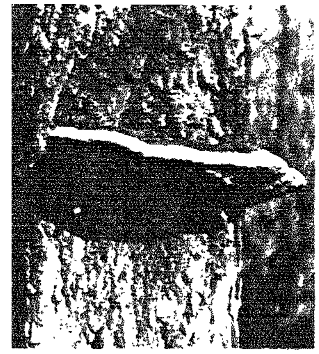

Decay in the UPLAND OAK Stands of Kentucky

by Frederick H. Berry

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NORTHEASTERN FOREST EXPERIMENT STATION, UPPER DARBY, PA.
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RICHARD D. LANE, DIRECTOR

Figure 1.—An even-aged stand of mature oak in Kentucky.

THE AUTHOR

FREDERICK H. BERRY received Bachelor of Science and Master of Forestry 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 Forest Insect and Disease Laboratory at Delaware, Ohio.

Decay in the UPLAND OAK Stands of Kentucky

HOW MUCH DECAY?

ONE PROBLEM THE forester faces in managing upland oaks in Kentucky is how to estimate the amount of cull and decay in these stands. To provide this information, the Northeastern Forest Experiment Station has made a study of these oak stands, how much decay they contain, and the principal causes of the decay.

Knowing how much decay these oak stands contain is important because these stands predominate on some 11.7 million acres of the commercial forest land in Kentucky (fig. 1). All together, these upland oak stands add up to about 5 million acres of commercial forest.[1]

The upland oaks include two general forest types: the oak-hickory type and the white oak type. The major oak species that occur in these types are: scarlet oak *(Quercus coccinea* Muenchh.), chestnut oak *(Q. prinus* L.), black oak *(Q. velutina* Lam.), northern red oak *(Q. rubra* L.), and white oak *(Q. alba* L).

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[1] Gansner, David A. THE TIMBER RESOURCES OF KENTUCKY. U. S. Forest Serv. Resource Bull. NE-9. 97 pp., illus. NE. Forest Exp. Sta., Upper Darby, Pa. 1968.

METHODS

Field Procedures

Field work was begun in 1963 and was completed the following year. During this period 37 sample plots were established in well-stocked, undisturbed (except for fire), even-aged oak or oak-hickory stands 30 to 110 years old. Most of the plots were on the Daniel Boone National Forest.

Sample areas consisted of circular plots 1/20, 1/10, and 1/5 acre in size, superimposed on a common plot center. All living trees 3.6 inches and larger in diameter at breast height (d.b.h.) were cut on the 1/20-acre plots; trees 5.6 inches and larger were cut on the 1/10-acre plots; and trees 11.6 inches 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.

General information about location, topography, aspect, age, and stand history was recorded for each plot. As trees that met specifications for the plot were tallied, they were marked with consecutively numbered tags. The diameter breast height, crown class, and tree condition were recorded; and the trees were classified as either residual (showing no external evidence of decay) or suspect (showing any significant defect). Dead trees were recorded on the tally sheet, but were not tagged or dissected.

The numbered trees were then cut at an average height of 1 foot from the ground line. The main stem and merchantable branches were marked into 4-foot lengths up to a 4-inch top diameter (inside bark). Total height was recorded. The nature, extent, and location of all surface defects were recorded. Each tree was cut into 4-foot bolts, which were examined critically for decay. Defects previously noted were examined and if decay was associated with them, this was noted on the tally sheet. Where decay appeared, its extent and dimensions were determined by splitting the bolts longitudinally.

The diameter inside bark at 16-foot intervals from stump height to a 4-inch-or-larger merchantable top was recorded. Top and bottom diameters and length of merchantable limbs were recorded. The maximum diameter of decay columns was located, diagrammed, and recorded. Lengths of decay columns were measured in both directions from the maximum diameter and were recorded to the nearest ½ foot.

Laboratory Procedures

In the laboratory, volumes were computed in cubic feet (by Smalian's formula) from the graphic tree-measurement sheets. The gross tree volume was computed at 16-foot intervals from a 1-foot stump to a 4-inch-or-larger merchantable top diameter. No reduction in gross volume was made for trim, taper, long-butting, or breakage. Where decay was present, its volume was also computed in cubic feet and subtracted from the gross volume to give the net tree volume. We included only visible decay in our determinations of decay volume, and only the stains that were confirmed as incipient decay.

Cultures were prepared from decay samples as soon as possible to determine the fungi responsible for decay. The samples were split, and from the freshly exposed faces of the infected wood six small bits of wood were extracted with a sterilized scalpel and placed in test tubes containing 2 percent Diamalt agar. If the decay organism was not isolated on the first attempt, additional re-isolations were made from the decay samples.

THE DECAY FUNGI

Occurrence of Fungi Causing Decay

A large number of fungi can cause decay in living oaks in Kentucky. However, some species of fungi occur much more commonly than others. Although 22 species were found in association with decay in oaks, four species—*Polyporus compactus* Overh., *Stereum frustulatum* (Pers. ex Fr.) Fckl., *Poria cocos* (Schw.) Wolf, and *S. gausapatum* (Fr.) Fr. — accounted for over 50 percent of the 183 identified infections (table 1). The more commonly isolated fungi were generally well distributed among the various species of oaks.

Poria cocos, which caused a brown root and butt rot, rarely extended more than 4 feet up the trunk. *Polyporus compactus*, *Stereum frustulatum*, and *S. gausapatum*—all white-rot fungi—

Table 1.—*Occurrence of fungi causing decay in the upland oaks of Kentucky, by tree species*

Fungus species	Identified infections						Infections
	Scarlet oak	Black oak	White oak	Chestnut oak	Northern red oak	Total	
	No.	*No.*	*No.*	*No.*	*No.*	*No.*	*Percent*
Polyporus compactus Overh.	17	15	3	—	1	36	19.67
Stereum frustulatum (Pers. ex. Fr.) Fckl.	19	3	5	—	—	27	14.75
Poria cocos (Schw.) Wolf	2	12	1	1	—	16	8.74
Stereum gausapatum (Fr.) Fr.	9	2	—	2	1	14	7.65
Unknown H[1]	10	1	2	—	—	13	7.10
Polyporus spraguei Berk. & Curt.	9	—	—	—	—	9	4.92
Poria nigra (Berk.) Cke.	6	2	—	—	—	8	4.37
Polyporus sulphureus Bull. ex. Fr.	6	—	1	—	—	7	3.83
Poria andersonii (Ell. & Ev.) Neuman	1	2	2	—	1	6	3.28
Poria oleracea Davidson & Lombard	6	—	—	—	—	6	3.28
Steccherinum setulosum (Berk. & Curt.) Miller	—	4	2	—	—	6	3.28
Merulius tremellosus Schrad. ex. Fr.	2	3	—	—	—	5	2.73
Hericium erinaceus (Fr.) Pers.	—	—	4	—	—	4	2.19
Irpex mollis Berk. & Curt.	—	—	4	—	—	4	2.19
Polyporus dryophilus Berk.	—	—	—	4	—	4	2.19
Polyporus versicolor L. ex Fr.	—	4	—	—	—	4	2.19
Poria sp.[2]	—	4	—	—	—	4	2.19
Stereum complicatum (Fr.) Fr.	—	—	2	2	—	4	2.19
Armillaria mellea (Fr.) Quél.	2	—	—	1	—	3	1.64
Polyporus cuticularis Bull. ex. Fr.	—	—	1	—	—	1	.54
Poria inflata Overh.	—	1	—	—	—	1	.54
Stereum subpileatum Berk. & Curt.	1	—	—	—	—	1	.54
Total	90	53	27	10	3	183	100.00

[1] Misidentified as *Corticium lividum* Pers. ex Fr. in U. S. Dep. Agr. Tech. Bull. 785, FUNGI CAUSING DECAY OF LIVING OAKS IN THE EASTERN UNITED STATES AND THEIR CULTURAL IDENTIFICATION, by Ross W. Davidson, W. A. Campbell and Dorothy B. Vaughn. 1942.

[2] Possibly *Poria mutans* Pk.

Table 2.—*Fungi causing decay in the oak stands of Kentucky and their relation to the portion of the tree bole affected*

Fungus species	Identified infections			Decay volume		
	In butt[1]	In trunk	Total	In butt[1]	In trunk	Total
	No.	*No.*	*No.*	*Cu. ft.*	*Cu. ft.*	*Cu. ft.*
Polyporus compactus	2	34	36	0.92	15.08	16.00
Stereum frustulatum	5	22	27	6.27	13.35	19.62
Poria cocos	16	—	16	30.41	—	30.41
Stereum gausapatum	3	11	14	2.66	16.03	18.69
Unknown H.	8	5	13	.94	4.86	5.80
Polyporus spraguei	9	—	9	13.31	—	13.31
Poria nigra	4	4	8	8.62	18.48	27.10
Polyporus sulphureus	2	5	7	1.62	7.61	9.23
Poria andersonii	2	4	6	.42	1.35	1.77
Poria oleracea	2	4	6	1.76	.64	2.40
Steccherinum setulosum	6	—	6	3.74	—	3.74
Merulius tremellosus	—	5	5	—	3.30	3.30
Hericium erinaceus	2	2	4	.80	.20	1.00
Irpex mollis	—	4	4	—	.44	.44
Polyporus dryophilus	—	4	4	—	4.28	4.28
Polyporus versicolor	—	4	4	—	1.46	1.46
Poria sp.	3	1	4	2.15	.23	2.38
Stereum complicatum	2	2	4	.34	.34	.68
Armillaria mellea	3	—	3	4.29	—	4.29
Polyporus cuticularis	1	—	1	2.98	—	2.98
Poria inflata	1	—	1	13.47	—	13.47
Stereum subpileatum	—	1	1	—	.04	.04
Total	71	112	183	94.70	87.69	182.39[2]

[1] Decay originating at stump height or below was considered as butt decay.
[2] Decay volume associated with identified infections; in addition, there were 127.82 cubic feet of decay volume in which the causal fungi were unknown.

occasionally caused a butt rot but were essentially trunk-rot fungi (table 2).

Another root- and butt-rot fungus, *Polyporus spraguei* Berk. & Curt., which caused a brown crumbly rot, was isolated from only scarlet oak (*Quercus coccinea* Muenchh.). However, this fungus has been reported from other oak species in both the red and white oak groups.[2]

Armillaria mellea (Fr.) Quél., the "honey mushroom," which also causes a root and butt rot, was isolated from three trees. Although this fungus is widespread as a saprophyte, it may also live as a parasite. It often attacks oaks and other trees already weakened by unfavorable environment, injuries, insects, or other diseases.

Some of the butt-rot fungi, such as *A. mellea* may be of more importance than shown here because badly infected trees may be subject to windthrow.

[2] INDEX OF PLANT DISEASES IN THE UNITED STATES. U. S. Dep. Agr. Handbk. 165. 531 pp. 1960.

Figure 2.—Sporophore of *Fomes everhartii* (Ell. & Gall.) von Schrenk & Spauld. on the trunk of a living scarlet oak.

Sometimes trees that suffer from butt rot show a slight swelling at the base. But this abnormality is not at all general and far from a safe criterion even when it does occur.

The majority of fungi listed in table 2 may enter either through wounds in the butt or along the trunk. However, there are some species, such as *Polyporus dryophilus* Berk., that rarely enter through butt scars but usually through wounds in the upper part of the trunk.

Most of the fungi associated with decay in oaks rarely produce sporophores or conks on living trees (fig. 2), making it often impossible to determine the causal fungus from the type of decay alone. Therefore, to identify these decay fungi, it was necessary to isolate them in pure culture and compare these unidentified isolates with sporophore isolates maintained in the culture collection at the Forest Disease Laboratory at Laurel, Maryland.

Relative Importance of Fungi Causing Decay

On the basis of cubic feet of decay, two species of *Poria* — *P. cocos* and *P. nigra* (Berk.) Cke. -- accounted for almost one-third of the total identified decay volume (table 3). As previously mentioned, rot caused by *P. cocos* was limited to the butt log, while *P. nigra* caused both a butt rot and a trunk rot (fig. 3).

Other fungi associated with appreciable decay losses were *Stereum frustulatum*, *S. gausapatum*, *Polyporus compactus*, *P. spraguei*, and *Poria inflata* Overh. The first three species caused decay in both the butt and trunk, while the latter two species were entirely restricted to the butt log. Total decay volume was about equally divided between the butt rots and trunk rots.

The decay volume reported in table 3 is based on the exact dimensions of the decayed wood. Actually, the volume lost through butt and trunk rots is considerably higher in logging operations. In butt rots, for example, the total cross-section of the stem is often lost through the practice of jump-butting to the upper limit of the decay.

Table 3.—*Relative importance of fungi causing decay in the oak stands of Kentucky, by tree species*

Fungus species	Decay volume					Total identified decay volume	
	Scarlet oak	Black oak	Chestnut oak	White oak	Northern red oak		
	Cu. ft.	*Cu. ft.*	*Cu. ft.*	*Cu. ft.*	*Cu. ft.*	*Cu. ft.*	*Percent*
Poria cocos	12.40	4.51	11.03	2.47	—	30.41	16.67
Poria nigra	26.86	.24	—	—	—	27.10	14.86
Stereum frustulatum	6.60	6.75	—	6.27	—	19.62	10.76
Stereum gausapatum	7.31	8.20	3.15	—	0.03	18.69	10.25
Polyporus compactus	8.21	6.32	—	.98	.49	16.00	8.77
Poria inflata	—	13.47	—	—	—	13.47	7.39
Polyporus spraguei	13.31	—	—	—	—	13.31	7.30
Polyporus sulphureus	8.94	—	—	.29	—	9.23	5.06
Unknown H	5.31	.07	—	.42	—	5.80	3.18
Armillaria mellea	1.22	—	3.07	—	—	4.29	2.35
Polyporus dryophilus	—	—	4.28	—	—	4.28	2.35
Steccherinum setulosum	—	.48	—	3.26	—	3.74	2.05
Merulius tremellosus	.20	3.10	—	—	—	3.30	1.81
Polyporus cuticularis	—	—	—	2.98	—	2.98	1.63
Poria oleracea	2.40	—	—	—	—	2.40	1.32
Poria sp.	—	2.38	—	—	—	2.38	1.30
Poria andersonii	.61	.61	—	.42	.13	1.77	.97
Polyporus versicolor	—	1.46	—	—	—	1.46	.80
Hericium erinaceus	—	—	—	1.00	—	1.00	.55
Stereum complicatum	—	—	.34	.34	—	.68	.37
Irpex mollis	—	—	—	.44	—	.44	.24
Stereum subpileatum	.04	—	—	—	—	.04	.02
Total	93.41	47.59	21.87	18.87	.65	182.39[1]	100.00

[1] Decay volume associated with identified infections; in addition, there were 127.82 cubic feet of decay volume in which the causal fungi were unknown.

Figure 3.—Fire scar on scarlet oak opened to show associated decay caused by *Poria nigra*.

DECAY RELATIONS

Entry Courts and Infection

Most decay-causing fungi are unable to penetrate the protective bark on living trees. They require a wound in the tree that penetrates to the heartwood, or dead tissue extending to the heartwood, before they can attack successfully.

Fungi that cause decay in oaks penetrate the host through numerous entry courts. The relative significance of these entry courts is summarized in table 4. Fire scars were the most important means of entry for decay fungi (fig. 4). More than one-fourth of all infections came from fire scars and almost one-third of the total decay volume was associated with fire scars. Fire scars are particularly vulnerable to decay because of the large area of exposed wood and the long period of time required for the growth of protective callus.

Table 4.—*Relationship between infection courts and incidence of infection and volume of decay*

Infection court	Infections		Volume of decay	
	No.	*Percent*	*Cu. ft.*	*Percent*
Fire scars	128	26.12	99.20	31.98
Insect wounds	78	15.92	28.00	9.03
Dead branch stubs	69	14.08	31.13	10.03
Parent stumps	41	8.37	38.21	12.32
Open branch stub scars	31	6.33	39.95	12.88
Branch bumps	31	6.33	16.33	5.26
Damaged tops	23	4.69	16.48	5.31
Roots	22	4.49	6.68	2.15
Mechanical injuries	21	4.29	11.87	3.83
Woodpecker injuries	18	3.67	5.96	1.92
Miscellaneous	13	2.65	9.79	3.16
Unknown	15	3.06	6.61	2.13
Total	490	100.00	310.21	100.00

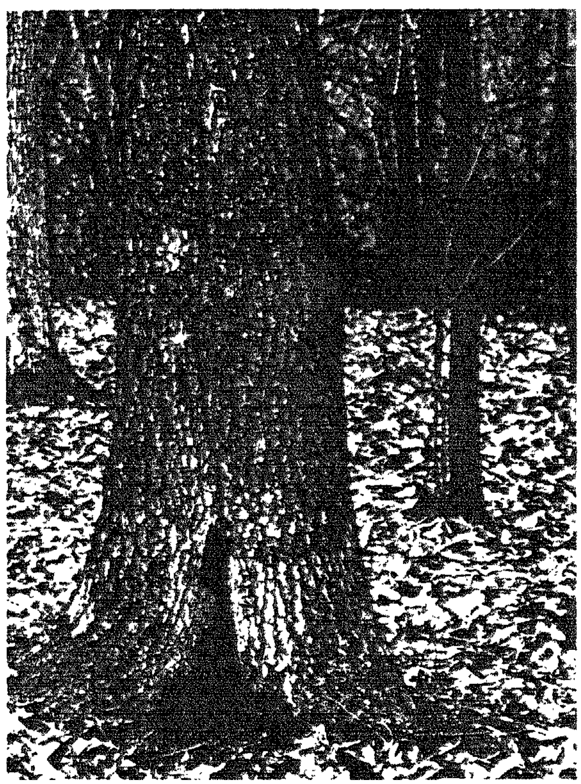

Figure 4.—An open fire scar on black oak.

Figure 5.—Advanced decay in scarlet oak, caused by the fungus *Stereum gausapatum*, which entered through an open branch wound.

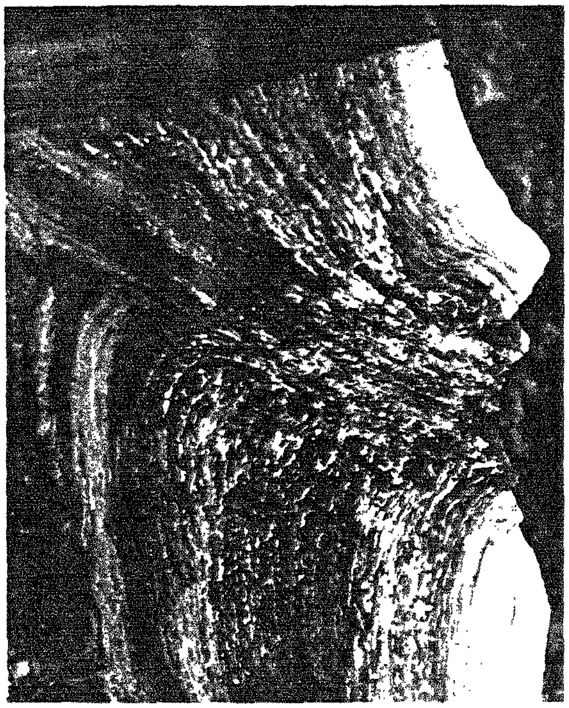

Table 5.—*The comparative effectiveness of visible defects as indicators of decay*

Defect	Frequency of occurrence			Frequency of decay
	Decay present	Decay absent	Total	
	No.	*No.*	*No.*	*Percent*
Open fire scars	30	3	33	90.91
Damaged tops	23	25	48	47.92
Closed fire scars	98	186	284	34.51
Unsound branch stubs[1]	7	37	44	15.91
Sound branch stubs[1]	11	94	105	10.48
Mechanical injuries	21	180	201	10.45
Woodpecker injuries	18	201	219	8.22
Branch bumps[1]	2	26	28	7.14
Unsound branch stubs[2]	9	121	130	6.92
Stem bulges	5	75	80	6.25
Open branch stub scars	31	938	969	3.20
Branch bumps[2]	9	366	375	2.40
Total	264	2,252	2,516	10.49

[1] 4 inches and more in diameter.
[2] 2-4 inches in diameter.

Appreciable amounts of decay were also found associated with dead branch stubs, particularly unsound stubs 4 inches in diameter and larger, parent stumps, and open branch stub scars (fig. 5). Although insect wounds were second only to fire scars as entry courts, generally relatively minor amounts of decay were associated with insect wounds. The comparative effectiveness of defects, visible on the tree surface as indicators of hidden decay, is shown in table 5. Trees frequently had more than one indicator.

Age Relationships

The gross volumes and decay volumes of sample trees were calculated by age classes to determine the relationship between tree age and decay.

Decay for all oak species averaged slightly less than 2 percent of the gross merchantable volume in cubic feet (table 6). Scarlet oak had the greatest amount of decay, followed by black oak, chestnut oak, northern red oak, and white oak, in that order. The percentage of decay ranged from 2.66 percent for scarlet oak to 0.57 percent for white oak. Even in the older age classes white oak was relatively free of rot.

It can be seen from table 6 that, generally, decay losses increased progressively with age. However, with only a few exceptions, decay was of little consequence in stands less than 90 years of age.

To bring out more clearly the relationship of decay to age, decay in trees 30 to 90 years old was compared with that in trees more than 90 years old. Decay losses averaged less than 1 percent in the former group and more than 5 percent in the latter (table 7). Apparently little decay is encountered in oak harvested before 90 years of age. And a rotation of not more than 90 years is suggested for natural stands to get the maximum volume of sound wood in the shortest time and to avoid serious losses from decay.

Diameter Relationships

When timber is sold on a tree-measurement basis, one often wants to know the probable amount of decay in trees at different

Table 6.—*Relationship between age and decay in the oak stands of Kentucky*[1]

Age class (years)	Scarlet oak		Black oak		Chestnut oak		Northern red oak		White oak		All species	
	Gross volume	Decay	Gross volume	Decay	Gross volume	Decay	Gross volume	Decay	Gross volume	Decay	Gross volume	Decay
	Cu. ft.	*Percent*	*Cu. ft.*	*Percent*	*Cu. ft.*	*Percent*	*Cu. ft.*	*Percent*	*Cu. ft*	*Percent*	*Cu. ft.*	*Percent*
30	373.06	0.68	257.12	0.51	123.20	0.00	—	—	235.66	0.19	989.04	0.43
40	1,873.82	.39	242.46	.20	96.08	60	—	—	667.60	.25	2,879.96	.35
50	899.04	1.27	185.17	7.13	507.94	.15	—	—	656.47	.64	2,248.62	1.32
60	554.72	4.18	768.27	.91	638.50	.22	36.62	1.80	1,001.63	.09	2,999 74	1.11
70	164.05	.98	712.53	1 30	235 75	1.41	203.88	.26	1,159 30	1.26	2,475.51	1.18
80	725.07	1.84	416.55	.31	13.18	3.34	—	—	665 22	.63	1,820 02	1.06
90	303.25	6.55	182.60	3.76	229.68	7.68	—	—	83 08	.00	798.61	5.56
100	973.15	7.58	718.15	5.90	334.30	2.68	—	—	70.28	.00	2,095.88	5.97
110	104.02	5.35	—	—	90.04	9.52	69.35	1 18	—	—	263.41	5.68
Total	5,970.18	2.66	3,482.85	2.35	2,268.67	1.84	309.85	0.65	4,539.24	0.57	16,570.79	1.87

[1] Decay indicated as percentage of gross merchantable volume.

Table 7.—*Decay in oak stands 30-90 years old and more than 90 years old*[1]

Age class (years)	Scarlet oak		Black oak		Chestnut oak		Northern red oak		White oak		All species	
	Gross volume	Decay	Gross volume	Decay	Gross volume	Decay	Gross volume	Decay	Gross volume	Decay	Gross volume	Decay
	Cu. ft.	*Percent*	*Cu. ft.*	*Percent*	*Cu. ft.*	*Percent*	*Cu. ft.*	*Percent*	*Cu. ft.*	*Percent*	*Cu. ft.*	*Percent*
30 to 90	4,589.76	1.30	2,582.10	1.26	1,614.65	0.40	240.50	0.51	4,385.88	0.59	13,412.89	0.94
90+	1,380.42	7.19	900.75	5.47	654.02	5.38	69.35	1.18	153.36	.00	3,157.90	5.84

[1] Decay indicated as percentage of gross merchantable volume.

Table 8.—*Relationship between diameter and decay in the oak stands of Kentucky*[1]

Diameter class (inches)	Scarlet oak		Black oak		Chestnut oak		Northern red oak		White oak		All species	
	Gross volume	Decay	Gross volume	Decay	Gross volume	Decay	Gross volume	Decay	Gross volume	Decay	Gross volume	Decay
	Cu. ft.	*Percent*	*Cu. ft.*	*Percent*	*Cu. ft.*	*Percent*	*Cu. ft.*	*Percent*	*Cu. ft.*	*Percent*	*Cu. ft.*	*Percent*
3.6- 5.5	84.04	0.24	8.80	0.55	56.48	0.07	—	—	220.80	0.74	370.12	0.64
5.6- 7.5	636.68	1.40	122.36	3.58	165.36	1.15	—	—	715.54	.48	1,639.94	1.31
7.6- 9.5	1,001.22	1.76	564.60	2.68	392.88	.66	—	—	1,211.86	.17	3,170.56	1.08
9.6-11.5	1,103.50	.50	564.88	1.60	663.26	.88	—	—	771.68	.91	3,103.32	.81
11.6-13.5	626.76	2.30	393.84	.58	407.76	1.71	—	—	792.19	.96	2,220.55	1.41
13.6-15.5	345.61	1.84	587.75	1.52	303.11	2.78	138.77	0.59	469.16	.81	1,844.40	1.54
15.6-17.5	330.29	6.61	718.07	1.88	114.52	.60	101.73	.37	358.01	.00	1,622.62	2.20
17.6-19.5	646.62	1.40	320.35	4.23	108.81	3.85	—	—	—	—	1,075.78	2.49
19.6-21.5	611.65	3.29	138.08	.66	56.49	19.53	69.35	1.18	—	—	875.57	3.75
21.6-23.5	583.81	9.75	64.12	21.29	—	—	—	—	—	—	647.93	10.89
Total	5,970.18	2.66	3,482.85	2.35	2,268.67	1.84	309.85	0.65	4,539.24	0.57	16,570.79	1.87

[1] Decay indicated as percentage of gross merchantable volume

Table 9.—*Relationship between diameter and incidence of infection in the oak stands of Kentucky*

Diameter class (inches)	Scarlet oak		Black oak		Chestnut oak		Northern red oak		White oak		All species	
	Trees	Decay	Trees	Decay	Trees	Decay	Trees	Decay	Trees	Decay	Trees	Decay
	No.	*Percent*	*No.*	*Percent*	*No.*	*Percent*	*No.*	*Percent*	*No.*	*Percent*	*No.*	*Percent*
3.6- 5.5	94	8.51	16	25.00	104	3.85	—	—	246	6.50	460	6.96
5.6- 7.5	116	29.31	34	23.53	50	24.00	—	—	140	14.29	340	21.76
7.6- 9.5	90	22.22	56	25.00	48	29.17	—	—	112	16.07	306	21.57
9.6-11.5	60	30.00	32	56.25	42	23.81	—	—	46	26.09	180	32.22
11.6-13.5	25	48.00	15	33.33	18	50.00	—	—	30	36.67	88	42.04
13.6-15.5	9	55.56	16	81.25	9	33.33	4	75.00	12	16.67	50	52.00
15.6-17.5	6	83.33	15	53.33	3	33.33	2	100.00	7	.00	33	48.48
17.6-19.5	9	77.78	5	60.00	2	50.00	—	—	—	—	16	68.75
19.6-21.5	7	100.00	2	100.00	1	100.00	1	100.00	—	—	11	100.00
21.6-23.5	5	100.00	1	100.00	—	—	—	—	—	—	6	100.00
Total	421	28.74	192	39.58	277	19.88	7	85.71	593	13.32	1,490	22.62

diameters. Tree diameter is, of course, a function of age. As stands increase in age, the trees increase in diameter. Hence the percentage of decay should increase with diameter as well as age.

To determine this relationship, trees in the study were divided into 2-inch diameter classes and the percentage of volume decayed was computed for each diameter class. Although for all oak species decay increased progressively with diameter, there was considerable variation within individual species (table 8). With only a few exceptions, relatively minor losses from decay were encountered in trees less than 19.6 inches d.b.h.

The relationship between incidence of infection and diameter is presented in table 9. Of the 1,490 trees in the study, 337 or 22.62 percent contained measurable amounts of decay. The percentage of all oak species with decay increased progressively with increasing diameter from less than 7 percent in the smallest diameter class to 100 percent in trees 19.6 inches in diameter and larger.

CONCLUSIONS

This study was part of a much broader investigation of heart rots in upland oak stands in the central hardwoods region; and eventually data from these Kentucky plots will be combined with data from plots in Ohio, Indiana, Illinois, and Missouri.

Examinations of the fungi responsible for decay in living oaks in Kentucky showed a high incidence of infection associated with four fungus species: *Polyporus compactus, Stereum frustulatum, Poria cocos*, and *S. gausapatum*. These species accounted for over 50 percent of the identified infections. In all, a total of 22 species of fungi were found associated with decay in oak. The above four fungus species, together with *Poria nigra. P. inflata*. and *Polyporus spraguei*. accounted for over 75 percent of the volume loss.

Usually some visible, external abnormality indicates defect within the tree. However, data were insufficient to determine a relationship between the type and size of visible defect indicators and the loss of cubic-foot volume. Fire scars, insect wounds, dead branch stubs, parent stumps, and open branch stub scars were found to be important entry courts for wood-destroying organisms.

Generally, decay volume increased progressively with increasing age and diameter. With only a few exceptions decay losses in trees 30 to 90 years old and less than 19.6 inches d.b.h. were relatively minor. Therefore, a rotation of not more than 90 years is suggested for upland oak stands in Kentucky.

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