AN ASSESSMENT OF THE PATHOLOGICAL QUALITY OF ASPEN SUCKERS ESTABLISHED ON CUTOVERS IN ONTARIO

J. T. BASHAM and S. NAVRATIL[1]

GREAT LAKES FOREST RESEARCH CENTRE

SAULT STE. MARIE, ONTARIO

REPORT O-X-236

CANADIAN FORESTRY SERVICE

DEPARTMENT OF THE ENVIRONMENT

DECEMBER 1975

[1] *Ontario Ministry of Natural Resources,*
Northern Forest Research Unit,
Box 2960, Thunder Bay, Ontario.
P7B 5G5

(Present address:

School of Forestry,
Lakehead University,
Thunder Bay, Ontario.
P7B 5E1)

Copies of this report may be obtained from:

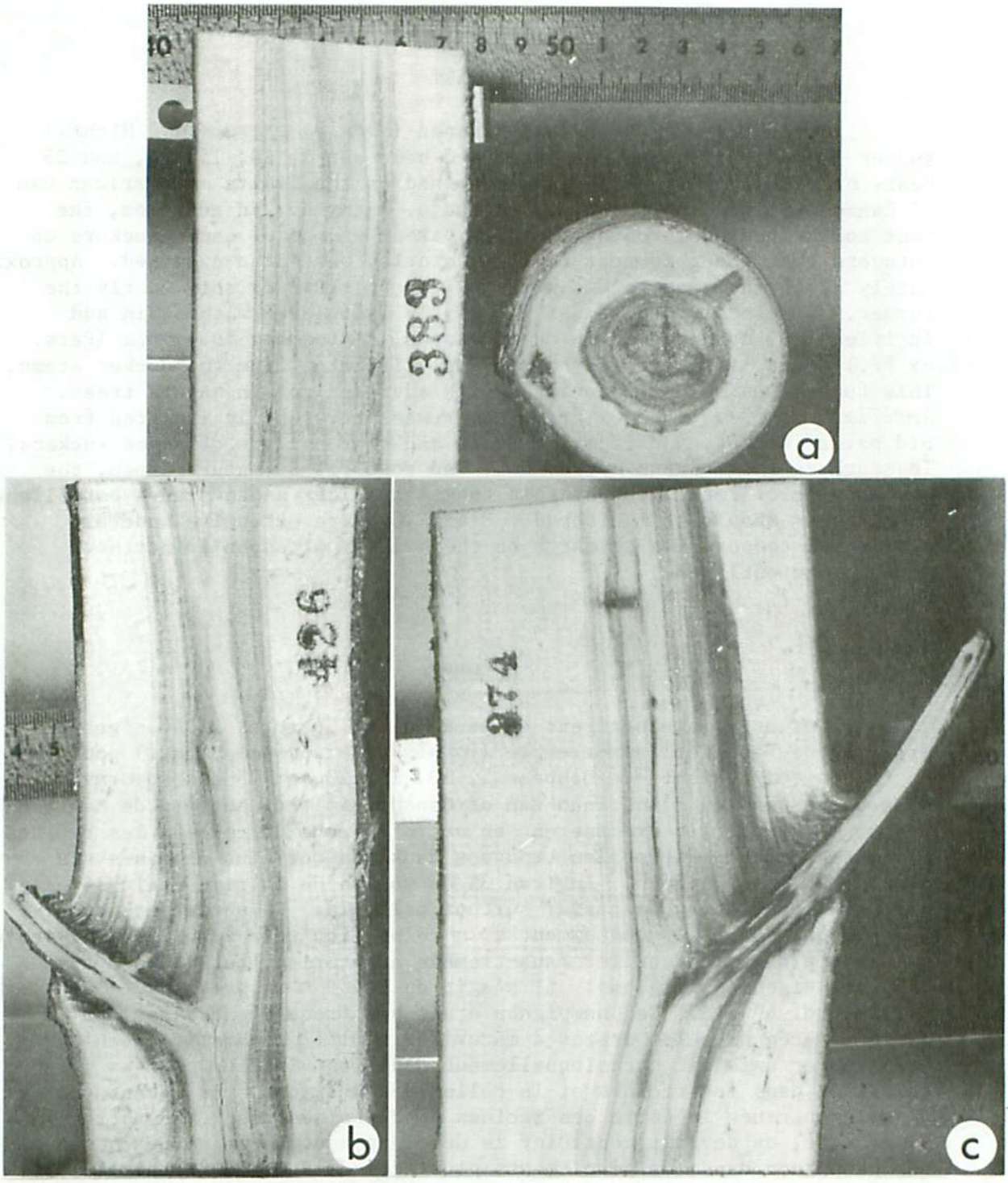
Information Office,
Great Lakes Forest Research Centre,
Canadian Forestry Service,
Department of the Environment,
Box 490, Sault Ste. Marie, Ontario.
P6A 5M7

ABSTRACT

A total of 2,040 trembling aspen (*Populus tremuloides* Michx.) sucker stems growing on areas that had been cut 5, 10, 15, 20, and 25 years previously were felled and examined on the limits of American Can of Canada Limited, north of Manitouwadge, Ontario. In addition, the root collar regions, roots, and four parent stumps of aspen suckers on cutovers that occurred near Dorion, Ontario, were also examined. Approximately 3% of the stem volume was affected by stain or rot, mostly the former. Only one of the fungi frequently associated with stain and incipient or advanced rot in mature aspen, *Peniophora polygonia* (Pers. ex Fr.) Bourd. & Galz., was consistently isolated from the sucker stems. This fungus was seldom associated with advanced rot in mature trees. *Armillaria mellea* (Vahl ex Fr.) Kummer was occasionally isolated from old parent stumps, and from the roots and root collars of aspen suckers. Inasmuch as this fungus causes butt and root rot of mature aspen, the development of rot caused by this fungus in older aspen stands established on cutovers should be monitored. Plans for more extensive federal–provincial cooperative research on the quality of aspen in northern Ontario are outlined.

RÉSUMÉ

Les auteurs abattirent et examinèrent au total 2,040 tiges de drageons de Peuplier faux-tremble (*Populus tremuloides* Michx.) poussant en forêts qui avaient été coupées 5, 10, 15, 20, et 25 ans auparavant dans la concession d'American Can of Canada Limited, au nord de Manitouwadge, Ontario. Ils examinèrent en outre la zone du collet, les racines et quatre souches parentales trouvées dans des terrains déboisés sis près de Dorion, Ontario. Environ 3% du volume de la tige était affecté par la coloration ou la carie, surtout celle-là. Un seulement des Champignons associés fréquemment à la coloration et à la carie incipiente ou avancée dans le Peuplier faux-tremble à maturité, fut isolé à tout coup des tiges de drageons: il s'agit de *Peniophora polygonia* (Pers. ex Fr.) Bourd. & Galz. Ce Champignon était peu fréquemment associé à la carie avancée dans les arbres à maturité. *Armillaria mellea* (Vahl ex Fr.) Kummer existait occasionnellement dans les vieilles souches parentales, et dans les racines et le collet des drageons. En autant que ce Champignon cause la carie des racines et des pieds des P. faux-trembles à maturité, on devrait contrôler le développement de la carie causée par ce Champignon dans les peuplements plus âgés de P. faux-tremble établis en peuplements autrefois récoltés. Les auteurs dressèrent des plans de recherche coopérative fédérale–provinciale plus poussée sur le degré de qualité du P. faux-tremble dans le nord de l'Ontario.



Frontispiece. a) Transverse and radial sections of a 23-year-old aspen sucker stem with extensive stain and a limited amount of incipient rot. b) and c) Radial sections of 23-year-old aspen sucker stems showing the pattern of stain associated with dead branches.

TABLE OF CONTENTS

INTRODUCTION

There exists in Canada a vast, hitherto little-used poplar (*Populus* spp.) resource. With few exceptions, the forest industry has until recently regarded poplars largely as weed species, and bypassed them because of the high incidence of rot in standing trees, their low fiber yields in pulping operations, their relatively low strength, and problems with drying and machining lumber. However, poplars do have three advantages over other Canadian deciduous trees: an abundant supply, a prolific reproductive capacity, and relatively fast growth.

Recently foresters and members of the forest industry of northern and northwestern Ontario have shown a heightened interest in poplar, particularly trembling aspen (*P. tremuloides* Michx.), the predominant poplar species. This has taken place for several reasons, the most important of which are probably the coniferous growing stock's relatively long rotation, its increasingly economically unfeasible accessibility due to intensive past utilization, the ever increasing demand for wood products, and the rapidly improving market for aspen products such as pulpwood and composite board. It seems highly probable that for at least the next three or four decades in the Boreal Forest Region of Ontario, aspen will be increasingly important as a commercial forest tree species. Increased interest in trembling aspen and other poplars in Ontario and other parts of North America is reflected by the many conferences on these species held in recent years. These include a symposium in 1967 at Harrison Hot Springs, British Columbia (Maini and Cayford 1968), a workshop in 1970 at Maple, Ontario (Anon. 1970), a symposium in 1972 at Duluth, Minnesota (Anon. 1972), a symposium in 1974 at Edmonton, Alberta (Neilson and McBride 1974), and a seminar in 1975 at Thunder Bay, Ontario (Van Bers 1975).

Because past attention has been focused predominantly on the management of conifers and high-value hardwoods, more knowledge is now needed upon which to base intelligent recommendations for the optimum management of aspen in Ontario.

As a rule aspen regenerates itself vegetatively by root suckering. It also produces large quantities of seed which can be carried many miles by air currents, giving it the potential ability to invade areas previously occupied by other species following fire, clearcutting, or other disturbances in which all or most of the vegetation has been removed. Some of the aspen occurring in northern Ontario may have been established from seed in this way, but most mature and overmature stands appear to regenerate vegetatively from suckers, presumably following fires (Heeney et al. 1975). In any case, it is inevitable that in northern Ontario future operations in aspen will involve a higher and higher proportion of stands established from root suckers following cutting. These stands for future harvesting will therefore have been established under different circumstances and ecological conditions than their parent stands already harvested or included in current operational plans.

An appreciable amount of aspen (though only a small percentage of the annual allowable cut) has been harvested in northern Ontario since World War II, particularly to supply pulp mills at Marathon and Espanola. From these operations, and from research carried out by the federal and provincial governments (Basham 1960, Basham and Morawski 1964), it is clear that aspen is one of Ontario's most defective commercial tree species. Its tendency to develop a high incidence of rot and stain at a relatively early age is one of the principal reasons for its under-utilization.

Considerable knowledge is available concerning physiological and ecological factors governing the production of aspen suckers; however, very little information has been published concerning their quality. Because widespread aspen cutovers are relatively new in Ontario, we have virtually no information on the quality of aspen suckers established on cutovers, nor do we know whether they will develop into more defective or less defective stands than their parents. In the mid-1960s provincial government and industry foresters began to wonder whether the extensive aspen sucker stands springing up following cutting would develop into more defective stands than the aspen already harvested up to that time.

The Northern Forest Research Unit of the Ontario Ministry of Natural Resources (OMNR) conducted studies in 1970 and 1971 in cooperation with American Can of Canada Limited in aspen sucker stands that had become established on their limits following cutting 5 to 25 years previously. The American Can area was chosen because of the company's interest in the study, and because they had been harvesting aspen on a large scale since 1946--longer than anyone else in Ontario. Although not directly involved in the planning or the field operations of the studies, personnel at the Canadian Forestry Service's (CFS) Great Lakes Forest Research Centre in Sault Ste. Marie, Ontario assisted by identifying the microorganisms isolated from some of the defective wood encountered in these suckers. This report is based largely on the results of these identifications, and discusses the implications of the results for the future quality of aspen sucker stands established following harvesting operations in Ontario. It is essentially a companion report to a preliminary report by Smith (1973) and an additional report by Kemperman et al. (1975).

METHODS OF STUDY

The aspen sucker stands were sampled in the Upper Pic–White Otter River region of the American Can limits, 35 to 60 km (21.73 to 37.26 miles) southeast of Longlac, Ontario. The 1970 study was conducted by G.D. Smith of OMNR, who sampled suckers growing on 5- to 20-year old cutovers. The 1971 study was supervised by his successor, S. Navratil, who limited his sampling to aspen growing on areas harvested 25 years previously.

In 1970, sucker stands were selected in areas cut 5, 10, 15, or 20 years earlier whose original stand composition was 75% to 100%, 50% to 74%, or 25% to 49% hardwood (principally aspen). The sampled stands were restricted to sites classified as moisture regime 2 (adequate) or 3 (somewhat moist), with a permeability range of moderate to very low. In all, 24 study areas were established; these consisted of two replications of the 12 combinations of age and stand composition. Sixty aspen on each study area were selected for sampling, for a total sample of 1,440 trees. Trees were cut close to the ground and bucked into 0.61-m (2-ft) lengths except for the trees on 20-year-old cutovers which were bucked into 1.22-m (4-ft) lengths. The diameters of the trees and of the defects were recorded at each cut. The defects were described as stain, incipient rot, or advanced rot, depending on their hardness. This study concentrated on methodology and on general defect volume and incidence relationships, with the identification of associated microorganisms included but not emphasized. From each study area seven bolts (all the CFS could handle because of other commitments) approximately 0.3 m (1 ft) long containing defects representative of those occurring in the 60 sample trees were chosen subjectively. These were shipped to Sault Ste. Marie where they were immediately processed by making isolation attempts from freshly exposed surfaces on 2% malt agar in test tubes.

In the 1971 study a different sampling technique and study basis were used. Ten pure or nearly pure aspen sucker stands were selected on 25-year-old cutovers. Two paired strip plots were laid out in each stand. The soil moisture regime in each plot was determined, according to the method of Hills and Pierpoint (1960). Within each plot 30 aspen, excluding those in the suppressed crown class, were selected for sampling for a total sample of 600 trees. Each tree was cut close to the ground and bucked into 1.22-m (4-ft) lengths up to a height of 4.88 m (16 ft), and into 2.44-m (8-ft) lengths above this height. Tree characteristics such as crown class (dominance), apparent rate of stub healing, and degree of natural pruning were observed and recorded. At each cut a disc was removed and taken to the laboratory in Thunder Bay. When time permitted these discs were dried and sanded, and the diameters of the discs and of any defect present were recorded. The defect was again described as stain, incipient rot, or advanced rot, and in addition the presence of "wetwood" was recorded.

The identification of microorganisms associated with defects was based mainly on stem samples cut 1.22 m (4 ft) above ground level, regardless of the presence or absence of rot or stain. This height was preselected to save time, and because it was felt that the majority of both stem and butt rots would occur at this height. The identifications were conducted in two separate phases. At the 1.22-m (4-ft) height in every tree and from occasional trees at ground level, bolts approximately 30 cm (1 ft) long were removed and shipped to OMNR refrigeration storage in Thunder Bay for processing during the winter of 1971-1972. From every fourth tree these bolts were halved prior

to refrigeration, and one of the 15-cm (6-in.) sections was shipped to the CFS in Sault Ste. Marie for immediate processing in the same manner as in the 1970 study. The limited sample (one section from every fourth tree) was again dictated by other CFS program commitments. In the winter of 1971-1972 the stored samples at Thunder Bay were removed from refrigeration and split, all defects including wetwood and branch stubs were diagrammed, and isolation attempts were made from the defective wood by OMNR research personnel on 2% malt agar in test tubes. Some isolates were identified there; however, the majority of the isolates were subsequently shipped to the CFS in Sault Ste. Marie for identification.

In an associated but separate investigation of stem and root defect relationships, aspen suckers ranging in age from 4 to 14 years were examined in 1971 in stands that were established following cutting near Dorion, Ontario, some 200 km (124.2 miles) southwest of the American Can limits. The trees were cut at ground level; if defect was present the root systems were excavated and refrigerated. These were later removed and dissected, all defects were diagrammed, and isolation attempts were made from the defective tissue by OMNR research personnel. Isolation attempts were also made in the basal regions of some of the stems, and in a few of the old parent aspen stumps from which the suckers originated. The isolates were subsequently shipped to the CFS in Sault Ste. Marie where they were identified.

RESULTS

Defect Relationships in Aspen Sucker Stems

The reader should bear in mind that the designation of freshly cut aspen sucker stem tissue as clear wood, stain, incipient rot, advanced rot, or wetwood, is largely subjective, and that as the wood dries it becomes increasingly difficult to do this accurately. The classification system generally used in wood pathology was adopted. In this system, stain is discolored wood which is as hard as or harder than healthy clear wood, and incipient rot is discolored wood that is slightly softer than healthy wood when tested with a sharp pencil or a knife. However, in many instances it is extremely difficult to decide whether or not the discolored wood is slightly softer than healthy wood. Advanced rot is defined as noticeably softened wood; however, without employing a precise mechanical testing device it is unlikely that any two people would consistently agree on the point at which incipient rot becomes advanced rot. The aspen defects in this investigation were examined and described by different OMNR personnel in 1970 and 1971, either on freshly cut section surfaces or on dried and sanded discs; the sections were then submitted to the CFS in Sault Ste. Marie where they were described by forest pathologists. Subsequent comparisons have indicated that there were noticeable differences in the various classification procedures; under the circumstances this is not surprising.

1970 sample, 5 to 20 years after cutting: Smith (1973) has reported that the original stand composition had no consistent effect upon the quality or rate of growth of the aspen suckers. A surprisingly high percentage (76%) of stems on the 5-year-old cutover were affected by some light-to-dark-brown stain. All stems on the 15- and 20-year-old cutovers had some stain volume. The percentage of trees with incipient rot and advanced rot remained quite constant, at 20% to 25% and 5%, respectively, for all four age classes of sucker stems. On a volume basis, a fairly constant average of 5% to 7% of the total tree volume was defective in all four age classes studied (ibid.).

Smith (ibid.) divided the defects into butt and trunk defects, and found that in stems on all ages of cutover their incidence was roughly equal except in 5-year-old cutovers where butt defects were noticeably more common. In most cases where both occurred in the same tree, they were separated by healthy, sound wood. He observed very few possible external entrance points for the butt rots, and concluded that a high proportion of the stain probably entered through the root systems. He traced many of the trunk defects to broken branches, even in 5-year-old trees.

1971 sample, 25 years after cutting: OMNR investigators found that 84% of 23-year-old sucker stems were affected by stain, and 63% had some form of rot (Kemperman et al. 1975). These frequencies of defect occurrence varied considerably between plots, ranging from 60% to 97% for stain and from 27% to 100% for rot. On a volume basis, they found an average of 1.4% of the tree volume examined was affected by stain and 0.5% by rot, for a total defect volume of 1.9%. When only the basal stem regions (0-1.22 m, or 0-4 ft) were considered, this figure rose to 2.8%.

The pronounced variation in defectiveness between sample plots was thought to be due perhaps to clonal differences, which were not assessed, and to site and related growth rate differences. Relationships were found between the incidence of defect and rate of stub healing, the degree of natural pruning, and crown class. Trees with the fastest apparent rate of stub healing tended to have the least defect, as did trees with the greatest dominance. There were no significant differences in the extent of stain in trees with different degrees of natural pruning; however, significantly less rot was found in the cleaner stems (Kemperman et al. 1975).

4- to 14-year-old sucker root systems: In all, 385 suckers were cut at ground level; 52% of these had some defect at this point. Below-ground examination of the defective stumps revealed that 48% of them had defect within the root collars, and 45% had one or more defective roots.

The volume of stain and rot in the suckers whose root systems were examined was not recorded; however, some information on the extent of these defects is available from descriptions made in connection with the isolation attempts. Isolation attempts were made in the root systems of 60 suckers, chosen as representative of the total sample.

Isolation attempts were made from four parent stumps, all with advanced rot. Three parent roots were sampled; all had advanced rot. The roots of 20 aspen suckers, as distinct from parent roots, served as host material for isolation attempts. Many of these had wounds where the bark had been completely removed exposing cambium or xylem. In 12 of these roots, isolation attempts were made from advanced rot, in five from incipient rot, and in three from stain. Isolation attempts were made in the root collar region of 28 of the trees. Descriptions associated with these attempts reveal 12 root collar regions with advanced rot, nine with incipient rot, and seven with stain. The stem region just above ground level was described in 23 trees. These data show seven trees with advanced rot in this region, 11 with incipient rot, and five with stain.

Defect Mycology and Pathology

The identity and frequency of occurrence of microorganisms isolated from aspen sucker stem samples shipped to CFS pathologists at Sault Ste. Marie in 1970 and 1971 were quite similar, despite the different sampling techniques used in the two years. However, there were a few pronounced differences in the microorganisms isolated by OMNR personnel from samples maintained for 3-8 months in refrigerated conditions in Thunder Bay. For this reason the mycological results are presented separately for the Sault Ste. Marie and Thunder Bay isolation attempts.

Sucker stems processed in Sault Ste. Marie: The distribution of isolation attempts made in wood classified as sound, stain, and rot by CFS forest pathologists in Sault Ste. Marie is shown in Table 1. The samples submitted from 5-, 10-, 15-, and 20-year-old cutovers were chosen to be representative of the defects encountered in the sample trees on each plot: they were collected at heights ranging from ground level to 8.5 m (28 ft), although 88% of them were within 1.8 m (6 ft) of the ground. On the other hand, the samples submitted from the 25-year-old cutovers the following year were selected systematically from every fourth tree examined, regardless of the presence or absence of defect, and were almost always cut at the 1.22-m (4-ft) level.

Very few isolation attempts were made from sound wood; these occurred in samples which, in the judgment of CFS pathologists, contained no defective wood. In all other samples isolation attempts were made in any rotten wood present; otherwise, attempts were made in stained wood.

Table 1. Distribution, by condition of wood, of isolation attempts made from aspen sucker stems by Canadian Forestry Service forest pathologists in Sault Ste. Marie

Condition of wood	Isolation attempts	Years following cutting operations at time of sampling[a]				
		5	10	15	20	25[b]
Sound, healthy	No.	3	0	0	0	11
	%	2.3	0.0	0.0	0.0	2.3
Stain	No.	120	106	121	86	398
	%	93.0	86.2	89.6	75.4	82.9
Rot	No.	6	17	14	28	71
	%	4.7	13.8	10.3	24.5	14.8

[a] The suckers were generally established 1 to 3 years after the cutting operation.

[b] Different sampling basis used (see text).

It is clear from Table 1 that the presence of rot in the samples submitted in 1970 increased, on a percentage basis, from a low in 5-year-old to a high in 20-year-old cutovers. A substantially smaller proportion of the samples submitted in 1971 from the stems occurring on 25-year-old cutovers contained rot than of those submitted from the 20-year-old cutovers, undoubtedly because of the different sampling methodology already outlined.

The overall frequency with which various microorganisms were isolated from the aspen sucker stem material shipped to Sault Ste. Marie is shown in Table 2. Only one fungus, *Peniophora polygonia* (Pers. ex Fr.) Bourd. & Galz., was consistently isolated from these samples. This fungus has frequently been isolated from stained wood and incipient rot, and occasionally from advanced rot, in mature trembling aspen (Basham and Morawski 1964) but is believed to be incapable of causing advanced rot in this species. Bacteria and yeasts are generally regarded as secondary organisms in the stems of living trees, incapable of causing stain or rot. Several fungi are known from earlier studies to cause substantial amounts of heart rot in mature and overmature living aspen trees in Ontario (ibid.), including trees sampled in the region of the aspen sucker sample plots (Basham 1958). Only one of these fungi is represented in Table 2, *Fomes igniarius* (L. ex Fr.) Kickx, one of two

Table 2. The frequency with which microorganisms were isolated from sections of aspen sucker stems sampled on 5- to 25-year-old cutovers and submitted to Canadian Forestry Service forest pathologists in Sault Ste. Marie

Microorganism or sterile	No. of isolations	Percentage of total isolations
Bacteria	269	23.4
Peniophora polygonia (Pers. ex Fr.) Bourd. & Galz.	238	20.7
Sterile	164	14.3
Yeasts	137	11.9
Rhinocladiella sp.	78	6.8
Miscellaneous unidentified	53	4.6
Cephalosporium sp.	37	3.2
Phoma spp.	31	2.7
Cytospora spp.	18	1.6
Trichoderma spp.	17	1.5
Pleurostromella sp.	15	1.3
Phlebia strigoso-zonata (Schw.) Lloyd	14	1.2
Gliocladium sp.	11	1.0
Phialophora sp.	8	0.7
Phycomycetes	7	0.6
Coniothyrium sp.	7	0.6
Fomes igniarius (L. ex Fr.) Kickx	7	0.6
Verticillium spp.	6	0.5
Hymenochaete tabacina (Sow. ex Fr.) Lev.	4	0.3
Gloeocystidiellum karstenii (Bourd. & Galz.) Donk	4	0.3
Hypoxylon sp.	3	0.3
Dothiorella sp.	3	0.3
Hyphoderma pallidum (Bres.) Donk	3	0.3
Candida sp.	3	0.3
Alternaria sp.	2	0.2
Cladiosporium sp.	2	0.2
Libertella sp.	1	0.1
Coryne sp.	1	0.1
Phanerochaete cremea Bres. (Parmisto)	1	0.1
Collybia velutipes (Curt. ex Fr.) Quel.	1	0.1
Peniophora duplex Burt	1	0.1
Polyporus versicolor L. ex Fr.	1	0.1
Trichoderma viride Pers. ex Fr.	1	0.1
Phomopsis sp.	1	0.1
Total	1,149	

fungi responsible for most trunk rot in older aspen, and it was isolated only seven times. None of the other isolated microorganisms has been associated with rot in mature or overmature living aspen, with the exception of *Collybia velutipes* (Curt. ex Fr.) Quel., which was isolated only once and was relatively rare in older trees.

The 14 isolation attempts made in sound wood yielded three isolates of *Trichoderma* sp.; the remainder were sterile. Bacteria accounted for slightly over one fourth of all isolation attempts made from stained wood; most of the remainder yielded either *P. polygonia* or yeasts, or were sterile (Table 3). Almost 70% of the isolation attempts made in stained wood from the youngest aspen sucker stems (on 5- and 10-year-old cutovers) yielded bacteria or yeasts, or were sterile. *Peniophora polygonia* was virtually absent in stain from these young stems, but became progressively more abundant until it accounted for slightly over one third of the isolates obtained from stained wood of suckers sampled on 25-year-old cutovers.

Peniophora polygonia was the only microorganism consistently isolated from discolored wood judged to be rot (softer than clear, sound aspen wood) (Table 4). *Fomes igniarius* was obtained five times from rotten wood in aspen growing on 20- and 25-year-old cutovers, accounting for only 3.3% of the total number of isolations.

Sucker stems processed in Thunder Bay: Identifiable isolates were obtained from isolation attempts made in Thunder Bay at 937 locations in the sucker stems growing on 25-year-old cutovers. Over three fourths of these attempts were made in tissue of the main stem at a height of 1.22 m (4 ft); most of the remainder were made in branch stubs at this height (only 25 were made in stem tissue at ground level). The condition of the wood from which the isolation attempts were made is shown in Table 5. In all three groups over half of the attempts were made in wood that was classified as incipient rot.

The overall frequency with which various microorganisms were isolated from aspen sampled on 25-year-old cutovers at Thunder Bay is shown in Table 6. The most frequently isolated microorganism was an unidentified species belonging to the genus *Cephalosporium*; it accounted for almost one third of the isolations. Bacteria accounted for almost one fourth of the isolations, and *P. polygonia* for about one fifth; no other microorganisms were consistently isolated from these trees.

Cephalosporium sp. and bacteria were practically always the two most frequently isolated microorganisms at a height of 1.22 m (4 ft), regardless of the condition of the wood or whether isolation attempts were made in stem tissue or from branch stubs (Table 7). This table reveals very little difference between the microflora occupying branch

Table 3. Stained (discolored but firm) wood in aspen sucker stems. The frequency with which microorganisms were isolated from stain in samples obtained from aspen growing on 5- to 25-year-old cutovers and submitted to Canadian Forestry Service pathologists in Sault Ste. Marie

	Percentage of total number of various micro-organisms, including sterile isolation attempts, obtained from aspen sucker stems (total number of microorganisms per age group in parentheses)[a]				
	Years following cutting operations at time of sampling				
Microorganism or sterile	5 (155)	10 (167)	15 (156)	20 (102)	25[b] (418)
Bacteria	24.5	37.1	21.8	24.5	22.2
Peniophora polygonia (Pers. ex Fr.) Bourd. & Galz.	0.7	0.0	5.1	10.8	37.1
Sterile	23.1	6.6	13.5	9.8	16.5
Yeasts	21.9	22.2	20.5	13.7	2.9
Rhinocladiella sp.	11.6	12.0	9.6	12.7	0.2
Miscellaneous unidentified	1.9	6.6	7.0	8.8	3.4
Cephalosporium sp.	1.3	6.6	3.2	3.9	2.9
Phoma spp.	0.0	1.8	0.0	2.9	4.3
Cytospora spp.	3.9	0.0	0.0	3.9	1.7
Pleurostromella sp.	3.9	0.6	4.5	0.0	0.2
Trichoderma sp.	0.0	2.4	1.3	4.9	0.0
Gliocladium sp.	0.7	0.0	1.3	0.0	1.7
Phlebia strigoso-zonata (Schw.) Lloyd	0.0	0.6	1.9	0.0	0.2
Hymenochaete tabacina (Sow. ex Fr.) Lev.	0.0	0.0	1.3	1.0	0.0
Fomes igniarius (L. ex Fr.) Kickx	0.0	0.0	0.0	0.0	0.5
Gloeocystidiellum karstenii (Bourd. & Galz.) Donk	0.0	0.0	0.0	1.0	0.2
Phanerochaete cremea Bres. (Parmisto)	0.0	0.6	0.0	0.0	0.0
Collybia velutipes (Curt. ex Fr.) Quel.	0.0	0.6	0.0	0.0	0.0
Peniophora duplex Burt	0.7	0.0	0.0	0.0	0.0

[a] Greater than number of isolation attempts because of instances where more than one microorganism was obtained from a single attempt. Among the fungi accounting for less than 1% of the total, only Basidiomycetes are included.

[b] Different sampling basis used (see text).

Table 4. Rot (unfirm wood) in aspen sucker stems. The frequency with which microorganisms were isolated from rot in samples obtained from aspen growing on 5- to 25-year-old cutovers and submitted to Canadian Forestry Service forest pathologists in Sault Ste. Marie

Microorganism or sterile	Percentage of total number of various microorganisms, including sterile isolation attempts, obtained from aspen sucker stems (total number of microorganisms per age group in parentheses)[a]				
	Years following cutting operations at time of sampling				
	5 (6)	10 (20)	15 (17)	20 (35)	25[b] (72)
Peniophora polygonia (Pers. ex Fr.) Bourd. & Galz.	16.7	10.0	47.1	20.0	63.9
Bacteria	0.0	10.0	11.8	17.1	9.7
Rhinocladiella sp.	0.0	20.0	5.9	17.1	0.0
Phlebia strigoso-zonata (Schw.) Lloyd	0.0	20.0	5.9	17.1	0.0
Sterile	33.3	10.0	5.9	2.9	4.2
Yeasts	0.0	30.0	0.0	0.0	2.8
Phoma spp.	0.0	0.0	11.8	5.7	4.2
Fomes igniarius (L. ex Fr.) Kickx	0.0	0.0	0.0	8.6	2.8
Miscellaneous unidentified	50.0	0.0	0.0	5.7	0.0
Cephalosporium sp.	0.0	5.0	0.0	0.0	2.8
Trichoderma sp.	0.0	0.0	0.0	8.6	0.0
Gloeocystidiellum karstenii (Bourd. & Galz.) Donk	0.0	0.0	0.0	0.0	2.8
Hymenochaeta tabacina (Sow. ex Fr.) Lev.	0.0	0.0	5.9	0.0	0.0
Polyporus versicolor L. ex Fr.	0.0	5.0	0.0	0.0	0.0
Gliocladium sp.	0.0	0.0	0.0	2.9	0.0
Phomopsis sp.	0.0	0.0	0.0	0.0	1.4
Cytospora sp.	0.0	5.0	0.0	0.0	0.0
Trichoderma viride Pers. ex Fr.	0.0	0.0	5.9	0.0	0.0
Verticillium sp.	0.0	0.0	5.9	0.0	0.0

[a] Frequently greater than number of isolation attempts because of instances where more than one microorganism was obtained from a single attempt.

[b] Different sampling basis used (see text).

Table 5. Distribution, by condition of wood, of isolation attempts made in the main stems and in branch stubs of aspen suckers growing on 25-year-old cutovers by Ontario Ministry of Natural Resources research personnel at Thunder Bay

Condition of wood	Main stem, 1.22 m		Branch stubs		Main stem, ground level	
	Isolation attempts[a]		Isolation attempts[a]		Isolation attempts[a]	
	No.	%	No.	%	No.	%
Sound, healthy	11	1.5	0	0.0	0	0.0
Pith	15	2.0	0	0.0	1	4.0
Wetwood	142	19.3	11	6.2	1	4.0
Stain	147	20.0	26	14.7	2	8.0
Incipient rot	376	51.2	119	67.2	17	68.0
Advanced rot	44	6.0	21	11.9	4	16.0
Total	735		177		25	

[a] It is more correct to refer to these as locations, since at Thunder Bay three attempts were made at each location. However, since the occurrence of the same microorganism more than once from one location is recorded as only one occurrence, and for the sake of uniformity with Sault Ste. Marie isolations, in this paper these are regarded as single attempts.

Table 6. The frequency with which microorganisms were isolated from sections of aspen sucker stems sampled on 25-year-old cutovers by Ontario Ministry of Natural Resources research personnel at Thunder Bay

Microorganism or sterile	Number of isolations	Percentage of total isolations
Cephalosporium sp.	483	31.2
Bacteria	380	24.6
Peniophora polygonia (Pers. ex Fr.) Bourd. & Galz.	301	19.5
Miscellaneous unidentified	89	5.8
Sterile	54	3.5
Verticillium spp.	38	2.5
Cytospora spp.	34	2.2
Yeasts	33	2.1
Cladosporium spp.	26	1.7
Trichoderma viride Pers. ex Fr.	15	1.0
Actinomycetes	14	0.9
Fomes igniarius (L. ex Fr.) Kickx	11	0.7
Phlebia strigoso-zonata (Schw.) Lloyd	11	0.7
Libertella sp.	10	0.6
Trichoderma spp.	9	0.6
Rhinocladiella sp.	8	0.5
Phycomycetes	7	0.5
Phoma sp.	7	0.2
Alternaria sp.	3	0.2
Beauvaria sp.	3	0.1
Pullularia pullulans (d By.) Berkh.	2	0.1
Gloeocystidiellum karstenii (Bourd. & Galz.) Donk	2	0.1
Gliocladium roseum (Lk.) Thom.	1	0.1
Stereum purpureum (Pers. ex Fr.) Fr.	1	0.1
Hymenochaeta tabacina (Sow. ex Fr.) Lev.	1	0.1
Trechispora brinkmannii (Bres.) Rogers & Jacks.	1	0.1
Armillaria mellea (Vahl ex Fr.) Kummer	1	0.1
Fusarium sp.	1	0.1
Paecilomyces sp.	1	0.1
Total	1,547	

Table 7. The frequency with which microorganisms were isolated by Ontario Ministry of Natural Resources research personnel at Thunder Bay from the different conditions of wood in the main stems and branch stubs at a height of 1.22 m in aspen sucker stems growing on 25-year-old cutovers

Microorganism or sterile[a]	Percentage of total number of isolated microorganims, including sterile isolation attempts, obtained from each condition of wood (total number of microorganisms isolated within each group in parentheses)[b]									
	Main stem						Branch stubs			
	Condition of wood						Condition of wood			
	Sound (20)	Pith (25)	Wetwood (227)	Stain (259)	Incipient rot (610)	Advanced rot (74)	Wetwood (22)	Stain (46)	Incipient rot (185)	Advanced rot (41)
Cephalosporium sp.	30.0	44.0	30.4	27.0	36.1	29.8	18.2	21.7	28.1	31.7
Bacteria	20.0	20.0	24.7	25.5	24.6	23.0	27.3	28.3	24.3	22.0
Peniophora polygonia (Pers. ex Fr.) Bourd. & Galz.	20.0	28.0	16.3	20.8	21.1	20.3	4.5	8.7	21.6	17.1
Miscellaneous unidentified	5.0	4.0	6.6	7.7	4.1	6.8	13.6	6.5	5.4	7.3
Sterile	10.0		6.6	2.7	1.8	2.7	9.1	8.7	5.4	
Verticillium spp.		4.0	2.6	3.1	1.5	1.4		4.3	3.2	
Cytospora spp.			3.1	2.7	2.6	1.4		2.2	0.1	2.4
Yeasts			1.8	3.5	1.5	1.4	13.6	2.2	2.2	4.9
Cladosporium spp.			2.6	1.9	1.1	1.4		4.3	0.1	
Trichoderma viride Pers. ex Fr.	5.0		1.8	0.8	0.7	1.4		2.2		4.9
Actinomycetes				1.2	0.8		9.1	2.2	1.6	
Fomes igniarius (L. ex Fr.) Kickx			0.4		0.5	5.4		2.2	0.1	2.4
Phlebia strigoso-zonata (Schw.) Lloyd				0.4	0.8	1.4			2.2	
Libertella sp.			1.3	1.2	0.6					2.4
Trichoderma spp.				1.2	0.7	1.4		2.2		
Rhinocladiella sp.			0.4			1.4	4.5		0.1	2.4
Phycomycetes	5.0				0.2			2.2	0.1	
Phoma sp.			0.4		0.5				0.1	2.4

[a] Includes those microorganisms isolated a total of seven or more times.

[b] Frequency greater than number of isolation attempts shown in Table 5 because of instances where more than one microorganism was obtained from a single attempt.

stubs and the main stems of aspen sucker stems sampled on 25-year-old cutovers. The relatively few isolation attempts made at ground level indicated that a similar microflora exists here, except that *Verticillium* spp. and Phycomycetes were a little more common, whereas *P. polygonia* and sterile attempts were somewhat less common. Of interest was one isolation of *Armillaria mellea* (Vahl ex Fr.) Kummer, a Basidiomycete responsible for butt decay in mature living aspen which was never isolated at 1.22 m (4 ft) in these sucker stems.

4- to 14-year-old sucker root systems: Isolation attemps made from the trees in this study were concentrated in the sucker root and root collar tissue. A few of the old parent aspen stumps and roots were tested for the presence of resident microorganisms, as were several of the stems that revealed defective wood at ground level. The four parent stumps and three parent roots all had advanced rot; fungi belonging to the genus *Verticillium* and bacteria were the most frequently isolated organisms. Earlier studies have shown that several Basidiomycete fungi are responsible for advanced rot in the basal stem regions of mature and overmature aspen (Basham 1958, Basham and Morawski 1964). One of these, *A. mellea*, was isolated from one of the parent stumps and from two of the parent roots.

The overall frequency with which various microorganisms were isolated from the below-ground portions of the suckers, i.e., from the roots and root collar region, is shown in Table 8. Bacteria and *Verticillium* spp. again were the two most commonly isolated organisms, in both the roots and the root collar regions. *Armillaria mellea* was obtained from rot in two root collar regions and one root. *Peniophora polygonia*, which was so frequently isolated from the stems of aspen suckers sampled on 5- to 25-year-old cutovers, was never isolated from these below-ground portions, or from the parent stumps or roots.

Several isolation attempts were made in the stems of these trees just above ground level. Once again, *Verticillium* spp. and bacteria were the most frequently isolated microorganisms; *Cephalosporium* sp. was the only other consistently isolated organism. *Peniophora polygonia* was not represented among these isolates. However, a few isolation attemps made higher up in these stems, from 30 to 160 cm (11.8 to 62.9 in.), most frequently yielded bacteria, *P. polygonia*, and *Cephalosporium* sp., the same three microorganisms that dominated the stem microflora of the aspen suckers sampled on 5- to 25-year-old cutovers.

DISCUSSION

Studies of the development of internal defect have almost without exception demonstrated that within individual trees the extent of defect increases with tree age. The microorganisms responsible for rot and stain, and to a certain extent those associated with heartwood stain of

Table 8. The frequency with which microorganisms were isolated from the roots and root collar region of 4- to 14-year-old aspen suckers

Microorganism	Number of isolations	Percentage of total isolations
Bacteria	30	24.2
Verticillium spp.	28	22.6
Miscellaneous unidentified	18	14.5
Trichoderma viride Pers. ex Fr.	9	7.3
Cephalosporium sp.	8	6.5
Phycomycetes	6	4.8
Armillaria mellea (Vahl ex Fr.) Kummer	3	2.4
Rhinocladiella sp.	3	2.4
Actinomycetes	3	2.4
Gliocladium roseum (Lk.) Thom.	2	1.6
Nematodes	2	1.6
Yeasts	2	1.6
Cylindrocarpon sp.	2	1.6
Papulospora sp.	2	1.6
Stereum purpureum (Pers. ex Fr.) Fr.	1	0.8
Cladosporium sp.	1	0.8
Fusarium sp.	1	0.8
Graphium sp.	1	0.8
Arthrobotrys sp.	1	0.8
Cephalosporiopsis sp.	1	0.8
Total	124	

physiological origin, depend on the formation of avenues through the bark and often the sapwood, such as wounds, branch stubs, dead or broken tops, etc. These avenues or entrance courts are usually not present in seedlings, but in most trees develop as the trees age. It is somewhat anomalous, therefore, that Smith in his 1970 sampling of aspen suckers less than 20 years old found an appreciably higher average percentage of the total tree volume defective (5% to 7%) than did Navratil in his 1971 sample of suckers averaging 23 years in age (1.9%).

These differences can be attributed partly to the highly subjective procedure, alluded to earlier, of determining whether wood is sound, stained, or rotten, particularly since such designations were made on freshly cut surfaces in 1970 but on dried, sanded discs in 1971. Furthermore, a reexamination of the six 1970 plots located in 20-year-old cutovers suggested that the trees in two of the plots may have been badly damaged by hail. Hail damage frequently results in the development of internal stain and rot. This suspicion was reinforced when it was discovered that these two plots had appreciably more defect than the other four. The 1970 data from 20-year-old cutovers were recalculated eliminating the two suspect plots. In this analysis all defects less than 3 mm in diameter were considered of no consequence and were omitted; this was the procedure used with the 1971 sample data. When analyzed in this manner, the data from the four sample plots located on areas that had been harvested 20 years earlier indicated that 3.8% of the total tree volume was defective.

The data obtained from the sucker stands growing on 25-year-old cutovers sampled in 1971 suggested that the extent of internal defect was related to the degree of natural pruning, the rate of stub healing, and the structure of the stand with respect to tree dominance or crown classes (Kemperman et al. 1975). These external indicators of stem quality could have considerable practical significance in the identification of superior and inferior aspen sucker stems, particularly when combined with an anticipated future knowledge of clonal variations in sucker stands.

The plots established on 25-year-old cutovers showed a slight trend of increasing rot volume in aspen suckers with increasing moisture regime, that is, as the soil moisture regime became more moist. This was particularly true as far as rot in the basal stem regions (0-1.22 m, or 0-4 ft) was concerned. In an earlier study of decay in mature trembling aspen in the same region of Ontario (Basham 1960), it was found that trees from 20 to 100 years old were somewhat more defective on wetter than on drier sites (this trend was reversed in older trees), but the occurrence of butt and trunk defect within this relationship was not analyzed. However, in neither of these studies were aspen clones differentiated. Recent work by Wall (1971) in Manitoba, and some of our own unpublished data, suggest interclonal variations in the extent of decay and stain in aspen. Wall has presented evidence indicating that

clones differ in their site preferences. Clearly, the consideration of clonal differences would make any relationships between aspen defects and site more meaningful.

Smith (1973) reported that the percentage of sample trees in which rot was found remained fairly constant from the 5-year-old to the 20-year-old cutover samples. He also found that the percentage of the total tree volume that was defective (stain plus rot) remained constant in all four age classes examined. His report did not include any data concerning the volume of rot at the different age classes; however, Table 1 of this report suggests that there was considerably more rot in the aspen suckers sampled on 20-year-old than on 5-year-old cutovers.

A comparison of Tables 2, 3, 4, and 6 reveals many similarities, but a few noticeable differences, in the frequency with which various microorganisms were isolated from aspen sucker stem tissue in Sault Ste. Marie and in Thunder Bay. The differences are particularly evident when comparisons are made of the microorganisms isolated at both locations from the stems sampled on 25-year-old cutovers (Tables 3 and 4). The most striking differences are found in the occurrence of sterile isolation attempts, *Cephalosporium* sp., and *Verticillium* spp. (14.3%, 3.2%, and 0.5%, respectively, of Sault Ste. Marie isolations compared with 3.5%, 31.2%, and 2.5% of Thunder Bay isolations). Since the samples processed in Sault Ste. Marie were obtained from one out of every four trees from which the Thunder Bay samples were obtained, these differences undoubtedly arise from the different manner in which the material was tested. The Sault Ste. Marie and Thunder Bay personnel may have used different bases for selecting loci for isolation attempts. The time of processing the samples was certainly different, with the Sault Ste. Marie samples being received, and isolation attempts made, within 2 weeks of the time the trees were felled. The Thunder Bay samples, on the other hand, were kept in cold storage for up to 8 months after the trees were felled before isolation attempts were made. Some fungi grow at substantial rates at the temperatures of 0 to 2°C that are usually found in cold storage facilities. It is conceivable that *Cephalosporium* sp. and *Verticillium* spp. have this capacity. This alone could explain their higher frequency of isolation, and the fewer sterile isolation attempts, from the Thunder Bay samples.

Because of the prevalence of dead branches and branch stubs in aspen suckers sampled on 25-year-old cutovers at a height of 1.22 m (4 ft), the height at which almost all isolation attempts in these trees were made, branch stub tissue as well as main stem tissue was tested. The results (Table 7) indicate that basically the same microflora, dominated by *Cephalosporium* sp., bacteria, and *P. polygonia*, exist in both tissues. This in turn suggests that many of the microorganisms present in the main stem at this height entered via branch stubs. In a study of branch infections of 34-year-old aspen in Alberta, the microorganisms

isolated most frequently from branch stubs were *P. polygonia*, *Cytospora* spp., *Phoma* sp., *C. chrysosperma* (Pers.) Fr., bacteria, and *Libertella* sp. (Etheridge 1961). The single major aspen decay fungus isolated from these stubs, *F. igniarius*, occurred in only three branch stubs, but solely as lateral extensions of heartwood infections in stubs dead 19 or more years. In another study carried out in Manitoba, the microorganisms most frequently isolated from branch stubs in 20-year-old aspen were bacteria, yeasts, *Cytospora* spp., *Phoma* sp., and *Peniophora polygonia* (Steneker and Wall 1972). Again *F. igniarius* was the only major aspen decay fungus isolated and it occurred only in decayed tissue adjacent to aged branch stubs in a single tree. The results of all three studies suggest that dead and broken branches, at least in relatively young trembling aspen, are not the main entrance courts for the two fungi, *F. igniarius* and *Radulum casearium* (Morg.) Lloyd, that cause most of the trunk rot in mature and overmature aspen.

Tables 2 and 6 show that only two microorganisms, bacteria and *P. polygonia*, were frequently and consistently isolated from aspen sucker stem samples at both Sault Ste. Marie and Thunder Bay. Tables 3, 4, and 8 involve further breakdowns of these isolation attempts on the basis of condition of the wood, age of suckers, branch stubs, etc. They reveal that the only cases where bacteria and *P. polygonia* were not among the most abundant microorganisms were in wood that was classified as rot at Sault Ste. Marie and yielded relatively few bacteria, in suckers less than 20 years old, and in wetwood or stain in the branch stubs of suckers sampled on 25-year-old cutovers which yielded relatively little *P. polygonia*. There is evidence in Tables 3 and 4 that much of the defect in aspen sucker stems growing on cutovers from 5 to 15 years old is of relatively minor pathological importance. About 70% of the isolates obtained from wood classified as stain in these stems consisted of sterile attempts, or bacteria and yeasts which are not primary causes of stain or rot. The only other organism consistently isolated from this tissue was *Rhinocladiella* sp., which is not believed to be capable of causing rot and was very rarely present in the oldest suckers sampled. The few isolation attempts made from wood classified as rot in 5- to 15-year-old suckers included quite a few that were sterile, and about one third yielded *P. polygonia* which is generally associated with stain or incipient rot in mature aspen.

A thorough knowledge of the fungi associated with rot in mature and overmature living aspen in Ontario is available from past studies (Basham 1958, Basham and Morawski 1964). These studies indicated that the most prevalent type of trunk rot, i.e., rot in the stem generally above breast height, was a white spongy rot caused almost entirely by *F. igniarius*. The only other common advanced rot in the trunk was a yellow-brown stringy trunk rot; *Radulum casearium* appears to cause most of this defect although about 10% of the isolations were *P. polygonia* (Basham and Morawski 1964). Incipient yellow trunk rot accounted for a

slightly higher percentage of the merchantable tree volume than the two advanced trunk rots combined; *P. polygonia* accounted for about 50% of the isolates obtained from this defect, and *R. casearium* for about one third. All three of these rots occurred also as butt rots, between stump height and breast height. *Radulum casearium* was the fungus most frequently isolated from butt rot, followed in order by *Pholiota spectabilis* (Fr.) Kumm., *F. igniarius*, *A. mellea*, *P. aurivella* (Batsch ex Fr.) Kummer, and *Peniophora polygonia*. The only Basidiomycete fungus consistently isolated from stain in mature and overmature aspen was *P. polygonia*, although several microfungi were also frequently isolated.

Only one of the major fungi associated with rot in mature aspen, *P. polygonia*, was consistently isolated from the 768 aspen sucker stems from which isolation attempts were made in the present study. This fungus is not a major cause of advanced rot; it was generally associated with stain or incipient rot. *Fomes igniarius* was isolated a total of 18 times--seven times at Sault Ste. Marie and 11 times at Thunder Bay. These accounted for only 0.6% of the total isolations made. It did not occur in suckers younger than 20 years. The only other major rot-causing fungus of mature aspen isolated from the sucker stems was *A. mellea*; it was isolated only once, from a 23-year-old stem in one of the few (only 25) cases where isolation attempts were made at ground level. *Armillaria mellea* was the only one of the major aspen rot-causing fungi isolated from the parent stumps and roots, and from sucker roots and root collar regions. Whitney et al. (1974) have presented evidence that *A. mellea* tends to occur more within the roots and extend a shorter distance up the stem than most of the other fungi associated with butt rot in mature and overmature coniferous tree species. Many of the mature aspen sampled in the two earlier studies (Basham 1958, Basham and Morawski 1964) very likely were infected with *A. mellea* in the stump or roots, but because only the stems above stump height were examined its presence was not recorded. The presence of *A. mellea* in the roots of 4- to 14-year-old aspen suckers could represent the most serious threat to the future quality of the aspen sucker stands established on cutovers that we examined, partly because of butt rot but mainly because of increased susceptibility to stem breakage and mortality.

It must be emphasized that it is too early to predict with any accuracy the future quality of aspen stems growing on 5- to 25-year-old cutovers on the basis of their present pathological condition. In the two studies of defect in mature aspen mentioned earlier, 28 trees in the 31-year to 40-year age class and about 200 trees in the 41-year to 50-year age class were sampled. The trees in the 31-year to 40-year age class had relatively little defect, and this was mostly stain; only 2.6% of their merchantable volume was affected by rot. The trees in the 41-year to 50-year age class had almost twice as much defect, and in the 51-year to 60-year age class considerable defect that would presumably have a severe economic impact was encountered. Despite the fact that only

28 trees were examined in the 31-year to 40-year age class, these data suggest that the 25-year period from age 30 to 55 is perhaps the most critical for the development of rot and stain in aspen stands in Ontario. Obviously the existence of fairly good quality aspen suckers growing on 25-year-old cutovers is no guarantee that those stems will remain high-quality stems at age 50. During the intervening years trunk wounds, broken tops, dead branch stubs, root mortality, basal wounds, etc., could result in massive invasions of the heartwood by rot-causing fungi such as *R. casearium*, *F. igniarius*, *A. mellea* or *Pholiota spectabilis*.

Some optimism concerning the future quality of the aspen suckers sampled is warranted because of the scarcity of rot-causing fungi in the stems, including the many dead branch stubs tested. However, the methods used in obtaining the results presented in this paper should be considered very carefully before any firm conclusions are reached. It has been pointed out that the trees in two of the plots established in 1970 in 20-year-old cutovers may have been extensively damaged by hail, thereby making those sucker stems more defective than would otherwise be expected. Furthermore, it is difficult to select only seven samples of defect that are truly representative of all the various defects encountered in the 60 stems on each sample plot, as was attempted in 1970. In 1971, largely to save time so that as many stems as possible could be sampled, all but 25 of the sections used for isolation attempts were obtained at a height of 1.22 m (4 ft) regardless of the height distribution of defects within the stems (the 25 other samples were obtained at ground level). Separate volumetric analyses carried out by both authors indicated that in general there was more extensive defect at ground level than at 1.22 m (4 ft).

These cooperative studies carried out in 1970 and 1971 have been handicapped somewhat by the limited time CFS personnel in Sault Ste. Marie were able to devote to the identification of isolates obtained from the aspen suckers. Beginning in the 1975 field season the CFS is again cooperating with OMNR on aspen quality studies, but on a full-time basis with active participation in the field aspects of the study. The immediate objectives involving CFS forest pathologists are (a) to obtain better information concerning the factors governing the extent of stain and rot, and the microorganisms associated with those defects, in both the above- and below-ground parts of aspen suckers established following cutovers on the American Can limits and in the Fort Frances District of Ontario, possibly on a clonal basis, and (b) to investigate clonal differences of rot resistance in mature aspen stands, and the relationship of defect to site and various physical characteristics of the trees.

LITERATURE CITED

Anon. 1970. Prospects of Ontario's poplar timber production. Ont. Dep. Lands For., Res. Br. 114 p.

Anon. 1972. Aspen: symposium proceedings. USDA For. Serv. Gen. Tech. Rep. NC-1. 154 p.

Basham, J.T. 1958. Decay of trembling aspen. Can. J. Bot. 36: 491-505.

Basham, J.T. 1960. Studies in forest pathology. XXI. The effects of decay on the production of trembling aspen pulpwood in the Upper Pic Region of Ontario. Can. Dep. Agric. Publ. 1060. 25 p.

Basham, J.T. and Z.J.R. Morawski. 1964. Cull studies, the defects and associated basidiomycete fungi in the heartwood of living trees in the forests of Ontario. Can. Dep. For. Publ. No. 1072. 69 p.

Etheridge, D.E. 1961. Factors affecting branch infection in aspen. Can. J. Bot. 39: 799-816.

Heeney, C.J., J.A. Kemperman, and G.A. Brown. 1975. A silviculture guide to the aspen working group in Ontario. Ont. Min. Nat. Res., Div. For. 41p. + Appendix.

Hills, G.A. and G. Pierpoint. 1960. Forest site evaluation in Ontario. Ont. Dep. Lands For., Res. Br., Res. Rep. No. 42. 56 p. + Appendix.

Kemperman, J.A., N.F. Lyon, and S. Navratil. 1975. Incidence and volume of defect in second growth aspen suckers in Ontario. Ont. Min. Nat. Res., For. Res. Br., Res. Rep. (in press).

Maini, J.S. and J.H. Cayford, *Ed.* 1968. Growth and utilization of poplars in Canada. Can. Dep. For. Rur. Dev., For. Br., Dep. Publ. No. 1205. 257 p.

Neilson, R.W. and C.F. McBride, *Ed.* 1974. Poplar utilization symposium. Can. For. Serv., Vancouver, B.C. Inf. Rep. VP-X-127. 248 p.

Smith, G.D. 1973. A preliminary report on the quality of trembling aspen regeneration. Ont. Min. Nat. Res., For. Res. Br., File Rep. No. 7-73. 12 p. + Appendix.

Steneker, G.A. and R.E. Wall. 1972. Wound healing and fungal colonization in stems of young trembling aspen after thinning and pruning. Can. For. Serv., Edmonton, Alta. Inf. Rep. NOR-X-37. 25 p.

Van Bers, H. 1975. Poplar seminar. Ont. Min. Nat. Res., Thunder Bay, Ont. Mimeogr. Pap.

Wall, R.E. 1971. Variation in decay in aspen stands as affected by their clonal growth pattern. Can. J. For. Res. 1: 141-146.

Whitney, R.D., E.B. Dorworth, and P.E. Buchan. 1974. Root rot fungi in four Ontario conifers. Can. For. Serv., Sault Ste. Marie, Ont. Inf. Rep. O-X-211. 28 p.