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Comparison of a Degree-Day Computer and a Recording Thermograph in a Forest Environment

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Abstract

A field test showed that degree-days accumulated by a miniature computer and a recording thermograph in early spring and summer were comparable. For phenological studies the biophenometer was as accurate and more efficient than the hygrothermograph.

Keywords: Degree days, phenology, temperature (-plants, field equipment, insect control.

Introduction

There has been increasing use of accumulated "degree-days" for predicting insect development and for timing other biological events. The phenology of most insects and plants is highly dependent on the thermal accumulation commonly described as "degree-days." Degree-days have usually been determined by averaging the daily maximum and minimum temperatures obtained from recording thermographs and by assuming the sine curve as an approximation of the diurnal temperature curve. The program accumulates a degree-day for every degree above a predetermined development threshold (Arnold 1960). The calculation of a degree-day by this method gives only an approximation of the true degree-days to which organisms are exposed. Fluctuating temperatures caused by the maritime influence or passing weather fronts can modify the actual degree-days accrued during any 24-h period. A method to correct for unusual fluctuations involving both lower and upper thresholds has been reported by Baskerville and Emin (1969) and further modified by Allen (1976).

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The interest in calculating degree-days for predictive models of insect development for management purposes (Harcourt 1981) and the development of miniature computers have resulted in the production of "growing degree-day" computers, or biophenometers, for field use. These compact, battery-powered instruments are now marketed by several companies. They have the advantage of measuring temperatures every 10 min and of instantly computing and updating all data; they thus provide a continuous record of heat-unit accumulation. Five channels of operation can be programmed for different maximum cutoff and minimum base temperatures. There are no charts to change, maximum-minimum readings to decipher on charts, or degree-day calculations to make. This paper reports a field of comparison of the TA51 Biophenometer, made by Omnidata International,[1/] and battery-powered, 31-d recording hygrothermographs for determining degree-day accumulations in a forest environment.

Materials and Methods

A battery-powered, 31-d recording hygrothermograph and a TA51 biophenometer were placed side by side in a standard weather shelter in an open area on two plots being used to study the phenology of Douglas-fir tussock moth, *Orgyia pseudotsugata* (McDunnough). The plots are located near Fort Klamath in southern Oregon and have been used continuously for monitoring degree-days and insect and host tree phenology during late spring and summer months since 1976 (Wickman 1977).[2/] They are located in mixed conifer stands on the east slope of the Cascade Range at elevations of 4500 ft (1372 m) on Plot C and 4200 ft (1280 m) on Plot H. More precise descriptions of the stands and plot configurations are given in Wickman (1977). Instruments were placed in the field on March 17, 1981, and checked approximately every 2-3 weeks in the spring and about once a month during the summer and early autumn.

Based on previous studies (Wickman 1976, 1977), a threshold temperature of 42 °F (5.6 °C) was used for calculating degree-days on the hygrothermograph charts. The daily mean temperature was obtained by summing the maximum and minimum and dividing by two. A base temperature of 42 °F and an upper cutoff temperature of 110 °F (43.3 °C) was programmed into the TA51.[3/] The starting date for accumulating heat units was April 1. Heat units were accumulated by subtracting 42 °F from the mean daily temperature and counting each degree above 42 °F as 1 degree-day.

[1/] Use of a trade name does not imply endorsement or approval of any product by the USDA Forest Service to the exclusion of others that may be suitable.

[2/] Unpublished data on file, B.E. Wickman, Forestry and Range Sciences Laboratory, La Grande, Oregon.

[3/] The instruments used for this test were programmed for calculating °F. The biophenometer is also available for calculating °C.

Results

A threshold for degree-day accumulation was not recorded on the hygrothermograph located at the higher elevation (Plot C) until April 14; on the lower elevation (Plot H), the first thresholds were recorded March 27 and 28 but were not used in the calculations because April 1 was the arbitrary starting date for measurements on both plots. By April 15, Plot C recorded 7 degree-days from hygrothermograph calculations and 16 degree-days on the TA51. Plot H on the same date had accumulated 17 degree-days on the hygrothermograph and 30 on the TA51. In most years, mid-April has been the starting date for accumulating heat units on the study plots at Fort Klamath. The TA51 started accumulating heat units sooner than the thermographs on both plots. It was evidently sensitive to brief periods of warm temperatures during spring days; these periods were masked by averaging maximum and minimum temperatures on the hygrothermographs. The data showed, however, that differences between the two sets of instruments were less than early spring variation found in 5 yr of previous measurements (Wickman 1981).

Degree-day accumulation in late spring can be used to predict development of Douglas-fir tussock moth and host tree bud burst (Wickman 1976). A comparison of the TA51 with hygrothermograph records during this period was the primary purpose for this test. Degree-day accumulations as measured by the hygrothermographs for April, May, and June for both plots were comparable to past measurements on both plots; but the TA51 had accumulated an additional 60 degree-days on both plots by June 23 (fig. 1). The differences, however, were not critical for predicting plant or insect development.

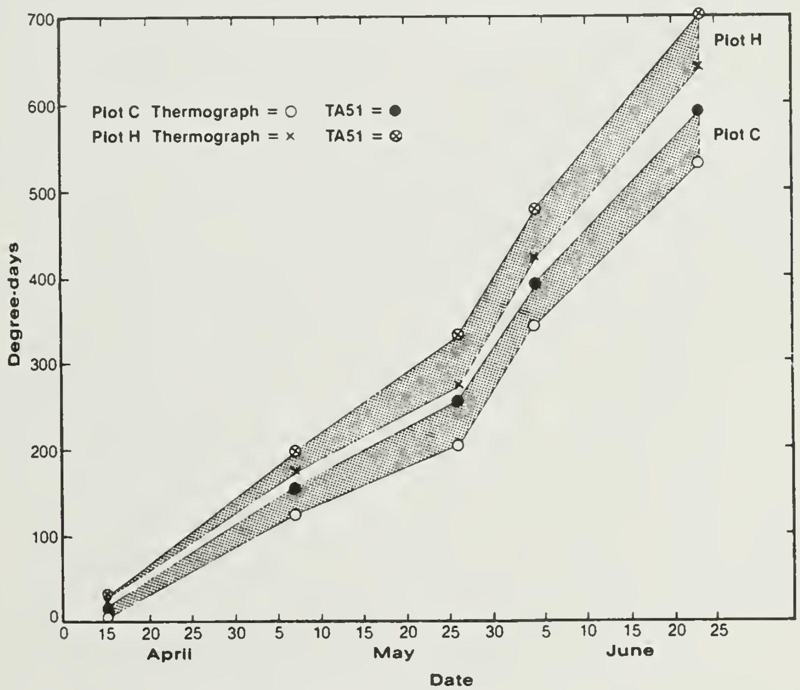

Figure 1.—Accumulated degree-days from the thermograph and TA51, by calendar date.

When accumulated degree-days (April-June) calculated from the thermographs were plotted against TA51 computations for each plot, the linear relation was excellent; but accumulations were slightly greater with the TA51; and most of this divergence of heat unit accumulation occurred before May 25 (fig. 2).

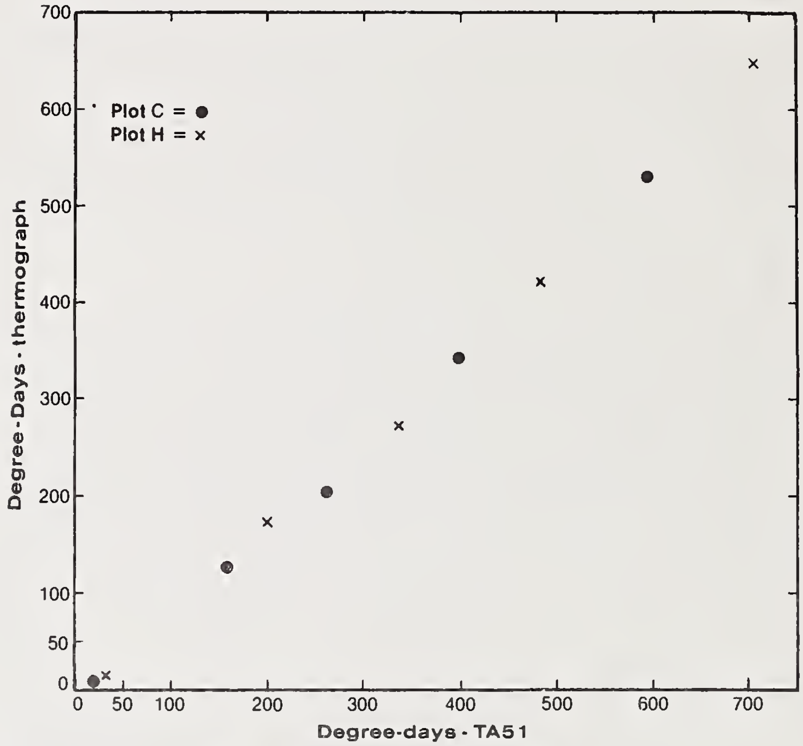

Figure 2.—Accumulated degree-days from the thermograph and TA51, April 1 to June 23, 1981.

A similar comparison of the accumulated degree-days for the total growing season (April 1 to October 8) produced an even better linear relation (fig. 3). This improvement was partially caused by an unknown anomaly late in the season on Plot H where degree-day accumulation calculated by the thermograph exceeded by 49 degree-days that computed by the TA51. The reverse occurred on Plot C: by the end of the season the TA51 accumulated 68 more degree-days than the amount calculated from the thermograph. From a total of nearly 3000 degree-days accumulated to October 8 these discrepancies are minor.

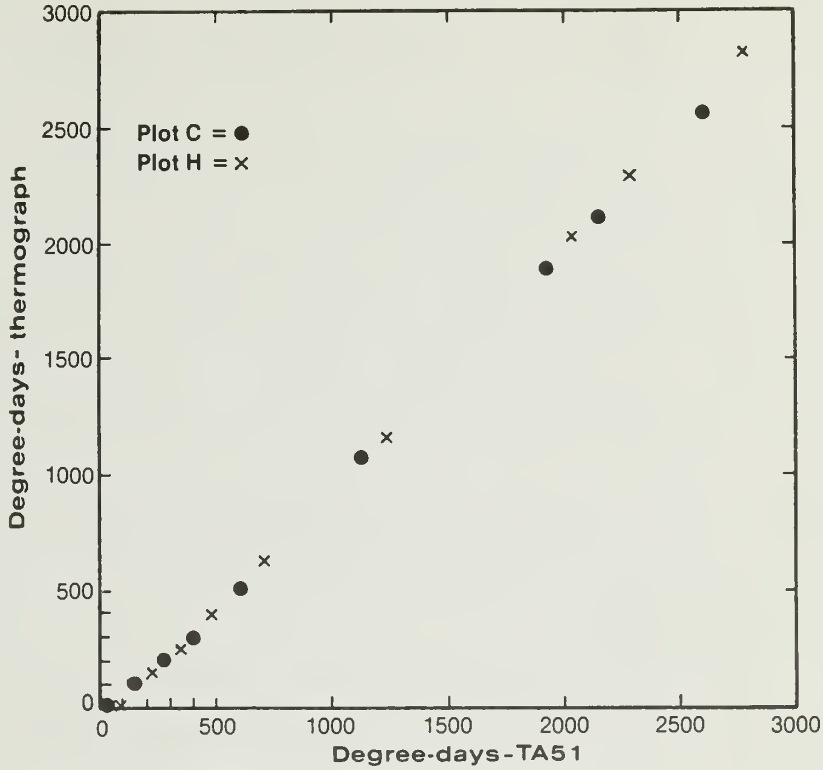

Figure 3.—Accumulated degree-days from the thermograph and TA51, April 1 to October 8, 1981.

Except for slightly higher degree-day accumulations during the first 2 mo of the growing season, the degree-days accumulated by the TA51 were very similar to those calculated from averaging daily maximum and minimum temperatures on hygrothermograph charts. This is not surprising as the spring and summer diurnal temperatures follow a consistent pattern at Fort Klamath except during an occasional spring storm or an afternoon summer thunderstorm. There were about 14 such weather episodes at Fort Klamath during the 6 mo from April to October 1981. Temperature fluctuations caused by some of the spring storms could account for the additional degree-days computed by the TA51 early in the season. The ability of the TA51 to record temperatures and compute degree-days at 10-min intervals gives it an inherent sensitivity advantage over a thermograph.

Hygrothermographs are useful for recording other types of weather measurements; but for accumulating degree-days, the TA51 proved to be a convenient, accurate instrument. For forest environments, it should compute degree-day data more precisely than would recording hygrothermographs and with a savings in time needed to service conventional hygrothermographs and to calculate degree-days.

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