

must cause a premature development of the eggs, and the larvae hatched in winter have little chance of survival.

A rectangle of favorable conditions for larvae (thin broken line), when transferred to the graph for plains, does not cover the larval portion of this graph. It appears that larvae in the plains are exposed to a much greater degree of moisture than in the reservations, while the temperature conditions remain favorable. Thus, excessive rainfall in spring may constitute another controlling factor acting on larvae.

The conditions to which adults are exposed in both areas do not differ substantially, the adult graph in the plains being almost entirely included within the rectangle of favorable conditions for this stage (thin continuous line).

The above example should make clear the principle of bioclimatographs, and the rectangle method for their comparison. The advantages of this type of graph are obvious, since it permits a rapid graphic comparison of local environments in relation to life history. Of course, the comparison merely reveals the *probable* controlling factors, and their effectiveness should be checked by suitable physiological studies on the respective stages of the insect, but this is a general consideration applicable to all climatographic studies.

It is easy to see that bioclimatographs can be adapted to various types of life-cycles of insects, though they are more suitable for studying those with one annual generation. The conventional signs can be multiplied when necessary. For example, it would be easy to introduce special signs to differentiate an active larva from a dormant one, etc.

The attention of those attempting to use bioclimatographs must be drawn to the fact, which may be easily overlooked, that the point for a particular month represents the mean temperature and the total amount of precipitation for the month. Therefore, the line connecting, for instance, the points for May and June should be regarded as representing the course of the two meteorological factors during June. This is, of course, not quite correct, but when necessary and possible the graph can be made not for whole months but for five or ten day periods, and this would render it more exact. This procedure would be probably particularly useful in the case of insects producing several generations in a year.

There is scarcely any need to add that bioclimatographs can be based on combinations of any climatic factors, just as the usual climatographs (see Tehon, '28).

The method is offered here only as a suggestion, in the hope that it will be tested by ecologists, with a view to improving or modifying it.

#### LITERATURE CITED

- Cook, W. C. 1931. Notes on predicting the probable future distribution of introduced insects. *Ecology*, 12: 245-247.  
Tehon, L. R. 1928. Methods and principles of interpreting the phenology of crop pests. *Bull. Ill. Nat. Hist. Survey*, 17: 321-346, 18 figs.  
Uvarov, B. P. 1931. Insects and climate. *Trans. Ent. Soc. London*, 79: 1-247, 53 figs.

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#### PREMATURE GERMINATION OF FOREST TREE SEED DURING NATURAL STORAGE IN DUFF

For some years forest investigators in the Pacific Northwest have been aware of the considerable quantity of tree seed which accumulates in the duff of heavy virgin timber stands and apparently retains its vitality for a few years in a sort of natural cold-storage condition. The major portion of the luxuriant regeneration which frequently follows logging and forest fires in the western white pine forest of northern Idaho has, in fact, been attributed by many foresters to this stored seed. The theory is that wholesale

germination is stimulated by removal of the dense overwood shade and consequent raising of temperature of the cold and damp storage medium.

The amount of viable seed in the duff in relation to the time elapsed since the last seed crop has, however, never been accurately determined. As an answer to this question is essential to any proper understanding of the rôle played by stored seed in the regeneration of burned and cutover areas, the Northern Rocky Mountain Forest Experiment Station has been conducting a series of tests in which seed is stored under natural conditions for periods up to eight years in length to see how long and how much seed will remain viable.

One very interesting fact brought out to date by recent storage experiments is that a certain amount of stored seed is lost by premature germination. For some unknown reason, some seed germinates preceding any disturbance or opening up of the overwood canopy. The accompanying photograph, figure 1, shows seed that germinated under the

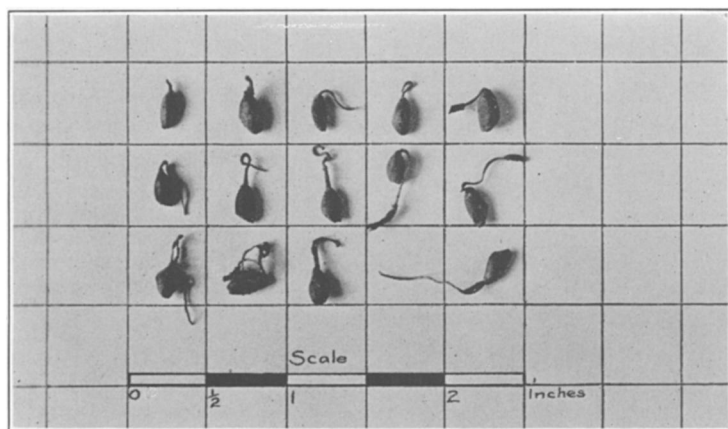


FIG. 1. Seed of *Pinus monticola* germinating during the second year of storage in duff under a stand of virgin timber.

dense shade of an overmature mixed stand of western white pine, *Pinus monticola*, western hemlock, *Tsuga heterophylla*, lowland white fir, *Abies grandis*, Douglas fir, *Pseudotsuga taxifolia*, and western larch, *Larix occidentalis*, during two years of storage in the raw humus characteristic of such stands. Most of this germination took place during the second season of storage, less than one per cent germinating in this manner during the first season. As the resulting seedlings promptly died, due to unfavorable light and moisture conditions created by the presence of the overwood stand, seeds germinating in this manner are wasted as far as future regeneration of the area is concerned. As about one-third of the viable seed originally stored in the tests described has germinated and died in this manner in the first two years of storage, it is evident that this premature germination is one of the factors which determine how long and how much of the seed of any one crop of western pine cones will remain dormant in the duff until the removal of the overwood stand and hence be available in regenerating the area.

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