TABLE 1
Fiber saturation point (FSP) and maximum crushing strength (MCS) of green heat-treated white spruce wood.

Treatment Temperature (°C)	Moisture Content at FSP (%)		MCS			
	Mean	Standard deviation	Mean		Standard deviation	
			k Pa	psi	k Pa	psi
Control	30.9	0.2	18926	2745	896	130
50	30.6	0.2	17526	2542	331	48
70	32.1	0.2	16313	2366	1648	239
90	35.5	0.6	15024	2179	1034	150
150	51.0	0.6	9660	1401	338	49

TABLE 2
Dimensional changes in green wood due to heat treatment in water.

Dimension	Sample Condition	Dimensional Change (% of original)	
		Treated at 70°C	Treated at 90°C
Volumetric	hot	+0.10	+0.44
	cooled	+0.23	+0.77
Longitudinal	hot	0.00	+0.01
	cooled	+0.01	−0.01
Radial	hot	0.00	−0.15
	cooled	+0.02	0.00
Tangential	hot	+0.10	+0.58
	cooled	+0.24	+0.75

curred. At the highest temperature (150 C) an average volumetric contraction of 2.4% was recorded for the samples, although no collapse was apparent.

The pH value of the water used for heating the wood samples decreased markedly with increasing temperature of treatment. Thus, it fell to 5.9 at 70 C, 4.8 at 90 C and 3.3 at 150 C. This reduction in pH is due to the hydrolysis of acetyl groups to form acetic acid, which in turn causes hydrolytic degradation of hemicelluloses to soluble substances that migrate from the cell wall, leaving voids. It is these voids that are responsible for the increase in fiber saturation point (Stone and Scallan, TAPPI 50:496-501, 1967).

Hydrolytic degradation is unavoidable under certain wood service conditions (for example, in water-cooling towers, in certain wooden conduits and tanks). The extent of degradation and the accompanying deterioration in strength depends mainly on the temperature, the duration of exposure, and the rate at which the products of hydrolysis are removed from the wood. In assessing the residual strength of wood under these and similar conditions, the FSP-value should serve as a useful indicator.—E. Perem, Eastern Forest Products Laboratory, Ottawa, Ont.

PATHOLOGY

Effect of Soil pH on Rhizomorph Growth of *Armillarie mellea*.— In Britain, forest sites with a hardwood history are frequently infested with *Armillaria mellea* (Vahl ex Fr.) Kummer. There, as in other temperate countries, rhizomorphs are regularly associated with disease caused by *A. mellea* (Redfern, Ann. Bot. 32:293-300, 1968) and are considered to be the principal means whereby the fungus spreads. Armillaria root disease has been observed on sites differing widely in soil moisture, texture and pH. Although certain soil conditions are reported to favor disease development (Twarowski and Twarowska, Prace Inst. Bad. Lesn. No. 192, 1959), factors affecting rhizomorph growth in soil have received relatively little study. Exceptions are some work on soil moisture (Garrett, Ann. Bot. 20:193-209, 1956) and soil temperature (Rishbeth, Trans. Br. mycol. Soc. 51:575-586, 1968); Bliss (Phytopathology 31:859, 1941) observed that rhizomorphs developed in soils differing in type and reaction, such as peat moss (pH 4) and sand (pH 8). In Thetford Chase forest, East Anglia, soil pH ranges from strongly alkaline, where a few centimeters of sand overlie chalk, to quite acid, where leaching has occurred in deep sand. The effect of soil pH on rhizomorph growth was studied at locations in the forest and under controlled conditions in the laboratory.

Fresh, unsterilized stem segments of oak [*Quercus robur* L.], about 2.5 cm in diameter and 6 cm long, were inoculated at one end with starter-disks colonized on a malt agar culture of *A. mellea* (Rishbeth, Eur. J. For. Path. 2:193-205, 1972). When thoroughly colonized, segments were buried 30 cm deep at locations where the pH values at that depth were 6.2 and 4.8. Soil moisture content (expressed as per cent saturation) at the two locations differed by not more than 3% each month during the experiment. After 7 months (May to November, inclusive), rhizomorphs were harvested by sifting the soil and their dry weights were measured.

At the two locations, the isolates responded differently; that is, isolate 2 produced a greater dry weight of rhizomorphs in alkaline soil, whereas isolate Bg produced more in acidic soil (Table 1). Similar results were obtained in the laboratory when inoculum segments were placed in jars of soil (moistened to 50% saturation) from 30 cm depth at the two locations and incubated for 16 weeks at 20 C (Table 1). Except for isolate 2 in the field, where there was a great deal of variation among replicates, differences in rhizomorph growth between soils were highly significant.

In a further laboratory experiment, rhizomorph growth of 13 isolates was assessed in soils having pH 4.4 and 7.6. Inoculum segments were incubated at 20 C for 16 weeks. Table 2 shows the number of segments producing rhizomorphs, rhizomorph dry weights, results of "t" tests and rhizomorph growth habits of isolates. Two isolates responded better to alkaline conditions, seven to acidic conditions, and four were indifferent. Three of the four isolates failed to produce rhizomorphs from a large proportion of segments in both soil types; such failures usually resulted from poor colonization of inoculum segments. Isolates 2 and Bg behaved as they had in the earlier field and laboratory experiments. In the soil type which was less favorable for rhizomorph growth, the number of inoculum segments producing rhizomorphs and the number of initials formed on a segment were frequently lower than in the more favorable soil. All isolates but one produced rhizomorphs in both soils and, as the field experiment showed, rhizomorph growth was only retarded, not prevented, in unfavorable soil.

TABLE 1
Dry weights of rhizomorphs produced by two isolates of *A. mellea* in soils with pH 4.8 and 6.2.

Expt.	Soil pH	Rhizomorph dry weight (mg)+	
		Isolate 2	Isolate Bg
field	6.2	670	63
	4.8	445ns	152**
lab	6.2	296	40
	4.8	186**	96**

+ mean of 10 replicates.
ns means not significantly different.
** means significantly different at P=.01.

TABLE 2
Number of segments producing rhizomorphs, rhizomorph dry weights and growth habits for isolates of *A. mellea* incubated in acidic (pH 4.4) and alkaline (pH 7.6) soils.

Isolate	Growth habit	Number of segments producing rhizomorphs		Rhizomorph dry weight (mg)	
		Acidic	Alkaline	Acidic	Alkaline
2	I	4/10	8/10	26 **	113
Df_1	I	6/10	9/10	93ns	87
Df_2	I	6/10	10/10	39 **	130
O_2	I	3/9	6/9	40 ns	27
R_1	I	3/8	2/8	85 ns	101
D	II	10/10	10/10	180 **	71
V	II	9/9	10/10	142 **	69
8	II	10/10	10/10	158 **	74
Bg	II	10/10	10/10	57 *	21
Sp_3	II	10/10	8/10	51 **	9
Sp_6	II	8/8	1/8	107 **	1
BC_2	II	3/7	2/7	21 ns	28
BC_5	II	8/8	0/8	88 **	0

ns means not significantly different.
* means significantly different, at P=.05.
** means significantly different, at P=.01.

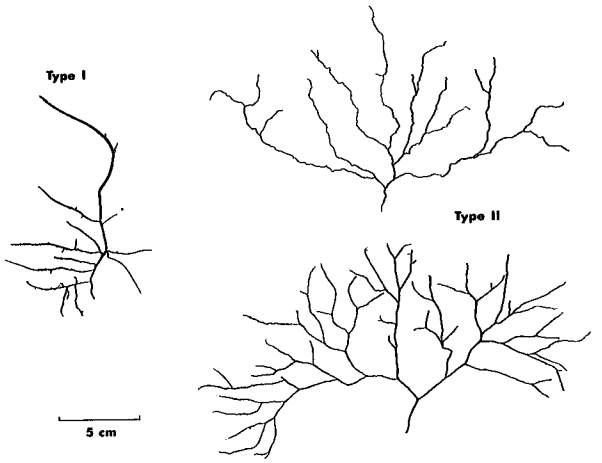

Figure 1. Type I and Type II rhizomorph growth habits.

Among isolates used in the study, two rhizomorph growth habits were observed; rhizomorphs produced by inoculum segments in soil branched either monopodially (Type I) or dichotomously (Type II, Fig. 1). Rhizomorphs of isolates that grew well in alkaline soil had Type I growth habits, whereas Type II isolates preferred acidic soil. This suggests that each type has a different pH optimum for rhizomorph growth.

This work formed part of a thesis submitted to the University of Cambridge for the degree of Ph.D. I express my gratitude to Dr. J. Rishbeth for his advice and encouragement.—D. J. Morrison, Pacific Forest Research Centre, Victoria, B.C.

Effect of Soil Extracts on Ecologically Different Fungi.—Sensitivity to effects of soil extracts seems to vary between fungi (Vaartaja and Agnihotri, Phytopath. Zeits. 60:63-72, 1967) and *Pythium ultimum* Trow, one of the most important seedling pathogens, has been found to be strongly inhibited (Vaartaja, Bi-Mo. Res. Notes 23:14, 1967a; 25:25-26, 1969). In the 1967a study, one extract was tested by placing it in agar at a colony edge of each of 27 fungi. In the 1969 study each of 22 extracts were incorporated in agar medium and one fungus studied. Further exploration of the varying sensitivity of fungi is reported here. In particular, this study was to determine whether the large variation found between fungal species in the 1967 study could be confirmed with the methods used in 1969, where only *P. ultimum* was used.

Samples were collected in May 1968, at Maple, Ont. from two sandy soils: one under mature pines; the other one from a nearby grassy pasture. The soils were extracted with distilled water, and the extracts passed through (0.2μ) filters, incorporated in agar and tested in petri dish cultures as reported in 1969. Cultures of the following pathogens were used as inocula: (1) *Ceratobasidium cornigerum* (Bourd.) Rog. (isolate No. 5651B; low virulence to conifer seedlings, Vaartaja, Phytopathology 57:765-768, 1967b), (2) *Pythium* sp. (probably a new species related to *P. splendens* Braun (9336), (3) *P. coloratum* Vaartaja (6030B; low virulence to conifer seedlings, Vaartaja, Mycologia 57:417-430, 1965), (7) *P. salpingophorum* Drechsler (9167A), (8) *P. ultimum* (9248) and (9 and 10) *Waitea circinata* Warcup & Talbot (7101 and 7745B; medium virulence to conifer seedlings (Vaartaja, 1967b). For comparison, a common mycorrhiza-forming fungus (11) *Cenococcum graniforme* (Sow.) Ferd & Winge (8902C), and a common antagonist of various fungi (12) *Gliocladium fimbriatum* Gilman & Abbott (7047) were also included. After 4 days of incubation at 15 C radial growth of these fungi was measured and expressed as a percentage of that in distilled water controls. The two replicates gave nearly identical results (mostly within 5%).

TABLE 1
Effects of two soil extracts on growth of fungi.

Species	Virulence[1] on conifer seedlings	Pine Soil	Pasture Soil	Avg
		(avg radial growth, control = 100)		
I. STIMULATION				
P. salpingophorum	low	141	127	134
C. cornigerum	low	133	113	123
II. NO EFFECT				
C. graniforme	(symbiotic)	90	95	93
G. fimbriatum	low	93	93	93
III. INHIBITION				
P. debaryanum I	high	80	68	74
P. debaryanum II	high	61	85	73
Pythium sp.	high	57	65	61
P. pyrilobum	high	45	62	53
P. ultimum	high	38	64	51
W. circinata (avg)[2]	medium	25	60	42
IV. STIMULATION OR INHIBITION				
P. coloratum	low	118	91	104
AVERAGE		76	82	79

[1] As determined from studies cited or unpublished results.
[2] Results for two isolates were similar.

Table 1 shows the main results. Microscopic observations indicated that the density of colonies and hyphal diameters were affected in the same way as radial extension growth. Thus the differences in the amount of growth were greater than those shown in Table 1. Furthermore, inhibited growth was accompanied by early lysis. Two morphologically different isolates of *P. debaryanum* responded differently while two identical isolates of *W. circinata* responded identically.

Data in Table 1 confirm the findings of the earlier study (Vaartaja and Agnihotri, *loc. cit.*), that different fungi have greatly different responses to soil extracts. Three of the fungi of Table 1 (*C. cornigerum*, *C. graniforme* and *W. circinata*) were tested earlier with similar results. In the tests employed here, the soil solution was in a uniform 1-1 dilution. In soil, however, the inhibitors likely occur in greater concentrations in certain micro-environments than in others, particularly when the soil is not saturated. Furthermore the degree of inhibition has been shown to vary greatly when the extracts are obtained at different times from the same soil (Vaartaja, 1969). Those *Pythium* species that are known to be virulent pathogens of tree seedlings were consistently inhibited. These data indicate that the sensitivity of *P. ultimum*, isolate 9248, represents a response common among virulent *Pythium* isolates. Therefore this isolate is being used extensively in further assays of soil mycostasis.

Prevailing ecological theories suggest that virulent soil-borne pathogens have evolved from saprophytes and usually have not retained their high tolerance of mycostatic factors. These fungi are saprophytic prior to contacting the living host. This is the stage in which mycostasis operates and which could be utilized for disease control. The antagonist *G. fimbriatum* and the mycorrhiza fungus *C. graniforme* may exert biological disease control. Since these fungi seem tolerant of at least some mycostatic factors, attempts should be made to utilize them in disease control.—O. Vaartaja, Forest Ecology Research Institute, Ottawa, Ont.

SILVICULTURE

Effect of Four Site Treatments on Survival and Growth of White Spruce and Lodgepole Pine Seedlings.—The usual machine for mechanical site preparation of moist white spruce/alpine fir [*Picea glauca* (Moench) Voss/*Abies lasiocarpa* (Hook.) Nutt.] sites in the Prince George Forest District of British Columbia is a bulldozer. Whether the machine is equipped with a standard or a toothed, land-clearing blade, the sites are commonly scalped. Duff and uppermost mineral soil is thereby pushed out of reach of the newly planted seedling. This drastic treatment has been adopted because seedling survival may be greatly reduced by competing vegetation. Scalping must be deep enough to eliminate the roots of competing