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Use of Temperature Pellets in Regeneration Research

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HIGH TEMPERATURES at the ground surface are a major cause of seedling mortality for many conifers. Critical temperatures are believed to occur in a tissue-thin layer at the surface. From this layer, temperatures decrease greatly in the first few millimeters upward into the air and downward into the soil.[1,2] Losses of Douglas-fir seedlings begin when surface temperatures exceed 123° F.,[3,4] but the threshold is not sharp. Newly germinated seedlings of such thin-stemmed species as Douglas-fir and hemlock generally die at temperatures between 123° F. and 140° F., but occasional individuals that manage to escape heat injury early in the season may survive temperatures in excess of 150° F.

Until very recently it was difficult to measure temperatures in this thin line of surface heat. Available instruments were, moreover, costly and most investigations of soil surface temperatures were necessarily limited to a relatively few samples.

Commercial temperature pellets[5] are now available which in some ways are superior to more expensive instruments such as thermometers, thermographs, and thermocouples. They are cheap enough to permit extensive sampling, and they provide an accurate measure of the temperature in the hairline at the surface of the soil. They come in the form of 7/16-inch by 1/8-inch tablets which are inexpensive, accurate, insoluble, distinctively colored, generally waterproof for at least a year, easily fragmented to any desired size, and available in useful intervals of melting temperatures (113° F., 125° F., 138° F., 150°F., and 163° F., error ± 1 percent). Results of studies on natural seedbeds with many thousands of pellets over three seasons have snown them to be highly useful when there is need for maximum temperature records at about 12° intervals.

Many temperature-measuring instruments such as mercury thermometers and thermograph bulbs are so large that their readings actually represent an integration of a range of temperatures near the surface. Although fine thermocouples overcome this difficulty, they can conduct appreciable heat down the metal wires to cooler layers,[6] and may easily be installed or become shifted above or below the plane of highest temperature. The temperature pellet, in contrast, intersects the soil surface and provides an accurate record of the exact location of the plane where the temperature exceeds the melting point of the pellet. There is only slight conduction of heat through the pellet to cooler layers. These characteristics make the pellet a fine addition to the instruments commonly used for measuring surface soil temperatures.

If a partially buried pellet is exposed to sun's radiation, it will begin to soften in a thin line at the soil surface when the melting temperature is reached. Should the temperature then drop, the pellet will reharden, but a thin eroded line will remain etched on its surface as a record. If instead the temperature should continue upward, all the portion above the surface will melt, but the part below the surface will generally remain intact.

Pellets were first used by the author to provide a measure of seedbeds reaching lethal temperatures on Douglas-fir clearcutting within the H. J. Andrews Experimental Forest. A large number of sampling points within each clearcut area were first chosen at random or systematically. Pellet fragments of several melting temperatures were then placed at each point to provide a range of maximum temperatures. Since seedbed temperatures may vary considerably even over an inch of surface, the pellet with the most important melting temperature was placed on the exact point. On the H. J. Andrews Experimental Forest, pellets melting at 138° F. were used at the exact point because this temperature correlates best with heat loss of Douglas-fir seedlings. Fragments of pellets having higher or lower melting points were then placed ¼ to ¾-inch to the east and west. The east-west orientation of the line of pellet fragments was adopted to prevent toothpick markers on either end from shading the fragments.

In placing each pellet fragment, the spot was first prepared by probing the point of a pencil about one-half inch into the soil to form a small conical hole. The fragment was then inserted with tweezers, point first, so that only a third or less showed above the ground.

This procedure was followed for two reasons. Experience had shown that considerable movement

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[1]Geiger, R. The climate near the ground. (2nd ed.) Harvard University Press, Cambridge, Mass. 1950.

[2]Smith, D. M. The influence of seedbed conditions on the regeneration of eastern white pine. Connecticut Agric. Expt. Sta. Bul. 545, 61 pp. Illus. 1951.

[3]Baker, F. S. Principles of silviculture. McGraw-Hill Book Co., Inc., New York. 44 pp. Illus. 1950.

[4]Isaac, L. A. Reproductive habits of Douglas-fir. Charles Lathrop Pack Forestry Foundation, Washington, D. C. 107 pp. Illlus. 1953.

[5]TEMPILS sold by the Tempil Corporation, New York, New York, were used in these trials.

[6]Vaartaja, O. Temperature and evaporation at and near ground level on certain forest sites. Canadian Journal of Botany 32:760-783. 1954.

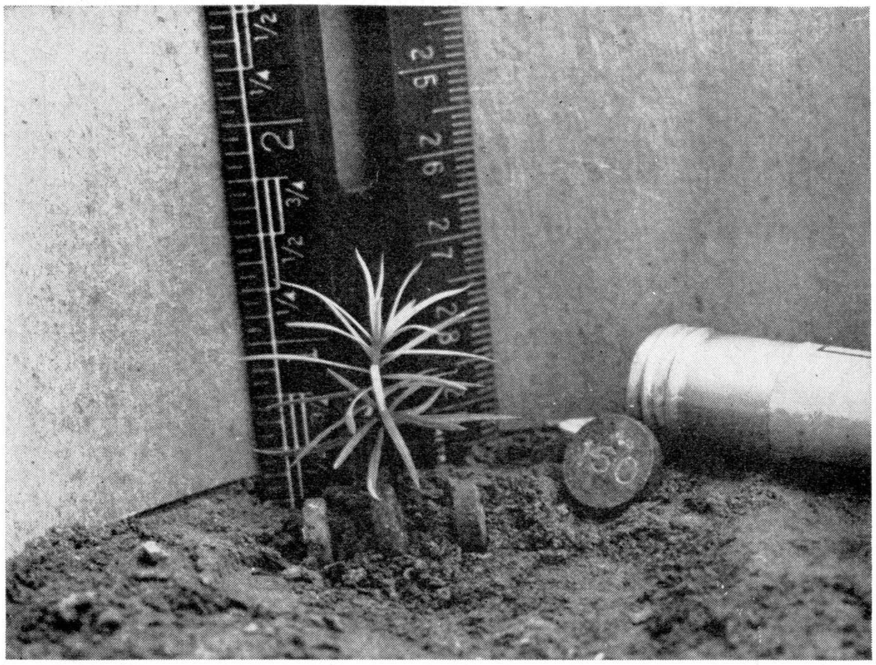

FIG. 1.—Temperature pellets installed near the stem of a Douglas-fir seedling. The 138° F. pellet fragment is closest to the stem; 125° F. and 150° F. fragments are on either side. Smaller splinter-like fragments would normally be used, but half pellets are shown here for clarity. Whole 150° pellets and their aluminum container are shown at right.

of soil particles and other small objects by rain, wind, gravity or biotic activity took place even on relatively flat surfaces during summer. This movement was much more pronounced on steep slopes. Pellet fragments merely placed on the surface often became lost, but partially buried fragments usually remained in place. In addition a pellet fragment partially buried would usually leave an unmelted portion below ground level to provide positive evidence that the surface temperature had exceeded the melting point of the pellet. Otherwise there was no certain way to determine whether the absence of a pellet meant it had completely melted, or had simply become lost.

Half pellets were the most satisfactory size of fragment when the tests were carried over several months. Whole pellets proved unnecessarily large for point sampling and fragments smaller than a half pellet took too long to find. The 125° F. pellet is an exception. When heated above its melting point, it partly vaporizes, leaving behind a black soot. This blackens the adjacent soil surface and may change the temperature characteristics of surface materials. For this reason, a small fragment (1/8-pellet or smaller) of the 125° F. pellet was used and was placed at least one-half inch away from fragments of other pellets. A toothpick marker was then inserted in the soil beside it. Upon melting, the 125° F. pellet leaves a persisting band of soot on the toothpick. Fragments of other pellets can be placed close together, but they should not touch or they may fuse and make it difficult to interpret results.

In addition to their usefulness in large scale sampling of clearcut areas, temperature pellets also proved admirably suited for sampling temperatures of the soil next to the stems of newly germinated seedlings (Fig. 1). When seedlings are under continuous observation, pellet fragments even as fine as a dust can be used effectively but are easily lost. For intermittent observation over long periods, relatively long splinter-like fragments of small diameter are better. These may be placed very close to a tiny stem without actually touching or shading it. Long fragments are especially desirable where loose seedbeds such as duff or moss make it hard to predict at what surface level the highest temperature will occur. The 125° fragment should be used some distance away from seedling stems because of sooting. With these precautions, the maximum surface temperatures near a seedling stem can be accurately measured with practically no disturbance of the natural conditions of the microsite.

Two further precautions should be taken in handling or transporting pellets. To guard against accidental melting, they should be carried in an insulated bag. Pellets frequently melt when left unprotected inside an auto parked in the sunshine. Since the 125° pellets react chemically with the others, they should be packaged separately. The 125° pellets also become oily from prolonged exposure to body heat when carried in the pockets of clothing.

Whether used for extensive sampling to find the percent of seedbeds reaching lethal temperatures or for determining maximum temperatures in the minute area near a seedling stem, temperature pellets show promise as a new and reliable research tool.