FUNGOUS DETERIORATION OF BALSAM FIR KILLED BY SPRUCE BUDWORM IN NORTHWESTERN NEW BRUNSWICK¹

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ABSTRACT

The rate of fungous deterioration was determined for 292 balsam fir (*Abies balsamea* (L.) Mill.) killed by the spruce budworm (*Choristoneura fumiferana* (Clem.)) in an area of heavy tree mortality in northern New Brunswick. Trees dead less than one year and up to seven years were examined. Fifty fir trees dead 0 to 2 years in a light mortality area were also examined. Trees in the heavy mortality area deteriorated much more slowly than those examined by other workers in Ontario. *Stereum chaillatii* (Pers.) Fr. and *S. sanguinolentum* (Alb. & Schw. ex Fr.) Fr. caused most of the incipient and advanced decay in New Brunswick, whereas *S. chaillatii* caused all the incipient decay in trees dead less than one year in Ontario but was replaced after one year by *Polyporus abietinus* Dicks. ex Fr. which then caused most of the advanced decay. Advanced decay progressed faster in trees in the light mortality area in New Brunswick than in trees in the heavy mortality area. Nineteen species of basidiomycetes were associated with sapwood decay. Comments concerning the position and frequency of fungous occurrence in the different parts of the tree in relation to the number of years since death are made for eight of the more commonly isolated fungi. The introduction of *S. chaillatii* into living trees by woodwasps and the differences observed in the development of *P. abietinus* in dead trees in the two regions are discussed.

INTRODUCTION

The spruce budworm (*Choristoneura fumiferana* (Clem.)) has caused extensive mortality of balsam fir (*Abies balsamea* (L.) Mill.) in eastern Canada during recent years. A major outbreak in the Lake Nipigon area of northern Ontario ended in 1948 (Belyea, 1952) and a later outbreak in northern New Brunswick collapsed in 1959 (Greenbank, 1963). Information on the rate of fungous deterioration in budworm-killed balsam fir was available for northern Ontario (Basham, 1951) but its applicability to New Brunswick conditions was questionable. Accordingly, studies were begun in 1955 to determine the nature and rate of fungous deterioration in balsam fir killed by spruce budworm defoliation in northwestern New Brunswick.

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METHODS

Sampling was conducted in the Green River Watershed of northwestern New Brunswick. Two hundred and ninety-two mature and overmature trees were examined in stands where tree mortality ranged from 50 to 100%, and 50 trees were examined in a stand where mortality was less than 10%. Tree death was recorded annually in July and August during the period 1955 to 1958. Trees living one summer but dead the next were classified during the second summer as having been dead 0 to 1 year.

All trees were felled and cut into 4-foot bolts. Firm wood discolored reddish-brown by the probable presence of wood-destroying fungi was classed as incipient decay. Unfirm wood, as determined by probing with a sharp instrument, was classed as advanced decay. The diameter of the bolt inside the bark and the radial penetration of incipient and advanced decay were determined at each cut by taking measurements at right angles with a scale stick. The diameter at breast height outside the bark was also recorded.

Cultural isolates of the decay fungi were made for identification and were obtained from the deteriorated sapwood at four points around the perimeter of discs collected at the stump, at the 3-inch top and at an intermediate point.

Gross merchantable volume (portion between a 1-foot stump and a 3-inch top), volume of sound wood, and volume of incipient decay and sound wood together were determined by Smalian's formula. The appropriate subtractions gave the volume of the incipient decay and the advanced decay.

The diameter classes in the groups of trees examined at different intervals after tree death were not equally represented. The error this introduced into the percentage figures relating decay volumes to total merchantable volumes was corrected in the following way. For each group of trees dying in a given year, curves were prepared showing incipient decay volume, advanced decay volume, and merchantable volume in relation to tree diameter. Curved values of these volumes, for each diameter class in a group, were multiplied by the number of trees in the respective diameter class in the total sample. The products were totalled and the figures so obtained for incipient and advanced decay and for merchantable volume were used to determine the weighted percentages (Table 1, cols. 5 and 6). The average radial penetration of the sapwood decay in each tree was obtained by totalling the penetration measurements and dividing by the total number of measurements.

RATE OF DETERIORATION

All trees examined contained incipient sapwood decay. The percentage of trees with advanced decay increased with time after death; all trees dead longer than five years contained some advanced decay. Data on the volume of decayed wood and the penetration of decay are presented in Table 1.

In the stand where 50 to 100% mortality occurred, incipient decay penetrated the sapwood to an average depth of 0.4 inch within one year of death. The average depth of deterioration (incipient and advanced decay) increased to 0.7 inch in trees dead 3 to 4 years; but did not exceed 0.7 inch in the trees sampled 4 to 7 years after death (Table 1, col. 8). This

TABLE 1
THE RATE OF FUNGUS DETERIORATION IN
BALSAM FIR KILLED BY THE SPRUCE BUDWORM IN NORTHWESTERN NEW BRUNSWICK

No. years since death	No. trees	Avg. d.b.h.	Gross ¹ merchantable vol. (cu. ft.)	Percentage of merchantable vol. showing incipient decay (weighted)	Percentage of merchantable vol. showing advanced decay (weighted)	Percentage of merchantable vol. showing incipient and advanced decay (weighted)	A. radial penetration of incipient and advanced decay (in.)	A. radial penetration of advanced decay (in.)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Mortality of 50 to 100%								
0-1	32	9.1	361.5	17	—	17	0.4	—
1-2	112	8.5	1115.6	22	—	22	0.5	—
2-3	24	8.8	236.5	29	3	32	0.6	0.1
3-4	25	6.5	107.8	23	14	37	0.7	0.2
4-5	33	7.3	269.3	16	27	43	0.7	0.3
5-6	33	7.2	264.2	14	27	41	0.7	0.4
6-7	33	7.6	307.2	17	22	39	0.7	0.3
Mortality less than 10%								
0-1	25	8.4	242.6	18	5	22	0.4	0.1
1-2	25	7.9	254.6	11	15	26	0.6	0.3

¹ Volume from a 1-ft. stump to a 3-in. top.

apparent slowdown in decay development in trees dead longer than 4 years was also reflected in the data on the penetration of advanced decay and the percentage of the total gross merchantable volume containing incipient and advanced decay (Table 1, cols. 9 and 7). This was due, in part, to the fact that the trees became progressively dryer after death and consequently, conditions for decay were probably less favorable. The apparent slowdown in decay development several years after tree death was also partly due to a sampling artifact. A considerable number of trees containing heart rot were either broken off near the base or mid-way up the trunk by wind within 5 years of their death. Therefore, the remaining trees sampled may have been a select group, more resistant to decay, since they contained little or no heart rot and less decayed sapwood.

In the stand of balsam fir suffering less than 10% mortality, the development of advanced decay was more rapid than in stands with 50 to 100% mortality. Whereas no advanced decay was found in the heavy mortality area until the trees had been dead 2 to 3 years, a measurable volume of advanced decay was found in the first year after tree death in the light mortality area (Table 1, col. 6).

IDENTITY AND INCIDENCE OF FUNGI CAUSING DETERIORATION

Data on fungous incidence in the heavy and light mortality areas were combined because a preliminary analysis showed little difference in the occurrence of the fungi in the two areas.

Two hundred and forty-four cultures of *Stereum chailletii* (Pers.) Fr. and 309 cultures of *S. sanguinolentum* (Alb. & Schw. ex Fr.) Fr. were isolated from incipient and advanced decay. Woodwasps (*Sirex* and *Urocerus* spp. Hymenoptera: Siricidae), common to the area, introduce *S. chailletii* during oviposition often before tree death (Stillwell, 1960). Most of the trees sampled that had been dead 0 to 1 year contained large woodwasp larvae and in many trees there were emergence holes.

S. chailletii was isolated most frequently from the decayed sapwood in the trunk and at the stump. This was particularly noticeable in trees dead 0 to 1 and 1 to 2 years.

S. sanguinolentum was isolated more frequently from the trunk and from a larger number of trees than was *S. chailletii*, particularly in the later years following death. *S. sanguinolentum* is not known to be introduced by woodwasps in this region; therefore, it was not surprising to find it less frequently than *S. chailletii* in newly dead trees.

Polyporus abietinus Dicks. ex Fr. was isolated frequently from advanced decay in trees dead longer than four years. Eighty-two cultures were obtained from 48 of the 99 trees dead longer than four years but only 27 cultures were obtained from 10 of the 193 trees dead less than four years. The fungus occurred at various levels in the tree but was most common mid-way up the trunk and at the 3-inch top. At these levels the bark did not readily fall away from the trunk because of the branches. Underlying wood was often wet and may have been more suitable for development of the fungus.

The brown rot fungi, *Fomes pinicola* (Sw. ex Fr.) Cooke and *Trechispora brinkmanni* (Bres.) Rog. & Jacks., were isolated less frequently than the above three white rot organisms (56 and 37 cultures obtained from 21 and 18 trees, respectively). They were obtained from the sapwood at the butt, trunk and top.

Ninety-seven cultures of *Coniophora puteana* (Schum. ex Fr.) Karst. were obtained from 39 trees and 60 cultures of *Armillaria mellea* (Vahl. ex Fr.) Kummer were obtained from 30 trees. They were isolated almost exclusively at the stump level and apparently entered from infected roots. *Armillaria mellea* was isolated most frequently from trees more recently killed. *Coniophora puteana* was most prevalent in trees dead for a longer period as was *S. cytinostroma galactinum* (Fr.) Donk, (*Corticium galactinum* (Fr.) Burt) the butt rot fungus next in prevalence (38 cultures obtained from 14 trees).

Eleven other fungi were isolated occasionally from the sapwood. They were *Merulius himantoides* Fr. [*Serpula lacrimans* (Wulf. ex Fr.) Bond. var. *himantoides* (Fr.) W. B. Cooke], *Odontia bicolor* (Alb. & Schw. ex Fr.) Quél., *Xeromphalina campanella* (Batsch ex Fr.) Kuhner & Maire (*Omphalia campella* Fr.), *Peniophora aspera* (Pers.) Sacc., *Peniophora crenea* (Bres.) Sacc. & Syd., *Peniophora picea* (Pers.) Ericksson, *Peniophora* sect. *coloratae*, *Polyporus immitis* Peck, *Poria subacida* (Peck) Sacc., *Radulum orbiculare* Fr., and *Stereum purpureum* (Pers. ex Fr.) Fr. Cultural identifications were confirmed by M. K. Nobles, Plant Research Institute, Research Branch, Canada Agriculture, Ottawa.

DISCUSSION

The rapid development of incipient decay in newly dead trees in New Brunswick was largely caused by *Stereum chailletii* which apparently was introduced into the sapwood by ovipositing woodwasps before tree death. No fruiting bodies of this fungus were found, however, despite its common occurrence in trees dead for as long as seven years. In Ontario, incipient decay in newly dead trees, caused exclusively by *S. chailletii*, developed at a similar rate to that reported here for northwestern New Brunswick (Basham, 1951). Woodwasps (*Sirex* spp. and *Urocerus* spp.) were also present in newly dead trees in Ontario (Belyea, 1952), and it is probable that they played a similar role in inoculating trees with *S. chailletii*.

Stereum sanguinolentum was one of the fungi most commonly isolated from decayed sapwood in New Brunswick; however, it was not isolated from decayed sapwood in Ontario (Basham & Belyea, 1960).

Polyporus abietinus occurred one year earlier in the succession of fungi in New Brunswick but was much more prevalent in killed balsam fir in Ontario, where advanced decay developed much faster. Twenty-five per cent of the gross merchantable volume was decayed to the advanced stage within two years of tree death, and five years after tree death 92.4% of the advanced decay, which occupied 41.9% of the gross merchantable volume, was caused by *P. abietinus* (Basham, 1951). In contrast, advanced decay in New Brunswick amounted to only 0.5% of the gross merchantable volume within two years of tree death and was caused mostly by *S. chailletii* and *S.*

sanguinolentum. Five years after tree death, *P. abietinus* accounted for only about 50% of the advanced decay which occupied 26.8% of the gross merchantable volume. *Polyporus abietinus* was found fruiting on only 19 of 226 trees dead 0 to 5 years in New Brunswick but it fruited commonly on trees dead 2 to 5 years in Ontario. Additional work is required on the biology, ecology and life history of *P. abietinus* to help explain the different behavior observed in the two regions.

The amount of decay recorded in the light mortality stand in New Brunswick was quite comparable to that reported for stands suffering heavy mortality in Ontario (Basham, 1951). However, culture results in the light mortality stand showed that *P. abietinus* occurrence was comparable to that observed in the heavy mortality stands in New Brunswick and thus was much lower than in Ontario. Trees in the heavy mortality stand were more exposed to direct sunlight and to air currents and consequently dried more rapidly as evidenced by the presence of split and hanging bark. Higher moisture conditions in the light mortality stand probably increased the deterioration rate there.

In stands suffering heavy spruce budworm mortality, the slower deterioration rate observed in New Brunswick suggests that salvage operations may be feasible for a somewhat longer period after tree death than in Ontario.

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