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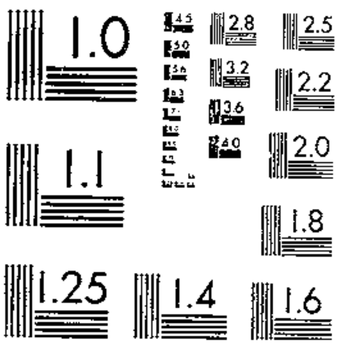

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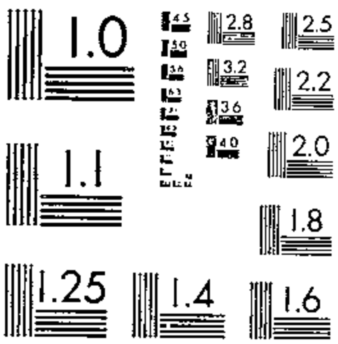

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TECHNICAL BULLETIN No. 257 OCTOBER, 1931

UNITED STATES DEPARTMENT OF AGRICULTURE
WASHINGTON, D. C.

DETERIORATION OF CHESTNUT IN THE SOUTHERN APPALACHIANS

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CONTENTS

INTRODUCTION

Although chestnut (*Castanea dentata* (Marsh.) Borkh.) has been a standard wood for pole timbers, lumber, ties, and other products, the problem of salvaging 15,000,000,000 board feet of lumber [2] that has been or will be killed by the blight (*Endothia parasitica* (Murr.) A. and A.) in the area of the southern Appalachian Mountains is one of the largest of American forest problems. Maps published by the Division of Forest Pathology [3] show that the blight is already widely distributed here. If it continues to spread at its present rate—and there is no reason to believe that it will not—most of the virgin chestnut timber will be killed within the next 10 or 15 years.

The uses for the northern blight-killed chestnut timber have been studied by Nellis.[4] Since the World War economic forces have unfortunately delayed the salvaging of much of the chestnut, particularly in the more remote sections of the southern mountains where the cost of logging and manufacturing has been greater than the market price. In view of these facts, the rate of deterioration of chestnut in the southern Appalachians and the problem of salvage becomes of immediate concern to the forester and the timberland owner. The primary purpose of this study is to furnish information on the rate of deterioration of blight-killed timber found in the South.

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[1] The writers are indebted to G. F. Gravatt, R. P. Marshall, R. M. Nelson, and R. B. Clapper, of the Division of Forest Pathology, who assisted in some phases of this project.

[2] Estimate prepared by the Forest Products Laboratory, Madison, Wis., 1925.

[3] GRAVATT, G. F., and GILL, L. S. CHESTNUT BLIGHT. U. S. Dept. Agr. Farmers' Bul. 1641, 18 p., illus. 1930.

[4] NELLIS, J. C. USES FOR CHESTNUT TIMBER KILLED BY THE BARK DISEASE. U. S. Dept. Agr. Farmers' Bul. 582, 24 p., illus. 1914.

FIELD WORK

The study of deterioration of the chestnut in the southern Appalachians embraced (1) a periodical examination for four years on 5 permanent plots laid out in cooperation with the Forest Service on the Natural Bridge National Forest, Va., 2 near Natural Bridge Station, and 3 on the Peaks of Otter, near Mons, Va. (pl. 1); (2) an examination of the trees on temporary plots located at Bluemont, Gordonsville, Monticello, Natural Bridge, and Orange, Va., and 1 plot at Mount Sanford, near New Haven, Conn., for comparison; (3) an examination of 1,496 felled chestnut trees for the study of heartwood decay at Gatlinburg, Tenn.; (4) the examination of trees for heart rot and checking at Floyd and Alto, Va., and Glenville, N. C.; (5) the examination of slash on the Natural Bridge National Forest at Alto, Va.; and (6) the examination of 17 plots containing a total of 1,165 girdled or fire-killed trees on areas at Cow Knob, Va., on the Shenandoah National Forest, at Alto, Va., on the Natural Bridge National Forest, and at Glenville, N. C., near the Pisgah National Forest. These latter are referred to hereafter as "girdled" plots.

The permanent plots (1) permitted observations on a number of trees that had been dead for known periods, i. e., on all those that had died between 1925 and 1928. In making the annual records the bark was left undisturbed until the fourth year, when it was removed from all dead trees so far as necessary to determine the degree of looseness and the area of sapwood decay. This applied also to those trees which had been dead a year or more when the first observations were made in 1925, and for which estimates as to the number of years they had been dead were made at that time. Since it was not possible to fell the trees on the permanent or temporary plots, the percentages of sapwood decay and bark loosening were estimated for each tree. Diameter and depth of decay at breastheight (4½ feet) were measured.

The temporary plots (2) were selected because their previous history was fairly well known through their use in earlier chestnut-blight investigations. The method used in taking notes on these areas was identical with that employed on the permanent plots, but since only a few living trees remained at the time of observation (1925), it was necessary to estimate the number of years each tree had been dead. The notes taken in the earlier investigations, and to a lesser degree the age of the oldest sprout, supplied a basis for making these estimates. Such a procedure undoubtedly permitted some error as far as individual trees were concerned, but gave a fairly accurate picture for each plot as a whole.

The distribution of trees on both permanent and temporary plots in classes based on the number of years dead is shown in Table 1. From this table it can be seen that data on trees dead over five years are meager on the southern plots. It therefore seemed necessary to study an area which would give added information on conditions prevailing after trees have been dead five years. For this reason, one area on Mount Sanford, near New Haven, Conn., is included with the temporary plots. The history of this area was known, and it was selected as a better basis for studying trees that had been dead for a longer period than could be obtained for study in the South. The data from this northern region had little or no effect upon the averages of the southern plots.

Photograph by United States Forest Service

Permanent plot No. 3, Mons, Virginia, where the rate of death and progress of sapwood decay have been studied

A, Chestnut trees that have been dead for 12 years. Temporary sample plot located near the Natural Bridge National Forest, Virginia; B, Decay caused by *Polyporus pilotae* Schw. in stave wood

TABLE 1.—*Distribution of trees on permanent and temporary plots*

Locality and type of plot	Plot No.	Living trees	Number of trees dead for—											
			Less than 1 year	1 year	2 years	3 years	4 years	5 years	6 years	7 years	8 years	9 years	10 years	11 years
Permanent plots:														
Mons, Va.	46	59	12	3	9	4	----	2	5	----	----	----	----	----
Do.	47	13	2	----	18	8	3	----	----	----	----	----	----	----
Do.	48	9	5	----	14	11	----	2	----	----	----	----	----	----
Natural Bridge Station, Va.	49	7	2	3	11	20	5	1	2	2	----	----	----	----
Do.	50	4	4	2	10	34	3	3	1	1	----	----	----	----
Total	----	92	25	8	62	77	11	8	8	3	----	----	----	----
Temporary plots:														
Bluemont, Va.	26	1	----	----	2	3	12	20	19	20	14	2	8	2
Do.	27	13	2	7	10	7	11	20	18	4	7	1	1	1
Gordonsville, Va.	29	14	7	6	10	0	24	16	9	4	4	----	----	----
Do.	30	13	2	16	23	19	11	11	2	5	2	----	----	----
Monticello, Va.	32	8	5	15	18	18	17	12	7	4	----	----	----	----
Mount Sanford, Conn.	33	4	----	----	3	----	3	9	17	12	38	15	1	----
Natural Bridge Station, Va.	34	6	6	9	12	4	3	----	----	----	----	----	----	----
Orange, Va.	35	7	8	13	18	28	19	6	----	----	----	----	----	----
Total	----	68	30	66	90	88	100	94	72	49	63	18	10	3
Grand total	----	168	55	74	158	165	111	102	80	52	63	18	10	3

Logging operations (3) near Gatlinburg, Tenn., made it possible to analyze 1,496 felled trees for heart rot in green timber. This felled timber was on two tracts, known as the Little Dudley and Roaring Fork mill sets. The chestnut was grouped into the upper-ridge type and the lower-slope type, and the data for these two sites were recorded separately in the field. The so-called "cove type" of chestnut was not present here. The type of rot, the presence or absence of fire scars, and the occurrence of fungus fruiting bodies were recorded for every tree on each site.

In the investigation of the decay in dead standing timber (4), trees that had been dead for 3½, 8, 12, 15, 18, 25, and 30 years were felled and bucked. All of these dead trees were sectioned into a first, a second, and, where present, a third log. Where decay was present, its extent and type were determined by splitting open the logs. Cultures were obtained wherever possible from many of these sections, at the stump, in the first log, and in the second log, to determine whether the heart-rot fungi were actually viable in much of this wood which appeared thoroughly seasoned on the stump.

For each of the diameter classes (1, 2, 3, 4, and over 4 inches), 1,000 measurements were recorded for 2-year-old slash on the Davis Mill Creek unit of the South River Lumber Co. sale, Natural Bridge National Forest, Va. (5). Five thousand measurements were obtained in slash on the ground, and 5,000 similar measurements in slash off the ground.[5] The individual branches were chopped in half so as to expose the wood in radial sections for measurement. The diameter of the slash wood, the thickness of the bark, and the depth of the decay on both sides of the branch were measured to the nearest sixteenth of an inch.

The trees on the girdled plots (6) were used chiefly for the study of checking in standing and fallen timber without sawing sections.

[5] Slash 2 feet or more off the ground and not protected from exposure to the sun by ground cover was designated as "slash off ground."

(Pl. 2, A.) The depth of checks on them was determined by inserting a thin celluloid rule into the crevice and taking the distance to the outside of the bole, no allowance being made for wood that had decayed and sloughed off. The length of the checks was estimated. In addition, the checks on 336 bucked trees were measured at the faces of the logs, from the very beginning of the fissure to the outside of the wood. The trees used in this latter work were those located on the areas described in (4), in addition to some that had been felled and bucked for a study on tannin [6] at Cow Knob, near Criders, Va., and Cruso, N. C.

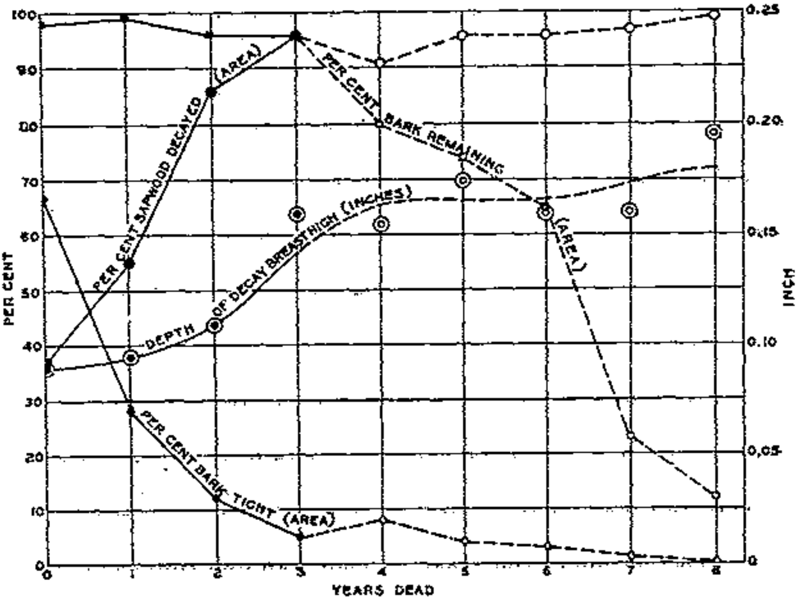

FIGURE 1.—Rate of sapwood decay and bark falling on the first 16-foot log in dead standing chestnut. Percentages of bark tight, bark remaining, and area of sapwood decay are based on the total surface area of the log. The right-hand scale for reading the depth of decay is comparable to the per cent scale, since the average thickness of sapwood is 0.25 inch. The solid lines and points are based on data from trees for which the exact time of death was known; dotted lines and hollow points are based on data from trees for which the time of death was estimated. (See p. 5)

DECAY OF SAPWOOD AND FALLING OF BARK IN STANDING TIMBER

RATE

The decay of sapwood and consequent loosening and falling of the bark is brought about largely through the agency of various Hymenomycetes which develop after the cambium has been killed by the blight. Insects also aid in loosening the bark. The species of fungi involved have been discussed in a previous paper.[7] A few of the more important forms are mentioned later in this work.

Since *Endothia parasitica* ordinarily attacks a tree first in or near the crown and works downward through the branches into the bole, the upper parts are usually killed from two to six years in advance of

[6] NELSON, R. M., and GRAVATT, G. F. TANNIN CONTENT OF DEAD CHESTNUT TREES. Jour. Amer. Leather Chemists Assoc., 24: 479-499, illus. 1929.

[7] BAXTER, D. V. THE FUNGI AND THE DECAY OF THE AMERICAN CHESTNUT. Part 1. Papers Michigan Academy of Science, Arts and Letters, 14: 259-290. 1930.

the butt. The speed at which the killing progresses along the longitudinal axis of a stem is extremely erratic. Attempts to correlate the rate of killing with diameter or height of the trees proved unsatisfactory. Because of this irregularity, it was impossible to arrive at an absolutely common starting point for studying the rate of decay. The one that seemed most satisfactory was the year in which the last living tissue above stump height was killed. In some trees one-half or even more of the butt log may have died that year, while in others this point marks the death of a small area of cambium which had continued to maintain itself for one, two, or possibly three years after the rest of the log had died.

The basic data showing the rate of sapwood decay and falling of bark on the permanent and temporary plots are given in Table 2. The figures in boldface type were summarized from the data taken on trees for which the time of death was positively known. They alone have been used in considering the trend of deterioration during the first three years after the tree died, and were used to plot the solid lines of the curves given in Figure 1. In order to follow deterioration beyond the third year it was necessary to make use of the data from trees for which the time of death had been estimated in the manner described on page 2. Here the combined averages of the permanent and temporary plots seemed to furnish the most reliable basis. These were used in plotting the broken lines of the curves in Figure 1.

Table 2.—*Bark falling and sapwood decay of chestnut trees on sample plots*

[Boldface type indicates data taken on trees for which the time of death was positively known]

Number of years dead	Plot group	Trees used as basis	First 16-foot log: Bark: Area tight	First 16-foot log: Bark: Area remaining	First 16-foot log: Area of sap decay	First 16-foot log: Depth of sap decay at breast-height
		Number	*Per cent*[1]	*Per cent*	*Per cent*	*Inch*
Less than 1	Permanent	25	54	97	39	0.08
	Temporary	30	76	98	36	.095
	Combined	55	66	98	37	.088
1	Permanent	8	28	99	55	.085
	Temporary	66	62	99	52	.096
	Combined	74	58	99	52	.095
2	Permanent	62	12	95	86	.11
	Temporary	96	26	97	76	.15
	Combined	158	21	97	80	.134
3	Permanent	77	5	98	98	.18
	Temporary	88	12	90	85	.136
	Combined	165	9	93	90	.147
4	Permanent	11	0	92	98	.12
	Temporary	100	9	79	90	.16
	Combined	111	8	80	91	.156
5	Permanent	8	0	81	99	.275
	Temporary	94	4	73	96	.17
	Combined	102	4	74	98	
6	Permanent	8	0	87	100	.175
	Temporary	72	3	63	98	.16
	Combined	80	3	65	98	.162
7	Permanent	3	0	67	100	.250
	Temporary	49	1	20	97	.155
	Combined	52	1	23	97	.160
8	Permanent	0				
	Temporary	63	0	12	99	.195
	Combined					

[1] Percentages are based on the total outside area of the log.

The agreement between the measurements for the permanent and temporary plots, respectively, where the population is sufficient, is on the whole closer than between plots within either group. The marked discrepancy in the percentages of tight bark on the first log at dead less than one year can well be attributed to the uneven rate of killing. The falling of bark from the upper parts of trees is extremely erratic and can not in itself be used as a criterion for estimating, even roughly, the number of years a tree has been dead.

Data for the first log are shown graphically in Figure 1. The three curves representing percentage values are directly comparable and indicate that the third year after death the sapwood and bark are no longer available for utilization. Even though 96 per cent of the bark may remain at that time, most of it is so loose that it would be knocked off in felling operations. The increase in depth of decay of the sapwood at breastheight is plotted directly in inches, as indicated on the right-hand scale of the graph. Since the average thickness of the sapwood as measured on over 100 green trees is approximately 0.25 inch, this curve is, for practical purposes, comparable to the others. In order to make this direct comparison, the scale was magnified beyond that which the accuracy of the field measurements (taken to the nearest one-sixteenth of an inch) would require, and for this reason a smoothed curve has been drawn through the points in order to indicate the trend more clearly.

As Figure 1 shows, the rate of sapwood decay and bark loosening is highest during the first two years after death and gradually subsides, becoming negligible after the sixth year. Examinations of the girdled plots showed that after this time reduction in diameter from deterioration would probably not exceed 0.25 inch in 20 or 30 years. These statements apply to the average tree. There are occasional instances where a fungus, such as *Polystictus pargamenus* Fr., attacks the sapwood and continues into the heart, causing decay of an inch or more in depth.

MEASUREMENT OF LOSSES

The actual changes resulting from sapwood decay and bark falling must be considered in terms of the product. It should be pointed out here that extract and pulpwood are important products of chestnut in the southern Appalachians and make the salvage of limb wood and inferior timber more feasible than in the North. Unpeeled wood can be used for fuel and for the manufacture of extract and wall board. The volume reductions in unpeeled wood, due to decay, are considerable and obviously increase relatively as the diameter of the tree decreases. This is indicated on a percentage basis in Figure 2. The curve is based on the difference in bole volumes, outside bark, and inside sapwood, respectively, of 84 trees near Damascus, Va. The volumes were calculated in cubic feet by Smalian's formula [8] for 5-foot lengths with a minimum upper diameter of 3.6 inches.

As the diameter increases above 15 inches, the volume of limb wood that can be utilized becomes appreciable. An estimate of the present loss from this source is presented in Table 3. The data were prepared from original notes [9] taken by the Forest Service on a mill-scale study at Bee Tree, N. C. The middle diameter outside bark of each 5-foot stick actually utilized for acid wood had been recorded to the nearest inch. The number of sticks in each inch class

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[8] $A+a\times\frac{H}{2}=V$.

[9] These notes were secured through the courtesy of W. W. Ashe, of the Forest Service.

were tallied for each tree and the results summarized in 5-inch d. b. h.[10] classes. The loss factors for each inch-diameter class were determined as follows: Nine trees were felled near Damascus, Va., and their limbs cut and stacked by an acid-wood chopper. The middle

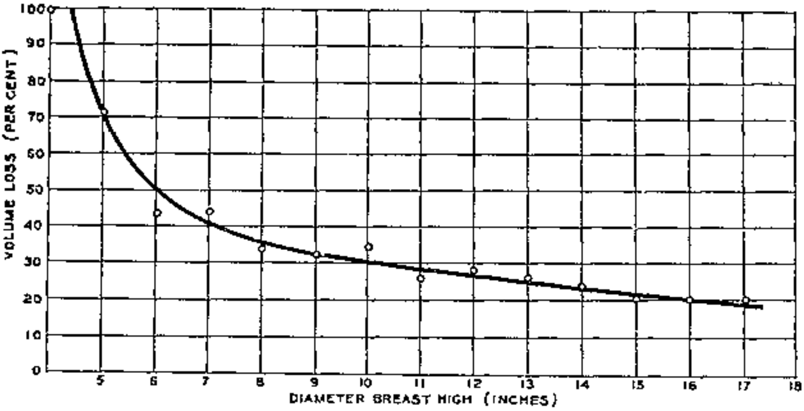


FIGURE 2.—Reduction in bole volume from loss of bark and sapwood

diameters, outside bark, and inside sapwood of each piece in the stack were determined by averaging the measurements taken at both ends. The differences in basal area resulting from the loss of sapwood and bark and the consequent reduction in the original volume, expressed in percentages, are shown in Table 4. These percentages were plotted,

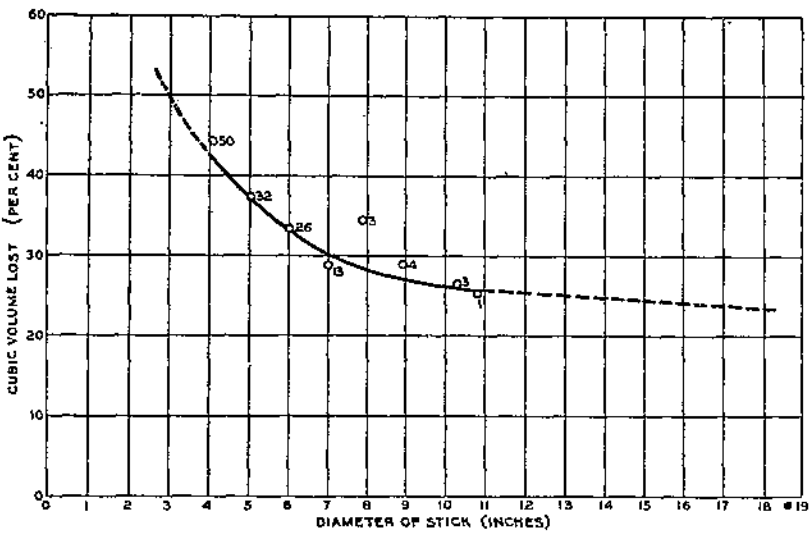


FIGURE 3.—Reduction of limb wood from loss of bark and sapwood. (See Table 4)

and a smoothed curve was drawn through the points, as shown in Figure 3. The curve was projected to 18 inches, in order to utilize all possible data given in Table 3. The curved values for even-inch classes were used in calculating the losses shown in Table 3.

[10] Diameter breast high.

TABLE 3.—*Volume loss in chestnut limb wood*

D. B. H. class (inches)	Trees	Loss	Average volume	Items of comparison	Middle diameter of stick outside bark (inches)															
					4[1]	5	6	7	8	9	10	11	12	13	14	15	16	17	18	Total
	Number	*Per cent*	*Cubic feet*																	
				Number	74	59	28	15	10	------	------	------	------	------	------	------	------	------	------	186
15 to 19	99	49	1.39	Volume (cubic feet)	32.6	40.1	27.4	20.1	17.5	------	------	------	------	------	------	------	------	------	------	137.7
				Volume of loss	32.6	14.7	9.0	6.0	4.9	------	------	------	------	------	------	------	------	------	------	67.2
				Number	110	143	77	51	18	15	3	9	4	3	1	------	------	------	------	434
20 to 24	123	39	3.47	Volume (cubic feet)	48.5	97.3	75.5	68.2	31.5	33.2	8.2	29.7	15.7	13.8	5.3	------	------	------	------	426.9
				Volume of loss	48.5	36.0	24.9	20.4	8.8	8.9	2.2	7.7	4.1	3.4	1.3	------	------	------	------	166.2
				Number	75	99	76	46	41	18	8	10	3	2	3	1	1	1	------	384
25 to 29	66	35	7.00	Volume (cubic feet)	33.0	67.3	74.5	61.7	71.7	39.8	21.8	33.0	11.8	9.2	16.0	6.1	7.0	7.9	------	460.8
				Volume of loss	33.0	24.9	24.6	18.5	20.1	10.7	5.9	8.6	3.1	2.3	4.0	1.5	1.7	1.9	------	160.8
				Number	24	50	32	28	18	18	12	9	7	1	2	1	1	------	1	204
30 to 34	31	31	10.00	Volume (cubic feet)	10.6	34.0	31.4	37.6	31.5	39.8	32.8	29.7	27.5	4.6	10.7	6.1	7.0	------	8.8	312.1
				Volume of loss	10.6	12.6	10.3	11.3	8.8	10.7	8.8	7.7	7.2	1.1	2.7	1.5	1.7	------	2.1	97.1
				Number	4	6	5	2	8	7	1	1	2	2	------	------	1	------	------	39
35 to 39	9	29	8.13	Volume (cubic feet)	1.8	4.1	4.9	2.7	14.0	15.5	2.7	3.3	7.9	9.2	------	------	7.0	------	------	73.1
				Volume of loss	1.8	1.5	1.6	.8	3.9	4.2	.7	.9	2.1	2.3	------	------	1.7	------	------	21.5
				Number	6	3	1	2	2	1	1	1	1	------	------	------	------	------	------	18
40 to 44	1	36	23.9	Volume (cubic feet)	2.6	2.0	1.0	2.7	3.5	2.2	2.7	3.3	3.9	------	------	------	------	------	------	23.9
				Volume of loss	2.6	.7	.3	.8	1.0	.6	.7	.9	1.0	------	------	------	------	------	------	8.6
				Number	293	360	219	144	97	59	25	30	17	8	6	2	3	1	1	1,265
Total	329	------	------	Volume (cubic feet)	129.1	244.8	214.7	193.0	169.7	130.5	68.2	99.0	66.8	36.8	32.0	12.2	21.0	7.9	8.8	1,434.5
				Volume of loss	129.1	90.4	70.7	57.8	47.5	35.1	18.3	25.8	17.5	9.1	8.0	3.0	5.1	1.9	2.1	521.4

[1] Sticks under 3.5 inches disregarded.

TABLE 4.—*Loss in volume of chestnut limb wood from decay of sapwood and falling of bark on various sizes of 5-foot sticks*

Diameter of sticks		Basal area outside of bark	Basal area inside of sapwood	Actual loss	Sticks used as basis
Class (inches)	Average				
	Inches	*Square feet*	*Square feet*	*Per cent*	*Number*
3.6 to 4.5	4.1	0.090	0.050	[1] 44.5	50
4.6 to 5.5	5.0	.139	.087	37.4	32
5.6 to 6.5	6.0	.194	.130	33.0	26
6.6 to 7.5	7.0	.266	.190	28.6	13
7.6 to 8.5	7.9	.340	.222	34.7	3
8.6 to 9.5	8.9	.432	.303	29.9	4
9.6 to 10.5	10.3	.579	.426	26.4	3
10.6 to 11.5	10.8	.636	.472	25.6	1

[1] Where the average diameter inside sapwood is less than 4.0 inches, the entire stick is considered lost.

Obviously the loss figures presented here can not be used for making accurate calculations on any individual stand. The very best that could have been done in a study of this nature would have been the preparation of regional volume and loss tables for various site conditions. Inasmuch as such an undertaking was neither warranted nor possible and lay outside the province of the Division of Forest Pathology, it is hoped that these methods can serve at least as an outline for making estimates from local volume-table data.

The financial losses will, of course, be dependent upon local economic conditions over limited periods of time and are not discussed in this bulletin. Where the bark is not included in the product, the losses due to decay of the sapwood are comparatively small. The reduction in diameter inside bark of bole and limb wood will average about 0.5 inch. The loss for peeled extract wood will be approximately one-third to one-fourth of the values given in the tables and figures where the bark has been included. The losses in board-foot volumes are very small, and no attempt has been made to estimate them in this bulletin.

DECAY OF HEARTWOOD IN STANDING TIMBER

DECAY IN GREEN TIMBER

The utilization of killed chestnut is in part dependent upon the amount of inferior grade of wood already in the forest before the trees are blighted. However, as much of the decay found in chestnut occurs in the basal section of the trees, such defective portions are butted off and the remaining sound sections salvaged.

In a mill-scale study of 221 trees at Waynesboro, N. C., Hedgcock[11] found more decay in the butts and first logs than in the logs taken from the upper part of the bole. The extent and area of the macroscopic decay in the timber were determined by following the logs through the mill. His unpublished data indicate that the types of decay were similar to those reported later on the Tennessee area (3, p. 2). Hedgcock measured the decayed portion of each decayed log as to length, width in lower end, width midway or in the center of the decay, width 12 inches from the upper end, and the cross-section

[11] Data arranged from unpublished notes of G. G. Hedgcock which were lent to the writers for this investigation. These notes were taken on a Forest Service mill-scale study of southern Appalachian hardwoods in 1923.

area at the upper and lower ends. The decay in this timber extended up the bole only 2 to 4 feet in 44 per cent of the trees in which rot was found in the first log. The average extent of the decay in the butt was found to be 5 feet. The logger is concerned, however, in the number of logs that are 100 per cent decayed and the number of logs that can be salvaged by long butting. As chestnut logs are of different lengths, depending on sweep, crook, crotch, knots, etc., it is evident that the percentage of decay based upon the total length of each log is an important figure.

The percentage of decay based on total log length for the first, second, and third logs on the area at Waynesboro is shown in Table 5. It can be seen that decay extended throughout the total length of only 7 first logs, 3 second logs, and 1 third log. In 54 of the first logs showing decay the extent of the rot was less than 50 per cent of the log length and less than 25 per cent of the log length in 30 first logs. The actual amount of decay on the area, therefore, is not great, since decay was found in only 73 first logs out of a total of 221 examined. In records based on scale of the trees in the woods, the Forest Products Laboratory finds a deduction of 11.4 per cent in Appalachian chestnut for rot or punk and a total deduction for defect, including sweep, crook, crotch, rot or punk, shake, fire damage, surface defect, and operating defect, of 24.3 per cent.[12]

TABLE 5.—*Extent of decay in first, second, and third chestnut logs at Waynesboro, N. C. (based on log length)*

Average length of log (feet)	Decay based on total length	Basis		Percentage of total number of logs showing decay
		Logs	Percentage of total	
First log:	*Per cent*	*Number*	*Per cent*	*Per cent*
14.8	100.00	7	3.17	[a] 9.59
14	78.65	1	.45	1.37
16	75.00	1	.45	1.37
14	71.50	1	.45	1.37
10	70.00	1	.45	1.37
12	66.66	1	.45	1.37
14	64.35	1	.45	1.37
16	62.50	2	.90	2.74
15	50.00	4	1.81	5.48
15	46.52	1	.45	1.37
16	43.75	3	1.36	4.11
14	42.90	1	.45	1.37
16	37.50	4	1.81	5.48
14	35.75	1	.45	1.37
12	33.38	1	.45	1.37
16	31.25	4	1.81	5.48
14.2	25.00	9	4.07	12.33
14	21.40	4	1.81	5.48
10	20.00	1	.45	1.37
16	18.70	4	1.81	5.48
12	16.66	4	1.81	5.48
14	14.20	6	2.71	8.22
16	12.50	9	4.07	12.33
14	7.15	1	.45	1.37
16	6.25	1	.45	1.37
14.7	0	145	65.61	
Unmerchantable [b]		3	1.36	
Total		221		
Second log:	*Per cent*	*Number*	*Per cent*	*Per cent*
14	100.00	3	1.42	[c] 13.04
12	75.00	1	.47	4.34
16	62.50	2	.95	8.69
14	57.20	1	.47	4.34
10	50.00	1	.47	4.34
16	43.75	1	.47	4.34
12	41.65	1	.47	4.34
16	37.50	1	.47	4.34
16	31.25	1	.47	4.34
14	28.60	1	.47	4.34
14	25.00	2	.95	8.69
16	18.70	3	1.42	13.04
12	16.66	3	1.42	13.04
14	14.20	1	.47	4.34
16	12.50	1	.47	4.34
14.3	0	188	89.10	
Total		211		
Third log:				
16	100.00	1	.93	[d] 11.11
12	83.30	1	.93	11.11
14	57.20	1	.93	11.11
15	50.00	2	1.85	22.22
14	35.71	2	1.85	22.22
12	33.33	1	.93	11.11
12	25.00	1	.93	11.11
13.7	0	99	91.67	
Total		108		

[a] Total number equals 73.
[b] Probably the logs were obviously not worth sawing.
[c] Total number equals 23.
[d] Total number equals 9.

[12] GARVER, R. D., and MILLER, R. SMALL SAWMILL UTILIZATION OF APPALACHIAN HARDWOODS. PART I. LUMBER. U. S. Dept. Agr., Forest Serv. in cooperation with the Univ. Wis. 103 p. 1929. (Mimeographed.)

It is rather generally believed that various correlations exist between the prevalence of decay and site. Such relationships probably vary with the different sites on which the chestnut is growing. On the Tennessee areas studied, and where the cove type of chestnut was not present, the larger number of trees that were decayed grew on the ridge-top sites. (Table 6.) The reason for this is difficult to explain. There the soil is dry, and the site is not one that produces a high quality of timber. There is a free access of wind there, and branches are frequently broken off. This, of course, extends the possibilities for fungous infection. As the ridge-top site is a drier one, fires probably have been more severe and have occurred perhaps more frequently during the life of the trees than on the more moist slopes. Although the best growth of chestnut is usually found on slopes with a northerly aspect, there seemed to be little difference in the presence of rot on the slopes facing different directions. The number of trees examined that were growing on different aspects and the decay present are recorded in Table 7.

TABLE 6.—*Types of decay in green chestnut timber on different sites in Sevier County, Tenn.*

Diameter class (inches)	Trees on—		Trees with—						Total trees with rot			
			Polyporus spraguei type		Polyporus pilotae [1] type		Type of decay unknown					
	Lower slope	Ridge	Lower slope	Ridge	Lower slope	Ridge	Lower slope	Ridge	Lower slope		Ridge	
	Number	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Per cent*	*Number*	*Per cent*
6 to 13	57	74	4	13	2	4	2	5	8	14.0	22	29.7
14 to 15	73	133	6	20	1	8	3	10	10	13.7	47	35.4
16 to 17	60	150	0	32	2	9	6	18	17	28.3	59	39.3
18 to 19	69	141	5	30	3	12	9	15	17	24.6	57	40.5
20 to 21	61	129	7	39	2	9	6	14	15	24.6	62	48.0
22 to 23	34	77	6	16	3	5	6	22	15	44.1	43	55.8
24 to 25	33	102	7	22	1	5	1	13	9	27.3	40	39.2
26 to 27	28	58	6	16	1	6	3	10	10	35.7	32	55.2
28 to 29	18	59	2	17	2	5	5	11	9	50.0	33	56.0
30 to 31	11	25	1	10	0	5	2	5	3	27.3	20	80.0
32 to 33	8	27	3	5	2	4	2	6	7	87.5	15	55.5
34 to 37	16	25	4	9	4	4	3	5	11	68.7	18	72.0
38 to 41	5	4	1	1	1	0	2	1	4	80.0	2	50.0
42 to 45	3	6	2	4	0	1	1	1	3	100.0	6	100.0
46 to 49	1	2	1	0	0	1	0	1	1	100.0	2	100.0
50 to 64	4	3	2	2	0	1	2	0	4	100.0	3	100.0
Total	481	1,015	57	236	24	79	53	146	143	29.7	461	45.4

[1] The name *Polyporus pilotae* Schw. has appeared extensively in American publications. *P. pilotae* Schw. and *P. croceus* Fr. are, however, considered as synonymous in the literature.

TABLE 7.—*Number of chestnut trees and rot present on slopes of different aspects, Sevier County, Tenn.*

Aspect	Trees	Polyporus spraguei type	Polyporus pilotae type	Type of decay unknown	Total rot
	Number	*Per cent*	*Per cent*	*Per cent*	*Per cent*
North	150	15.3	4.0	18.0	37.3
East	347	19.0	6.3	12.6	37.9
South	97	23.7	4.1	12.4	40.2
West	406	23.3	7.4	13.0	43.8

In the majority of heart-rot studies, relationships are usually determined between age and decay, as well as between diameter and decay. Such data are used in regulation studies and aid in the determination of the period of rotation. In chestnut stands such studies in regard to rotation would now be useless, since the chestnut blight has thrown out American chestnut from all forest-management plans. Facts obtained regarding the relation between the age and the decay are therefore of little practical value in the utilization of chestnut.

DECAY IN DEAD TIMBER

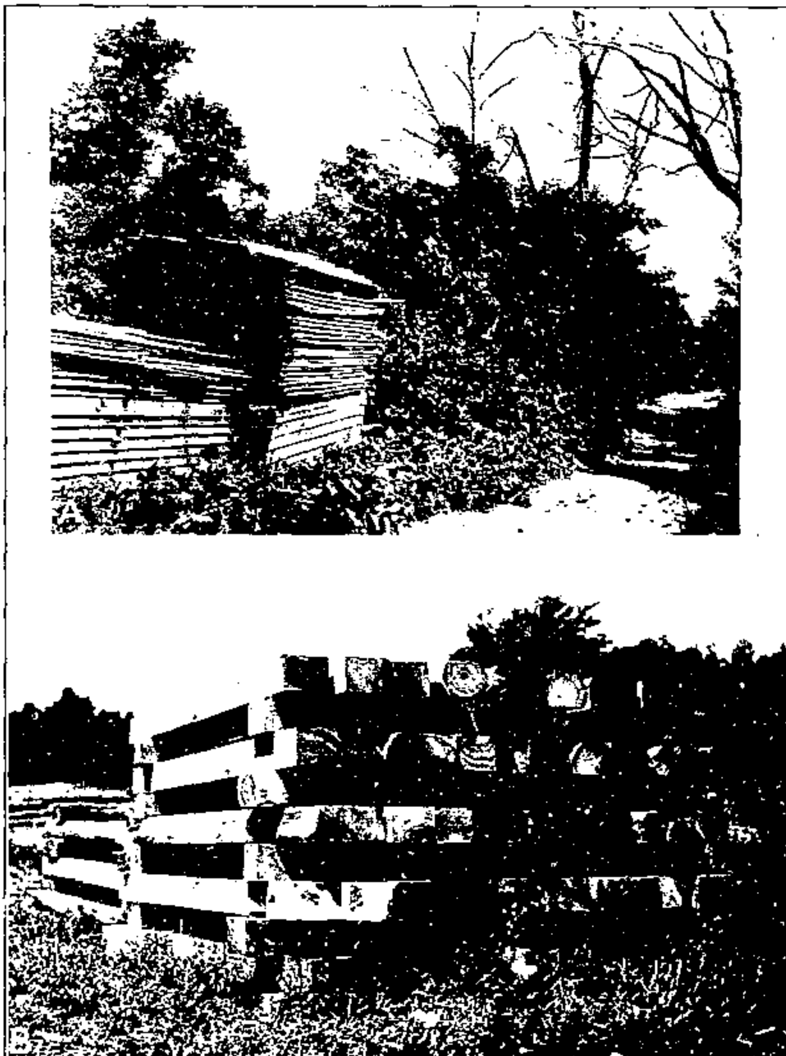
In the dead trees felled in both the study of tannin content [13] and for the present study, the characteristic heartwood decay was found similar to that already recorded for green timber. Both the "piped rot," *Polyporus pilotae* type (pl. 2, B), and the brown friable cubical rot, *P. sulphureus* and *P. spraguei* types (pl. 3), were found in standing trees practically regardless of how long they had been dead.

In the timber that had been dead for 3½, 8, 12, 15, 18, 25, and 30 years (4, p. 2) there seemed to be no correlation between the number of decayed dead standing trees and the number of years such trees had been dead. On one sample plot listed in Table 8, 100 per cent of the trees that had been dead for 8 years were sound, while only 40 per cent of the trees dead for only 3½ years on another plot were sound. On plot No. 9, 70.8 per cent of the trees were sound even though they had been dead for 25 years, whereas on plot No. 5 only 19.4 per cent of the trees dead 12 years were sound.

Table 8 indicates that one may expect to find a surprising number of sound trees in stands that have been dead as long as 25 years. Fence posts, mine timbers, ties, extract and pulpwood, and even lumber can be salvaged from such wood. Many of the trees felled for this study on the heartwood decay were converted into cordwood and sold to extract plants. Lumber cut from trees that had been in a dead standing condition for 10 years before felling is shown in Plate 4, A. Tie timbers made from chestnut dead for 6 years are shown in Plate 4, B.

[13] NELSON, R. M., and GRAVATT, G. F. Op. cit. (See footnote 6.)

Polyporus spraguei on chestnut extract wood that had been in storage for two months. *P. spraguei* continues to rot the wood after the tree has been felled. Note the white fruiting body of this fungus on the badly diseased stick of extract wood



B, photographed by Edward Litchfield in New York State

A, Chestnut lumber sawed from dead trees that had been killed by girdling 10 years before cutting. This lumber, despite the poor method of piling, is still merchantable. Near Natural Bridge National Forest, Virginia. B, Ties sawed from chestnut that has been dead for six years. Although the sapwood is decayed, the heartwood is in good condition

TABLE 8.—*Rot types from sections of dead standing chestnut trees*

[P. indicates Polyporus]

Plot		Time dead	Trees showing decay														
			First log								Second log						
No.	Locality		Trees	P. spraguei type	P. pilotae type	P. sulphureus type	P. berkeleyii type	Unknown type	Sound	Logs sound	Trees	P. spraguei type	P. pilotae type	P. sulphureus type	Unknown type	Sound	Logs sound
		Years	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Per cent*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Per cent*
1	Floyd, Va.	3½	15	2	1	2	--------	4	6	40.0	15	--------	--------	--------	5	10	66.6
2	Glenville, N. C.	8	16	--------	--------	--------	--------	--------	16	100.0	16	--------	1	--------	--------	15	93.8
3	Glenville, N. C. (Bryson area)	8	15	--------	3	1	--------	1	10	66.6	15	--------	--------	--------	1	14	93.4
4	Cold Mountain, Va.	12	25	--------	--------	--------	--------	3	22	88.0	25	--------	2	--------	1	22	88.0
5	Glenville, N. C. (Jackson area)	12	31	14	5	--------	1	5	6	19.4	29	14	--------	--------	4	11	37.9
6	Cold Mountain, Va.	15	23	--------	2	1	--------	1	19	82.6	22	--------	--------	--------	2	20	90.9
7	Glenville, N. C. (Bryson area)	18	11	6	--------	--------	--------	3	2	18.2	11	3	1	--------	1	6	54.5
8	Glenville, N. C. (Franks area)	18	12	3	2	--------	--------	6	1	8.3	11	3	2	--------	3	3	27.3
9	Cold Mountain, Va.	25	24	--------	--------	--------	--------	7	17	70.8	24	--------	1	1	2	20	83.4
10	Do.	30	24	1	--------	--------	--------	20	3	12.5	17	--------	2	--------	10	5	29.4
11	Glenville, N. C. (Wilson area)	30	30	16	4	1	--------	3	6	20.0	31	14	8	3	4	2	6.5

DECAY OF SAPWOOD IN SLASH AND FALLEN TIMBER

The rate and type of decay in the sapwood of chestnut slash correspond generally to that recorded for dead standing timber. Records that have been obtained from various regions in the southern Appalachians, and which are supported by the measurements mentioned in the following paragraphs, show that the sapwood of chestnut slash is decayed generally within two years. The two measurements obtained in the manner described on page 3 were averaged, and this figure was used as the basis for determining the percentage of decay. Although the depth of decay in chestnut slash is not uniform over the entire sapwood, the percentages expressed in Table 9 are believed to be representative of what is to be expected in the decay of sapwood in slash.

TABLE 9.—*Decay of sapwood in 2-year-old chestnut slash, Natural Bridge National Forest, Va.*

[Based upon 1,000 measurements for each diameter class, on and off the ground]

Diameter outside of bark	Decay (per cent)		Number of fruiting bodies found in August, 1928 of—															
			Polystictus hirsutus		Polystictus versicolor		Irpex lacteus		Schizophyllum commune		Polyporus cinnabarinus		Stereum sp.		Stereum ochraceoflavum		Stereum fasciatum	
	On the ground	Off the ground	On the ground	Off the ground	On the ground	Off the ground	On the ground	Off the ground	On the ground	Off the ground	On the ground	Off the ground	On the ground	Off the ground	On the ground	Off the ground	On the ground	Off the ground
1 inch	87	87	6	5	5	1	3	2	2	2	3	0	3	1	2	1	1	1
2 inches	31	34	8	0	2	0	4	7	1	4	18	1	6	0	2	1	2	0
3 inches	17	13	8	5	0	0	1	2	0	0	17	0	0	2	0	3	2	1
4 inches	11	11	9	3	0	2	0	2	0	2	12	0	1	1	0	0	3	0
Over 4 inches			11	0	0	0	0	1	1	0	8	0	0	0	0	0	2	0
Total			42	19	7	3	8	14	4	8	58	1	10	4	4	5	10	2
Grand total			61		10		22		12		59		14		9		12	

Because of the large amount of sapwood in proportion to heartwood in small slash, small débris in the forest is rapidly decayed by the sapwood-rotting organisms. In the Natural Bridge National Forest 87 per cent of the wood in small slash was decayed after two years. This figure was obtained from measurements made on slash both on and off the ground. If there was any difference in the amount of decay of slash on and off the ground, it was so slight that it could not be measured in units of sixteenths of an inch. Table 9 shows that the percentage of decay in the slash (off the ground) of the 3-inch and particularly the 4-inch classes is relatively small, 13 and 11 per cent, respectively. This, as has been explained, is due to the large amount of heartwood present.

Although it is well known that sapwood is generally less durable than heartwood, the difference in the rate of decay of sapwood and heartwood in chestnut is particularly striking, certainly more so than in such species as poplar and birch. In slash of the larger diameter classes the heartwood decays very slowly and seldom rots until long after the sapwood has fallen away. Inasmuch as this heartwood remains as a fire menace for years after logging, it is evident that the removal of the larger limbs for extract wood or for cordwood is even more important if this hazard is to be reduced within a short period.

FUNGI CAUSING DECAY OF SAPWOOD AND HEARTWOOD

FUNGI ON SAPWOOD [14]

The majority of the fungi that are responsible for the decay of the sapwood in standing trees are also widely distributed geographically and are common on chestnut slash. Although extensive collections of both slash-rotting and other chestnut-inhabiting fungi have been made throughout the entire range of the American chestnut, only a few of the more important plants are mentioned in this bulletin.

Polystictus pargamenus Fr. and *Polyporus gilvus* Fr. are commonly found on both standing trees and slash that still retain the bark. They are active in the disintegration of bridge timbers and cribbings and are capable of producing much decay in extract wood when it is stored for long periods. *Polystictus hirsutus* Fr. and *Polyporus cinnabarinus* Fr. also produce much decay in extract and slash wood. *P. cinnabarinus* decays the sapwood of the larger prostrate limbs and is a common fungus on extract wood stored in the stack. The two last-mentioned fungi generally attack the larger slash (2 inches and over) which is on the ground. Other important fungi which decay slash timbers in the southern Appalachians and which were collected in the slash study already referred to under 5, page 2, are shown in Table 9. Although *Poria mutans* Pk. is not listed in this table, it is a very common fungus which aids in the decay of old logs and of larger slash. This fungus is more apt to be found where such logs occur in the forest before the timber is cut over and where the slash is not exposed to the sun.

Blight-killed sprouts, which are a decided fire menace in the forest, are attacked chiefly by the following sapwood-inhabiting fungi: *Irpex lacteus* Fr., *Polyporus gilvus* Fr., *P. nidulans* Fr., *Poria mucida* Fr., *P. ferruginosa* (Schrad.) Fr., *Panus stipticus* Fr., *P. rudis* Fr., *Stereum sericeum* Schw., *S. rameale* Schw., *S. umbrinum* B. and C., *S. ochraceo-flavum* Schw., and *Peniophora cinerea* (Pers.) Cooke.

FUNGI ON HEARTWOOD

It can be seen from Tables 6 and 8 that the most important cause of cull in green or dead standing chestnut is attributed to *Polyporus spraguei*, *P. pilotae*, and possibly *P. sulphureus*. Undoubtedly the majority of rots listed in these tables under "*Polyporus spraguei* type" and "*Polyporus pilotae* type" are respectively caused by these two fungi. The number of known infections of *P. spraguei* on the Tennessee areas studied, as is indicated by the number of logs and stumps actually showing fruiting bodies, is shown in Table 10. Fruiting bodies were actually found on 110, or 7.3 per cent, of the trees.

[14] It is impossible to sharply define those fungi which produce decay in the sapwood and heartwood. *Polystictus pargamenus*, for instance, frequently decays the heartwood under favorable conditions.

TABLE 10.—*Number of living chestnut trees actually known to be infected with Polyporus spraguei, as indicated by the presence of fruiting bodies, in Sevier County, Tenn.*

Area	Site	Total trees	Trees with P. spraguei fruiting bodies	Trees showing fruiting bodies
		Number	*Number*	*Per cent*
Little Dudley	Ridge top	815	69	8.5
Do	Lower slope	318	15	4.7
Roaring Fork	Ridge top	200	14	7.0
Do	Lower slope	163	12	7.4
Total or average		1,496	110	[1] 7.3

[1] Computed from total number of trees and total number with fruiting bodies.

Structural timbers are attacked also by *Polyporus sulphureus* Fr., *P. spraguei* B. and C., and in some regions *Daedalea quercina* Fr., in addition to *Polyporus pilotae* Schw. *Lenzites vialis* Pk. is common on chestnut trees, and *Trametes sepium* Berk. is to be found almost invariably on chestnut poles and on other structural timbers. The large number of records of the important decay-producing fungi that were obtained from sections of the dead girdled trees and from green standing timber may be summarized as follows:

Polyporus spraguei continues to develop in the larger pieces of slash after the tree has been wind thrown. This fungus was found fruiting on 30-year-old dead chestnut that had been on the ground for at least six years. *P. spraguei* frequently has been found fruiting on old logs in chestnut forests elsewhere. This is an important item, in that there are relatively few fungi on record that produce both heart rot in living timber and also decay in fallen limbs and slash on the ground.

Polyporus sulphureus produces decay in chestnut heartwood in living timber, and not only has it been observed in these dead girdled trees that have been standing for a number of years, but its fruits have also been observed on lightning-killed snags in the forest, on fence posts, telegraph poles, and logs. *P. sulphureus*, therefore, decays the heartwood of living trees and attacks the larger slash as well. Although this fungus usually fruits at the base of the tree, it has been found occasionally 10 to 12 feet high.

The fungi that infect the heartwood of dead standing trees are in general the same species that decay the heartwood in living trees. Inasmuch as cultures of the important and common fungi have been obtained from trees that have been dead for 3½, 8, 12, 15, and 25 year periods and seasoned on the stump, it is believed that these heart-rotting fungi can continue to decay the heartwood after the timber is cut. This fact is particularly important, in that such fungi may continue to develop in set pole timbers if conditions are favorable for the growth of the heart-rotting fungus in chestnut.

Polyporus spraguei and *P. pilotae* produce much of the decay in the deadwood and are contributory causes to windfall in such timber.

The many cultures of mycelium obtained from the white-pocket decay areas in the upper parts of the trunk indicate that *P. pilotae* decays much of the wood in the upper part of the bole in dead standing trees.

Additional or new infection of heartwood in decorticated trees may be initiated in the large checks in which moisture may accumulate.

CHECKING IN DEAD STANDING TIMBER

Although chestnut heartwood is unusually durable, it is subject to severe checking when allowed to die and season on the stump. Observations on the permanent and temporary plots indicate that damaging checks do not ordinarily appear while the bark remains on the bole. The degree of checking seems to vary greatly in trees of the same size, even on similar sites. One to three checks usually run deep into the heartwood, occasionally extending the entire radial distance. In small trees two radial checks frequently join so as to split practically the entire bole into two parts, which may render it unmerchantable for poles or lumber.

In Table 11 the depth of the deepest check represents the deepest measurement that could be found on that check, while the depth at breastheight is the average depth of all checks over 1 foot long occurring at 4½ feet above ground. The data in Table 12 were taken on trees that had been felled and bucked at measured lengths. The check measurements were made as described on page 4. It was observed that in hot, dry weather the depth of the checks oftentimes increased one-fourth to one-half an inch within 24 hours after bucking, but this did not continue appreciably after the first day. Ordinarily the point is of little or no practical importance, since the resulting fissures are negligible in thickness and probably do not extend more than an inch or two longitudinally beyond the cut face.

TABLE 11.—*Degree of checking measured on standing and wind-thrown chestnut trees* [1]

Time dead (years)	Trees	Trees wind thrown	First 16-foot log: Deepest check: Length	First 16-foot log: Deepest check: Depth	First 16-foot log: Checks over 1 foot long: Average depth at breastheight	First 16-foot log: Checks over 1 foot long: Average length
	Number	*Per cent*	*Feet*	*Inches*	*Inches*	*Feet*
4 to 10	184	1.1	5.3	2.2	1.2	2.5
11 to 15	198	37.9	6.6	2.3	1.3	3.7
16 to 20	402	18.9	6.8	2.4	1.6	4.4
28 to 30	280	77.3	7.9	2.4	1.4	4.1
40	27	93.0	12.8	2.6	1.8	6.2

[1] Depth of checks was determined by inserting a thin celluloid rule into the crevice. Many checks were actually one-half an inch deeper than the measurements shown by the thin rule.

TABLE 12.—*Degree of checking measured on bucked chestnut trees*

Time dead (years)	Trees	Checks over 1 foot long at stump: Deepest	Checks over 1 foot long at stump: Average depth	Checks over 1 foot long at 12 to 16 feet: Deepest	Checks over 1 foot long at 12 to 16 feet: Average depth	Checks over 1 foot long at 32 feet: Deepest	Checks over 1 foot long at 32 feet: Average depth
	Number	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*
3 to 10	66	1.8	0.9	2.1	1.5	1.9	1.4
11 to 15	115	2.3	1.5	2.9	1.8	2.1	1.5
18 to 20	47	2.8	1.7	3.9	2.1	3.3	1.7
25 to 30	108	2.0	1.0	3.5	2.0	2.9	1.7

A comparison of Tables 11 and 12 indicates that the most serious checking occurs during the first 10 years after death and that the increase for the following 20 years is comparatively small. Nellis,[15] in studying deterioration of chestnut in the North, states:

> During the fifth year (after death) the bark usually falls from the trunk, and the rotted sapwood, which is full of insect burrows, dries out and starts to peel off. On Long Island the sapwood was off all trees which had been dead seven years. The heartwood was hard and sound, but all trees under 18 inches in diameter were so badly checked as to be unmerchantable. Checking starts in small trees in the second year, and in all trees it is rapid from the fifth year on.

This agrees with observations in the southern Appalachians, in that checking is not serious while the bark remains on the tree, but follows rapidly after decortication. The permanent and temporary plot records show that it is negligible on the first log up to the seventh year after death, but takes place very rapidly in the following three years. An explanation of the unusually shallow checks at stump height in the trees dead 3 to 10 years as shown in Table 12 may be

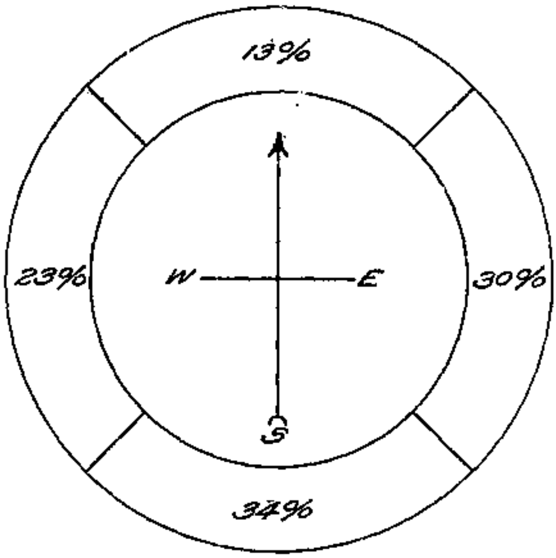


FIGURE 4.—Distribution of largest checks measured

that 38 per cent of the trees had been dead less than 7 years, in contrast with the 18 per cent in the corresponding class in Table 11.

On practically all trees the checks were distributed evenly over the circumference of the bole. It is interesting to note in Figure 4, however, that only 13 per cent of the largest checks occurred on the north side, whereas 64 per cent were to the east and south sides. Table 12 indicates that checks on the small end of the first log will range from 1.5 to 2 inches in depth. This may be equivalent to a reduction in diameter of 3 to 4 inches where trees are to be sawed into lumber.

LOSS AND SALVAGE

The actual losses resulting in the deterioration of blight-killed timber in the southern Appalachians must be measured in terms of

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[15] NELLIS, J. C. Op. cit. (See footnote 4.)

product. The sapwood is largely disintegrated in southern chestnut by the end of the second year after death, and in trees that are slowly killed by the blight decay is evidenced on parts of the trunk before the tree is dead. The loss of sapwood from that part of the tree which would be below the ground line if used for pole timber makes it impracticable to utilize the attacked wood for treated poles, because the heartwood of chestnut is practically impervious to liquid preservatives. On the exposed parts of the butt-treated pole this makes little difference and in most cases is desirable, as climbing is rather difficult so long as the decaying sapwood persists.

It might seem that decay in southern chestnut would progress more rapidly than that observed in such timber farther north, and particularly so because of the apparently more favorable conditions for fungous growth. These studies indicate that there is little difference in the rate of sapwood decay in northern and southern chestnut. Decay proceeds rapidly in both regions as long as the bark is retained.

Although it was observed that southern blight-killed chestnut retains its bark for varying periods, it was found in general that the bark and sapwood are lost for utilization purposes after the third year. The volume reductions in this instance are considerable for cordwood. Fortunately the sapwood in chestnut is narrow, which justifies the statement by Nellis [16] that "for sawed products (lumber dimension stuff, sawed ties, switch timbers, sawed fence posts, shingles, and slack staves and heading) sapwood injury may be disregarded, as it will slab off."

The heartwood of chestnut remains sound on the stump for at least 25 years on some areas, and lumber has been manufactured out of southern chestnut that has been killed 10 years previous to the time of felling. These studies emphasize the already well-established fact that chestnut heartwood is very durable. Because of its excellent decay-resisting qualities, prolonged standing of the dead timber does not exclude the continued use of this species for many purposes. Furthermore, as there is a sufficient quantity of chestnut to meet commercial demands, it is evident that there is no reason, for the present at least, for users of many chestnut products to turn to other species. Trees that have been dead for 10 or more years, however, are subject to wind throw. In such wind-thrown timber deterioration progresses much more rapidly than it does in standing timber.

The type of products obtained from future sales of blight-killed chestnut are in part dependent upon cull percentages, due to heart rots and wind-shake already in the tree. If, however, the tree is sound at the time of being killed by the blight, in all probability there will be little or no loss in volume from center rot for the first 10 years after death. Although the prevalence of heart rot may vary widely with different stands, decay seems to be a more common defect in the stumps and first logs than in any other part of the tree. On areas where the timber is largely defective through wind-shake and rot, lumbering is economically impossible. Under favorable economic conditions this southern timber can be manufactured into extract, provided long hauls to the railroad are not necessary.

Nelson and Gravatt [17] have found that according to the method of analysis used (official method) the loss of tannin through the action

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[16] NELLIS, J. C. Op. cit. (See footnote 4.)
[17] NELSON, R. M., and GRAVATT, G. F. Op. cit. (See footnote 6.)

of decay-producing fungi is not great. They were also unable to find any marked correlation between tannin content and length of period dead, and so far as tannin content alone is concerned they state that trees can be profitably used for the manufacture of extract until decay makes them unfit for handling. Many of their samples were collected from trees used in the present work for the study of heartwood decay and checking.

Checking is responsible for the rejection of much timber that would otherwise be suitable for poles and lumber. Checks may also reduce the merchantable volume of saw logs. An accurate estimate of this reduction would be impossible from the figures at hand.

SUMMARY AND CONCLUSIONS

Owing to the irregular rate of killing along the longitudinal axis of a tree, it becomes impossible to obtain a wholly satisfactory starting point from which to study the deterioration of blight-killed timber. If death is considered to occur when the last tissue above stump height is killed, the condition of the upper parts of a tree is a poor criterion for judging the time of death.

By the third year after death 96 per cent of the sapwood of the first log has decayed, and there is almost an equal area of loosened bark.

By the fourth year after death the sapwood and bark are lost for utilization purposes. A large part of the bark, however, may hang on until the seventh year and thus form a protection against severe checking up to that time.

The sapwood averages about one-fourth of an inch in thickness and is largely decayed by the fifth year after death. Following decay of the sapwood, the heartwood in standing trees probably does not deteriorate more than an eighth of an inch from the outside in 20 or 30 years.

The percentage of volume loss from sapwood decay and bark falling increases inversely to the diameter of the tree and does not exceed 20 per cent of the actual cubic volume of wood and bark in trees over 16 inches d. b. h. This loss is negligible for saw timber.

The heartwood in chestnut slash, whether on or off the ground, remains sound for many years, and pieces 3 inches or over in diameter constitute a long-time fire hazard.

Several of the important fungi that decay slash in the forest are also the important fungi attacking the sapwood of standing trees. *Polystictus pargamenus* and *Polyporus gilvus* are especially active in destroying the sapwood of both standing blight-killed chestnut and fallen or structural timbers that still retain the bark. *Polystictus hirsutus* and *Polyporus cinnabarinus* are very common on slash.

Polyporus spraguei, *P. sulphureus*, and in some of the northern sections of the Appalachians *Daedalea quercina* destroy the heartwood of standing timber and also attack the larger pieces of slash in the forest as well as structural timbers.

The viable cultures of *Polyporus pilotae*, which were obtained from trees that had been in a dead standing condition for 12 or more years, indicate that this heart-rotting fungus found in green chestnut may continue to decay the heartwood after the death of the tree. This fact is particularly important in that such a fungus may continue to develop in set pole timbers, if conditions are favorable for the growth of the heart-rotting fungus in chestnut. It is also possible that *P. pilotae* may infect dead standing timber. Other fungi resembling the mycelia of *P. spraguei* and *P. sulphureus* were obtained from dead standing timber.

There is no relation between the number of decayed dead standing trees and the number of years such trees have been dead. The rate of heartwood decay in timber seasoned on the stump, however, may be very slow. On one area studied, over 70 per cent of the first logs and 83 per cent of the second logs were sound, even though the trees had been dead for 25 years.

Few areas are known on which dead trees have been standing for more than 30 years. After the trees are wind thrown the progress of decay is more rapid than in dead standing timber. On one area only 12 per cent of the first logs and 29 per cent of the second logs were sound in such windfallen trees. This 30-year dead timber had been on the ground for approximately 10 years.

Although heartwood decay is common in both living and dead chestnut, it is not generally extensive enough in the individual trees to prevent utilization. Timber left standing for one year after death is nearly as good as green timber for treated poles, and fortunately such pole timbers can be salvaged from the stand two and sometimes three years after death. It is possible to manufacture lumber from dead standing chestnut for at least four years after the death of the tree, and 10 or more years on some areas. The use of chestnut in the manufacture of pulp and extract wood affords an outlet for much of the blight-killed timber. It was pointed out that tests made on some wood observed for these decay studies indicated that the percentage of tannin in trees which had been dead 25 to 30 years is not materially less than that in living chestnut. Defect is most prevalent in the basal sections of the tree. Ordinarily much of this defect may be butted off and the wood surrounding the doaty or hollow portions can be utilized by extract plants.

Checking takes place most rapidly after decortication, i. e., between 6 and 10 years after death, and may reduce the volume and quality of lumber, especially in the smaller timber classes.

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U. S. GOVERNMENT PRINTING OFFICE: 1931

For sale by the Superintendent of Documents, Washington, D. C. - - - Price 10 cents

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