DETERIORATION OF BEETLE-KILLED DOUGLAS-FIR IN OREGON AND WASHINGTON

A SUMMARY OF FINDINGS TO DATE

RESEARCH PAPER NO. 10

U. S. DEPARTMENT OF AGRICULTURE · FOREST SERVICE
PACIFIC NORTHWEST FOREST AND RANGE EXPERIMENT STATION
R.W. COWLIN, DIRECTOR

PORTLAND, OREGON JUNE 1954

CONTENTS

Page

Frontispiece

SUMMARY . . . . . .

INTRODUCTION 1

COLLECTION AND ANALYSIS OF DATA 2

RESULTS 3

Progressive deterioration by areas 3
Variation in percent of sapwood in study trees 7
Indicators of deterioration in standing trees 7

DISCUSSION 11

Association of beetle attacks with decay 11
Effect of deterioration on log quality 11
Effect of deterioration on breakage 11
Fire hazard caused by beetle-killed trees 12

TABLES AND ILLUSTRATIONS

Table 1. Board-foot deterioration of beetle-killed Douglas-fir . . . 4
Table 2. Cubic-foot deterioration of beetle-killed Douglas-fir . . . 4
Fig. 1 - Deterioration analysis of a beetle-killed Douglas-fir . . 3
Fig. 2 - Relation of cubic-foot to board-foot deterioration losses 6
Plate I - Progress of deterioration in beetle-killed Douglas-fir. . 8
Plate II - Douglas-fir beetle work and associated fungi. 10

Group of trees killed by Douglas-fir beetle. Mortality is typical of that occurring on some 4,800,000 acres in western Oregon and southwestern Washington since 1951. The rate of deterioration of this timber is of prime concern to owners and land managers.

SUMMARY

In 1952 and 1953 cooperative research was conducted by the Pacific Northwest Forest and Range Experiment Station and the Research Department of Weyerhaeuser Timber Company to obtain information concerning the rate of deterioration of beetle-killed Douglas-fir. The study was prompted by an outbreak of the Douglas-fir beetle that developed in 1951 and has since killed an estimated nearly 2 billion board feet of timber over an area of some 4,800,000 acres in western Oregon and southwest Washington. In order to salvage a maximum amount of the insect-killed timber the timber industry needs to know how long the timber will remain merchantable.

By analyzing dated beetle-killed trees on study plots and other areas some fairly reliable data on the salvage period of the killed timber have been secured. They are presented in the following report. The deterioration studies are still in progress and a more complete report will be prepared upon their completion. Highlights of the findings to date are as follows:

1. Volume loss from wood decay is considerably faster in young timber because of the greater ratio of sapwood in young trees.

2. When killed timber is salvaged for pulp, a higher recovery will result than if the end product is lumber.

3. After 2 years the sapwood of beetle-killed trees is generally deteriorated to where it is no longer suitable for lumber; some recovery of the sapwood for pulp may be possible even after 3 years.

4. By the fourth year after kill, deterioration usually begins to penetrate the heartwood and by the sixth year from 25 to 50 percent of the tree volume will be lost, depending on the age and size of the trees and other factors.

5. Deterioration of the sapwood destroys a large percentage of the high quality wood of the tree, and is therefore an important consideration in prompt salvage of beetle-killed timber.

6. Once the sapwood has deteriorated, breakage when falling beetle-killed timber is much greater than in green timber.

7. Progress of wood-boring insects for at least the first 6 or 7 years is directly related to the advance of wood decay.

8. The rate of deterioration appears to be directly related to intensity of the beetle attack.

DETERIORATION OF BEETLE-KILLED DOUGLAS-FIR TIMBER

By

Ernest Wright, Pathologist, and K. H. Wright, Entomologist
Pacific Northwest Forest and Range Experiment Station

INTRODUCTION

The Douglas-fir beetle (Dendroctonus pseudotsugae Hopk.) is continuing to cause widespread killing of Douglas-fir timber in western Oregon and Washington. An estimated 2 billion board feet of timber has been killed since the first year of epidemic outbreak in 1951. The epidemic has reached its peak and will probably gradually subside. However, the problem of salvaging the great volume of killed timber in the region before it is lost through deterioration is of major concern to timber owners. It is highly desirable, therefore, to make available the known information on the deterioration of beetle-killed timber.

In recognition of the seriousness of this problem and the urgency of obtaining usable information, deterioration studies were started in 1952. A preliminary report released in 1952 1/ gave the findings for one locality. This report covers data gathered during the 1952 and 1953 field seasons, including information from 3 additional localities and data from the old locality. A total of 100 beetle-killed trees have been analyzed to date, and additional analyses will be made as time since the death of trees elapses.

This study is a cooperative undertaking by the Divisions of Forest Disease Research and Forest Insect Research of the Pacific Northwest Forest and Range Experiment Station, the Weyerhaeuser Timber Company, and the Gifford Pinchot National Forest. Special acknowledgement for help in collecting the data reported here is due P. G. Lauterbach, H. C. Sommer, and J. E. Lodewick of the Company for their assistance in the project. Dr. Lodewick, a utilization specialist, was especially helpful in evaluating the usability of the killed timber; Mr. Lauterbach provided several of the illustrations in the report.

1/ Deterioration of beetle-killed Douglas-fir in the Millicoma area of Coos Bay, Oregon. Wright, E. and Wright, K. H. Dec. 1, 1952. Progress report. Multilithed.

COLLECTION AND ANALYSIS OF DATA

Obtaining a supply of beetle-killed trees for analysis was difficult. It was desirable to examine trees that had been killed in different years and over as long a period of time as records permitted. However, epidemics by the Douglas-fir beetle are very sporadic, with the most recent major outbreak dating back only until 1951. Accordingly, trees dead only 2 years were available in most cases. In a few instances trees that had been killed by the beetle on various research plots over a period of 6 or more years were available and the exact year of kill known. The trees felled for analysis were from 4 different localities as follows:

1. Millicoma (Coos County) Oregon - Weyerhaeuser-Experiment Station mortality plots.

2. Sutherlin (Douglas County) Oregon - Weyerhaeuser logging operation.

3. Wind River (Skamania County) Washington - Gifford Pinchot N. F. timber sale area.

4. St. Helens (Lewis County) Washington - Weyerhaeuser thinning plots.

Most of the beetle-killed trees analyzed were felled specifically for use in this study but some were trees felled and bucked in the course of logging operations. Examinations were made at each log cut, which were usually at 32-foot intervals. Additional cuts were frequently made when the pattern of decay was inconsistent.

In recording the data, the average depth of both sapwood and decay was measured to allow computation of sapwood, heartwood, and decay volumes separately. Incipient decay and stain were noted but are not included in decay volumes. These factors, however, are important in degrading and need to be taken into consideration when the logs are to be used for lumber. Observations on the intensity of beetle attack and the damage done by wood-boring larvae were also made (fig. 1).

The tree measurements and rot data collected in the field were plotted on U. S. Forest Service Form 558a 2/, and the volumes were computed by planimeter in cubic feet. Gross volumes were taken from a 2-foot stump height to an 8-inch top diameter (outside bark). Board foot volumes were computed by the Scribner Decimal C scale.

The determinations of species of rots present in the beetle-killed trees were based on both visual and cultural identifications.

2/ In this graph the abscissa values are plotted in terms of tree height while the ordinate values are in terms of diameter based on cross section measurements at the small end of the log.

Figure 1. Deterioration analysis of beetle-killed Douglas-fir

RESULTS

Progressive Deterioration By Areas

The progressive annual rate of deterioration after beetle-kill for the 4 areas studied is shown in Tables 1 and 2 which follow. The study trees show a definite yearly increase in rate of decay. At the end of the first year following kill the principal loss is from sapstain. After that the rot advances at an increased rate through the sapwood and penetrates the heartwood quite appreciably by the fifth year. From that time on, heartwood deterioration progresses so rapidly that after 8 years the beetle-killed tree is frequently of very little commercial value, especially if decay has been accelerated by the top breaking out.

Table 1. - Board-foot deterioration of beetle-killed Douglas-fir on four areas in Oregon and Washington

Area and age of stand	Years dead	Trees analyzed	Gross Volume	Decay Volume	Decay
MILLICOMA	No.	No.	Bd. Ft.	Bd. Ft.	Pct.
(180-200 years old)	1	7	13,750	390	3
	2	20	44,360	8,720	20
	3	7	3,930	760	20
	4	9	7,770	1,350	17
	5	10	15,490	5,220	34
	6	5	5,210	1,580	30
	7	6	8,600	3,560	41
SUTHERLIN					
(250-300 years old)	2	12	70,110	11,390	16
WIND RIVER					
(100-110 years old)	1	11	8,220	330	4
	2	14	10,240	2,930	29
ST. HELENS					
(100-110 years old)	5	4	3,370	960	28
	8	4	1,500	1,360	91
	9	2	5,200	3,950	76

Table 2. Cubic-foot deterioration of beetle-killed Douglas-fir on four areas in Oregon and Washington

Area and age of stand	Years dead	Trees analyzed	Gross Volume	Decay Volume	Decay
MILLICOMA	No.	No.	Cu. Ft.	Cu. Ft.	Pct.
(180-200 years old)	1	7	2,298.3	38.6	2
	2	20	7,323.3	870.5	12
	3	7	861.2	74.7	9
	4	9	1,803.2	298.7	17
	5	10	2,538.3	696.5	27
	6	4	884.0	217.6	25
	7	6	1,727.5	539.5	31
SUTHERLIN					
(250-300 years old)	2	12	9,977.6	1,004.3	10
WIND RIVER					
(100-110 years old)	1	11	1,500.8	14.4	1
	2	14	2,047.2	389.7	19
ST. HELENS					
(100-110 years old)	5	4	557.3	55.5	10
	8	4	271.8	203.2	75
	9	2	82.7	41.4	50

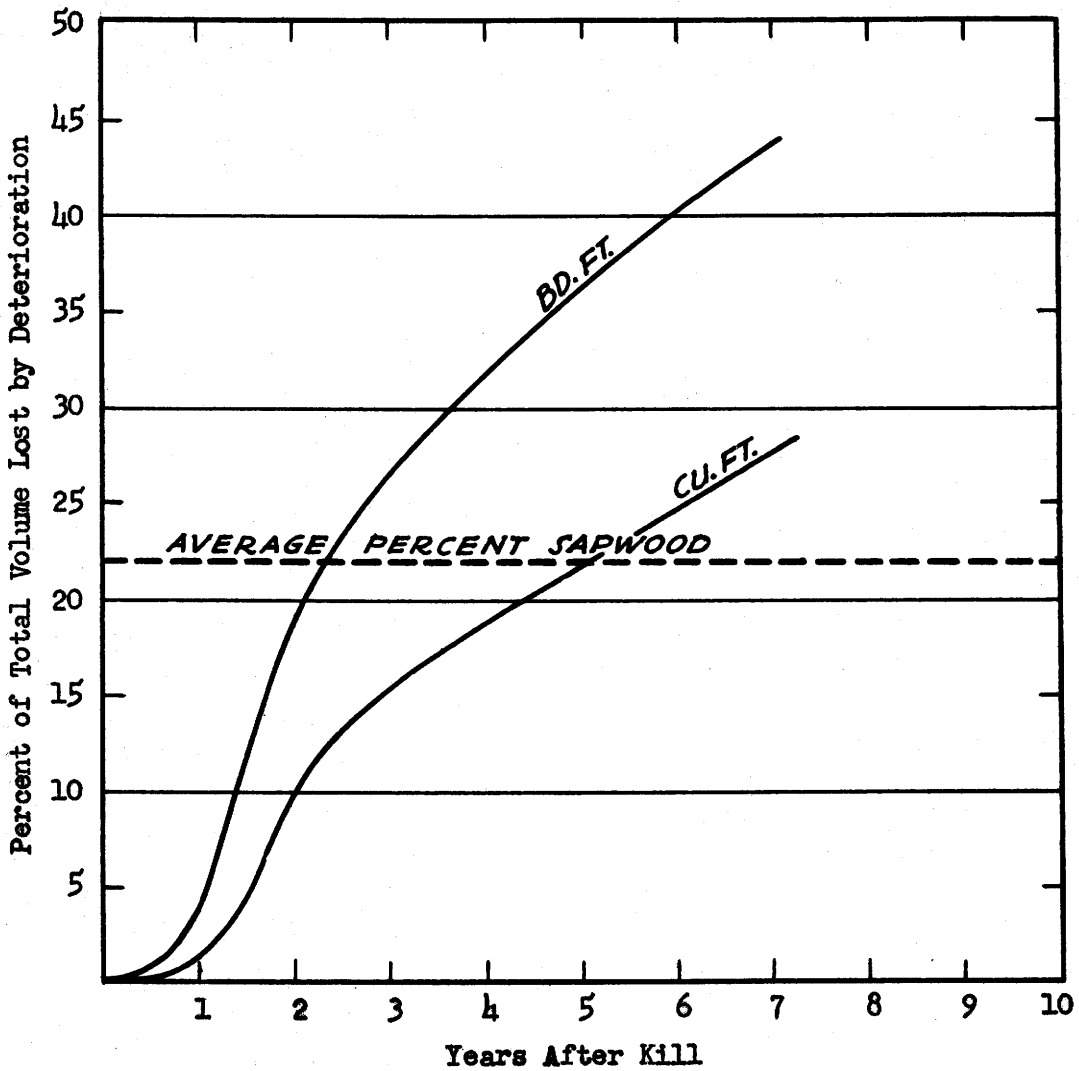
The number of years covered by the analyses is variable from area to area as would be expected when varying years of kill are represented in the trees available for study. The most complete data are for the 180-200 year-old stand in the Millicoma area, where "dated" trees were available for each of the past 7 years (fig.2). However, since information on the rate of deterioration is urgently needed throughout the beetle-kill area it seemed advisable to present all data collected, even though some trees had been dead only 2 years.

In many cases, and especially in the trees dead 2 years or more, sporophores of the red belt fungus, Fomes pinicola (Schwartz) Cke., were directly associated with the decay. Cultural isolations have shown that this brown-cubical rot penetrates beetle-killed trees extremely fast; in trees dead only 2 years the rot was isolated at depths of 1 inch or more and had frequently penetrated through the sapwood.

Larvae of wood-boring beetles, which also contribute materially to loss of merchantability in dead trees, were found in abundance but in only a few cases had advanced beyond the zone of decay. Experience with fire-killed timber, however, indicates that borers can be expected to extend their galleries into the heartwood more rapidly in the latter stages of deterioration. Populations of various species of borers will undoubtedly increase considerably in the areas of heavy timber mortality because of the large amount of favorable breeding material. In short, borers can be expected to become increasingly important as agents of deterioration as time passes.

The cumulative rate of deterioration for the Millicoma area is shown graphically in Figure 2. (See page 6).

Fig. 2. Relation of Cubic Feet to Board Feet Deterioration Losses in Beetle-Killed Douglas Fir



On a board foot basis, practically all the usable sapwood is destroyed by the end of the second year after the tree has been killed by the beetles. On a cubic foot basis, however, when the log is used for chips or pulp, it takes about 4 years to reach a similar degree of deterioration. The deterioration is progressively more important when the log is to be used for lumber as is shown in photographs of typical beetle-killed trees from the Millicoma area (plate I).

Variation in Percent of Sapwood in Study Trees

It is generally known that the sapwood of Douglas-fir is much more subject to decay than the heartwood. Accordingly, the percentage of sapwood will determine to a large measure the early losses resulting from decay. On similar sites the percentage of sapwood varies directly with the age of the stand--the youngest trees have the highest percentage of sapwood (table 3).

Table 3.--Sapwood volume by age class

Area	Age of Trees	No. Trees	Total Volume	Sapwood Volume	Sapwood
	Years		Cu. Ft.	Cu. Ft.	Percent
Wind River and St. Helens	100-110	29	4,881	1,503	30.8
Millicoma	180-200	60	15,310	3,281	21.4
Sutherlin	250-300	12	9,978	1,739	17.4

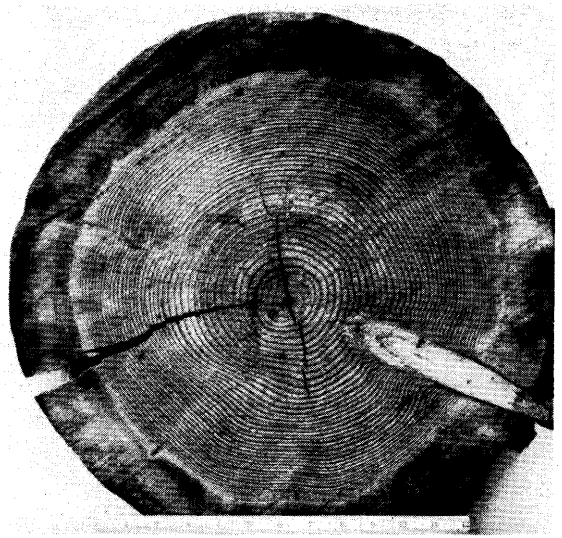
In this study, early deterioration was greatest in the youngest stands, which had the most sapwood. Two years after death the trees at Wind River were 19 percent decayed, those at Millicoma 12 percent, and those at Sutherlin only 10 percent. No examinations were made at St. Helens 2 years after death. The correlation of rate of decay with thickness of sapwood and tree age points up the importance of giving highest priority to prompt salvage of the youngest age classes.

Indicators of Deterioration in Standing Trees

Standing beetle-killed Douglas-fir exhibit several indicators that will give the forester some idea of the length of time the tree has been dead and the progress of deterioration. If the foliage of the tree has faded to yellow or red, the tree has been killed within the past year. When beetles attack in the spring, fading may sometimes take place in the fall of the year. Frequently, however, and particularly at higher elevations in the Cascades, the killed trees overwinter with green foliage and turn color the next spring or early summer. Trees of these types will contain sapstain and perhaps some superficial decay of the sapwood.

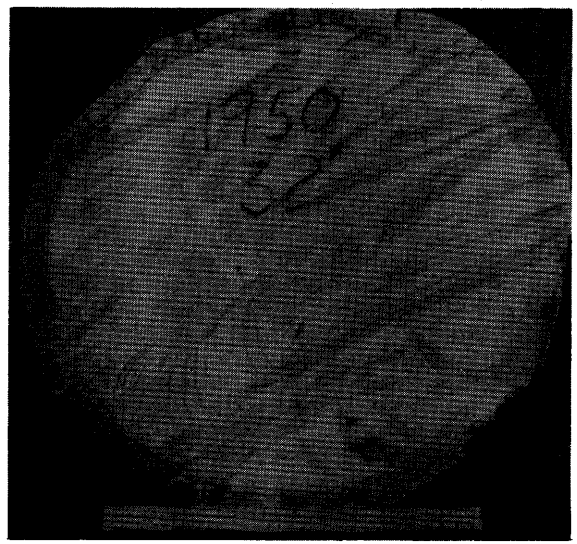
PLATE I

Progress of deterioration in trees killed 1 to 6 years ago



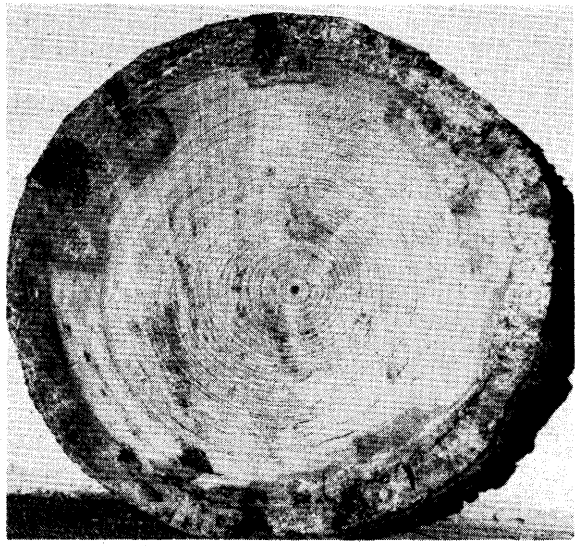
1 YEAR

2 YEARS

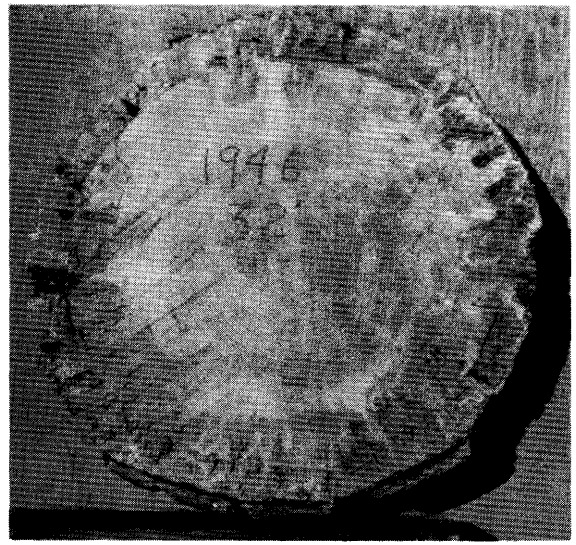


3 YEARS

4 YEARS



5 YEARS



6 YEARS

If the killed trees have lost their foliage but still retain even the smallest branches, they may have been dead anywhere from 1 to 3 years--depending largely on whether they went through the first winter after death as green or red-topped trees. If the foliage has faded by fall, the winter storms will invariably remove the dead needles and the tree will appear as a snag the next spring. As a general rule, trees that have lost their foliage, but still have all the fine branches will contain at least serious deterioration of the sapwood. The frontispiece shows a typical example of the condition of the crown on trees which have been dead for 2 years.

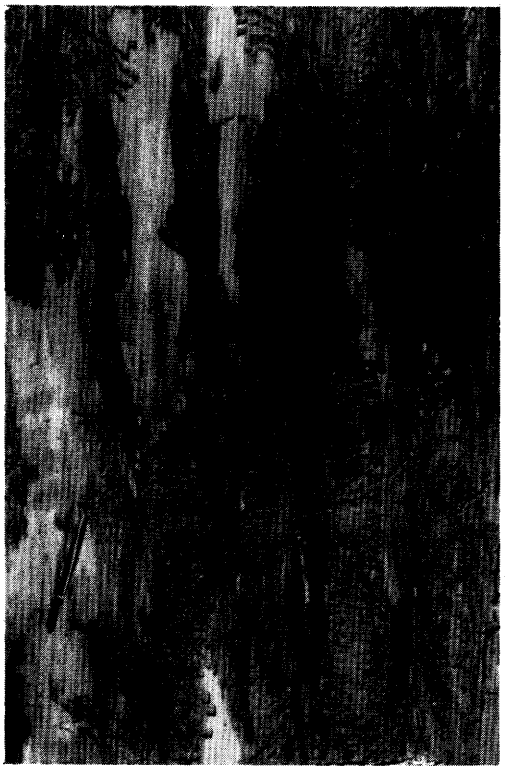
After trees have been dead for several years and the small branches have fallen, it is difficult to use exterior indicators for determining the length of time the tree has been dead or the amount of deterioration that has taken place. It is then usually necessary to make some examination of the bole of the tree. Chopping into the bark at the base of the tree, however, is often misleading, since the beetle attacks and the decay frequently do not extend to the ground. It is preferable that chopping be done at 10 feet or higher above the ground. This frequently will reveal the typical beetle galleries and the associated blue stain or rot (plate II, A and B). If the trees have been dead for several years, some idea of the extent of decay can thus be determined. The principal difficulty with this type of sampling is its limited nature. Sampling by chopping at intervals along the trunk after the tree is felled, is preferable and gives a much better indication of the degree of deterioration.

Frequently trees killed 1 year previously by beetles will bear an abundance of sporophores of the pouch fungus, Polyporus volvatus Pk. (plate II, B and C). This is a small, whitish to buff-colored, somewhat globose sporophore. The undersurface is covered with a leathery membrane containing a small hole through which beetles and other insects pass to the pore surface and thus assist in distributing the spores. These sporophores indicate a shallow rot of the sapwood.

On trees killed 2 years or longer, the rudimentary sporophores of the red belt fungus (Fomes pinicola) are common (plate II, D). These young sporophores are faintly yellowish in color and of irregular shape, appearing in the bark crevices. When cut, they reveal a solid yellowish context. Later they may develop into the more familiar red belt bracket, or hoof-shaped sporophore with a reddish margin. The presence of these sporophores indicates an advanced stage of rot in which the sapwood is destroyed and the heartwood may be invaded.

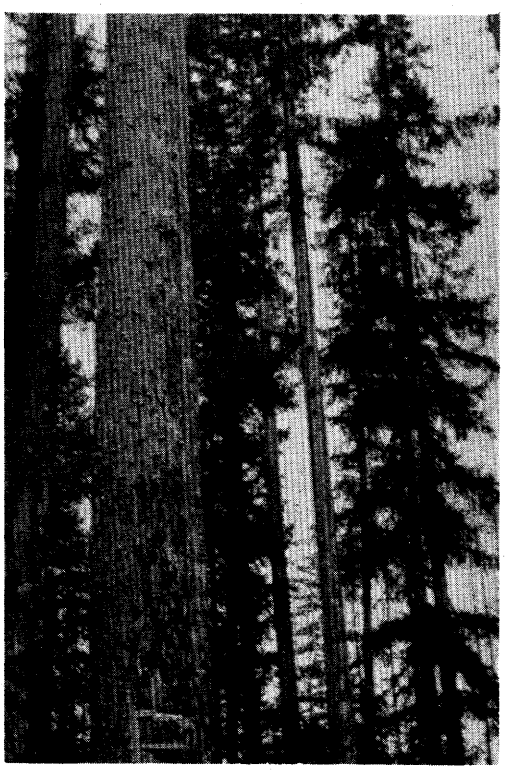
PLATE II

Douglas-fir beetle work and associated fungi

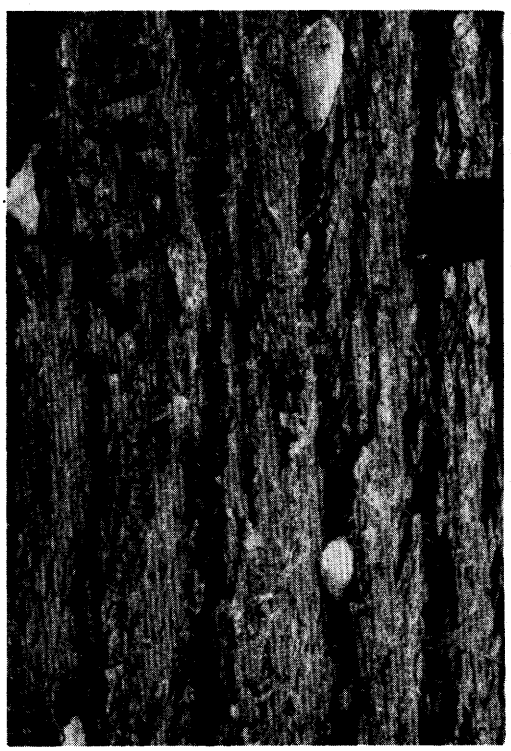


A. Wood-staining fungi associated with Douglas-fir beetle galleries.

B. Strip killing of cambium by Douglas-fir beetle. Note Polyporus volvatus sporophores at bottom of photo.



C. Heavy fruiting of P. volvatus on trees killed 1 year previously by beetles.



D. Sporophores of Fomes pinicola on tree killed 2 years previously by beetles.

DISCUSSION

Association of Beetle Attacks with Decay

In these studies it has been found that galleries of the Douglas-fir beetle are closely associated with the sapwood decay on fairly recently killed trees. This constant association strongly indicates that beetles introduce the rots at the time they infest the tree. For this reason, when the beetles kill only strips of cambium in a tree (plate II, B) rot development frequently is localized. More intensive sampling is needed in these trees to determine the extent of the deterioration.

The degree of deterioration for the first year or two depends to a large extent upon the time of the year when the initial beetle attack took place. Rot advances most rapidly during the warm season of the year and much more slowly during the colder months. Beetle attacks early in the spring give about 2-1/2 months more for the rot to develop than attacks late in the summer of the same year. Therefore a tree dead 2 years may have essentially either 2 or 3 seasons for growth of rot, depending upon the time of the attack. In comparing rates of deterioration between localities, or even within a single locality, the season as well as the year of attack should be taken into consideration.

Effect of Deterioration on Log Quality

Trees dead for 2 years or less often do not produce logs of grades comparable to those shown by a cruise. The fast deterioration of sapwood leaves only a core of sound wood containing many knots that are not visible on the exterior of the tree. Even when decay is not well advanced there will be considerable degrade due to sapstain. Depending on the length of time the trees have been dead, it may be necessary in timber estimating to lower the log grades both as to volume and quality. If the timber is to be used for chips or pulp, however, these factors are of less importance.

Effect of Deterioration on Breakage

Breakage in felling increases directly with time since death of the beetle-killed tree. When the sapwood is destroyed by decay, much of the resilience or elasticity of the tree is lost. Furthermore, loss of the green crown reduces the cushioning effect when falling. Breakage losses when falling dead timber are therefore much heavier than in green timber. In one locality where the trees were killed by beetles 2 years previously, fallers estimated a 25 percent increase in breakage.

In stands killed by beetles 5 years or more previously, an increasing number of tops is broken off by the wind. This breakage, too, is directly related to resilience of the wood. Broken-topped trees, when left for several years, show an appreciably faster rate of decay because of the entrance of top rots. Consequently, salvage operations in timber killed several years ago should first remove the broken-top trees if losses due to deterioration are to be kept to a minimum.

Fire Hazard Caused by Beetle-Killed Trees

The tremendous number of beetle-killed trees in the region caused by the recent infestation has greatly increased fire hazards. This hazard will continue to increase as deterioration takes place and the snags become "punky". It further emphasizes the need for prompt salvage of the beetle-killed timber.