Nevertheless, if the starting moisture content of litter is well above equilibrium, the drying process may take several days and a daily log drying rate can be measured. The Fine Fuel Moisture Code (FFMC) of the FWI, based largely on old research (Wright, Forest Fire Hazard Tables, Dom. For. Serv. 1937), has a log drying rate of 0.5/day at 70 F and 50% RH; since the FFMC refers to a layer of pine litter of about 0.25 kg/m^2, it follows the same trend of wk = 0.12 very well. A set of short outdoor experimental drying runs with jack pine needle litter at 0.5 kg/m^2 had an average log drying rate over the season of about 0.3/day. This is somewhat higher than the graph predicts, but still passably close.

I conclude that the log drying rates of litter and duff layers of the same general nature may be expected to correlate fairly well with the inverse of their dry weight per unit area. This is a useful principle in fuel moisture prediction and fire danger rating.—C. E. Van Wagner, Petawawa Forest Experiment Station, Chalk River, Ont.

FOREST PRODUCTS

Composition of Volatile Oil From the Bark of Lodgepole Pine.—The composition of volatile oil in bark (phloem and rhytidome) of lodgepole pine (*Pinus contorta* Dougl. var *latifolia* Englm.) was examined as part of a study on interactions between this pine and the mountain pine beetle with its blue stain fungi. These beetles mine in the phloem region, and the fungi attack living cells in both wood and bark; the tree responds by producing increased amounts of volatile oil and other compounds in both wood and bark (Shrimpton, Can. J. Bot. 51:527, 1973). The composition of volatile oil from foliage (Pauly and von Rudloff, Can. J. Bot. 49:1201, 1971) and wood (Shrimpton, *op. cit.*) of lodgepole pine has been described, but bark has not. The resin ducts are not continuous from needles to wood and, in the bark, much of the oil is in discrete pockets. It was, therefore, of interest to compare the oil from bark with that from foliage and wood. The terpene hydrocarbons in bark were similar in composition to those found in needles and wood, but the relative amount of higher boiling components was much greater in the bark.

Five butt logs were cut near Horsethief Creek in the East Kootenay region of British Columbia, in early September 1971. In the laboratory, bark was ground with added dry ice in a Wiley mill to pass a 2 mm screen. Bark millings were steam-distilled for 8 hrs. The oil was recovered, weighed and analyzed by gas chromatography over both OV-17 and Carbowax 20M with and without the addition of isopropylbenzene as an internal standard (Shrimpton, *op. cit.*). Individual components were identified from retention characteristics and by peak enhancement with authentic standards.

The predominant monoterpene hydrocarbons were α-pinene, camphene, β-pinene, 3-carene, β-phellandrene and terpinolene. Also present were myrcene, α-terpinene, limonene and trans-ocimene. Oxygenated terpenes present were linalool, α-fenchol, bornyl acetate, terpinen-4-ol, estragole, isoborneol, α-terpineol, borneol, citronellol and cis-anethole. One sesquiterpene, β-caryophyllene, was also present. Some oil in each sample, mostly eluted beyond anethole, was unidentified; the amount varied between 2 and 16%. Sesquiterpenes and some volatile diterpenes have been isolated from lodgepole pine bark (Rowe *et al.* Phytochemistry 11:365, 1972); such compounds probably account for this unidentified fraction. The internal standard indicated that about 5% was unaccounted for from each sample. Table 1 shows the relative composition of oil from the five bark samples, amount of oil recovered and weight of bark used.

The terpene hydrocarbons found in volatile oil of lodgepole pine bark have been reported in oil from foliage (Pauly and von Rudloff, *op. cit.*) and from wood (Shrimpton, *op. cit.*). The relative composition is variable from tree to tree. Differences between oil from bark and from wood or needles are the generally high proportion of oxygenated terpene in all samples and a large unidentified fraction that eluted beyond the oxygenated fraction.—D. M. Shrimpton, Pacific Forest Research Centre, Victoria, B.C.

TABLE 1
Yield and composition of the volatile oil from bark of five lodgepole pines

	Tree Number				
	1	2	3	4	5
α-pinene	*5.5	0.7	2.1	0.9	1.2
camphene	2.2	5.5	3.3	0.5	0.5
β-pinene	2.2	2.1	4.3	2.5	1.8
3-carene	2.4	2.1	3.8	1.5	1.8
myrcene	0.7	tr	tr	tr	tr
limonene	0.9	1.8	2.6	0.5	0.5
α-terpinene	—	tr	—	tr	tr
β-phellandrene	6.5	11.8	34.1	8.4	10.6
trans-ocimene	0.5	0.6	—	0.6	0.6
terpinolene	0.8	1.0	1.5	1.2	1.9
linalool	1.1	0.5	tr	0.7	tr
α-fenchol	0.5	1.4	0.5	1.2	0.8
bornyl-acetate	1.3	0.5	tr	1.6	tr
terpinen-4-ol	16.1	3.1	1.5	3.1	3.4
β-caryophyllene	1.7	1.0	1.2	6.5	3.5
estragole	5.7	5.6	6.0	8.3	4.2
isoborneol	12.5	12.1	10.1	17.4	15.2
α-terpineol	19.0	26.9	22.4	19.3	22.3
borneol	6.9	5.7	3.6	8.6	10.1
citronellol	0.8	1.8	0.6	tr	tr
cis-anethole	—	tr	—	1.0	5.7
unidentified (total)	12.5	14.1	2.0	16.2	14.6
Fresh weight of bark (gm)	99.8	98.3	99.6	100.0	98.7
	218.0	255.0	300.0	205.0	315.0
Weight of oil (gm)	0.10	0.27	0.42	0.21	0.15
Yield of oil (percentage)	0.10	0.10	0.15	0.10	0.05

* Values are percentages of the fraction.
Note: minus indicates not found; tr, trace quantities less than 0.5%

PATHOLOGY

Bacteria From Balsam Fir Roots Inhibit Growth of Decay-causing Fungi.—Bacteria, some of which may promote growth of decay fungi, have been reported to occur in the stems of balsam fir [*Abies balsamea* (L.) Mill.] (Etheridge and Morin, Can. J. Bot. 45:1003-1010, 1967; Bourchier, Proc. 33rd Ses., Can. Phytopath. Soc. No. 34), but no information could be found on the occurrence of bacteria in the roots. In root inoculation studies with *Scytinostroma galactinum* (Fr.) Donk in New Brunswick, bacteria were frequently isolated from uninoculated roots and from wood associated with control inoculations and abortive *S. galactinum* inoculations. Since bacteria were seldom isolated from tissue which yielded the decay fungus and vice-versa, preliminary work was done to investigate the possible inhibitory nature of the bacteria.

Forty-eight isolates of gram-negative rod bacteria obtained from 48 different roots of balsam fir were tested for their influence on the growth of *S. galactinum* and *Coniophora puteana* (Schum. ex Fr.) Karst. The organisms were grown together on malt agar medium and malt agar medium containing ground wood obtained from the center of decay-free roots. Three agar plugs containing mycelium of one of the fungi were placed in a line between two diverging bacterial streaks (Fig. 1). The cultures were incubated, in the dark, for 14 days at 25 C.

Forty-four of the bacterial isolates inhibited *S. galactinum* to some degree on one or both of the media while 45 were inhibitory to *C. puteana.* It was apparent that the type of medium employed influenced the results of the *in vitro* antagonism tests. Nine isolates were inhibitory to *S. galactinum* only when grown on malt agar medium; of these three were