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ENTOMOLOGY

Arthropod Taxa Common to Cronartium Cankers and the Forest Litter Layer.—Powell (Can. Entomol. 103:908-918, 1970), listed the arthropod fauna associated with cankers of the comandra blister rust [*Cronartium comandrae* Peck] on lodgepole pine [*Pinus contorta* Dougl. var. *latifolia* Engelm.] in Alberta. Three of the 160 species reported were shown to be mycetobionts; others were considered to be mycetophiles or mycetoxenes. Some of the insects overwintered in the rust canker, but others were thought to inhabit the soil and forest litter layers at the base of the tree. As a separate aspect of the study, samples of the litter layer from around 30 rust-infected trees were collected at six locations in southwestern Alberta, 10 in mid-April 1969 and 20 in mid-September 1970. The locations, method of collection and rearing of the associated arthropod fauna and the total list of 327 taxa collected are given in another report (Powell and Skaley, Can. For. Serv., North. For. Res. Cent., Inf. Rep. NOR-X-130, 1975).

This note summarizes the taxa found on the rust canker and in the forest litter at the base of infected trees, and gives the numbers collected in each habitat (Table 1). In some cases the taxa have been grouped by genera rather than by species to make the habitat lists more comparable, because of the difficulty in identifying certain specimens. Of the 42 taxa listed, the larval stages of three species, *Epuraea obliquus, Mycodiplosis* sp. and *Paracacoxenus guttatus,* are dependent on the host fungus for food (Powell, Can. Entomol. 103: 908-918, 1970). Larvae or puparia of the drosophilid fly, *P. guttatus,* probably drop from the canker to the forest floor to overwinter, emerging as adults in the spring. This may also be the case with the cecidomyiid fly, *Mycodiplosis* sp., although only three adult specimens were reared from the litter some may overwinter in the rust canker. The larvae of the nitidulid beetle, *E. obliquus,* appear to overwinter in the canker, as none were collected from the litter. The mycetobiont species are probably restricted to areas of the forest floor around rust-infected trees, whereas most of the other species given in Table 1 may be found elsewhere on the forest floor.

Of the other species encountered in both habitat niches the *Bradysia* spp. were most common, along with the mites *Dentizetes rudentiger* and *Diapterobates principalis,* and the springtails of the *Tomocerus flavescens* group. The adult weevils, *Pissodes schwarzi* and *Cylindrocopturus deleoni,* the beetle, *Corticaria* sp., and the micromoths, *Laspeyresia* sp. and *Eucordylea starki,* were incidental in the litter. The numbers of individuals of other species found in the two habitats were generally low in one or both habitats, indicating that these are not their normal or only habitats or that they only occur in limited numbers.

I am indebted to taxonomic specialists at the Biosystematics Research Institute, Canada Department of Agriculture, Ottawa, for the identification of most of the arthropod material.

TABLE 1

List of arthropod taxa found in the forest litter layer which had earlier been found associated with cankers of the comandra blister rust on lodgepole pine

	No. of specimens Canker	Litter
ARANEIDA		
Clubiona sp.	4	15
ACARINA		
Proctolaelaps spp.	1	11
Bdellodes longirostris (Hermann)	3	1
Abrolophus sp.	1	1
Bochartia sp.	1	15
Tyrophagus putrescentiae (Schrank)	3	1
Camisia biurus Koch.	2	7
Scheloribates sp.	1	7
Dentizetes rudentiger Hammer	10*	767
Diapterobates principalis (Berlese)	260*	81
Trichoribates sp.	5	6
COLLEMBOLA		
Hypogastrura spp.	28	1
Entomobrya nivalis (L.)	3	2
Entomobrya sp. immature	1	10
Tomocerus flavescens Tullberg grp.	27	12
PSOCOPTERA		
Peripsocus sp.	1	1
THYSANOPTERA		
Taeniothrips sp.	1	1
Haplothrips sp.	1	4
HOMOPTERA		
Cinara medispinosa (G. & P.)	120*	13
NEUROPTERA		
Coniopterygidae undetermined sp.	2	4
COLEOPTERA		
Calathus ingratus Dej.	1	2
Epuraea obliquus Hatch	210*	28
Corticaria sp.	15*	1
Melanophthalma sp.	7	2
Pissodes schwarzi Hopk.	35*	2
Cylindrocopturus deleoni Buchanan	79*	2
LEPIDOPTERA		
Laspeyresia spp.	28*	1
Eucordylea starki Free.	8*	2
DIPTERA		
Tipula sp.	1	4
Bradysia spp. (at least 4 spp.)	494*	803
Lestremiinae spp. immature	10*	2**
Mycodiplosis spp.	110*	3
Phora spp.	4	1
Megaselia (*Aphiochaeta*) spp.	4	3
Leucopis spp.	1	11
Paracacoxenus guttatus H. & W.	91*	57
HYMENOPTERA		
Aparteles sp.	5	1
Mastrus sp.	1	2
Gelis sp.	1	2
Lissonota sp.	1	1
Eurytoma sp.	4	3
Ceraphron sp.	1	1

* Species more common than the number of specimens collected would indicate.

** An underestimate, because four other specimens of the subfamily Lestremiinae were identified to genus or tribe from the forest litter (Micromyini, *Micromya, Bryomyia).*

Other specialists who contributed to the identifications were R. J. Gagné, U.S. Department of Agriculture, Systematic Entomology Laboratory, Washington, D.C. (Cecidomyiidae); B. Heming, Department of Entomology, University of Alberta, Edmonton, Alberta (Thysanoptera); and C. T. Parsons, Manchester Depot. Vermont (*Epuraea*).—J. M. Powell, Northern Forest Research Centre, Edmonton, Alta.

FIRE

Foliar Moisture Trends During Bud Swelling and Needle Flush in British Columbia.—Troublesome spring fires in British Columbia are not necessarily associated with lack of moisture in deep organic soil layers. At this time, when short-term drying conditions make it possible for surface fires to initiate and spread, fire control problems can be intensified by the low moisture content of conifer needles. These low foliar-moisture contents reinforce the ground fire potential and contribute to the ease of crowning when the fuel arrangement is favorable. Evidence (Gary, Rocky Mountain Forest and Range Experiment Station, Bot. Gaz. 132(4):327-332, 1971) suggests that the decline in 1-year-old spruce needle moisture content before flushing, and subsequent increase in moisture content, are primarily the result of temporary increase in dry weight of the needles which may amount to 30%. After flushing has taken place, the increase in relative moisture content of old needles becomes a matter of academic interest when compared with the much higher moisture contents of new needles and new leaves of associated undergrowth.

Previous studies have shown significant drops in the moisture content of 1-year-old conifer needles in Ontario (Van Wagner, Dep. For. Rural Develop., For. Br. Pub 1204, 1967) and in Alberta (Kiil and Grigel, Dep. Fish. For., Inform. Rep. A-X-24, 1969) during this period; and the suggestion has been made that low soil temperatures might cause water intake to be insufficient for the demands of transpiration at this time.

The sampling program herein reported was undertaken to (a) determine the magnitude of the effect with relatively warm unfrozen soil conditions, and (b) to demonstrate that altitudinal differences can be significant during this period.

Routine sampling of 1- and 2-year-old needles collected from a 10-year-old plantation near the Pacific Forest Research Centre was initiated in early February 1973. On each sampling afternoon, two 2-gram needle samples were collected from the 1- and 2-year-old branches of selected conifers. Each sample was a composite from locations around the lower third of the crown. The samples were weighed, oven-dried for approximately 20 hours at 100°C and then reweighed to determine the moisture content as a percentage of the oven-dry weight. Site differences combined with tree vigor and genetic variation between neighboring trees of the same species result in moisture differences of as much as 20%; but, within their respective time scales for flushing, all trees appear to exhibit the same seasonal trends.

Figure 1 shows the trend of needle moisture content and indicated date of flushing of the new needles. Table 1 compares

TABLE 1

The range in foliar moisture for one-year needles of several western and eastern Canadian tree species in spring and summer

	Grand Fir	Western Hemlock	Douglas-fir	Norway spruce	Pine species	Balsam fir	White spruce
Max M.C. %	176	156	142	106	125	113	115
Min M.C. %	127	110	96	77	99	89	84
Range %	49	46	46	29	26	24	31

Figure 1. Needle moisture traces for four western conifers.

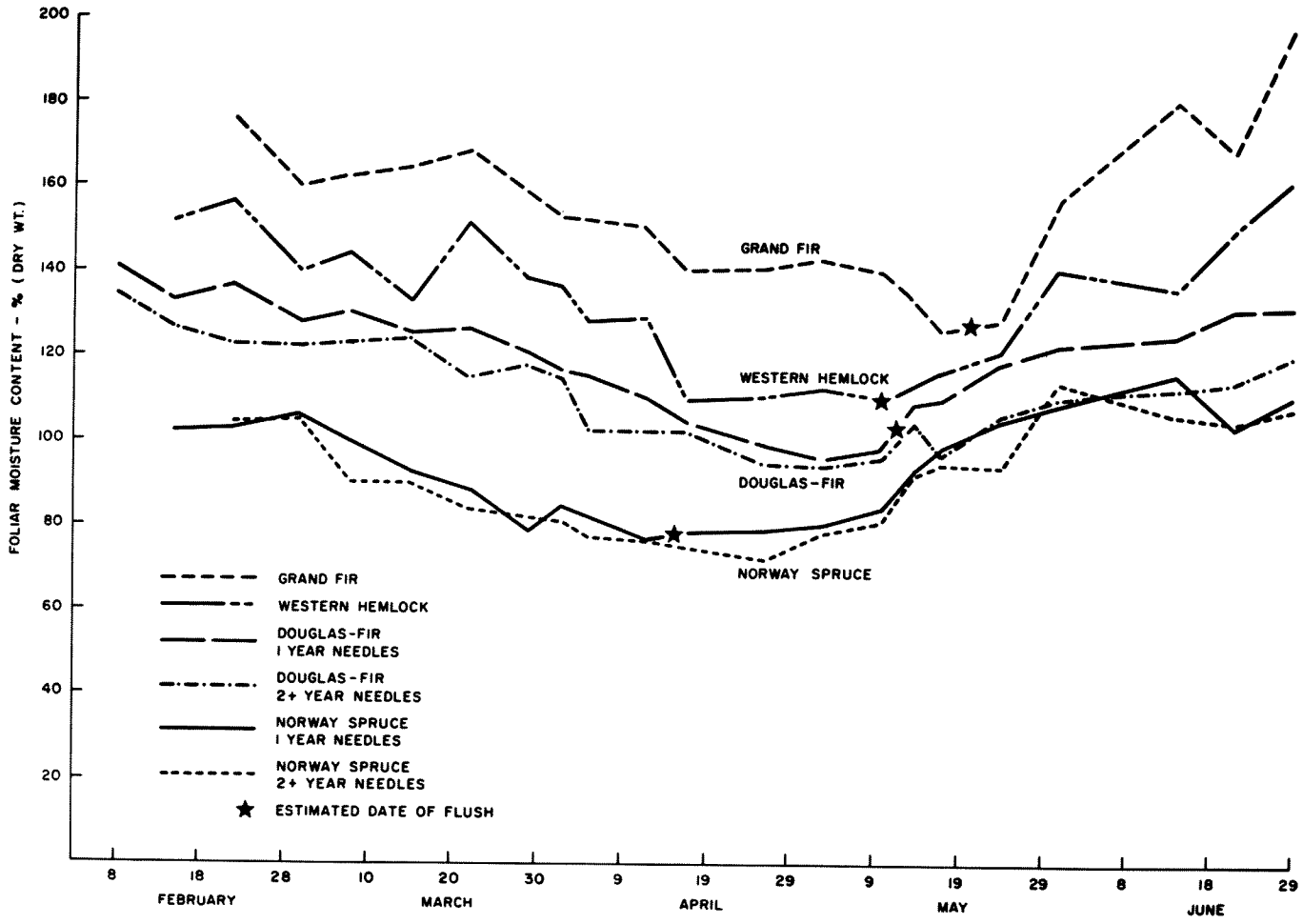
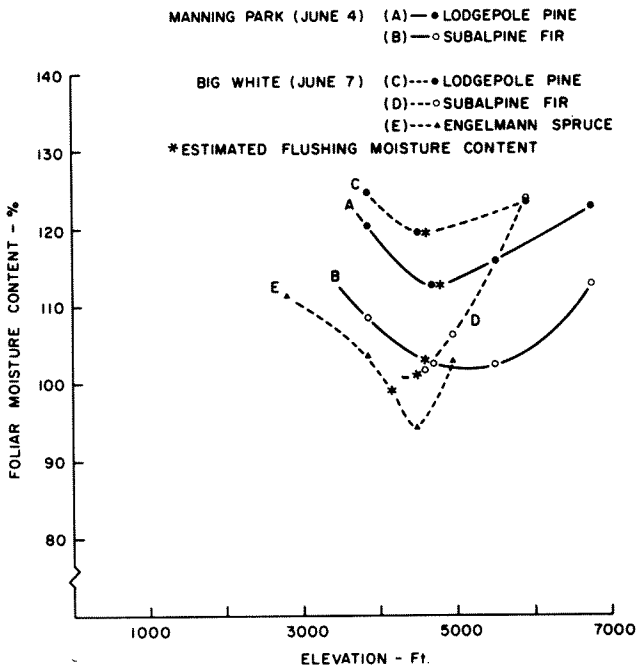


Figure 2. Needle moisture contents at varying elevations in the southern interior of British Columbia in early June.



the ranges of moisture content found in this study with those found by Van Wagner (loc. cit. table 4) in eastern Canada. The levels of moisture in all needles show a gradual decrease, reaching a minimum in late April to early May. These trends are similar to Van Wagner's, although the minimum moisture levels occur approximately 3 weeks earlier, coinciding with the time of flush for this region.

By using the same methods of collection as on the coast, additional needle samples were collected over a range of elevations near the Manning Park Lodge and Big White Mountain in the southern interior of British Columbia, on 4 June and 7 June 1973, respectively. Beginning at the highest possible elevation and sampling at approximately 500-foot intervals, decreasing foliar moisture levels were found down to the elevations where flushing was just being initiated (Fig. 2). The variation of moisture content with elevation on these two transects illustrates the existence of a zone of minimum foliar moisture content that would be expected to progress upwards as the season and state of flush advances. This progression is currently being investigated in the vicinity of Castlegar, B.C.

The existence of this zone of minimum foliar moisture, and its location at any given time, is a fuel factor which deserves recognition by fire managers.—R. N. Russell and J. A. Turner, Pacific Forest Research Centre, Victoria, B.C.

FOREST PRODUCTS

Purification of Tetrachlorophenol.—Chlorinated phenols are among the most commonly used pesticides for the protection of manufactured products, including wood. There is a need to be able to produce individual chlorinated phenols and a number of methods are available for dichlorophenol, trichlorophenols (Milnes, Ger. Offen. 2060844, 14 pp., 1971; Renner and Stein, Ger. Offen. 2004985, 6 pp., 1971; Greco, W. J. Jr., Ger. Offen. 2121445, 12 pp., 1971; Sharov *et al.*, U.S.S.R. 326169, 1972) and pentachlorophenol (PCP) (Renckhoff and Steneberg, Ger. Offen. 1080565, 2 pp., 1960), but we have found no method of purification for tetrachlorophenol (TCP).

During experiments on the possible escape of PCP and TCP from heated TIMBOR solution (disodium tetraborate octahydrate) of a pH of 7.0 used to treat lumber against insect and fungal attack in service, it was observed that TCP has much higher volatility than PCP from this solution; therefore, the possibility of using steam distillation from buffered solution was tested as a means of TCP purification.

A solution (300 ml) of 100 g TIMBOR and 5 g technical TCP (containing about 16% PCP as impurity) was distilled, keeping its volume constant. Distillates in 25-ml fractions were collected. The amount of chlorinated phenols in these fractions was determined (Table 1) by gas chromatography (Cserjesi and Johnson, Can. J. Microbiol. 18:45-49, 1972).

TABLE 1

The amount of TCP and PCP in 25 ml fractions collected by distillation of technical TCP from a solution containing TIMBOR

Fractions	TCP mg	PCP mg	Total mg	% TCP
1st	93	2	95	97.9
3rd	115	3.5	118.5	97.1
5th	116	3.5	119.5	96.8
7th	80	3	83	96.4

In a following experiment, the first 100-ml fractions were collected from six distillations of TIMBOR solutions as described above to obtain higher purification. Redistillation of the collected 600-ml solution gave better than 99.6% pure TCP in the first 100 ml of distillate.

Raising of the pH to 8 by the addition of NaOH solution results in almost no PCP in the distillate, but with a low yield of TCP. Depending on requirements, an adjustment of the pH between 7 and 8, or redistillation, will produce TCP of higher purity than 97-98% if desired.—A. J. Cserjesi and E. L. Johnson, Western Forest Products Laboratory, Vancouver, B.C.

MENSURATION

A Simple and Quick Method to Assess Yearly Diameter Growth Response to Fertilization in Natural Forest Stands.—The choice of models to evaluate the effect of different treatments on natural forest stands presents numerous problems in experimental design and in analysing results because it is difficult to find natural forest stands large enough to contain the numerous homogeneous sample plots required for a sound, conventional statistical analysis. Although plots are selected for their relative homogeneity, they nearly always differ either in number of trees, diameter class distribution, or stocking density. Also variations in growth rate for a given tree in a diameter class may mask the effect of various treatments over a short period of time.

To obtain the highest financial benefits, fertilization must take place about 10 years before harvesting when diameter increment is low. Because of this slow growth rate, often many years must elapse before diameter growth response to fertilization becomes evident when data are subjected to analysis of variance or covariance. With these techniques, acceptable results are obtained only after considerable time is spent adjusting the initial variation due to uncontrollable factors. Even then the error variance, although reduced, is not excluded. In fertilization experiments where annual measurements of the response to treatments are needed, analyses of variance or covariance fail because differences are slight and often masked by plot variability.

Whyte (personal communication, School of Forestry, University of Canterbury, Christchurch, New Zealand, 1974) sug-

gested that researchers, who wish to evaluate yearly growth response to fertilization, should concentrate on obtaining reliable and detailed information on a suitable representative sample from each treatment, and analyse differences between treatments on one or more traits per tree rather than analysing data from all measured trees.

This note describes a simple and quick method of assessing growth response of natural stands to fertilization by a statistical treatment of data from representative trees. This approach does not prevent recording yearly measurements of all trees. Yearly recording is advisable since it gives tree mortality for every diameter class and, in case of serious windfall, insect infestation, or other disaster, the fertilization trial is not a total loss. However, after using the "quick" method for a number of years, it is my opinion that the effort spent on analysing data, yearly, from all trees does not merit the results obtained. As an alternative, the "single tree method" where trees are paired is proposed. The efficiency of this method is dependent on two strict rules: 1) representative trees that are paired must be as similar as possible; 2) pairs of trees, one from the treatment and one from the control plot, must be randomly selected from among the sample pairs.

Within a randomly-selected sample plot a certain number of trees representative of various diameter classes of the stand are randomly-chosen. Trees are identified according to diameter, height, position in the stand, crown class, distance from neighboring trees, apparent pathological conditions, etc. Taking these factors into account, trees from treated and from the control plots are matched by diameter at breast height. Then, a choice at random can be made between the main diameter classes to evaluate yearly reaction to fertilization for various tree sizes. Growth increment can be assessed either by the "t" test method or by analysis of variance or covariance. In the present case comparison between two sample plots was made by the "t" test method.

Since the efficiency of the described method is dependent upon the degree of similarity of matched trees, the value of pairing should be determined by the two-tailed "t" test.

Before fertilization, the difference between the average diameter of the two groups of trees was not significant and th pairing of trees by diameter was well done (Table 1).

To evaluate the effect of fertilization on diameter growth of paired trees it must be assumed that fertilization cannot inhibit growth of the treated trees. The hypothesis must be raised that diameter growth increment of fertilized trees after x years is greater than that of non-fertilized trees. This assumption should be tested by the "t" test (Table 2).

Differences in diameter growth, expressed in percentage, are more precise than straight differences. On the other hand, it lessens the chances of obtaining a significant difference. Indeed, using the straight differences between growth, the "t" test value would have been 3.8598 rather than 3.4422 (Table 2).

At the end of a fertilization experiment, when all trees will be cut for determination, conventional techniques, such as variance or a covariance analyses, will be required to evaluate growth, i.e. the effect of fertilization. However, during fertilization trials of natural forest stands, company foresters will want to know annually, with a high degree of accuracy, the growth response to treatments. The "single tree method" where trees are paired is simple, quick and sufficiently accurate because absolute values are compared whereas, with classical methods average or adjusted values are compared.

The "single tree method" where paired trees are matched in terms of dbh, height, position in the stand, crown class, distance from neighboring trees, apparent pathological conditions, etc., does not replace conventional methods, but it gives a quick and simple method of annually evaluating the effects of fertilizers on a natural stand.

TABLE 1

Two-tailed "t" value for test of difference in diameter before treatment

Trees fertilized		Control trees				
Tree no.	Diameter (1967)	Tree no.	Diameter (1967)	Difference (d)	$d-\bar{d}$	$(d-\bar{d})^2$
979	.91	4421	.92	−.01	.0485	.002352
2986	4.14	4465	4.07	.07	.1285	.016512
948	2.53	4475	2.50	.03	.0885	.007832
928	7.44	4457	7.70	−.26	−.2015	.040602
910	1.29	9381	1.30	−.01	.0485	.002352
—	—	—	—	—	—	—
—	—	—	—	—	—	—

Total difference (d) $= -1.17$
Mean difference $(\bar{d}) = 1.17 - 20 = -.0585$
Summation $(d-\bar{d})^2 = 1.6797$
Number of pairs $= 20$

$$s_d^2 = \sum_1^N \frac{(d-\bar{d})^2}{N-1} = \frac{1.6797}{19} = .0884 \qquad t = \frac{4.4721 \times .0585}{.2973} = 0.879 \text{ N.S.}$$

With 19 D.F. for P = .05, t = 2.09

TABLE 2

One-tailed "t" test of significance in diameter growth after treatment expressed as percentage of original diameter

Tree no.	Dia. 1972 / Dia. 1967	Tree no.	Dia. 1972 / Dia. 1967	Difference (d)	$d-\bar{d}$	$(d-\bar{d})$
979	1.15 / 0.91	4421	0.94 / 0.92	.2420	.1912	.036557
2986	4.48 / 4.14	4465	4.16 / 4.07	.0600	.0092	.000085
948	2.80 / 2.53	4475	2.79 / 2.50	−.0093	−.0601	.003612
928	7.90 / 7.44	4457	8.00 / 7.70	.0229	−.0279	.000778
910	1.35 / 1.29	9381	1.35 / 1.30	.0080	−.0428	.001832
—	—	—	—	—	—	—
—	—	—	—	—	—	—
Total $\bar{d}$	$1.0161 \div 20 =$			1.0161 / .0508		.082859

$N = 20 \quad \bar{d} = .0508 \quad s_d^2 = \dfrac{\sum_1^N (d-\bar{d})^2}{N-1} = \dfrac{0.082859}{19} = 0.0044$

$$t = \frac{4.4721 \times 0.0508}{0.0663} = 3.422 \text{ H.Sig.}$$

With 19 D.F. for P = .005, t = 2.86
With 19 D.F. for P = .0005 t = 3.88

A useful complement to this method is the competition index described by Areny (Can. For. Serv. BC-X-78, 1973.)

The author wishes to thank Dr. A. W. Douglas of the Computing & Applied Statistics Directorate, Ottawa for his comments on statistical procedures.—J. D. Gagnon, Laurentian Forest Research Centre, Quebec, Que.

PATHOLOGY

Fungitoxic Effects of Fatty Acid Salts.—An investigation of the effects of fatty acids and soaps on *Adelges piceae* (Ratz.) showed that the insecticidal activity of saturated fatty acids increased with increasing carbon number and reached a peak around capric acid (C_{10}) (Puritch and Talmon de l'Armee, Bi-mon. Res. Notes, 30:35-36, 1974). A second peak of insecticidal activity occurred around the unsaturated 18-carbon fatty acids, oleic and linoleic. Activity was similar for the fatty acid salts. Reports have indicated that fatty acids around capric are also toxic to fungi. Rothman, Smiljanic and Weitkamp (Sci. 104:201-203, 1946) found that a combina-

tion of fatty acids in the range of C_7 to C_{11} inhibited growth of *Microsporon audouini* Gruby, the ring-worm fungus, at concentrations of 0.0002 to 0.0005%. Wyss, Ludwig and Joiner (Ann. Biochem. 7:415-425, 1945) showed that the optimum saturated fatty acid chain length for fungistatic action varied according to the organisms tested and solubility, and was C_{11} for *Aspergillus niger* van Tiegh, C_{13} for *Trichophyton interdigitale* Priestley and C_{14} for *T. purpurem* Pres. Kitajima and Kawamura (Bull. Imp. Forestry Exp. Stn., Japan 31:108-113, 1931) bioassayed the effects of fatty acids on the wood-rot fungi *Poria vaporaria* Pers. and *Paxillus panuoides* Fr. and found that activity increased with chain length and reached a maximum around C_{12} (lauric acid). We tested the response of some common forest fungi to certain fatty acid compounds in the form of water-soluable potassium salts (soaps).

The agar-plate bioassay method described by Etheridge and Craig (Can. J. Microbiology, 19:1455-1458, 1973) was adapted for these tests. Appropriate concentrations of the soap solutions were incorporated into 2% malt agar, autoclaved at 120 C for 20 min and then poured into petri dishes. The pH of controls was adjusted to that of the autoclaved soap-agar solutions by adding of 1 *N* KOH before sterilization. Infrared spectrophotography showed that sterilization did not affect the chemical structure of the soaps. The fungitoxicity of the soaps was evaluated by the growth response of up to 10 isolates of each organisms on a single layer of the agar-soap mixture. Fungicidal activity was determined by transferring the inoculum plugs at the end of the test to fresh untreated malt agar.

By the agar-plate bioassay method, a 0.15% solution of K caprate was tested against seven isolates each of *Fomes annosus* (Fr.) Karst. and *Armillaria mellea* (Vahl ex Fr.) Kummer and four isolates of *Poria weirii* Murr. The treatments were replicated twice with two controls for each fungus. After 10 days, all isolates on the K caprate-agar were killed; controls showed abundant growth. Fine, feather-like crystals in the agar indicated that capric acid had precipitated.

The fungitoxic effects of K caprate and K oleate soaps were tested against *F. annosus* on 1.5 cm discs of freshly cut western hemlock. The discs were sterilized on both sides for 0.5 hr with ultraviolet light, placed in sterile petri dishes and sprayed to run-off with K caprate or K oleate at each of the following concentrations: 0.005, 0.05, 1.0 and 1.5%. There were three replicates per treatment; the six controls were sprayed with sterile distilled water. Two hours after spraying, inoculum plugs from the margin of 10 isolates of *F. annosus*, prepared according to the agar-plate bioassay method, were placed mat-side-down on the discs. The discs were incubated at room temperature and 100% relative humidity for 7 days. The fungitoxic effect was evaluated according to the scale: 0 = no mycelial growth on inoculum plug; 1 = growth on the plug of a few scattered mycelial bristles; 2 = growth uniform around plug but not on entire surface; 3 = growth on entire plug surface but not on adjoining wood disc; 4 = growth on adjoining disc less than 1 mm from plug (colony diam. < 6 mm); 5 = growth on adjoining disc more than 1 mm from plug.

Results (Table 1) show higher concentrations of K caprate inhibit growth, although the degree of inhibition varies with concentration and isolate. K oleate showed no toxic effect on *F. annosus*. A field trial is currently underway to test the effectiveness of K caprate as a stump treatment against *F. annosus*.

We also tested K caprate for fungitoxic effect against *Ceratocystis picea* (Munch) Bakshi (7 isolates), *C.* sp. (2 isolates) and *Europhium clavigerum* R. and D. (1 isolate), using the agar-plate method. Three concentrations (0.01, 0.1, 1.0%) were tested and each treatment was replicated three times. Fungitoxic effect was scored as descript, except that values greater than 3 indicate growth on agar rather than wood. After 18 days, all 10 isolates of the test fungi were killed by the 1.0% concentration, but only 7 by the 0.1 % and none by the 0.01% (Table 2). However sensitivity of the isolates to the different concentrations of K caprate was variable and had the bioassays been based on only one of the test isolates, e.g. one of the insensitive strains, or terminated after the shorter test period, fungitoxicity at the two lower concentrations would have been greatly overestimated. The toxic effect of K caprate on *Ceratocystis* spp. suggests that this compound should be tested against *C. ulmi*, the Dutch elm disease. Recently, Doskotch *et al.* (Phytopathology 65:634-635,1975) reported that capric acid will prevent spore germination of *C. ulmi, C. minor* (Hedge) Hunt, *C. fagacearum* (Bretz.) Hunt, *Nectria cinnabarina* Tode ex Fr. and *Fusarium solani* (Mart.) Appel and Wr. They also reported that it is a natural antifungal agent in *Ulmus americana* L. seed. However, the soaps, unlike fatty acids, are water soluble and preliminary results have shown that K caprate will move in the xylem stream of certain softwoods and hardwoods. Experiments are now underway to ascertain their mobility in white elm.

TABLE 1

Effect of various concentrations of K caprate on growth of *Fomes annosus* after 7 days on cut hemlock discs. Results shown are the average of 3 replications for each treatment and 6 for the controls

% K caprate	*Fomes annosus* isolates tested										
	1	2	3	4	5	6	7	8	9	10	Avg
0.005	5+	5+	5+	5+	5+	5+	5+	5+	5+	5+	5+
0.050	5+	5+	5+	5+	5+	5+	5+	5+	5+	5+	5+
0.500	4	3	4	3	2	1	3	2	2	5	2.9
1.000	0	0	0	2	0	0	0	0	0	0	0.2
1.500	0	0	0	0	0	0	0	0	0	0	0
Control	5+	5+	5+	5+	5+	5+	5+	5+	5+	5+	5+

TABLE 2

Effect of various concentration of K caprate on growth of *Ceratocystis picea* (isolates 1-7), *Europhium clavigerum* (isolate 8) and *Ceratocystis* sp. (isolates 9-10) after 18 days. Results are averages of 3 replicates. Values greater than 5 indicate colony diameter (mm)

% K caprate	*Ceratocystis picea*				*Europhium clavigerum*				*Ceratocystis* sp.		
	1	2	3	4	5	6	7	8	9	10	Avg
0.01	8.3	20	20	18	20+	20+	8	20+	20+	4	15.8
0.10	0	0	0	0	20+	20+	0	0	15.3	0	5.8
1.00	0	0	0	0	0	0	0	0	0	0	0
Control	20+	20+	20+	20+	20+	20+	20+	20+	20+	20+	20+

Our findings indicate that certain soap solutions warrant further testing as treatments against pathogenic fungi such as *Fomes annosus* and *Certatocystis ulmi*. Because soaps are water soluble, very low in phytotoxicity, cheap, fairly abundant and relatively harmless to humans, they should be reconsidered as fungal control agents.—George S. Puritch and D. E. Etheridge, Pacific Forest Research Centre, Victoria, B.C.

SILVICULTURE

Preliminary Observations on Mortality of Red Pine on a Calcareous Soil in Southern Ontario.—In two of the oldest plantations of red pine [*Pinus resinosa* Ait.] in Grey County, mortality has recently become apparent. The plantations are situated at approximately 44°15'N, 80°50'W and are known as the King and Grey Main plantations. The trees are between 30 and 35 years old and their diameters at breast height are mainly between 15 and 20 cm (5.85–7.8 in.). The Grey Main

plantation has been thinned; ground vegetation is sparse. Onset of the decline occurs at the dense pole stage, with diminution in leader length and chlorosis of the new needles. Older needles remain green. In the course of 1 or 2 years these symptoms intensify throughout the crown until, in the second or third year of the decline, new needles abort soon after flushing and older needles are chlorotic. Death of the trees ensues internode by internode from the leader as old leaves die and are shed. Blue staining of the wood in dead internodes was observed, but there was no evidence of fungal attack on living portions of the crown. Similarly, no larval galleries were found in the living wood or cambium of the trunk. The cambrium of the root collar remained alive until death of the crown was complete. Initially, the trees were observed to die in groups. However, the groups did not exhibit any consistent relationship to the macro or microtopography, and the decline now appears to be spreading randomly within the stand.

The soil material is a stony, generally well-drained, calcareous till of dolomitic origin. The soil profiles are considered to be intergrades between brown forest and grey-brown podzolic and are described under the Osprey series. The pH of the upper 10 cm (3.9 in.) of the soil ranges from 5.4 to 7.5, with a mean of 6.6. The crown symptoms alone suggested that the decline might accompany the development of a nutrient imbalance in the trees, while the symptoms associated with the initial occurrence of groups of dead trees indicated that a root-rotting fungus could be involved. During the summer and autumn of 1971, therefore, samples of both affected and unaffected red pines were examined for root defects, and foliage was analyzed for eight nutrient elements.

Examination of roots showed no stains or decays, typical of those caused by root-rotting fungi, in roots larger than 2–3 cm (0.78–1.7 in.) in diameter. In roots up to 4–5 cm (1.56–1.95 in.) in diameter on diseased living trees, the wood was light brown and saturated. However, there were no symptoms typical of red pine roots killed by an excess of soil water. Nor was the form of the root system flattened as described by Brown and Lacate (For. Res. Br. Tech. Note 108, 16p., 1961) for pine grown on very moist soils. Mycorrhizae were not well developed on any of the six living trees examined. On the living, diseased trees many fine rootlets were dead and 70–80% of the mycorrhizal tips on each tree were dark borwn and somewhat shrivelled; these mycorrhizae had a partially disintegrated Hartig Net suggestive of previously healthy mycorrhizae. The remaining 20–30% of the mycorrhizal tips, though functional, were not well developed. About 50% of the fine rootlets on the healthy tree in the King plantation, and 20% on the healthy tree at Grey Main, had light brown, slightly swollen mycorrhizae with a well-formed Hartig Net and mantle; however, they were still too sparse and poorly branched to be considered well developed. The remaining rootlets of the two healthy trees were dark brown and shrivelled, and displayed partial disintegration of the Hartig Net, similar to those on diseased, living trees. In one superficially healthy tree, feeder rootlet mortality was as high as that on trees with advanced symptoms, and this suggests that the initial stress may be accompanied by impaired absorption.

In September, 1971 foliage samples were taken from seven trees in the King plantation, selected to represent several stages of the disease from apparently healthy to almost dead. Samples were also obtained from two healthy trees in a 25-year-old plantation growing on a calcareous till near Williamsford, 2 miles (3.21 km) away, and from four 40-year-old red pine in a natural stand near Thessalon in northern Ontario. These latter trees were growing on acidic soil developed on outwash stand. The conditions of the trees from which foliar samples were taken were designated as follows: A, apparently healthy, no chlorosis; B, slight yellowing of upper crown, leader alive; C, leader dying, chlorosis of new growth throughout crown; D, leader and upper whorl dead, much of crown yellow; E, similar to D but most of crown yellow; F, top dead and defoliated, rest of crown yellow and defoliating, current year's needles aborted after ushing; G, similar to F but crown almost defoliated; W, healthy trees from the Williamsford plantation; T, healthy trees from the Thessalon stand.

The foliar concentrations of N, P, and K in healthy trees from the King and Williamsford stands were similar to those of the trees from the Thessalon stand. However, Ca and Mg concentrations were higher in the former stands than in the Thessalon stand. An increase in the severity of the decline (A–G, Table 1) was accompanied by an increase in the foliar concentrations of N, P, K, and Zn in young needles that probably was due to diminishing needle size. Whilst the ratios of concentration of P:N, Zn:N and K:N remained approximately constant during the course of the decline, the ratios of other elements to N varied considerably, and in a pattern that appeared to be associated with the intensity of decline. Of particular note in the affected trees are the relatively low Mn:N ratios in both ages of needle; the low Fe:N ratio of current foliage and the high Fe:N ratio of older foliage; high Ca:N and Mg:N ratios that are especially marked in the older leaves of the badly affected trees; and Fe:Mn ratios that are apparently aberrant in the early stages of the decline in both ages of needles.

TABLE 1

The concentrations of elements in red pine foliage from healthy and diseased trees

Condition of tree[a]	Foliar concentrations							
	N (%)	P (ppm)	K (%)	Ca (%)	Mg (%)	Fe (ppm)	Mn (ppm)	Zn (ppm)
	Current year's needles							
T	0.94	1250	0.44	0.14	0.08	32	240	23
W	1.06	1420	0.51	0.49	0.12	32	73	28
A	1.04	1150	0.48	0.43	0.11	28	22	37
B	0.94	1280	0.46	0.40	0.13	23	16	36
C	1.24	1560	0.63	0.50	0.16	26	33	55
D	1.11	1520	0.48	0.50	0.16	25	40	48
E	1.49	1770	0.58	0.51	0.15	30	55	55
F	1.64	1970	0.64	0.48	0.15	29	54	61
G	1.90	1690	0.51	0.49	0.19	23	47	44
	Older needles							
T	0.97	920	0.31	0.22	0.08	47	350	21
W	1.09	970	0.34	0.71	0.16	81	97	32
A	1.04	930	0.34	0.48	0.17	79	18	36
B	0.92	820	0.29	0.57	0.19	73	13	40
C	0.92	830	0.35	0.65	0.21	60	27	47
D	0.95	900	0.34	0.74	0.26	117	39	48
E	1.10	980	0.33	1.10	0.31	100	99	55
F	1.10	950	0.31	2.11	0.29	113	69	62
G	1.27	1120	0.27	0.90	0.29	64	90	32

[a] See text for descriptions.

The figures (Table 1) and visible symptoms indicate that the trees could be suffering from a lime-induced deficiency of Mn and/or Fe. Chlorosis and, in severe cases, death of the new needles symptomatic of lime-induced deficiency of Mn in Norway spruce [*Picea abies* Karst.] as described by Ingestad (Medd. från statens skogsforskningsinst, Band 48, Nr. 4, 20 p., 1958) and by Kreutzer (Forstwis. centralbl. 5:275-299, 1970). Peace (Pathology of trees and shrubs. Oxford Univ. Press, 753 p., 1962) cited an example of groups of trees dying in a stand of Scots pine [*Pinus sylvestris* L.] that grew on calcareous soil. Mortality was correlated with the occurrence of free lime in the soil and was attributed to lime-induced deficiency of iron. Peace also noted that lime-induced deficiencies may not appear until the canopy begins to close, or even later. Such could be the case in the King plantation.

This preliminary study has revealed striking aberrations in both the condition of the roots and of the concentrations and ratios of elements in the foliage of decadent red pine. Further studies are necessary to determine the relationships between these phenomena in southern Ontario plantations.—R. C. Ellis and R. D. Whitney, Great Lakes Forest Research Centre, Sault Ste-Marie, Ont.

Propagating Four Species of Spruce by Stem Cuttings.—*Picea*, a genus long designated as being difficult to propagate from stem cuttings, is now known to produce adventitious roots reasonably well provided the stock plants are young (Ruden, Can. Dep. Environ. Lib. Transl. OOENV TR-155, 9 p., 1972). However, cuttings from different tree species vary in rooting capacity. Shoots taken in spring from Norway spruce [*P. abies* (L.) Karst.] are generally easy to root, while shoots of red spruce [*P. rubens* Sarg.] are difficult (Girouard, Bi-mon. Res. Notes, 26:41, 1970). Rauter (Can. J. For. Res. 1:125-129, 1971) found cuttings of white spruce. [*P. glauca* (Moench) Voss], Shrenk spruce [*P. schrenkiana* Fisch. & Mey.] and their hybrid to root well, and those of black spruce [*P. mariana* (Mill.) B.S.P.], with less ease. Cuttings are generally collected and planted during two periods: summer or autumn-winter. In summer, semi-lignified shoots of the current season's growth are used once shoot elongation is nearly complete and winter buds are beginning to form (Larsen, Silvae Genet. 4(3):69-80, 1955). In autumn-winter, the propagation material consists of lignified shoots with bud-dormancy partially or totally removed by cool temperatures (Farrar, For. Chron., 15:152-163, 1939). Cuttings taken from higher branch orders (lateral shoots) root more readily than cuttings from lower orders (terminal shoots). However, lateral shoots retain a plagiotropic growth habit longer than terminal shoots (Fröhlich, Can. Dep. Environ. Lib. Transl. No. 332, 60 p., 1973). Plain cuttings, made with a cut above the base, are used in preference to cuttings with a heel (Roulund *et al.*, Plant Propag. 20(2):20-26, 1974). This article gives the results of three experiments, performed at different dates, which are related to the experiment reported by Girouard (Bi-mon. Res. Notes, 26:41, 1970).

Seedlings, 2-2 in 1966, of black, Norway, red and white spruce were grown in a nursery at the Forest Experiment Station, Valcartier, Quebec. Plants were extracted for propagation by cuttings on the following dates: 17 August 1967, when height growth was nearly complete and buds were visible; 1 November 1967, after repeated exposure to both freezing and thawing temperatures for at least 1 month: and 23 April 1968, before flushing. Plants were moistened and stored overnight in a cool room. For each collection date, plain cuttings were made by shearing the most recently formed terminal and lateral shoots; heel cuttings were made by tearing the youngest lateral shoots from supporting branches.

For each propagation date, the experiment was a 3 x 3 factorial in a randomized design. Each of the nine treatments were represented by 5 blocks of 20 cuttings. The cuttings, approximately 8 cm long, were inserted in perlite, 100 to a wooden flat (58 x 37 x 10 cm) and placed on benches in a greenhouse with an intermittent mist system operating for 10 sec every 10 min between 08:00 and 16:00 hr. Ventilation was provided automatically when the air temperature exceeded 21 C. Incandescent lamps, giving 1,620 lux at cutting level, provided additional illumination between 17:00 and 24:00 hr. Cuttings were examined after 11 weeks to determine the number rooted and the number of roots per rooted cutting.

TABLE 1

Percent rooting of stem cuttings of *Picea* and mean number of roots formed per rooted cutting, as affected by cutting type, species and planting date, after 11 weeks in the propagation bed

Cutting type	Species				
	P. abies	*P. glauca*	*P. mariana*	*P. rubens*	Mean
			Per cent rooting of cuttings[1]		
			Mid-August		
Terminal shoots, basal cut	54.0 bc	77.0 de	55.0 bc	11.0 a	49.3
Lateral shoots, basal cut	66.0 cde	81.0 e	71.0 de	16.2 a	58.5
Lateral shoots, heel of bark	64.0 bcd	55.0 bc	49.0 b	20.0 a	47.0
Mean	61.3	71.0	58.3	15.7	51.6
			Early November		
Terminal shoots, basal cut	93.0 cd	68.0 b	82.0 bc	41.0 a	71.0
Lateral shoots, basal cut	99.0 d	85.0 cd	91.0 cd	67.0 b	85.5
Lateral shoots, heel of bark	93.0 cd	37.0 a	86.0 cd	45.0 a	65.3
Mean	95.0	63.3	86.3	51.0	73.9
			Late April		
Terminal shoots, basal cut	76.0 ef	65.0 bcd	62.0 bcd	53.0 abc	64.0
Lateral shoots, basal cut	100.0 g	72.0 cde	94.0 fg	79.0 ef	86.0
Lateral shoots, heel of bark	88.0 efg	40.0 a	64.0 bcd	48.0 ab	60.0
Mean	88.0	59.0	73.3	60.0	70.1
			Mean number of roots formed per rooted cutting[1]		
			Mid-August		
Terminal shoots, basal cut	5.9 d	5.8 d	4.2 c	1.6 a	4.4
Lateral shoots, basal cut	6.0 d	3.6 bc	4.3 c	2.0 a	4.0
Lateral shoots, heel of bark	2.8 ab	2.6 ab	1.9 a	2.1 a	2.3
Mean	4.9	4.0	3.5	1.9	3.6
			Early November		
Terminal shoots, basal cut	6.0 d	4.0 c	4.1 c	3.3 bc	4.4
Lateral shoots, basal cut	6.2 d	3.8 c	3.3 bc	3.4 bc	4.2
Lateral shoots, heel of bark	3.0 abc	1.9 a	2.5 ab	1.8 a	2.3
Mean	5.1	3.3	3.3	2.8	3.6
			Late April		
Terminal shoots, basal cut	8.3 ef	5.3 c	7.5 de	4.4 bc	6.4
Lateral shoots, basal cut	10.1 f	4.4 bc	6.1 cd	5.0 c	6.4
Lateral shoots, heel of bark	2.7 ab	2.2 a	3.1 ab	2.5 a	2.6
Mean	7.0	4.0	5.6	4.0	5.1

[1] At any one date, values followed by at least one letter in common are not significantly different from each other at the 5% level by Tukey's Honestly Difference Test (Steel, R. G. D. and J. H. Torrie, 1960. Principles and procedures of statistics. McGraw-Hill, Toronto).

Figure 1. Mean rooting percentage of stem cuttings of four species planted on three different dates.

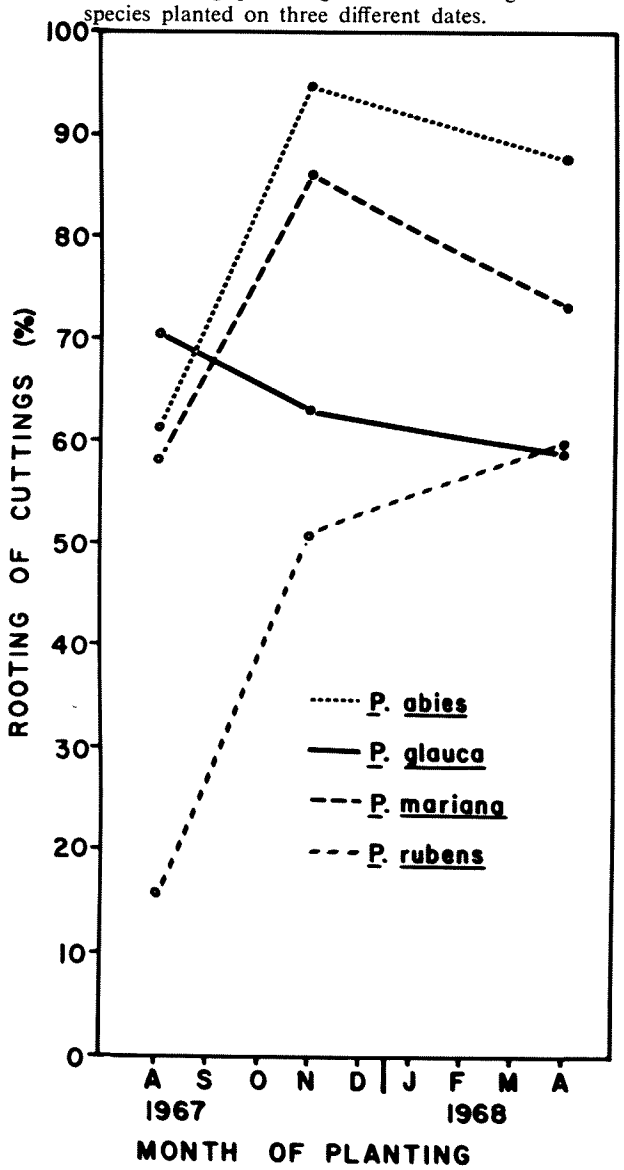
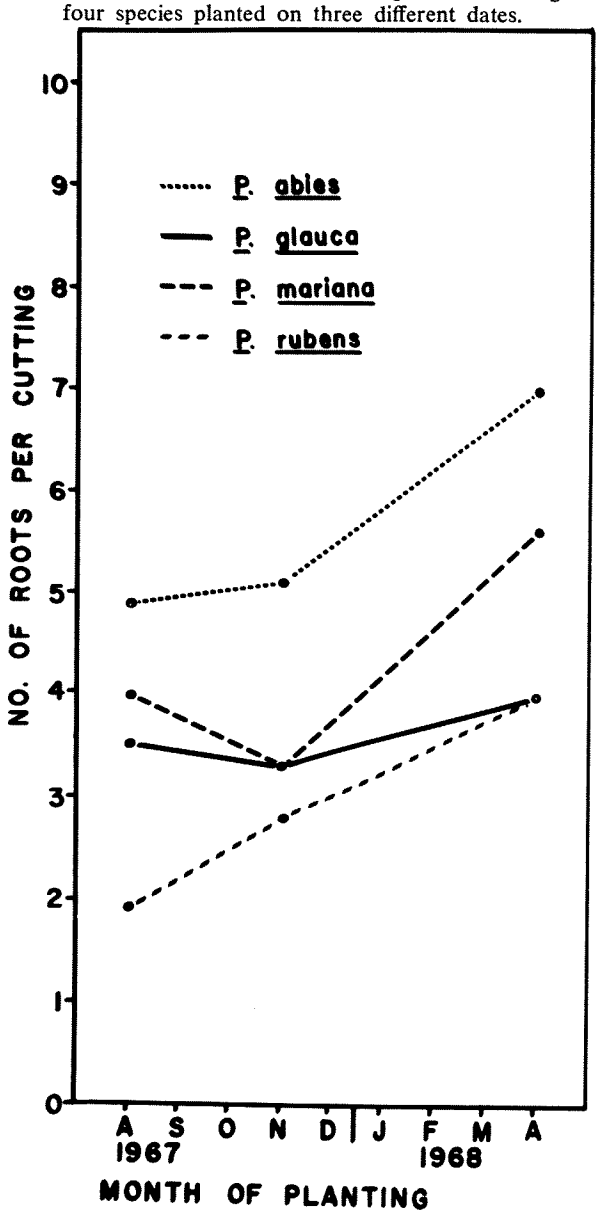


Figure 2. Mean number of roots formed per stem cutting of four species planted on three different dates.



An analysis of variance of rooting percentages (Table 1) showed no significant differences due to cutting types for *P. abies,* and no differences between terminal shoots and heel cuttings of *P. mariana* and *P. rubens* collected at different dates. Cuttings of *P. glauca* prepared with a heel of bark, rooted significantly less well than shoots lacking a heel. Although best rooting for the four species on three propagation dates was obtained with lateral shoots cut above their base, only 5 of the 12 treatments were significantly different, two each for *P. mariana* and *P. rubens,* and one for *P. glauca.* Significant differences due to species were quite evident in the three cutting types: best rooting was found in *P. abies* and the poorest in *P. rubens.* The rooting response of *P. mariana* cuttings was almost as good as that of *P. abies* for all collection dates (Fig. 1). In general *P. glauca* cuttings collected in August rooted better than cuttings taken in November or April; the opposite was true for the other species. There was a significant species-cutting type interaction.

Except for *P. glauca* cuttings collected in November (1 of 12 treatments), an analysis of the mean number of roots formed per rooted cutting of three collections (Table 1) revealed no significant differences between terminal and lateral shoots cut without a heel of bark. Root numbers for lateral shoots with a heel from four species and three collections were invariably less than those of shoots lacking a heel. No particular cutting type was best for *P. rubens* in the August collection, and *P. mariana* in the November collection. In all three collections, shoots of *P. abies* removed by cutting were significantly different from shoots of *P. rubens. P. abies* was always noted for high root numbers and *P. rubens* for low values (Fig. 2). Collection dates had very little effect on the number of roots per cutting of *P. glauca.* However, collection dates did influence root numbers on cuttings from the other species. Maximum root numbers were obtained from cuttings of the April collection for *P. abies, P. mariana,* and *P. rubens.* A species-cutting type interaction was found.

For propagation of *P. abies, P. glauca, P. mariana,* and *P. rubens* plain cuttings made by shearing young lateral and terminal shoots above their base should be used in

preference to cuttings with a heel of bark. If the propagation material is abundant and a propagation date can be selected, then preference should be given to lateral shoots collected in spring when both rooting percentage and number of roots formed per cutting are high.—R. M. Girouard, Laurentian Forest Research Centre, Sainte-Foy, Qué.

Black Spruce: Stocking Five Years After Seeding.—An experiment was initiated in 1968 to determine the best seeding densities along with the most suitable period for seeding black spruce [*Picea mariana* (Mill.) B.S.P.] under the conditions prevailing in Quebec's boreal forest. Background data related to this project are given by J. T. Arnott (Can. Dep. Fish. For., Can. For. Serv., Int. Rep. Q-17, 1970). This note gives the results obtained at Bersimis, Quebec.

The study area, a 320 acres (130 ha) 23-year-old burn has been scarified with shark-fin-barrels 1 year before seeding. Four different sowing densities were selected: 56,000 (138,380/ha), 112,000 (276,750/ha), 168,000 (415,130/ha), and 224,000 (553,500/ha) viable seeds per acre. Seeding took place in May and October. The seeds used were divided in two lots, one consisting of cleaned but untreated seeds, the other of cleaned and treated seeds. The treated seeds were coated with an Arasan-Endrin-Dow Latex 512-R mixture.

A factorial arrangement with randomized complete-block with split-plot design was used, the entire design being repeated four times. The basic unit for the regeneration survey was the combination seeding density — seeding season — seed treatment. Each block was 5 x 6.6 chain (100 x 132 m). The sowing was manually, with a cyclone seeder, in rows approximately 40 feet (12 m) apart.

Regeneration surveys were carried out 1 and 5 years after seeding, by the milacre (4 m²) quadrat method.

Results (Table 1) show that, for both the stocking and the number of stems per acre, spring seeding was superior to fall seeding. The small difference observed, in most cases, between the results obtained with treated and untreated seeds is surprising. However, this may be explained by local, unfavorable conditions for damping-off or predators. In fact, seed treatment sometimes had a negative effect on the stem distribution and the number of stems per acre.

It can be concluded that spring seeding at a rate of 112,000 seeds per acre (276,650/ha) gives good results after 5 years although the number of stems per acre is slightly high. If a standard of 1,000 stems per acre (2,471/ha) is accepted, it seems useless to sow more than 112,000 seeds per acre. Seeding with 56,000 seeds per acre would be enough, were it not for the slightly low stocking level obtained with that rate of seeding.

On the other hand, as indicated by the difference between the number of stems 1 and 5 years after seeding, it seems that many seeds do not germinate immediately after seeding. This is obvious as the seeding was carried out in the center of a 320-acre area burned 23 years earlier and thus without any seed source, whether it be remnants or logging slash. Results were fairly consistent for the four replications.

The author acknowledges the colaboration of J. T. Arnott who devised the experimental block design and supervised the first survey. Gilles Frisque, Laurentian Forest Research Centre, Sainte-Foy, Qué.

TABLE 1

Number of stems per acre and stocking for black spruce 1 and 5 years after seeding*

Number of viable seeds per acre and treatment	Seeding period	
	May	October
One year after seeding		
56,000 untreated	1,400; 55%	200; 10%
treated	800; 40%	400; 30%
112,000 untreated	1,000; 65%	400; 30%
treated	2,400; 60%	400; 50%
168,000 untreated	3,200; 75%	4,600; 70%
treated	3,800; 65%	1,800; 60%
224,000 untreated	2,000; 50%	2,400; 60%
treated	2,000; 65%	3,000; 70%
Five years after seeding		
56,000 untreated	1,920; 64%	960; 40%
treated	1,760; 64%	480; 48%
112,000 untreated	5,120; 80%	1,120; 52%
treated	6,400; 76%	1,120; 52%
168,000 untreated	4,320; 80%	2,720; 72%
treated	3,680; 64%	3,680; 60%
224,000 untreated	8,000; 88%	1,280; 68%
treated	8,000; 92%	4,000; 60%

* The number of stems per hectare can be obtained by multiplying the given figures by 2.471.

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15 **Tyrrell, D., and J. E. Simpson. 1975.** Glycolytic enzymes in resting spores and vegetative mycelia of *Entomophthora pyriformis. Can. J. Microbiol.* 21(3): 301-304.

7 **Wall, R. E. 1974.** Recent conifer disease problems in forest nurseries in the maritime provinces. *Can. Plant. Dis. Surv.* 54(4):116-118.

7 **Wall, R. E. 1975.** Timing of fungicidal drench treatments in relation to fungicide injury to conifer seedlings. *Phytoprotection* 47-53.

8 **Wong, H. R. 1975.** The *Abietina* group of *Pristiphora* (Hymenoptera: Tenthredinidae). *Can. Entomol.* 107:451-463.

ERRATA

Vol. 31, No. 2, 1975

Front cover, add Bacterial innoculations influence growth of containerized Douglas-fir

Page 9, col. 2, line 20: This solution dissolves . . .

Page 10, col. 1, line 28: Regression analysis . . .

Page 10, col. 2, line 8: *Pinus ponde-* . . .

Page 11, col. 1, line 1: spruce budworm . . .

Page 11, col. 1, line 15: spruce budworms . . .

Page 11, col. 1, line 23: the farthest 8.8 km . . .

Page 12, col. 2, line 30: of aggregation . . .

Page 13, col. 1, line 54: the vial technique . . .

Page 13, col. 2, line 39: Six lodgepole pine . . .

Page 14, col. 1, line 28: D. M. Shrimpton . . .

Page 15, col. 1, line 21: Nitrogen was also . . .

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should read

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