HEART-ROT OF OAKS AND POPLARS CAUSED BY POLYPORUS DRYOPHILUS

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INTRODUCTION

The oaks (Quercus spp.) of the United States are diseased by a number of species of fungi which attack the heartwood. Von Schrenk and Spaulding (1909)\(^1\) briefly described some of these diseases and also a piped rot of the heartwood of oaks and chestnuts (Castanea dentata) the cause of which was unknown to them. In 1909, the senior writer found *Polyporus dryophilus* constantly associated with a whitish piped rot of several species of oaks in the southwestern and western United States. This rot was much like that described by Von Schrenk and Spaulding and was identical with that of specimens in oak collected by them. Later observations by the senior writer established the causal relation of *Polyporus dryophilus* to this piped rot.

The junior writer in 1913 found a second form of piped rot caused by *Polyporus pilotae* in the heart-wood of the root and basal portion of the trunks of oaks and also in chestnuts. This was identical with the rot in chestnut trees figured and collected by Von Schrenk and Spaulding.

The oaks of the southwestern and western United States are not used to any extent for lumber and timbers and are, as a rule, valuable only for fuel. This is due to the rotted condition of the heartwood in the larger and older trees. For example, the trunks of the valley oak (Quercus lobata),\(^2\) which attains a large size in the valleys of central California, are usually either badly decayed or hollow and are of no value except for the poor grade of fuel they furnish. The senior writer in 1909 ascertained that *Polyporus dryophilus* was the chief cause of the deterioration of the oaks of the western United States. Meinecke (1914) reports a destructive heart-rot of oaks caused by this fungus in California and Nevada, and data by him will be cited in the section on the distribution of the fungus. In Arizona and New Mexico the oaks are diseased in the heartwood nearly as badly as in California and Oregon, and *P. dryophilus* is the common cause of decay. In these States oaks are usually small and are valuable only for fuel.

In Texas and the adjacent States of Oklahoma and Arkansas the piped rot produced by this fungus is very common, and among other

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1 Bibliographic citations in parentheses refer to "Literature cited," p. 77.
2 The nomenclature for trees used in this paper is that of George B. Sudworth (1898).
species the valuable white oak (*Quercus alba*) is commonly attacked. To the east and north the fungus has been found less frequently, but it occurs in many sections.

From observations and estimates *Polyporus dryophillus* ranks with the most common heart-rotting fungi which attack the oaks. In 1912 the senior writer found aspens (*Populus tremuloides*) in Colorado attacked by this fungus. It apparently is not commonly found on this host.

**PIPE ROT CAUSED BY POLYPORUS DRYOPHILUS**

The whitish piped rot caused by *Polyporus dryophillus* has been found by the writers to be directly associated with the sporophores of this fungus in the following 15 species of trees: *Quercus alba, Q. arizonica, Q. californica, Q. digitata, Q. emoryii, Q. gambelii, Q. garryana, Q. marilandica, Q. minor, Q. prinoides, Q. prinus, Q. texana, Q. velutina, Q. virginiana,* and *Populus tremuloides.*

**PIPE ROT IN THE WHITE OAK**

**MACROSCOPIC CHARACTERS**

The first indication of the whitish piped rot in white oak is a discoloration of the heartwood, which assumes a water-soaked appearance (Pl. VIII, fig. 1). This "soak" may extend from 1 to 10 feet beyond the actually rotting region where delignification is occurring. When dry, this water-soaked heartwood becomes hazel to tawny in color. The next stage of the rot is one of delignification, which usually begins alongside of and following more or less regularly the medullary rays, thus producing a mottled appearance of the wood in radial view (Pl. VIII, figs. 2, 5, and 6). This type of the rot is very common in the medium-sized branches (6 to 12 inches in diameter) and in the early stages of the disease in the bole of the tree. In final stages the diseased wood is firm, has a white, stringy appearance (Pl. VIII, figs. 3 and 4) and consists of white cellulose strands of delignified wood fibers and other wood structures bounded by areas of apparently sound but actually slightly diseased and discolored heartwood. Cinnamon-brown areas are scattered throughout the oldest rotted wood (Pl. VIII, fig. 3). These areas are especially common and abundant in the vicinity of sporophores and along checks or openings through the sapwood. The rot immediately adjacent to a sporophore is therefore often cinnamon brown to russet in color. No cavities large enough to be seen by the naked eye are produced by this rot, but much of the white cellulose is finally absorbed, leaving minute irregular cavities in the wood.

**MICROSCOPIC CHARACTERS**

Delignification usually begins in the wood fibers lying next to the vessels in the spring wood and adjacent to the large medullary rays. The solvents secreted by this fungus apparently are able to delignify all of the
elements of the wood. All, or only the outer rows, of cells of the large medullary rays may be delignified, the middle lamellae dissolved, and the completely delignified cell membranes partially absorbed.

Isolated areas between the large medullary rays may also be delignified. The cells of some of the medullary rays and of the wood parenchyma often contain starch grains even after the absorption of a portion of the inclosing cell walls. A ferruginous substance is also present in many of the cells of the small medullary rays, in the lumen of the wood fibers, and even in some of the other wood structures. Many of the vessels adjacent to each large medullary ray contain hyaline branching hyphæ 0.5 to 1μ in diameter. The association of the delignified areas with the medullary rays is readily seen in a cross section of the wood where delignification is just beginning, but later in the more advanced stages of the rot this association is not so evident when the delignification of the wood fibers has become general throughout the rotting area. The early absorption of portions of the delignified tissue prevents the formation of long continuous strands of cellulose fibers, although in a tangential view irregular white lines may be seen which consist of fragments of the delignified cells (Pl. VIII, fig. 5). In very advanced stages of the rot near the center of the tree white longitudinal lines are seen in a radial view (Pl. VIII, fig. 4). These usually consist of remnants of partially absorbed cellulose fibers bound together by strands of white mycelium, which also fill the vessels and the minute cavities left by the absorption of the delignified tissue.

PIPED ROT IN CHESTNUT OAK

The rot produced by *Polyporus dryophillus* in the chestnut oak (*Quercus prinus*) is slightly different from that in white oak. The diseased wood is hazel in color, with very narrow concentric zones of ivory-yellow cellulose. These zones are adjacent to the large spring vessels of each year and consist of the delignified wood fibers of this tissue. The large vessels in radial-longitudinal view are seen, even under a hand lens, to be filled with cobwebby strands of colorless hyphæ. It is in the tissue adjacent to such hyphæ-filled vessels where the delignification is most pronounced.

PIPED ROT IN THE WESTERN OAKS

The rot caused by *Polyporus dryophillus* in these oaks differs but little from that found in the white oak. The mottled appearance of the rot in its earlier stages is not so pronounced. In the final stage of the rot, after a very large proportion of all the elements is delignified, there is but little apparently sound heartwood. In the older rot in the center of the heartwood the white color by far exceeds the brown, of which there is very little.
PIPED ROT IN EUROPEAN OAKS

Robert Hartig (1878), in his epoch-making work on the true nature of the rots of woods, described a whitish heart-rot of the oak, which he attributed to *Polyporus dryadeus*. A careful study of Hartig’s figures, and the description of the sporophore which he found associated with the white heart-rot so accurately described by him, is sufficient to convince anyone who is familiar with the true *P. dryadeus* that Hartig’s fungus was not *P. dryadeus*. It is undoubtedly identical with the heart-rotting fungus known in America as *P. dryophillus* and found by the senior author to be associated with a whitish piped rot in oak. Through the kindness of Dr. Von Tubeuf the junior writer obtained a piece of the original rot (Pl. VIII, figs. 7 and 8) which Robert Hartig (1878) ascribed to *P. dryadeus*. A careful study of this specimen showed that it is identical in every respect with the rot produced by *P. dryophillus* in the white oak. There is also another European specimen (Pl. VIII, fig. 9) of this rot in oak in the Laboratory of Forest Pathology, of the Department of Agriculture, which has all the characters of the rot produced by *P. dryophillus*.

CHARACTERS OF PIPED ROT COMMON TO ALL SPECIES OF OAKS

The rots produced by *Polyporus dryophillus* in all the species of oak examined had the following characters in common: (1) A water-soaked discolored area in the first stage (Pl. VIII, fig. 1); (2) a general association of the earlier delignification with the medullary rays (Pl. VIII, figs. 5 and 6); (3) later a more general delignification of all the wood fibers (Pl. VIII, fig. 3); (4) the formation of white mycelial longitudinal lines (Pl. VIII, fig. 4); (5) the presence of cinnamon-brown areas in the older rotted wood (Pl. VIII, fig. 3). These brown patches, ranging from 2 by 4 mm. up to 10 by 35 mm. in size, consist of fragments of wood interwoven with ferruginous, thick-walled, septate hyphae, which easily break into short pieces. The hyphae are about 3μ thick, have many short (3 to 8μ) branches, and are mixed with various sizes of hypha down to 1μ or less in diameter, the smaller of which are hyaline.

HEART-ROT PRODUCED BY POLYPORUS DRYOPHILUS IN ASPEN

The description of the heart-rot which follows was made from the diseased wood of a dead aspen (*Populus tremuloides*) bearing the sporophores of *Polyporus dryophillus*.

MACROSCOPIC CHARACTERS

The general color of the diseased wood varies from a light buff to a maize yellow. In a cross section the rotted wood shows alternating concentric zones of light buff and ochraceous tawny. The light-colored zones consist of the vessels and wood fibers which have been the most vigorously attacked by the solvents of the fungus. The ochraceous-
tawny zones consist of vessels, cells of wood parenchyma, and other elements of the wood in the cells of which a ferruginous amorphous substance has been deposited. These cells are not as strongly attacked by the fungus as are those of the light zones. The rotted wood easily splits into concentric layers, the cleavage usually occurring along the boundary between the white and dark zones. In a tangential view, small, more or less isolated areas of delignified wood fibers may be seen. These delignified fibers are most abundant in the older, rotted portion. In the vicinity of the sporophores the typical cinnamon-brown areas seen in the oak are also present. The rotted wood is soft, almost silky to the touch, is very light in weight, and is easily broken into fragments between the fingers.

MICROSCOPIC CHARACTERS

The vessels in the light-colored zone have very thin walls, owing to the action of the fungus; the bordered pits are often eroded until only large irregularly shaped holes are left and the middle lamellae of the vessels and of the wood fibers in this region are dissolved. The wood fibers and some of the adjacent cells are finally delignified and absorbed. The delignification occurs most rapidly along the boundary lines between the light-colored and dark-colored zones, along which the cleavage commonly occurs. The small amount of delignified fibers present and their rather rapid absorption prevent the formation of the large areas of white cellulose which are so common in the rot produced by this fungus in oak. In the zone of cleavage cobwebby masses of white mycelium occur which fill the vessels and the small cavities left by the absorption of the wood fibers. The medullary rays are readily attacked by the solvents of this fungus and usually have completely disappeared by the time the final stage of the rot is reached.

ENTRANCE OF THE ROT IN THE HOST

*Polyporus dryophilus*, so far as known to the writers, gains entrance in the wood of the host trees only through wounds in which the heartwood is exposed. The most common point of entrance is a broken or dead limb, although in the western and southwestern United States it also frequently enters through fire scars and other basal wounds.

In Arkansas and eastward, where the species of oaks differ from those in the West and Southwest, the rot caused by this fungus is apparently confined chiefly to the branches and upper portion of the trunk. This may be due to the fact that often there are one or more large dead branches in the crown of the tree, while there are very few on the lower part of the trunk. The fungus has therefore little or no opportunity to enter the bole of the tree below the crown.

When the fungus enters the stub of a broken limb, it grows downward through heartwood of the stub till it enters the trunk, when it spreads
both upward and downward through the heart of the tree. When it enters near the base of the tree, it sometimes spreads upward throughout the heart of the entire trunk. This occasionally was noted in the white oak in Arkansas, and such trees were worthless for lumber.

In Oklahoma and to the west oaks frequently have large dead branches at any point on the trunk of the tree. Through these the fungus may enter. The rot therefore is not confined as closely to the upper half of the trees as it is in the oaks of Arkansas and to the east. Probably 50 per cent of the western oaks attacked by this fungus have the rot throughout the entire trunk.

The sporophores of *Polyporus dryophilus* when growing on oak are usually found only on living trees; however, specimens have been collected growing on the boles and large branches of trees which had been cut for at least three years, and in one instance a sporophore was found growing directly on the top of an old oak stump. The fungus apparently continues to grow slowly in the infected trees after they have been cut, but rarely fruits under such conditions. There is no evidence at hand concerning the possibility of infection by *P. dryophilus* after the death of the tree.

In no instance in Arkansas has the junior writer found this fungus entering a tree through fire scars or other wounds on the butt of oaks, even where fire scars were common. The rot always originated at some point above the base of the tree, and if a tree was found in which the rot had reached the collar of the tree it came from above and not from below. All of the sporophores of this fungus found on specimens of Populus were growing on dead or dying trees. In this case the fungus is able to fruit abundantly on both living and dead trees.

This fungus on Populus seems to be truly parasitic, to some extent at least. It attacks the trunks of the trees chiefly, entering the heartwood through dead limbs after they are broken off. The trees die by either breaking off or in some cases apparently from the direct effect of the fungus, which attacks the sapwood when the disease becomes far advanced.

Several instances were found in oak where the fungus had apparently penetrated and killed small areas of the sapwood and formed its sporophores at these points.

No positive evidence was found indicative of the age of the fungus in either oaks or poplars or of its rate of growth in the infected tree. Apparently trees of all ages are susceptible to this rot, provided the branches are old enough to have formed heartwood.

**SPOROPHORE OF POLYPORUS DRYOPHILUS**

*Polyporus dryophilus* has a hard, granular, sandstone-like core, a character that is unique and not possessed by any other polypore known to the writers. The sporophore of this plant, represented by numerous specimens collected by the writers in various portions of the United
States, in every instance shows this hard granular core (Pl. IX, figs. 2 and 4) exactly as figured and described by Hartig (1878) in case of his P. dryadeus. This core extends back some distance into the tree in oaks; it is usually irregularly cylindrical while in the tree, but on its emergence from the tree it swells into a tuberous or spheroid mass and finally occupies the central and rear part of the sporophore (Pls. IX, fig. 2, and X, fig. 6). If the sporophore is formed from a large branch hole, it is usually of the applanate type, with a small core, but when the sporophore forms directly on the body of the tree, as it usually does, the shape is tuberous, unguiform, or even subglobular (Pl. IX, figs. 2 and 4), with the bulk of the sporophore composed of hard, granular core. This core usually has white mycelial strands (Pl. IX, fig. 4). The sporophore of P. dryophillus, therefore, has normally three distinct kinds of structures (Pl. X, fig. 4): (1) The hard, granular core; (2) the fibrous layer which surrounds this core except at the rear; (3) the layer of tubes on the lower surface. Specimens are often found, however, especially from the western part of the United States, in which this fibrous layer may be entirely absent between the tubes and the granular core (Pl. IX, fig. 4).

*Polyporus dryophillus* is known in Europe under at least five different names: *Polyporus fulvus* Fries, *P. friesi* Bresadola, and *P. corruscans* Fries for the form on oak, and *P. vulpinus* Fries and *P. rhades* Persoon for the form on poplar. The identity of *P. dryophillus* with the *P. corruscans* Fries (Pl. X, fig. 4) and with *P. rhades* Persoon is based on the specimens of these plants found in the Lloyd Herbarium at Cincinnati, Ohio. If these specimens are correctly determined, then the American plant is identical with the European plants named above. Authentic specimens of the form of *P. dryophillus* found on species of *Populus* were seen by the junior writer at the New York Botanical Gardens in collections from Finland and Sweden and also from Maine. In the Lloyd Herbarium at Cincinnati, Ohio, are collections under the name of *P. rhades* on *Populus tremula* from Sweden (Pl. X, fig. 3) and Denmark, and a collection from Austria on *Quercus ilex*. In the Cryptogamic Herbarium of Harvard University there is a collection on *Populus grandidentata* Michx. from New Hampshire, while in the Laboratory of Forest Pathology there is a fine collection on *Populus tremuloides* Michx. (Pl. X, figs. 1, 2, and 5) from near Steamboat Springs, Colo.

This fungus on *Populus* agrees in all essential characters with the form of *Polyporus dryophillus* found on oak. The sporophores are, however, somewhat smaller than those usually found on oak and approach the applanate type (Pl. X, figs. 1 and 2). The hard granular core is always present, but is formed between the sapwood and bark (Pl. X, fig. 4), as the fungus is able to rot the sapwood, as well as the heart of this host. It therefore does not have to depend on branch holes or other openings through the sapwood in order to form its sporophores as it does in the oak.
DESCRIPTION OF THE SPOROPHORE OF POLYPORUS DRYOPHILUS

Pileus thick, unequal, smooth to irregular nodulose, often convex below, unguiform (Pl. IX, fig. 5), subglobose (Pl. IX, fig. 1) or even applanate (Pl. X, fig. 1), simple or rarely subimbricate (Pl. X, figs. 2 and 5), rigid, 4 to 22 cm. broad by 3 to 13 cm. wide (measured from front to rear of sporophore) by 2.5 to 21 cm. thick (measured from pore surface to top of sporophore); surface at first densely tomentose, becoming scabrous to smooth with age; tomentum rather stiff, deciduous, short, maize yellow to ferruginous; surface of weathered sporophores after the tomentum has partially disappeared, zonate, zones several, narrow, extending entirely around the pileus near its margin (Pl. IX, fig. 3); margin in immature specimens thick, usually obtuse (Pls. IX, figs. 1 and 5, and X, figs. 1 and 2), concolorous or slightly pallid, entire or undulate; context dual, consisting of a hard granular core, surrounded except in the rear by a thin fibrous layer; core subglobose to pulvinate, 3 to 10 cm. thick, ferruginous to cinnamon brown, granular, often with white mycelial strands ramifying through it (Pl. IX, fig. 2); fibrous layer on upper surface of core a mere pellicle about 0.5 mm. thick, expanding in mature specimens into a border (Pl. IX, fig. 4) 1 to 3 cm. wide and 5 to 15 mm. thick; fibrous layer between tubes and core thin, 1 to 15 mm., usually not over 6 to 8 mm., fibrous layer zonate, concolorous; tubes slender, concolorous or slightly paler than core in some specimens, rather fragile in age, 5 mm. to 3.5 cm. long, shorter near margin of sporophore, usually about 1 cm. long; mouths regular when young, but becoming somewhat irregular and angular at maturity (Pls. IX, fig. 6 and X, fig. 8), two or three to a mm., glistening, grayish when young, becoming hazel to russet with age, edges thin; spores broadly oval, smooth, ferruginous, 4.8 to 8 by 3.4 to 6.4μ, average size 6.54 by 4.85μ when on oak (Pl. IX, fig. 6), 4.8 to 6.4 by 3.4 to 5.6μ, average size 5.82 by 4.05μ when on poplar (Pl. X, fig. 8); cystidia none; hyphae ferruginous, 4 to 6μ. The sporophores found on oak in Arkansas and in the eastern portion of the United States often have shorter tubes (Pl. IX, fig. 4), slightly smaller spores, and a more applanate pileus than those found in the Western States (Pl. IX, fig. 2).

DISTRIBUTION OF POLYPORUS DRYOPHILUS

The rot caused by Polyporus dryophilus is very widely distributed in the United States, having been found in 23 States: Arizona, Arkansas, California, Colorado, Illinois, Kansas, Louisiana, Maine, Maryland, Mississippi, Missouri, Nebraska, New Hampshire, New Mexico, New York, North Carolina, Ohio, Oklahoma, Oregon, Pennsylvania, Tennessee, Texas, and Wisconsin. Authentic specimens of the fungus have also been examined from the following foreign countries: Austria, Denmark, Finland, France, Germany, and Sweden. The sporophores of the fungus are frequent and the rot caused by the fungus is exceedingly common in New Mexico, Arizona, and California.

DISTRIBUTION IN EUROPE

Polyporus dryophilus is known to occur in Europe as follows, the junior writer having examined authentic specimens:

GERMANY (?):
On Quercus sp. (F. P. 12404)^1.

^1 "F. P." = Forest-Pathology Investigations number.
GERMANY:
On Quercus sp.—ROBERT HARTIG (from Herb. Von Tubeuf); PFEIFFER (Herb. N. Y. Bot. Gard.), part of the type specimen for Polyporus frieii; Berlin, LLOYD (Herb. Lloyd).

AUSTRIA:
On Quercus ilex.—Travnik, REV. E. BRANDIS (No. 08864, Herb. Lloyd).

DENMARK:
On Populus (?).—J. LIND (No. 06339, Herb. Lloyd).

FINLAND:
On Populus sp.—Murtiala, Sept., 1882 (No. 5724, Herb. N. Y. Bot. Gard.).

SWEDEN:
On Quercus sp.—Upsala, LLOYD (No. 08936, Herb. Lloyd); Stockholm, ROMELL (No. 08936, Herb. Lloyd).
On Populus sp.—HAGELUND (No. 09375, Herb. Lloyd); Stockholm, ROMELL (No. 08414, Herb. Lloyd).

FRANCE:
On Pinus (?) sp.—Fontainebleau, P. HARIOT (No. 08880, Herb. Lloyd); this specimen from France was reported as on pine, and has spores similar in size and shape to those growing on species of Populus and a sporophore much like those found on species of Quercus.

DISTRIBUTION IN UNITED STATES

Polyporus dryophilus has been reported from and collected in the various States of this country as follows:

MAINE:
On Betula (?) sp.—Near Moosehead Lake, VON SCHRENK, in 1899 (Herb. N. Y. Bot. Gard.).

NEW HAMPSHIRE:
On Populus grandidentata.—Chocorua, FARLOW (?), in 1904 (Herb. W. G. Farlow).

NEW YORK:
On Quercus alba.—Bronx Park, MURRILL, in 1908 (F. P. 1416).

Pennsylvania:
On Quercus (?) sp.—Kittanning, SUMSTINE 32 (Herb. N. Y. Bot. Gard.).

MARYLAND:
On Quercus alba, Q. coccinea, and Q. minor.—Takoma Park, HEDGECOCK, in 1910.

Ohio:

Virginia:
On Quercus prinus.—Elkins, LONG, in 1913 (F. P. 12418).

On Quercus (?) sp.—Falls Church, LUTTRILL, in 1902 (Herb. N. Y. Bot. Gard.).

North Carolina:
On Quercus prinus.—Brim, LONG.

On Quercus velutina.—Jonesboro, P. L. BUTTRICK, in 1913 (F. P. 15045).
TENNESSEE:
On Quercus alba and Q. velutina.—Roan Mountain, Hedgcock, in 1913.

MISSISSIPPI:
On Quercus lyrata.—Sand Point, Hedgcock, in 1908.

LOUISIANA:
On Quercus lyrata, Q. mariandica, Q. michauxii, and Q. phellos.—Near Bogalusa, Hedgcock, in 1908.

MISSOURI:
On Quercus alba.—Mountain Grove, Hedgcock.
On Quercus mariandica.—Steelville, Spaulding; Mountain Grove, Hedgcock.
On Quercus minor.—Webster Groves, A. H. Graves, in 1909 (F. P. 1617).
On Quercus palustris.—Mountain Grove, Hedgcock.

ILLINOIS:
On Quercus alba.—Near Plymouth, Hedgcock, October, 1909.

WISCONSIN:
On Populus sp.—Oakfield, in 1903 (Herb. Univ. Wis.).
On Quercus macrocarpa.—Rockton, L. H. Pammel, in 1886 (Herb. N. Y. Bot. Gard.).

NEBRASKA:
On Quercus macrocarpa.—Near Nelson, Hedgcock, in 1911.

OKLAHOMA:
On Quercus alba.—Cache, Long, in 1912 (F. P. 12407).
On Quercus mariandica.—Cache, Long, in 1912 (F. P. 12420).
On Quercus minor.—Cache, Long, in 1912 (F. P. 12408, 12419, 12421).
On Quercus prinoides.—Cache, Long, in 1912 (F. P. 12414).

ARKANSAS:
On Quercus alba.—Treat (F. P. 12102), Casteel (Ozark National Forest; F. P. 12137, 12140, 12142, 12154, 12210, 12243, 12263, 12268, 12296, 12422, 12402, 12403, 12405, 12406, 12409, 12413, 12425); Bigflat (F. P. 12158, 12156, 12160), Long, in 1912: Womble (F. P. 12413), Cedar Glades (F. P. 12422), Long, in 1913; Fayetteville and Farmington, Hedgcock, in 1906.
On Quercus digitata.—Casteel, Long, in 1912 (F. P. 12272).
On Quercus minor.—Whiterock, Long, in 1912 (F. P. 12240).
On Quercus texana.—Mountain View, Long, in 1912 (F. P. 12415).
On Quercus velutina.—Casteel, Long, in 1912 (F. P. 12410).

TEXAS:
On Quercus mariandica.—Near Boerne, Hedgcock, in 1909 (F. P. 760).
On Quercus minor.—Austin (F. P. 12424) and Denton (F. P. 12423), Long in 1912.
On Quercus nigra.—Near Houston, Hedgcock, in 1909.
On Quercus phellos.—Near Houston and near Boerne, Hedgcock, in 1909.
On Quercus texana.—Near Houston and near Boerne, Hedgcock, in 1909 (F. P. 762).
On Quercus velutina.—Near Boerne, Hedgcock, in 1909.
On Quercus virginiana.—Near Houston and near Boerne, Hedgcock, in 1909 (F. P. 320).

COLORADO:
On Quercus gambelii.—Square Top Mountain (San Juan National Forest; F. P. 9229); near Mancos (Montezuma National Forest); southeast of Delta (Uncompahgre National Forest); Hedgcock, in 1912.

NEW MEXICO:
On Quercus arizonica.—Pecos, Long, in 1913 (F. P. 12412).
On Quercus emoryii.—Mogollon Mountains Hedgcock, in 1911.
On Quercus gambelii.—Sandia Mountains (Manzano National Forest), Hedgcock, in 1906 (F. P. 126, 230); in 1908 (F. P. 270, 551–553, 558); near Pinos Altos (Gila National Forest), Hedgcock, in 1909 (F. P. 511, 812); in Alamo National Forest, L. L. Janes, 1909 (F. P. 1142); Mogollon Mountains, Bear Creek Canyon, and Trout Creek (Gila National Forest), Hedgcock and Long, in 1911 (F. P. 9877); Cloudcroft, Long, in 1911 (F. P. 12015); Pecos, Long, in 1912 (F. P. 12426).

On Quercus oblongifolia.—Near Mogollon, Hedgcock, in 1911.

Arizona:

On Quercus arizonica.—Chiricahua Mountains, H. D. Burrall, in 1908; near Sedona (Coconino National Forest), Hedgcock, in 1910; Santa Catalina Mountains, Hedgcock, in 1911.

On Quercus chrysolepis.—Sedona, Hedgcock, in 1910.

On Quercus emoryii.—Chiricahua Mountains, Burrall, in 1908; Groom Creek and Crown King (Prescott National Forest), Hedgcock, in 1910; Santa Catalina Mountains, Hedgcock, in 1911.

On Quercus gambelii.—Groom Creek (F. P. 4557), Crown King (F. P. 4877), Sedona (F. P. 4941), and near Flagstaff, Hedgcock, in 1910; Santa Catalina Mountains, Hedgcock and Long, in 1911 (F. P. 9801).

On Quercus hypoleuca.—Near Pinos Altos, Hedgcock, in 1909.

On Quercus oblongifolia.—Groom Creek and Crown King (F. P. 4876) and near Sedona, Hedgcock, in 1911; Santa Catalina Mountains, Hedgcock, in 1911.

On Quercus tourney.—Santa Catalina Mountains, Hedgcock, in 1911.

California:

On Quercus californica.—Scott River Valley (Klamath National Forest), Hedgcock, in 1909 (F. P. 1886); near Mirror Lake (Yosemite Park), Clarks (Plumas National Forest), North Fork, and O'Neals (Sierra National Forest), Meinecke, in 1910; near El Portal and Yosemite (Yosemite Park), Hedgcock and Meinecke, in 1910 (F. P. 4794); near Kennett, Hedgcock and Meinecke, in 1911 (F. P. 9649).

On Quercus chrysolepis.—El Portal and Yosemite, Hedgcock and Meinecke, in 1910; North Fork (Sierra National Forest), Meinecke, in 1910.

On Quercus garryana.—Scotts River and Mount Marble (Klamath National Forest), Hedgcock, in 1910 (F. P. 1847).

On Quercus lobata.—Stanford University, C. F. Baker, in 1902 (Herb. Univ. of Wisconsin); near Chico, Hedgcock, in 1909; Dobe and Italian Bar (Sierra National Forest), Meinecke, in 1910.

On Quercus wislizeni.—El Portal, Yosemite, and near Raymond, Hedgcock, in 1910; near Kennett, Hedgcock, in 1911.

On Quercus sp.—Crane Valley (Sierra National Forest), and El Portal, Meinecke, in 1910.

Oregon:

On Quercus garryana.—Near Mount Hood (Oregon National Forest) and Rogue River Valley, Siskyou National Forest), Hedgcock, in 1909 (F. P. 1717); near Medford, Hedgcock, in 1911 (F. P. 9611).

On Quercus californica.—Rogue River Valley, Hedgcock, in 1909.

From the foregoing data the following trees are attacked by the disease caused by Polyphor pus dryophilus: Quercus alba, Q. arizonica, Q. californica, Q. chrysolepis, Q. coccinea, Q. digitata, Q. emoryii, Q. gambelii, Q. garryana, Q. hypoleuca, Q. imbricaria, Q. ilex, Q. lobata, Q. lyrata, Q. macrocarpa, Q. mariandica, Q. michauxii, Q. minor, Q. nigra, Q. oblongifolia, Q. palustris, Q. phellos, Q. prinoides, Q. prinus, Q. robur, Q. texana, Q. velutina, Q. virginiana, and Q. wislizeni; Populus grandidentata, P. tremula, and P. tremuloides; Betula (?) sp., and Pinus (?) sp.
CONTROL OF THE PIPED ROT OF POLYPORUS DRYOPHILUS

The piped rot caused by Polyporus dryophilus is one of several important heart-rots of oaks in the United States. Suggestions made for its control will apply more or less to all of these. So long as oak trees are allowed to stand long past maturity in our wood lots and forests, heart-rots will continue to be common. The practice of leaving uncut in a lumbered area all the badly diseased trees, especially those with heart-rot, is radically wrong from the standpoint of proper forest sanitation, for this practice enables heart-rotting fungi to maintain themselves in the forest while the new generation of trees slowly develops and attains the age at which they form heartwood and thus become susceptible to the attacks of heart-rotting fungi. Trees diseased with heart-rot ought not to be left for seed trees wherever it is possible to leave healthy ones for this purpose. In hardwood forests it is often not necessary to leave seed trees, owing to the abundant sprout production, and the presence of young trees intermingled among the more mature ones.

Trees in the wood lot should be inspected annually, and all trees evidently rotted at the heart should be removed. If the trunk of a tree diseased with heart-rot is struck with an axe, it does not ring with a clear sound. The presence of the fruiting body of Polyporus dryophilus on a tree also is evidence of the presence of the piped rot and of the necessity of removing the tree. Sporophores on trees should be removed whenever found.

In large forested areas it is not possible to personally inspect the trees every year nor to search the forests annually for sporophores, although the present prices of good white-oak lumber nearly justify the expense necessary in a system of careful forest sanitation. It will certainly pay in lumbering tracts of oak and other valuable hardwoods to cut out all unsound or diseased trees, remove the parts that can be used, and burn the remainder. Many trees under the present methods of lumbering are left standing because they are decayed in the trunk near the butt. If cut down, these trees would be found to contain enough lumber to pay for the cost of operation. Such a procedure will lead to a better and closer utilization of our gradually decreasing supply of hardwood lumber, especially of white oak.

The destruction of all trees that are rotted in the heart in timber sales will be a step far in the direction of control for these diseases of timber. A new forest grown on areas lumbered with due regard to sanitation will be certain to be nearly free from heart-rot.
Heart-Rot of Oaks and Poplars

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PLATE VIII

Fig. 1.—Quercus alba: Crescent-shaped "soak," the initial stage of the piped rot produced by Polyporus dryophilus; from Arkansas.

Fig. 2.—Quercus alba: A radial view of the rot in a limb, showing delignification; from Arkansas.

Fig. 3.—Quercus oblongifolia: A radial view of rot, showing delignification; from Arizona.

Fig. 4.—Quercus alba: A final stage of the rot, radial view, with more complete delignification; from Arkansas.

Fig. 5.—Quercus alba: A tangential view of the rot, showing delignification in pockets; from Arkansas.

Fig. 6.—Quercus alba: An end view showing a cross section from the same tree as the preceding; from Arkansas.

Fig. 7.—Quercus sp.: A section of oak from Von Tubeuf, sent to the junior writer as a specimen of the rot caused by Polyporus dryadeus in Europe.

Fig. 8.—Quercus sp.: The reverse side of the specimen shown in the preceding.

Fig. 9.—Quercus sp.: A section of oak from Europe, obtained by Von Schrenk, with a piped rot similar to that of Polyporus dryophilus.

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Fig. 1.—A sporophore of *Polyporus dryophilus*, tuberous form on *Quercus gambelii*; from Arizona.

Fig. 2.—Sectional view of a sporophore of *Polyporus dryophilus* on *Quercus gambelii*, showing the hard granular core with whitish mycelial strands; also the pore layer; from New Mexico.

Fig. 3.—A sporophore of *Polyporus dryophilus* on *Quercus californica*, showing the upper surface with a faint zonation; from California.

Fig. 4.—A section through a sporophore of *Polyporus dryophilus* on *Quercus garryana*, showing the structure of the hard granular core; from California.

Fig. 5.—A front view, showing the margin of the same sporophore as in figure 3, representing the ungulate form.

Fig. 6.—A view of the pore surface of an applanate sporophore of *Polyporus dryophilus* on *Quercus alba*; from Arkansas.
PLATE X

Fig. 1.—A sporophore of *Polyporus dryophilus*, front view showing the margin, on *Populus tremuloideae*; from Colorado.

Fig. 2.—A second sporophore from the same tree as figure 1, showing an imbricated form.

Fig. 3.—A view of the upper surface of a sporophore of *Polyporus rhodes* on *Populus tremula*; from Stockholm, Sweden.

Fig. 4.—A sectional view of a sporophore of *Polyporus corruscans* on Quercus; from Upsala, Sweden.

Fig. 5.—A side view of an imbricate sporophore of *Polyporus dryophilus*, applanate form on *Populus tremuloideae*; from Colorado.

Fig. 6.—A sectional view of the same sporophore as in the preceding figure, showing the hard granular core and whitish mycelial strands.

Fig. 7.—A view of the upper surface of an applanate sporophore of *Polyporus dryophilus* on Quercus alba; from Arkansas.

Fig. 8.—The pore surface of a sporophore of *Polyporus dryophilus* on *Populus tremuloideae*; from Colorado.