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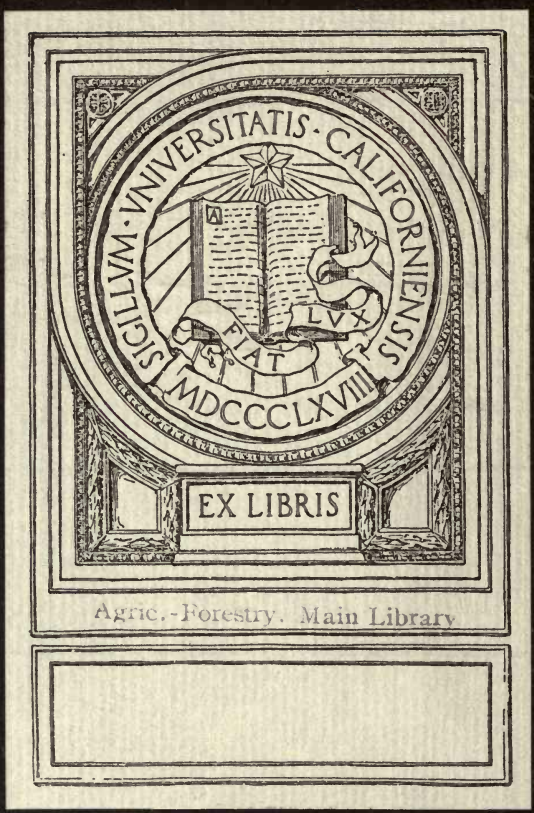

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F. G. MILLER, Dean

BULLETIN NO. 1

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STUDIES IN WOOD DECAY I[1] LABORATORY TESTS ON THE RELATIVE DURABILITY OF SOME WESTERN CONIFEROUS WOODS WITH PARTICULAR REFERENCE TO THOSE GROWING IN IDAHO.

By

HENRY SCHMITZ *and* A. S. DANIELS

Intelligent use is a fundamental concept of conservation. Thus the recent interest in conservation has given an unusual impetus to invesigations making possible a more rational utilization of the various species of wood.

Although information concerning the durability of the various American species of wood is rather meagre, Humphrey [2] conducted tests on both the heart and sap wood of a representative list of American woods. The results of these experiments were based upon single specimens of each sample of wood and may, therefore, not even be indicative of the relative durability of the various species tested and since many of the specimens became too wet for a fair test, comparisons between his results and those recorded here would be of very little value.

The painstaking work of Zeller [3, 4, 5] marks the beginning of a new era in investigations dealing with the durability of wood. Altho our results are not entirely in accordance with those found by him, it should be remembered that the species of pine investigated in the present study belong to different groups while those studied by Zeller all fall in the hard pine group.

The work of Schmitz [6] indicates that there may be a great

1 Several investigations are already in progress in the Forest Products Laboratory, University of Idaho, dealing with the decay of wood and it is proposed to give considerable attention to this important line of investigation during the next few years. These investigations will include studies on the durability of the various woods, the value of certain chemicals as preservatives, enzyme action in various wood destroying fungi, and various phases of the general phenomena of wood decay. In order to show the continuity or relationship between these several problems, it is proposed to group them under the general title of "Studies in Wood Decay," of which the present article is Number 1.—Henry Schmitz.

2 Humphrey, C. J. Laboratory tests on the durability of American woods I. Flask tests on conifers. Mycologia *8*: 80-92. pl.1. 1916.

3 Zeller, S. M. Studies in the physiology of the fungi II. Lenzites saepiaria Fries, with special reference to enzyme activity. Ann. Mo. Bot. Gard. 3: 439-512. pl.8-9. 1916.

4 Ibid III. Physical properties of wood in relation to decay induced by Lenzites saepiaria Fries. *Ibid.* 4: 93-164. pl.9-13.f.1. Charts 1-11. 1917.

5 Humidity in relation to moisture inbibition by wood and to spore germination on wood. *Ibid* 7: 51-74. 1920.

6 Schmitz, H. Studies in the physiology of the fungi VI. The relation of bacteria to cellulose fermentation induced by fungi with special reference to the decay of wood. Ann. Mo. Bot. Gard. 6; 93-136, 1919.

difference in results obtained under laboratory pure-culture methods and those that would be obtained under natural conditions where there is the invariable presence of ordinary types of bacteria. It is therefore hoped that it will be possible to continue this work and extend it to natural conditions.

PURPOSE

The purpose of the present study is to test the relative durability under laboratory conditions of the more important coniferous woods found in Idaho with the hope of extending the use of the so-called inferior species.

METHODS AND MATERIALS

The species of woods used in these tests were selected because of their apparent wide diversity of durability and since they represent the important western commercial woods. They are as follows: western white pine (*Pinus monticola* Dougl.), western yellow pine (*Pinus ponderosa* Lawson), Douglas fir (*Pseudotsuga taxifolia* (Poir.) Britt.), western larch (*Larix occidentalis* Nuttall.), western red cedar (*Thuja plicata* Don.), white fir (*Abies grandis* Lindley), and Engelmann spruce (*Picea engelmanni* Engelmann). The western larch, Engelmann spruce, western red cedar, western white pine and western yellow pine were obtained from a local lumber yard. The Douglas fir and white fir were donated by the Potlatch Lumber Company, Potlatch, Idaho.

The fungi used in the present study are: *Polyporus lucidus* (Lys.) Fries, *Lenzites saepiaria* Fries, *Fomes pinicola* Fries, *Merulius pinastri* (Fries) Burt, *Polystictus versicolor* (L.) Fries, *Pleurotus sapidus* Kalchbr, *Echinodontium tinctorium* Ellis and Everhart, *Trametes pini* Fries, *Trametes carnea* (Nees) Cooke, and *Lentinus lepideus* Fries. The cultures were obtained either by the tissue method as described by Duggar [7] or the spore method as developed by Zeller [8]. There is no question as to the purity of the cultures. The stock cultures of the fungi are maintained on both hardwood and pine sawdust and for these experiments, transfers were taken from the pine sawdust cultures.

One inch boards composed entirely of heart wood were obtained and were resawed into blocks measuring ¾x1x3 inches.

7 Duggar, B. M. The principles of mushroom growing and mushroom spawn making. U. S. Dept. Agri., Bur. Pl. Ind. Bul. *85*. 1-60 pl. 1-7. 1905.

8 Zeller, S. M. *loc. cit.*

The blocks were dried to constant weight in an electric oven at 100°C. and weighed to the nearest 0.01 gram. Except in the case of Engelmann spruce, ten blocks of each species were placed in each of ten two-quart Mason jars having a layer of absorbent cotton on the bottom. The purpose of the cotton is merely to absorb any excess moisture and thus insure a more even water supply. In the case of Engelmann spruce, eight blocks were placed in each of ten two-quart jars also having the layer of absorbant cotton on the bottom. The blocks were placed on end in every case.

To each jar 250 cc. of distilled water were added. The amount of water to be added was roughly determined by adding varying amounts of trial flashs so that after sterilization the blocks and cotton were well moistened. In the case of the jars containing larch a small amount of free water remained when sterilization was completed. After a comparatively short time, however, this free water was taken up by the blocks. After the water had been added, the jars were carefully plugged with cotton plugs and sterilized. Sterilization was effected at fifteen pounds pressure for twenty minutes. It may be objected that by this method of sterilization certain volatile components of the resins which might be present in the wood would be driven off. Be that as it may, such very volatile components would soon disappear from the wood on exposure to the air and accordingly this would not be a deciding factor in the durability of any particular wood.

The inoculations were made as follows: transfers from sawdust cultures of the fungi were made to sterile hard agar plates. When practically the entire surface of the plate was grown over with mycelium, it was cut by means of a sterile scalpel into small squares with an area of approximately one square centimeter. With a very few exceptions, a single square was added to each of the culture jars. An effort was made to locate the inoculum in the center of the group of blocks. The fact is of course appreciated that by this method of inoculation the blocks in the center of the group may become infected first and may be well along the road to decay before the mycelium comes in contact with the blocks in the periphery of the group. When wood specimens are subjected to decay under laboratory conditions, there is usually a great diversity in the results for any

given wood. This is true whether the individual specimens are in different culture jars or in the same culture jars. The reasons for this variation are not definitely known and it may merely be the law of "chance" that determines whether or not infection takes place. Whatver it be, "chance" or any other factor, that influences the possibility of infection it must, *a priori,* largely determine the resistance to decay of any specific wood. However, since the cultures were incubated for almost one year and since the average of ten blocks was taken in each case except in that of Engelmann spruce, where an average of eight was taken, it is felt that this fact offers no serious objection.

After inoculation the culture jars were incubated for a period of 10.5 months at room temperature. It was found necessary to water the blocks several times during this period. Whenever this was done, sterile distilled water was added and every effort was made to have the moisture conditions in all of the culture flasks as nearly the same as possible.

After the period of incubation, the blocks were again dried to constant weight in an electric oven at 100°C. and weighed. The difference in weight in the two weighings represents the amount of decay. The results for the ten blocks in each jar were averaged and the percent loss in weight calculated on the basis of the dry weight of the wood.

RESULTS

In Table I, the average loss in weight percent of ten blocks after ten and one half months' incubation at room temperature is given.

TABLE I.

Showing average loss in weight in per cent after ten and a half months' incubation when subjected to the action of the various fungi indicated.

Fungus	Pine, White	Pine, Yellow	Fir, Douglas	Larch	Cedar	Fir, White	Spruce	Ave. loss all woods in weigght
1. Polyporus lucidus	14.1	3.9	5.5	5.7	0.2	3.5	4.1	5.3
2. Lenzites saepiaria	50.5	30.0	11.8	5.4	0.3	10.6	9.8	16.9
3. Fomes pinicola	28.1	11.6	6.7	7.7	0.4	11.3	9.3	10.7
4. Merulius pinastri	3.7	3.8	3.1	*	0.3	2.3	1.2	2.4
5. Polystictus versicolor	2.3	3.1	1.5	4.5	0.5	1.3	2.3	2.2
6. Pleurotus sapidus	9.4	3.4	5.1	5.1	0.3	2.2	3.1	4.0
7. Echinodontium tinctorium	5.6	3.6	4.6	6.2	0.4	4.1	3.8	4.0
8. Trametes pini	3.8	2.2	3.8	7.5	0.2	1.4	2.3	3.0
9. Trametes carnea	10.2	17.4	12.2	8.4	0.3	2.0	3.9	7.8
10. Lentinus lepideus	33.0	39.2	15.8	7.3	0.4	1.2	10.6	15.3
11. Control	0.3	0.3	0.2	0.4	0.3	0.3	0.3	
Average loss in weight (all fungi)	16.1	11.8	7.0	6.4	0.3	4.0	5.0	7.2

* This flask broken by accident.

A study of the results tabulated in Table I brings out some very interesting points not only relative to the various woods but relative to the action of the various fungi.

Under the conditions described, the average loss in weight in the woods used due to the action of the fungi is 7.2%. Only white pine and western yellow pine lost more weight than this general average. Douglas fim represented approximately the average loss in weight and western larch, Engelmann spruce, white fir, and western red cedar are below the average, in the order named.

The maximum amount of decay is caused by the action of

Lenzites saepiaria on white pine and the following show less decay in the order named: *Lentinus lepideus* on western yellow pine, *Lentinus lepideus* on western white pine, *Lenzites saepiaria* on western yellow pine and *Fomes pinicola* on western white pine. It is significant that the five highest rates of decay are found on western white and western yellow pine. The fungi causing these losses in weight are not in any way peculiar to the two species of wood, but are found generally on both coniferous and the hard woods.

The results in the case of white fir are indeed interesting. Although this wood is usually considered as being very susceptible to decay, under the conditions of these experiments it is only surpassed by western red cedar in its resistance to decay. Even *Echinodontium tinctorium,* the fungus causing the very prevalent brown heart wood rot of white fir, did not cause even the average amount of decay. This may be explained in part by the fact that the fungus grows rather slowly. The slow rate of growth of *Echinolontium tinctorium* on hard agar and carrots has been previously reported by Schmitz [9].

As anticipated none of the fungi used made any apparent growth on western red cedar. It is evident from the table that the results obtained in the case of each fungus approximate the limit of error as found in the controls for that species. The cause or causes of the durability of this species will be the subject of further investigation in this laboratory.

The most desructive fungus as shown by the highest average rate of decay is *Lenzites saepiaria.* The physiology of this fungus has been carefully investigated by Zeller [10]. *Lentinus lepidus, Fomes pinicola,* and *Fomes carnea* follow in degree of destructiveness in order named.

Working with various species of pines, Zeller [11] has shown that "specific gravity or density materially influence resistance to decay of the heartwood, i. e., the more dense the wood, the more durable it is." However, this may be within a genus, it is evident that it does not necessarily hold between different genera since the specific gravity of larch is greater than that of Engelmann spruce, white fir or cedar.

9 Schmitz, H. Enzme action in *Echinodontium tinetorium.* Ellis and Everhart. Jour. Gen. Phys. 2: 613-616. 1919.

10 Zeller, S. M. *loc. cit.*

11 Zeller, S. M. *loc. cit.*

The work of Zeller [13] also indicates that in the case of the various species of pine investigated by him that "the width of the growth rings furnishes a further index of durability, the narrower rings showing more resistance to fungous attack than broad, open rings." The results recorded in the present paper indicate that this relation need not necessarily hold between different genera since the samples of larch used in the present work had an average of 32 rings per inch while white fir had an average of five rings per inch. Even within the genus Pinus, this relation did not hold since the western white pine used had an average of 26 rings per inch while the western yellow pine had an average of 12 rings per inch. It is evident that in this case a soft pine is compared with a hard pine while the pines studied by Zeller all belonged to the hard pine group.

As has been said, the average loss in weight induced by all the fungi on all the woods is 7.2 per cent. A study of Table I indicates that four fungi, namely: *Lenzites saepiaria Lentinus lepidus, Fomes pinicola* and *Fomes carnea* induced a rate of decay above this average.

While no direct study was made relative to the rate of growth of the various fungi used, even a cursory observation shows that these four fungi are among the more rapidly growing species. Although *Echinodontium tinctorium* and *Trametes pini* are among the more important forms causing heart wood rots in the Northwest the average rate of decay induced by them is low. This, as has been mentioned, may in part be explained by the fact that they are relatively slow growing forms. Even so, the relation between rate of growth and rate of decay need not necessarily hold, for example, *Polystictus versicolor* has a relatively rapid rate of growth but induced a low rate of decay. Detailed information concerning the relative rate of growth of the common and more important wood destroying forms would be of great practical and immediate importance in determining how soon after a fire or other disaster a tree would become badly decayed.

From a technical and practical point of view, it is evident that under certain conditions, as for example those of these experiments, white fir is not as susceptible to decay as generally thought. When the susceptibility to decay of any wood is considered, the fungus inducing that decay must also be considered.

13 Zeller, S. M. *loc. cit.*

For example, *Fomes pinicola* induced a higher rate of decay in white fir than in Douglas fir while *Fomes carnea* induced a much higher rate of decay in Douglas fir than in white fir.

If the average rates of decay are considered, the results indicate that with the exception of western red cedar, under the conditions of these experiments, white fir is the least susceptible to decay while western white pine is the most susceptible and Douglas fir represents approximately the average degree of durability.

It is clearly recognized that, however interesting the above results may be, before they can be generally accepted it will be necessary to carry out similar experiments under natural conditions. The various species of wood should be used under similar conditions and a careful study of the results made. The School of Forestry is at present carrying on these experiments.

CONCLUSIONS

It would seem that, from the results of the preliminary experiment above discussed, it would be safe to conclude that:

1. White fir and Englemann spruce may not be as susceptible to decay as generally thought.

2. When different genera are considered, the specific gravity of the wood is not necessarily an indication of its durability.

3. Within the same genus, the number of annual rings per inch is not necessarily an indication of the durability of the various species.

4. Certain fungi causing very prevalent and complete heart rots of standing timber may not induce a high rate of decay due to their slow growth.

5. The durability of any wood is not only a question of the inherent properties of the wood itself, but also depends upon the species of fungi prevalent in any particular locality in which the wood is used.

6. Under the conditions of these experiments, western red cedar is the least susceptible to decay, while western white pine is most susceptible and Douglas fir represents approximately the average of durability.

7. Experiments involving the use of the different species of wood under natural conditions are necessary before final conclusions can be drawn.