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Relation Between Subcortical Temperature and Size of White Pine (*Pinus Strobus*) Slash

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## RELATION BETWEEN SUBCORTICAL TEMPERATURE AND SIZE OF WHITE PINE (*PINUS STROBUS*) SLASH<sup>1</sup>

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Study of the decay of white pine slash in the vicinity of Petersham, Massachusetts, shows that there is considerable variation in the rates of decay of different sizes of material. It was suggested that these different rates of decomposition were influenced by temperature. Work by S. A. Graham ('24) showed that high temperatures beneath the bark of logs quite surely limit the activities of subcortical insects. The rate of decay of slash is of practical importance because both fire hazard and reproduction can be correlated with it. The persistence of sound slash material forms one of the major fire hazards of this region. Slash has been shown to be an effective barrier to reproduction. (Averill, Averill and Stevens, '23—p. 18.)

In his study of the subcortical temperatures of logs Graham ('20) gives a number of different factors influencing the temperature, but does not include the factor of the size of the log. The present study was made at the suggestion of Dr. Perley Spaulding in order to determine, (1) whether Graham's conclusions were applicable to this region, and (2) whether the size of white pine material influences the temperatures under the bark with maximum summer radiation.

To measure the temperatures a system of thermocouples was used. Thermocouples have been used by Blackman and Matthaei ('05), by E. B. Shreve ('19) in measuring leaf temperatures, and by Harvey ('23a, '23b) in determining the subcortical temperature in living trees.

The thermal junctions were made by fusing (electric arc welding, see Kimball and Hobbs, '23) a piece of copper wire to a piece of constantan ("Ideal") wire, the fused junction placed within a hole in a short piece of No. 15 (B. & S.) copper wire, and the hole filled with lead. For each thermocouple two junctions are necessary, a hot and a cold.

With a No. 32 (B. & S.) twist drill a hole was bored just under the bark at an angle of about 30 degrees to the surface of the log (the "surface" implies the tangential plane at the point of drilling). The junction was forced into the hole, and the hole filled with a piece of wood; the "common cold" junction was placed in ice water. The resistance of each of the circuits was controlled by a small rheostat. A wiring diagram for the system

<sup>1</sup> A study made on the Harvard Forest. The writer wishes to express his appreciation for the direction and aid of Dr. P. R. Gast in carrying out this work.

of sixteen junctions and a sixteen point commutator switch is given in fig. 1. The resistance of the system was so adjusted that a single calibration curve could be used for all junctions; the curve showed the linear relation of the millivolt readings to the temperature in degrees centigrade.

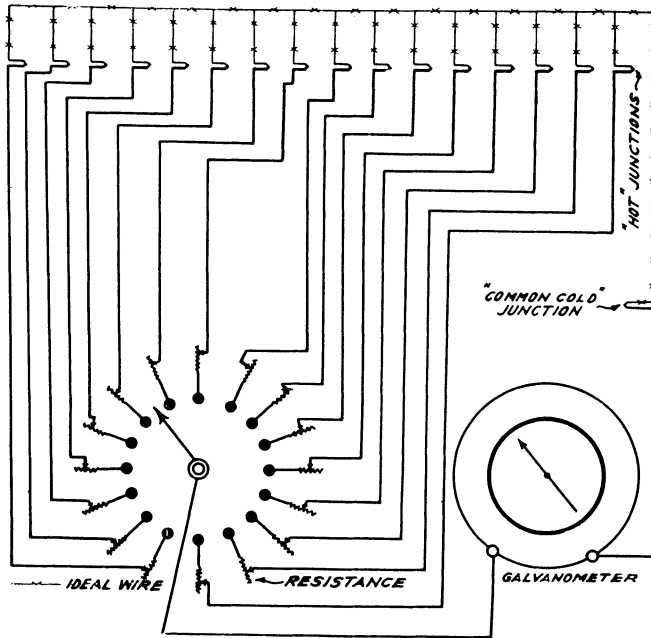


FIG. 1. Wiring diagram of multiple junction apparatus for measuring log temperatures.

A white pine (*Pinus strobus*) tree of about 14 inches in diameter at breast height was felled on July 9, and the bole cut up into ten foot logs on July 12. A number of various sized branches were lopped off, and all were placed in the open, the logs lying approximately east and west with the butts pointing west.

The site selected was in a stand of white pine and hemlock (*Tsuga canadensis*) on a sandy glacial esker. The position of the slash was in a 100-foot east and west clear cut strip in the stand. Most of the slash on the cut area had been removed, but the ground was still covered with a layer of coniferous litter. The apparatus was set up and calibrated, the junctions being placed in the various specimens as indicated in table I; these varied in size from .3 to 9.7 inches in diameter, caliper measurements at the positions of the junctions. In locating the junctions the butt end of the pile of logs was taken as the face of a clock, and the position of each junction is given as the corresponding hour. The locations varied from eleven to one o'clock; and, since the logs were all lying parallel, the rays of the sun struck the logs at the points where the temperatures were being measured at approximately the

same angle. Therefore differences in temperature between the logs cannot be due to differences in the angle of incidence of the sunlight.

TABLE I. Location of points in white pine (*Pinus strobus*) slash at which temperatures were taken by thermocouple

| Thermal junction |  | Diameter of log | Surface of bark | Color of bark |
|------------------|--|-----------------|-----------------|---------------|
| No.              | Position*                                |                 |                 |               |
| 1                | 12                                       | 9.7"            | Rough           | Gray          |
| 2                | I  | 6.2"            | Fairly smooth   | Brown         |
| 3                | I  | 5.5"            | Smooth          | Brown         |
| 4                | 12                                       | 9.7"            | Rough           | Gray          |
| 6                | 12:30                                    | 5.5"            | Smooth          | Brown         |
| 7                | I  | 2.0"            | Smooth          | Brown         |
| 8                | 11                                       | .9"             | Smooth          | Almost black  |
| 9                | 11                                       | .5"             | Smooth          | Brown         |
| 10               | I  | 6.1"            | Smooth          | Brown         |
| 11               | I  | 4.1"            | Smooth          | Brown         |
| 12               | 12                                       | 2.2"            | Smooth          | Brown         |
| 13               | I  | .8"             | Smooth          | Almost black  |
| 14               | 12                                       | .3"             | Smooth          | Almost black  |
| 15               | 12                                       | .5"             | Smooth          | Almost black  |
| 18               | In the air approximately 8" above ground |                 |                 |               |
| D                | Duff approximately 1" below the surface  |                 |                 |               |

Logs lying approximately east and west, butts pointing west.

\* Butt end of log taken as the face of a clock, and thermal junctions located according to the hours on the face of a clock.

Readings were taken for three full days and at random on several days. A graph is given (Fig. 2) showing the course of the temperature of the various sizes of sticks throughout the day for August 20. This shows that slash from 4 to 6 inches in diameter reached the highest temperature measured. The others, in order of decreasing temperatures, are as follows: 6 to 8 inches; 2 to 4 inches, 8 to 10 inches, and 0 to 2 inches. The readings on the other days showed the same relative positions of the different diameter classes.

Figure 3 is based on the averages of three days' readings for the air, the duff, and the various diameter classes of sticks. It can be seen that the 4 to 6 inch diameter class maintained a higher temperature than any of the other classes throughout the larger part of the day. The 4 to 6 inch class averaged 22.3° C. higher than the air temperature at 1:30 P.M., the time of the maximum slash temperature, and 15.7° C. higher than the 0 to 2 inch class at the same hour. The minimum difference between the 4 to 6 inch class and the air was 10° C. at 8:15 A.M., when it was 2.4° C. higher than the 0 to 2 inch class. The 0 to 2 inch class followed the air temperature more closely than any of the other diameter classes, the minimum difference between the air and this class being 1.3° C. at 4:30 P.M. and the maximum difference being 8° C. at 10:30 A.M.

The findings of Graham are substantiated by these experiments. Tem-

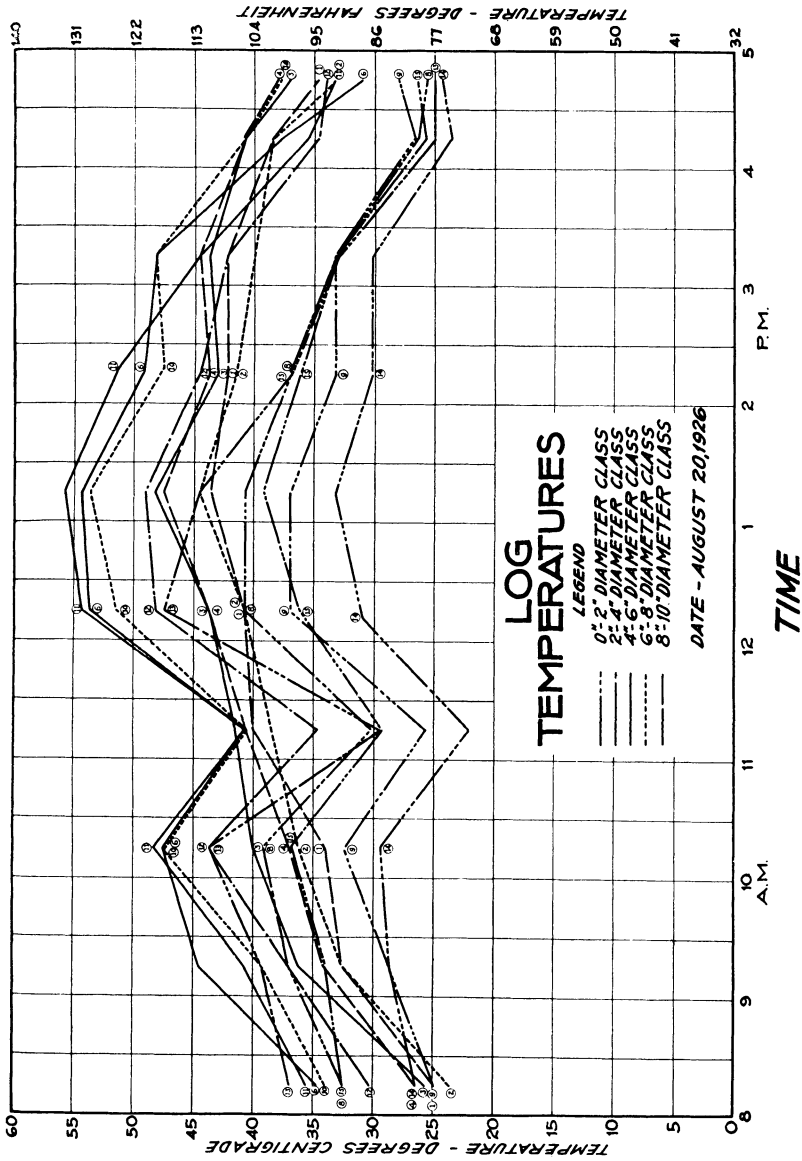


FIG. 2. Graph showing the course of the temperatures in the single specimens throughout the day for Aug. 20, 1926.

peratures above 55° C. were found in August with thermocouple equipment; Graham found temperatures in excess of 60° C. in June. It is apparent from the graphs that the subcortical temperature of slash varies considerably with the diameter of the log or stick. On warm summer days temperatures are

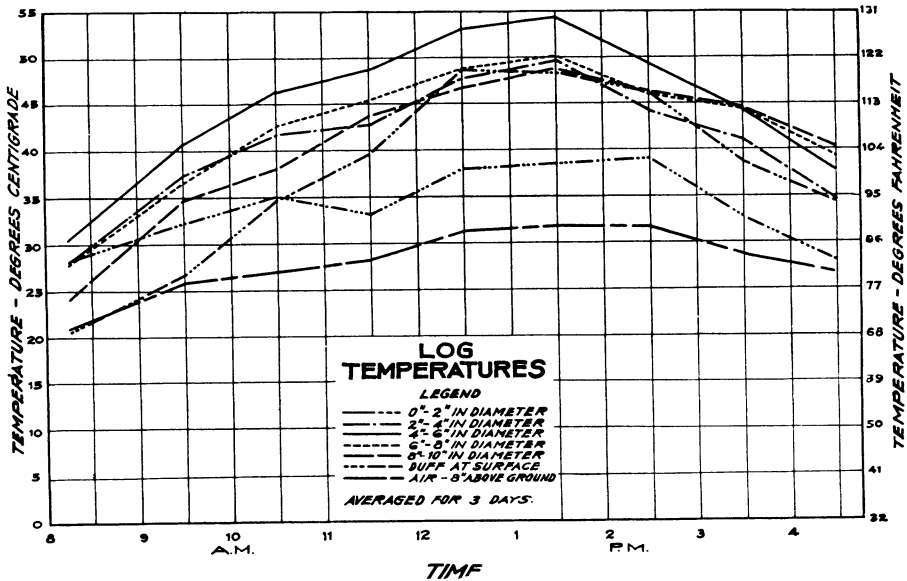


FIG. 3. Graph showing the course of the temperatures averaged according to diameter size classes of material and averaged for three days.

reached which approximate fatal temperatures for some of the fungi and may inhibit their growth. It may well be that the various temperatures attained by the different sized pieces are an important factor in the different rates of decomposition of the various sizes of slash.

**SUMMARY**

To determine the relation between the diameter of the stick in white pine (*Pinus strobus*) slash and temperatures under the bark, a series of readings was made with a system of thermocouples. It was found that sticks from 4 to 6 inches in diameter reached the highest temperature. The others in order of decreasing temperatures are as follows: 6 to 8 inches, 2 to 4 inches, 8 to 10 inches and 0 to 2 inches. This variation was sufficient to indicate that temperature may be an important factor in the rate of decomposition of different sizes of slash.

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