean an increase in the alkali consumption when the infected wood is cooked.—K. Hunt and A. Kuechler, Forest Products Laboratory, Vancouver, B.C.

TABLE 1
Chemical analyses of healthy and infected lodgepole pine.

Lodgepole pine		Arabinose %	Galactose %	Xylose %	Mannose %	Glucose %	Uronic Acid Anhydride %	Klason Lignin %	Alcohol: Benzene (1:2) Extractives % o.d. wood	Density lb./cu ft
Healthy	a	1.0	4.5	8.0	12.4	42.8	4.15	28.1	2.3	28
	b	0.6	2.2	4.3	5.8	20.0	1.6			
Infected	a	1.0	4.4	7.8	10.4	40.8	7.35	26.9	23.6	45
	b	0.6	2.2	4.4	5.1	20.0	2.9			

[a]Sugars expressed as percentage of original oven-dry, extractive-free wood.
[b]Sugars expressed as mole ratios.

Continued from page 00)

Kasper, J. B. and T. Szabo. 1970. The physical and mechanical properties of whitebark pine. Forest. Chron. 46 (August).

Kennedy, R. W. 1970. Specific gravity of early- and late-flushing Douglas-fir trees. Tappi 53:1479-1481.

Logan, K. T. 1970. Adaptations of the photosynthetic apparatus of sun- and shade-grown yellow birch (*Betula alleghaniensis* Britt.). Can. J. Bot. 48:1681-1688.

MacHattie, L. B. 1970. Kananaskis valley temperatures in summer. Amer. Meteorol. Soc. 9:574-582.

Marshall, Valin G. 1970. Tydeid mites (Acarina: Prostigmata) from Canada. I. New and redescribed species of *Lorryia*. Ann. Soc. Entomol. 15:17-52.

McCraw, W. E. and R. M. Hallett. 1970. Studies on the productivity of skidding tractors. Dep. Fish. Forest., Can. Forest. Serv., Pub. 1282. 38 p.

Moeck, Henry A. 1970. An olfactometer for the bio-assay of attractants for scolytids. Can. Entomol. 102:792-796.

Morris, Oswald N. 1970. Precocious development of adult characteristics in virus-infected Lepidoptera. J. Invertebr. Pathol. 16:173-179.

Morris, Oswald N. 1970. Metabolic changes in diseased insects. III. Nucleic acid metabolism in Lepidoptera infected by densonucleosis and *Tipula* iridescent viruses. J. Invertebr. Pathol. 16:180-186.

Nanassy, A. J. 1970. Overlapping of dielectric relaxation spectra in oven-dry yellow birch at temperatures from 20 to 100°C. Wood Sci. Tech. 4:104-121.

Nijholt, W. W. 1970. The effect of mating and the presence of the male ambrosia beetle, *Trypodendron lineatum*, on "secondary" attraction. Can. Entomol. 102:894-897.

Park, J. Y. 1970. Antifungal effect of an ectotrophic mycorrhizal fungus, *Lactarius* sp., associated with basswood seedlings. Can. J. Microbiol. 16:798-800.

Parker, A. K. 1970. Effect of relative humidity and temperature on needle cast disease of Douglas-fir. Phytopathology 60:1270-1273.

Petty, J. A. and G. S. Puritch. 1970. The effects of drying on the structure and permeability of the wood of *Abies grandis*. Wood Sci. Tech. 4:140-154.

Pnevmaticos, S. M., F. J. Petro, and I. B. Flann. 1970. Yellow birch log attributes and sawmill productivity. Forest Prod. J. 20(8):53-58.

Quednau, F. W. 1970. Competition and co-operation between *Chrysocharis laricinellae* and *Agathis pumila* on larch casebearer in Quebec. Can. Entomol. 102:602-612.

Quednau, F. W. 1970. Notes on life-history, fecundity, longevity, and attack pattern of *Agathis pumila* (Hymenoptera: Braconidae), a parasite of the larch casebearer. Can. Entomol. 102:736-745.

Reid, R. W. and H. Gates. 1970. Effect on temperature and resin on hatch of eggs of the mountain pine beetle (*Dendroctonus ponderosae*) Can. Entomol. 102:617-622.

Roberge, M. R. 1970. Behavior of urease added to unsterilized, steamsterilized, and gamma radiation-sterilized black spruce humus. Can. J. Microbiol. 16:865-870.

Sahota, T. S. and A. Mansingh. 1970. Cellular response to ecdysone: RNA and protein synthesis in larval tissues of oak silkworm *Antheraea pernyi*. J. Insect. Physiol. 16:1649-1654.

Shaw, George Gerald. 1970. Grease-film extraction of an arthropod: a modification for organic soils. J. Econ. Entomol. 63:1323-1324.

Shaw, D. D. 1970. The supernumerary segment system of *Stethophyma*. I. Structural basis. Chromosoma (Berlin) 30:326-343.

Smirnoff, W. A. 1970. Rhombohedral twisted crystalloids found in the cytoplasm of nuclear-polyhedrosis-infected larvae of the uglynest caterpillar. Can. J. Microbiol. 16:906-907.

Recent Publications

Agnihotri, V. P. 1970. Solubilization of insoluble phosphates by some soil fungi isolated from nursery seedbeds. Can. J. Microbiol. 16:877-880.

Bailey, G. R. 1970. A simplified method of sampling logging residue. Forest. Chron. 46 (August).

Brown, J. E. 1970. New silvicide proves potent for thinning dense stands. Pulp Pap. Mag. Can. (July 3).

Brownell, Harold H. 1970. Spruce milled wood lignin and lignin-carbohydrate complex: molecular size and shape and frequency of lignin-carbohydrate linkages. Tappi 53:1278-1281.

Croome, G. C. R. 1970. A trial of selection management in a mature fir-spruce-birch forest. Forest. Chron. 46 (August).

Dobie, J. and D. M. Wright 1970. The lumber recovery factor revisited. B. C. Lumberman (May).

Embree, D. G. 1970. The diurnal and seasonal pattern of hatching of winter moth eggs, *Operophtera brumata* (Geometridae: Lepidoptera). Can. Entomol. 102:759-768.

Evert, F. 1970. Black spruce growth and yield at various densities in the Ontario clay belt. Forest Sci. 16:183-195.

Fast, Paul G. 1970. Insect lipids. *In* Progress in the chemistry of fats and other lipids. Vol. II, Part 2. R. T. Holman (*ed*). Pergamon Press, Oxford and New York. pp 181-242.

Feihl, O. and V. Godin 1970. Rotary cutting of veneer from white spruce. Dep. Fish. Forest., Can. Forest. Serv. Pub. 1281. 12p.

Fortescue, J. A. C. and G. G. Marten. Micronutrients: Forest ecology and systems analysis. *In* Ecological studies. Analysis and synthesis, Vol. 1. D. E. Reichle (*ed*). Springer-Verlag, Berlin. 1970.

Fowler, D. P. Maternal effects in red pine, *Pinus resinosa* Ait., and their implications to provenance and progeny testing. *In* Proc. Int. Union Forest Res. Organ., Sect. 22, Working Group Meet, at Varparanta, Finland, May 28-June 5, 1970. 11p.

Fox, Selwyn, P. 1970. Radial stresses in curved glulam members. Can. Constr. Eng. (August).

Funk, A. 1970. Fungal symbionts of the ambrosia beetle *Gnathotrichus sulcatus*. Can. J. Bot. 48:1445-1448.

Funk, A., and J. Kuijt. 1970. *Dermea rhytidiformans* n. sp., the fungus associated with cork-bark of alpine fir. Can. J. Bot. 48:1481-1483.

Gardiner, L. M. 1970. New northern Ontario spruce beetle compels May start on log spraying. Can. Forest Ind. (July).

Godin, V. 1970. The grinding of veneer knives. Dep. Fish. Forest., Can. Forest. Serv. Pub. 1236 (Revised). 23p.

Hayashi, Y., and F. T. Bird. 1970. The isolation of cytoplasmic polyhedrosis virus from the white-marked tussock moth, *Orgyia leucostigma* (Smith). Can. J. Microbiol. 16:695-701.

Hayashi, Y. and S. S. Sohi. 1970. Metabolism of *Aedes aegypti* cells grown in vitro. 1. Incorporation of ^{3}H-uridine and ^{14}C-leucine. In Vitro 6:148-152.

Hocking, D. 1970. Semesan fungicidal dip controls canker diseases of poplar cutting in Alberta. Tree Planters' Notes. 21(3):18-20.

Hulme, M. A. and J. K. Shields. 1970. Biological control of decay fungi in wood by competition for non-structural carbohydrates. Nature. 227-300-301.

(*Continued on page 59*)