ODC 443.3--172.8: 176.1 (77) (769)

Basidiomycetes Associated with Decay of Living Oak Trees

by Frederick H. Berry
and Frances F. Lombard

FOREST SERVICE RESEARCH PAPER NE-413
1978
FOREST SERVICE, U. S. DEPARTMENT OF AGRICULTURE
NORTHEASTERN FOREST EXPERIMENT STATION
370 REED ROAD, BROOMALL, PA 19008

THE AUTHORS

FREDERICK H. BERRY received B.S. and M.F. degrees from Duke University, and a Ph.D. degree in plant pathology from the University of Maryland. He joined the Forest Service in 1945 and has served successively as forester, forest pathologist, and plant pathologist in various parts of the country. He is now project leader at the Northeastern Forest Experiment Station's laboratories at Delaware, OH.

FRANCES F. LOMBARD received a M.A. degree in mycology from the University of North Carolina, Chapel Hill. She joined the U. S. Department of Agriculture in 1941 and has served in the Agricultural Research and Forest Services as mycologist, specializing in the identification of wood-decaying and wood-inhabiting Homobasidiomycetes in pure culture. She is presently stationed at the Center for Forest Mycology Research, Forest Products Laboratory, Madison, WI.

MANUSCRIPT RECEIVED FOR PUBLICATION 5 DECEMBER 1977

ABSTRACT

Thirty-one identified species of wood-rotting hymenomycetes were associated with decay and cull in upland oak stands in Illinois, Indiana, Kentucky, Missouri, and Ohio. Seven of these species produced brown rots that accounted for a volume loss of approximately 381 ft^3 in the trees sampled. The remaining species produced white rots that were associated with a volume loss of 557 ft^3. *Stereum frustulatum, Inonotus andersonii, Polyporus compactus, S. gausapatum,* and *Phlebia chrysocrea* were the most frequently encountered species, accounting for 70 percent of the white rot infections; 79 percent of the brown rot infections were caused by *Laetiporus sulphureus, Poria oleracea,* and *P. cocos.* Together, these brown and white rot fungi (excluding *P. oleracea* and *Phlebia chrysocrea*) were associated with 61 percent of the volume of decay. *Laetiporus sulphureus* caused more butt rot—and more decay—than any other fungus. *Inonotus andersonii* caused more trunk rot than any other fungus.

INTRODUCTION

THE PURPOSE of this study is to provide the pathological and mycological information on decay in upland oak forests in the central United States.

Early papers on heart-rotting fungi of oak by von Schrenk and Spaulding (1909), Hedgcock (1912), Hedgcock and Long (1914), and Long (1915) were based on local studies or on scattered observations of fruiting bodies and types of rot found. More recent lists of fungi common on oak published by Hepting (1935, 1941), Hepting and Hedgcock (1937), Roth and Sleeth (1939), and Genaux and Kuenzel (1939) included numerous species not mentioned in earlier publications. In 1942, Davidson et al. (1942) published pure-culture descriptions of 49 species of fungi isolated from decay in living oak species from widely separate localities. A study of decay after fire injury to southern bottomland hardwoods (Toole 1959) showed that more than 30 species of fungi caused decay. Toole isolated and identified 24 species of fungi from red oaks. Berry (1969) found 22 fungal species associated with decay in even-aged oak stands in Kentucky, and Berry and Beaton (1972) isolated and identified 29 species of fungi from oaks in the Central Hardwoods Region.

STUDY AREAS AND METHODS

From 1962 through 1968, decay was studied in even-aged, undisturbed (except by fire) upland oak stands—20 to 120 years old—in Illinois, Indiana, Kentucky, Missouri, and Ohio. Sample areas consisted of concentric circular plots 1/20-, 1/10-, and 1/5-acre in size. All living trees 3.6 inches in diameter at breast height (dbh) and larger were cut on the 1/20-acre plots; trees 5.6 inches in dbh and larger were cut on the 1/10-acre plots; and trees 11.6 inches in dbh and larger were cut on the 1/5-acre plots. Data collected from trees on the 1/20- and 1/10-acre plots were weighted so that all computations were based on 1/5-acre. Most of the 150 sample areas were on national or state forests. The results reported in this paper are based on dissections of approximately 3,000 oak trees on these plots.

After the trees were felled, the main stem and merchantable branches were cut into 4-foot bolts and examined for decay. The extent of decay was determined by splitting the bolt longitudinally. The maximum diameter of each decay column in the heartwood was located, diagramed, and recorded. The length of a decay column was measured from the maximum diameter—in each direction—and recorded to the nearest one-half foot.

Most of the decay fungi that attack oak rarely produce fruiting bodies on living trees, nor was it usually possible to diagnose the casual fungus from the type of decay alone. Therefore, to identify the fungi isolated from decay columns, it was necessary to compare pure cultures of these unidentified isolates with isolates from sporophores maintained in the reference collection of cultures at the Center for Forest Mycology Research at Madison, Wisconsin. Samples of decayed wood, each about 1 foot long, were split to expose a fresh face of infected wood. Six cores of wood, each about 4 mm in diameter, were extracted with a sterilized increment hammer and placed in test tubes containing 2.5 percent Fleischmann's diamalt[1] with 2 percent agar. If a decay organism was not isolated on the first attempt, a reisolation was attempted. All isolations of the same fungus from one sample were considered as one infection.

After the fungi had grown sufficiently in test tubes, the cultures were shipped to the Center for Forest Mycology Research for identification. About 95 percent of the decay fungi isolated from oak in this study were identified after their cultural characteristics were compared with those of identified isolates (Davidson et al. 1942).

Many of the decay columns did not yield basidiomycetous fungal isolates; however, some

[1] The use of trade, firm, or corporation names in this publication is for the information and convenience of the reader. Such use does not constitute an official endorsement or approval by the U.S. Department of Agriculture or the Forest Service of any product or service to the exclusion of others that may be suitable.

of the columns yielded bacteria and non-basidiomycetes. The non-basidiomycete fungi most commonly isolated from oak, in order of frequency, were: *Margarinomyces* sp., *Gliocladium* sp., *Phialophora* sp., *Trichocladium* sp., and *Paecilomyces* sp. The close association of bacteria, non-basidiomycetes, and basidiomycetes suggests that all are important in the decay process (Shigo 1967).

RESULTS

The fungi

A total of 31 species of fungi were associated with decay in oaks (Table 1). These fungi are hymenomycetes in the families Corticiaceae, Hericiaceae, Hymenochaetaceae, Polyporaceae, Steccherinaceae, Steraceae, and Tricholomataceae.

Of the species of basidiomycetes associated with decay, *Pleurotus sapidus* and *Rigidoporus vitreus* were isolated from only two trees each, and *Fistulina hepatica, Inonotus cuticularis, Poria inflata, Scytinostroma galactinum,* and *Spongipellis fissilis* were isolated from single trees (Table 2).

In earlier studies, *Phellinus everhartii* and *Inonotus hispidus* were thought to be common decay fungi in oak. However, these species were not isolated from our samples. Davidson et al. (1942) also reported that these fungi were seldom isolated from decay samples.

Poria mutans, which was isolated from scarlet and black oak, had not been previously reported on oak. An authenicated basidiocarp specimen and culture of this fungus species from oak is in the collections of the Center for Forest Mycology

Table 1. Basidiomycetes occurring on living oak in the Central Hardwood Region

Family CORTICIACEAE
Phlebia chrysocrea (Berk. & Curt. in Berk.) Burds. ("Unknown H" of earlier publications)
Scytinostroma galactinum (Fr.) Donk (= *Corticium galactinum* (Fr.) Burt)
Family HERICIACEAE
Hericium erinaceus (Bull. ex Fr.) Pers. (= *Hydnum erinaceus* Bull. ex Fr.)
Hericium spp. (not identified to species)
Family HYMENOCHAETACEAE
Hymenochaete rubiginosa Dicks. ex Lev.
Inonotus andersonii (Ell. & Ev.) Černý (= *Poria andersonii* (Ell. & Ev.) Neuman)
Inonotus cuticularis (Bull. ex Fr.) Karst. (= *Polyporus cuticularis* Bull. ex Fr.)
Inonotus dryophilus (Berk.) Murr. (= *Polyporus dryophilus* Berk.)
Family POLYPORACEAE
Bjerkandera adusta (Wild. ex Fr.) Karst. (= *Polyporus adustus* Willd. ex Fr.)
Coriolus versicolor (L. ex Fr.) Quél. (= *Polyporus versicolor* L. ex Fr.)
Fistulina hepatica (Huds.) Fr.
Laetiporus sulphureus (Bull. ex Fr.) Bond. & Sing. (= *Polyporus sulphureus* Bull. ex Fr.)
Merulius tremellosus Schrad. ex Fr.
Polyporus compactus Overh.
Polyporus frondosus Dicks. ex Fr.
Poria cocos (Schw.) Wolf
Poria inflata Overh.
Poris mutans Pk.
Poria nigra (Berk.) Cke.
Poria oleracea Davidson & Lombard
Rigidoporus vitreus (Pers. ex Fr.) Donk
Spongipellis fissilis (Berk. & Curt.) Murr. (= *Polyporus fissilis* Berk. & Curt.)
Spongipellis pachyodon (Pers.) Kotl. & Pouz. (= *Irpex mollis* Berk. & Curt.)
Spongipellis unicolor (Schw.) Murr. (= *Polyporus obtusus* Berk.)
Tyromyces spraguei (Berk. & Curt.) Murr. (= *Polyporus spraguei* Berk. & Curt.)
Family STECCHERINACEAE
Steccherinum setulosum (Berk. & Curt.) L. W. Miller
Family STEREACEAE
Stereum complicatum (Fr.) Fr. (= *Stereum rameale* (Schw.) Burt)
Stereum frustulatum (Pers. ex Fr.) Fckl.
Stereum gausapatum (Fr.) Fr.
Stereum subpileatum Berk. & Curt.
Family TRICHOLOMATACEAE
Armillariella mellea (Vahl ex Fr.) Karst. (= *Armillaria mellea* (Vahl ex Fr.) Quél.)
Pleurotus sapidus (Schulz. in Kalchb.) Sacc.

Table 2. Number of infections by identified white-rot and brown-rot fungi in living oak, by host species

Fungus species	Scarlet oak	Black oak	Northern red oak	White oak	Chestnut oak	Total	Percent
			WHITE-ROT FUNGI				
Stereum frustulatum	73	35	4	12	6	130	14.0
Inonotus andersonii	13	58	3	38	13	125	13.5
Polyporus compactus	32	52	9	8	5	106	11.4
Stereum gausapatum	37	30	4	10	8	89	9.6
Phlebia chrysocrea	47	3	3	10	2	65	7.0
Spongipellis pachyodon	2	26	1	17	7	53	5.7
Hericium erinaceus	4	14		22	3	43	4.6
Armillariella mellea	4	3		4	4	15	1.6
Merulius tremellosus	4	6		2	3	15	1.6
Spongipellis unicolor	2	3		8	2	15	1.6
Inonotus dryophilus	4			2	7	13	1.4
Coriolus versicolor	3	7	1	2		13	1.4
Stereum complicatum		3		4	3	10	1.1
Hymenochaete rubiginosa	8	1				9	1.0
Poria mutans	3	4				7	.8
Steccherinum setulosum		5		2		7	.8
Hericium spp.				6		6	.7
Polyporus frondosus	3			2		5	.5
Bjerkanderi adusta		2			2	4	.4
Stereum subpileatum	2	1				3	.3
Pleurotus sapidus	2					2	.2
Rigidoporus vitreus					2	2	.2
Scytinostroma galactinum		1				1	.1
Inonotus cuticularis				1		1	.1
Spongipellis fissilis				1		1	.1
Total	243	254	25	151	67	740	79.7
			BROWN-ROT FUNGI				
Laetiporus sulphureus	47	12	3	4	1	67	7.2
Poria oleracea	41	5	3			49	5.3
Poria cocos	6	17	2	2	7	34	3.6
Tyromyces spraguei	22	3	1			26	2.8
Poria nigra	7	4				11	1.2
Fistulina hepatica	1					1	.1
Poria inflata		1				1	.1
Total	124	42	9	6	8	189	20.3
All species	367	296	34	157	75	929	100.0

Research. Also, *Steccherinum setulosum,* which was isolated from black and white oak, had not been previously reported isolated in a decay survey.

The most frequently isolated species, in order of frequency, were: *Stereum frustulatum, Inonotus andersonii, Polyporus compactus, S. gausapatum, Laetiporus sulphureus, Phlebia chrysocrea, Spongipellis pachyodon, Poria oleracea, Hericium erinaceus, P. cocos,* and *Tryomyces spraguei.* Brief descriptions of these fungal species, which accounted for 85 percent of the identified infections, follow.

Stereum frustulatum—Causes a white pocket rot known as "partridge wood"; the small, spindle-shaped pockets are lined with white mycelium. The sporophores, less than 1 inch long, are flat, raised, and dirty white. In culture, *S. frustulatum* resembles *S. subpileatum* but may be distinguished by its faster growth rate, lighter orange mat, and consistent negative oxidase reaction (Davidson et al. 1942).

Inonotus andersonii—Causes a white spongy rot. The bright orange sporophores develop under the bark of dead trees and downed logs, eventually rupturing these tissues and becoming exposed. In culture, *I. andersonii* is characterized by its mustard-colored-to-brown mat, short, bulbous, brown setae, and positive oxidase reaction (Davidson et al. 1942).

Polyporus compactus—Causes a white rot. The creamy white to light tan, mostly resupinate sporophores can fruit over large areas of the host. In culture, *P. compactus* is distinguished by its fast growing white mat with scattered yellow abortive poroid areas, abundant chlamydospores, and positive oxidase reaction (Davidson et al. 1942).

Stereum gausapatum—Causes a white pocket or white mottled rot. The small, thin, slightly shelf-shaped sporophores develop abundantly on old stumps and slash. Decay is particularly prevalent in sprout stands because the fungi invade the heartwood of the sprouts from the decay in old stumps. In culture, the species develops a buff-colored mat, single and multiple clamp connections, and dark brown exudation droplets on gallic acid agar. The oxidase reaction is positive. It can be distinguished from cultures of *S. complicatum,* which are faster growing and lack the exudation droplets (Davidson et al. 1942).

Laetiporus sulphureus—Commonly called the sulphur fungus, causes a brown cubical rot. The shelf-like sporophores are orange on the upper surface (with a sulphur-yellow undersurface when fresh), weathering to a dirty white. They frequently overlap to form large rosette-like clusters, and may occur on the tree trunk or on the ground at the base of the tree. In culture, the species is characterized by its pink fast-growing mat, lack of clamp connections, abundant chlamydospores, and negative oxidase reaction (Davidson et al. 1942).

Phlebia chrysocrea—Previously misidentified as *Corticium lividum* Pers. ex Fr. (Davidson et al. 1942). It was later designated "Unknown H" until correctly identified in 1975 (Lombard and Burdsall 1975). This fungus causes a white mottled or small pocket rot, the wood being reduced to a white fibrous mass with bright yellow mycelial deposits in advanced stages of decay. In culture, *P. chrysocrea* develops a white mat with scattered areas of bright yellow mycelium that turns purple when touched with KOH solution, and emits a strong carbide odor. The oxidase reaction is positive (Davidson et al. 1942; Lombard and Burdsall 1975).

Spongipellis pachyodon—Causes a white spongy heart rot. After becoming established in the heartwood, the fungus attacks living sapwood and the cambium, causing irregular rough cankers to develop on the tree trunk. Well-developed mature sporophores of *S. pachyodon* are conspicuously toothed, while those of *S. unicolor* are poroid. In culture, isolates of these species are so similar that they could not be differentiated in previous studies (Davidson, et al. 1942, as *Irpex mollis* and *Polyporus obtusus*). In the present study, cultures of *S. pachyodon* were faster growing at high temperatures, and the two species were readily differentiated by mat diameter after 4 days' growth at 35° C. The culture of each species is characterized by a moderately fast-growing white mat, abundant chlamydospores, and positive oxidase reaction (Davidson et al. 1942).

Hericium erinaceus—Commonly called the hedgehog fungus, causes a white piped or pocket rot in the early stages; the wood decomposes completely, leaving large hollows lined with pale yellow mycelium in advanced stages. The soft annual sporophores are white (turning pale yellow or pale brown with age) and globular, with a hairy pilear surface and long slender teeth on the lower surface. In culture, this species is characterized by a medium growth rate, white appressed mat, hyphae with end cells of coarsely granular contents, chlamydospores, and positive oxidase reaction (Davidson et al. 1942).

Poria oleracea—Causes a brown cubical rot. The creamy white sporophores are resupinate and inconspicuous and are often found on down dead trees. In culture, *P. oleracea* is characterized by a white mat, odor of rotten cabbage (in old cultures), abundant chlamydospores, and negative oxidase reaction (Davidson et al., as *Poria* sp.).

Poria cocos—Causes a brown root and butt rot. The creamy-white sporophores may be found on slash, down trees, roots, etc. The fungus also forms large oblong to subglobose sclerotia (known as "tuckahoes") in the soil. In culture, the fast-growing pale pink mat, the very large hyphae and inflated cells, and the negative oxidase reaction are characteristic of the species.

Tyromyces spraguei—Causes a friable brown rot. The sporophores are annual, slightly bracket-shaped, and can be as much as 6 inches wide. In culture, *T. spraguei* develops a fast growing white

Table 3. Number of infections by identified white-rot and brown-rot fungi in living oak, by infection entry court.

Fungus species	Unsound branch stub	Fire scar	Closed branch bump	Insect wound	Sound branch stub	Parent stump	Damaged or dead top	Mechanical injury	Root	Open branch bump	Miscella-neous	Total
					WHITE-ROT FUNGI							
Stereum frustulatum	26	7	5	7	52	5	9	9	4	5	1	130
Inonotus andersonii	41	6	44	5	1	4	6	5	1	9	3	125
Polyporus compactus	21	7	6	31	2	2	5	12	—	6	14	106
Stereum gausapatum	21	4	3	—	13	14	24	4	1	2	3	89
Phlebia chrysocrea	4	5	7	14	4	14	—	7	3	2	5	65
Spongipellis pachyodon	6	3	13	—	3	—	—	9	6	6	7	53
Hericium erinaceus	5	17	4	6	—	3	—	5	3	—	—	43
Armillariella mellea	—	12	—	—	—	1	—	—	2	—	—	15
Merulius tremellosus	1	9	—	5	—	—	—	—	—	—	—	15
Spongipellis unicolor	10	—	—	—	—	—	—	—	5	—	—	15
Inonotus dryophilus	9	—	—	—	—	—	2	—	—	2	—	13
Coriolus versicolor	3	—	4	—	—	—	4	1	—	—	1	13
Stereum complicatum	1	—	—	3	—	3	3	—	—	—	—	10
Hymenochaete rubiginosa	2	—	1	—	5	—	—	—	—	—	1	9
Poria mutans	4	—	—	3	—	—	—	—	—	—	—	7
Steccherinum setulosum	—	7	—	—	—	—	—	—	—	—	—	7
Hericium spp.	—	2	—	2	—	2	—	—	—	—	—	6
Polyporus frondosus	—	—	—	—	—	—	—	—	5	—	—	5
Bjerkanderi adusta	—	3	1	—	—	—	—	—	—	—	—	4
Stereum subpileatum	—	—	1	—	1	1	—	—	—	—	—	3
Pleurotus sapidus	—	—	—	2	—	—	—	—	—	—	—	2
Rigidoporus vitreus	—	—	2	—	—	—	—	—	—	—	—	2
Scytinostroma galactinum	—	—	1	—	—	—	—	—	—	—	—	1
Inonotus cuticularis	—	1	—	—	—	—	—	—	—	—	—	1
Spongipellis fissilis	—	—	—	—	—	—	—	—	—	1	—	1
Total	154	83	92	78	81	49	53	52	30	33	35	740
					BROWN-ROT FUNGI							
Laetiporus sulphureus	5	18	14	5	—	4	—	1	4	5	11	67
Poria oleracea	6	2	1	7	5	4	13	1	—	4	6	49
Poria cocos	—	16	—	—	—	10	—	—	8	—	—	34
Tyromyces spraguei	1	2	—	—	—	13	—	—	7	—	3	26
Poria nigra	2	2	—	—	2	—	2	—	2	1	—	11
Fistulina hepatica	—	1	—	—	—	—	—	—	—	—	—	1
Poria inflata	—	1	—	—	—	—	—	—	—	—	—	1
Total	14	42	15	12	7	31	15	2	21	10	20	189
All species	168	125	107	90	88	80	68	54	51	43	55	929

mat, abundant chlamydospores, and fiber hyphae. The oxidase reaction is negative.

Host species

The 31 species isolated and identified as causing decay in oak were associated with one or more of the following species: scarlet oak (*Quercus coccinea* Muenchh.); black oak (*Q. velutina* Lam.); northern red oak (*Q. rubra* L.); white oak (*Q. alba* L.); and chestnut oak (*Q. prinus* L.). The frequency of infection by these fungi for each oak species is shown in Table 2.

Most of these fungi exhibited very little preference for a particular oak species. However, the following fungi were confined to species in the red oak group: *Poria oleracea* (49 infections); *Tyromyces spraguei* (26 infections); *P. nigra* (11 infections); *Hymenochaete rubiginosa* (9 infections); and *P. mutans* (7 infections). With the exception of *P. mutans,* these fungi have been reported previously from the white oak group (U. S. Department of Agriculture 1960).

Entry courts

Fungi that cause decay in the heartwood in live standing trees require an infection court that directly or indirectly provides access to the heartwood. The apparent avenues of entrance of the decay fungi are shown in Table 3. Basal wounds from fire and branch stubs and wounds caused by normal death of limbs are the most common sites of infection. Unsound branch stubs and fire scars were associated with about one-third of all identified infections.

The fungal species most frequently isolated entered the heartwood through three or more entry courts. However, 60 percent of the infections caused by *Stereum frustulatum* were associated with branch stubs. Branch stubs also were associated with more than one-third of the infections by the following white-rot species: *Inonotus andersonii, I. dryophilus, Hymenochaete rubiginosa, Spongipellis unicolor,* and *Stereum gausapatum* Fire scars were important entry courts for the brown rotters *Laetiporus sulphureus* and *Poria cocos,* and for the following white-rot fungi: *Armillariella mellea, Bjerkandera adusta, Hericium erinaceus, Merulius tremellosus,* and *Steccherinum setulosum.*

Infections by *Phlebia chrysocrea, Poria cocos,* and *Tyromyces spraguei* commonly occurred through parent stumps. Although *Stereum gausapatum* frequently entered through parent stumps, the majority of infections by this species were associated with damaged or dead tops.

Decay

Decay may be designated as "brown rot" or "white rot" according to the color or character of the decay. The brown rots include those in which the cellulose and associated polysaccharides of the cell wall are attacked and the decayed wood turns a shade of brown. When a greater proportion of lignin is broken down, the color of the decayed wood becomes lighter; these rots are known as white rots. Almost 80 percent of the fungi isolated from oak were white rotters; these fungi accounted for a volume loss of 556 ft^3 (Table 4). Although brown-rot fungi are not as numerous as white-rot fungi in oaks, the brown rotters nevertheless accounted for a volume loss of 381 ft^3.

Depending on its position in the tree, decay in living trees may also be classified as trunk rot or as butt and root rot. Most of the wood-decay fungi isolated from oak can cause both types of rot. However, some species, for example, *Armillariella mellea, Poria cocos,* and *Tyromyces spraguei,* caused rot only in the roots and butt.

Although the number of root and butt infections was less than half the number of trunk infections, the former accounted for a greater volume of decay, 508.61 ft^3 compared to 428.21 ft^3.

On the basis of cubic feet of decay, the fungi associated with the most serious losses were *Inonotus andersonii, Laetiporus sulphureus, Polyporus compactus, Poria cocos, Stereum gausapatum,* and *S. frustulatum. Laetiporus sulphureus* was associated with more butt rot (103.80 ft^3) than any other fungus; *I. andersonii* was the most destructive trunk-rot fungus (71.48 ft^3).

The volume of decay varies greatly between trees of the same species, size, age, and between trees with similar injuries. This variation may be due to the individual characteristics of each fungal species. For example, fungi of one group, typified by *Armillariella mellea,* confine their activity almost entirely to the roots and butts of trees, and rarely extend more than a few feet up into the trunk. Those of another group, typified by *Laetiporus sulphureus* and *Hericium erinaceus,* may enter at the butt or through some wound in the top, and are capable of producing extensive rot throughout the tree. Those of a third group, including *Stereum frustulatum* and *Inonotus andersonii,* are primarily top or upper trunk-in-

habiting species; these fungi rarely extend down to the butt.

Stem and butt rots cause considerable loss in both timber volume and quality in oak forests. These losses can be reduced by forest management practices that prevent wounding, ensure proper handling of sprout stands, maintain adequate stocking densities, and provide for the proper selection of crop trees.

ACKNOWLEDGMENTS

The authors thank Dr. Alex A. Shigo for the identification of the non-basidiomycetous fungi, and John A. Beaton for assistance in the isolation of cultures and collection and analysis of data.

Table 4. Relationship between infection by identified white-rot and brown-rot fungi in living oak and the portion of the tree bole affected.

Fungus species	Number of infections			Decay volume(ft^3)		
	In butt[a]	In trunk	Total	In butt[a]	In trunk	Total
			WHITE-ROT FUNGI			
Stereum frustulatum	27	103	130	19.68	61.86	81.54
Inonotus andersonii	15	110	125	22.61	71.48	94.09
Polyporus compactus	12	94	106	19.65	40.83	60.48
Stereum gausapatum	22	67	89	28.44	56.14	84.58
Phlebia chrysocrea	27	38	65	17.78	13.26	31.04
Spongipellis pachyodon	1	52	53	11.78	28.87	40.65
Hericium erinaceus	26	17	43	36.73	4.20	40.93
Armillariella mellea	15	—	15	17.18	—	17.18
Merulius tremellosus	9	6	15	18.80	3.37	22.17
Spongipellis unicolor	6	9	15	.77	5.42	6.19
Inonotus dryophilus	1	12	13	6.38	17.77	24.15
Coriolus versicolor	2	11	13	8.45	2.45	10.90
Stereum complicatum	2	8	10	.34	.70	1.04
Hymenochaete rubiginosa	—	9	9	—	2.11	2.11
Poria mutans	3	4	7	2.15	1.73	3.88
Steccherinum setulosum	7	—	7	3.74	10.48	14.22
Hericium spp.	3	3	6	4.31	.47	4.78
Polyporus frondosus	5	—	5	3.58	—	3.58
Bjerkanderi adusta	3	1	4	4.04	.05	4.09
Stereum subpileatum	1	2	3	2.18	1.06	3.24
Pleurotus sapidus	—	2	2	—	.04	.04
Rigidoporus vitreus	—	2	2	—	.14	.14
Scytinostroma galactinum	—	1	1	—	.51	.51
Inonotus cuticularis	1	—	1	2.98	—	2.98
Spongipellis fissilis	1	—	1	1.77	—	1.77
Total	189	551	740	233.34	322.94	556.28
			BROWN-ROT FUNGI			
Laetiporus sulphureus	35	32	67	103.80	67.48	171.28
Poria oleracea	10	39	49	30.43	13.50	43.93
Poria cocos	34	—	34	86.42	—	86.42
Tyromyces spraguei	26	—	26	29.86	—	29.86
Poria nigra	4	7	11	8.62	24.29	32.91
Fistulina hepatica	1	—	1	2.67	—	2.67
Poria inflata	1	—	1	13.47	—	13.47
Total	111	78	189	275.27	105.27	380.54
All species	300	629	929	508.61	428.21	936.82

[a] Decay originating at stump height or below was considered butt decay.

LITERATURE CITED

Berry, Frederick H.
1969. **Decay in the upland oak stands of Kentucky.** U.S. Dep. Agric. For. Serv. Res. Pap. NE-126. 116 p.

Berry, Frederick H., and John A. Beaton.
1972. **Decay in oak in the central hardwood region.** U.S. Dep. Agric. For. Serv. Res. Pap. NE-242. 11 p.

Davidson, Ross W., W.A. Campbell, and Dorothy Blaisdell Vaughn.
1942. **Fungi causing decay of living oaks in the eastern United States and their cultural identification.** U.S. Dep. Agric. For. Serv. Tech. Bull. 785. 65 p.

Genaux, Charles M., and John G. Kuenzel.
1939. **Defects which reduce quality and yield of oak-hickory stands in southeastern Iowa.** Iowa Agric. Exp. Stn. Res. Bull. 269:409-444.

Hedgcock, George G.
1912. **Notes on some diseases of trees in our national forests.** Phytopathology 2:73-80.

Hedgcock, George G., and W.H. Long.
1914. **Heart-rot of oaks and poplars caused by** *Polyporus dryophilus.* J. Agric. Res. 3:65-77.

Hepting, George H.
1935. **Decay following fire in young Mississippi delta hardwoods.** U.S. Dep. Agric. For. Serv. Tech. Bull. 494. 32 p.

Hepting, George H.
1941. **Prediction of cull following fire in Appalachian oaks.** J. Agric. Res. 62:109-120.

Hepting, George H., and George G. Hedgcock.
1937. **Decay in merchantable oak, yellow-poplar, and basswood in the Appalachian region.** U.S. Dep. Agric. For. Serv. Tech. Bull. 570. 30 p.

Lombard, Frances F., and Harold H. Burdsall, Jr.
1975. **Taxonomy of** *Corticium chrysocreas* **and** *Phlebia livida.* Mycologia 67:495-510.

Long, William H.
1915. **A honeycomb heart-rot of oaks caused by** *Stereum subpileatum.* J. Agric. Res. 5:421-428.

Roth, Elmer R., and Bailey Sleeth.
1939. **Butt rot in unburned sprout oak stands.** U.S. Dep. Agric. For. Serv. Tech. Bull. 684. 43 p.

Shigo, Alex L.
1967. **Successions of organisms in discoloration and decay of wood.** P. 237-239. *In:* J.A. Romberger & P. Mikola [ed.]. Int. Rev. For. Res. II. Academic Press, New York.

Toole, E. Richard.
1959. **Decay after fire injury to southern bottomland hardwoods.** U.S. Dep. Agric. Serv. Tech. Bull. 1189. 25 p.

U.S. Department of Agriculture.
1960. **Index of plant diseases in the United States.** U.S. Dep. Agric. Agric. Handb. No. 165. 531 p.

Von Schrenk, Herman, and Perley Spaulding.
1909. **Diseases of deciduous forest trees.** U.S. Dep. Agric. Bur. Plant Ind. Bull. 149. 85 p.

☆U.S. GOVERNMENT PRINTING OFFICE: 1978—703-112:46

Headquarters of the Northeastern Forest Experiment Station are in Broomall, Pa. Field laboratories and research units are maintained at:

- Beltsville, Maryland.
- Berea, Kentucky, in cooperation with Berea College.
- Burlington, Vermont, in cooperation with the University of Vermont.
- Delaware, Ohio.
- Durham, New Hampshire, in cooperation with the University of New Hampshire.
- Hamden, Connecticut, in cooperation with Yale University.
- Kingston, Pennsylvania.
- Morgantown, West Virginia, in cooperation with West Virginia University, Morgantown.
- Orono, Maine, in cooperation with the University of Maine, Orono.
- Parsons, West Virginia.
- Pennington, New Jersey.
- Princeton, West Virginia.
- Syracuse, New York, in cooperation with the State University of New York College of Environmental Sciences and Forestry at Syracuse University, Syracuse.
- Warren, Pennsylvania.