RESEARCH NOTES
SOUTHEASTERN FOREST EXPERIMENT STATION
Asheville, North Carolina

Number 148 June 1960

TIME-TEMPERATURE RELATIONSHIPS OF TEST HEAD FIRES AND BACKFIRES

Time-temperature relations were measured during the course of a preliminary investigation of the thermal characteristics of forest fires. Observations on 5 head fires and 5 backfires in 8-year-old gallberry-palmetto roughs on the Alapaha Experimental Range near Tifton, Georgia, are the basis for this report.

All burning was done on July 22, 1959, between 10 a.m. and 2 p.m., with air temperatures about 90° F. The moisture content of the upper layer of fuels, as measured by fuel moisture sticks, decreased from 12 to 8 percent during the burning period. Winds varied from 1 to 4 miles per hour and the burning index was 1. Fuels, including litter and lower vegetation, averaged 5 to 10 tons per acre. Backfires advanced at the rate of about one chain per hour and head fires at the rate of 10 to 20 chains per hour. Temperature measurements were made at 3-second intervals as the fires (with about a 20-foot run) passed thermocouples located at 1- and 4-foot heights above ground.

Chromel-alumel thermocouples, when used with leads insulated with fiberglass and stainless steel mesh were very satisfactory in these tests. Milliameters were used as measuring devices because they are relatively cheap and are readily wired and transported. Recording potentiometers would serve the purpose better but are expensive and more cumbersome to use in the field.

Composite time-temperature lines for these head and backfires are plotted on the reverse of this sheet. At the 1-foot level, the head fire temperatures rose abruptly to a maximum of about 1600° F. They then fell off, at first sharply, and then at a decreasing rate. The slower moving backfires produced temperatures from 250° to 600° F. at the 1-foot level and maintained this temperature range for several minutes. The second temperature peak associated with backfires occurred when the line of fire had passed the thermocouple, but the flames were still directed at it as a result of wind movement.

At the 4-foot level, head fire temperature peaks barely exceeded 500° F.; backfire temperature peaks at the same level barely exceeded 125° F.

Lindenmuth and Byram 1/ made a comparison of heat factors associated with backfires and head fires in the longleaf pine type. In this type, which was primarily grass mixed and overlain with longleaf needles, their measurements indicated that head fires are cooler near the ground--up to 18 inches--than backfires. Our measurements do not indicate such a relationship for the gallberry-palmetto roughs, at least at the 1- and 4-foot levels. If there is a zone in this type where head fires are cooler than backfires, it is probably within a few inches of the ground.

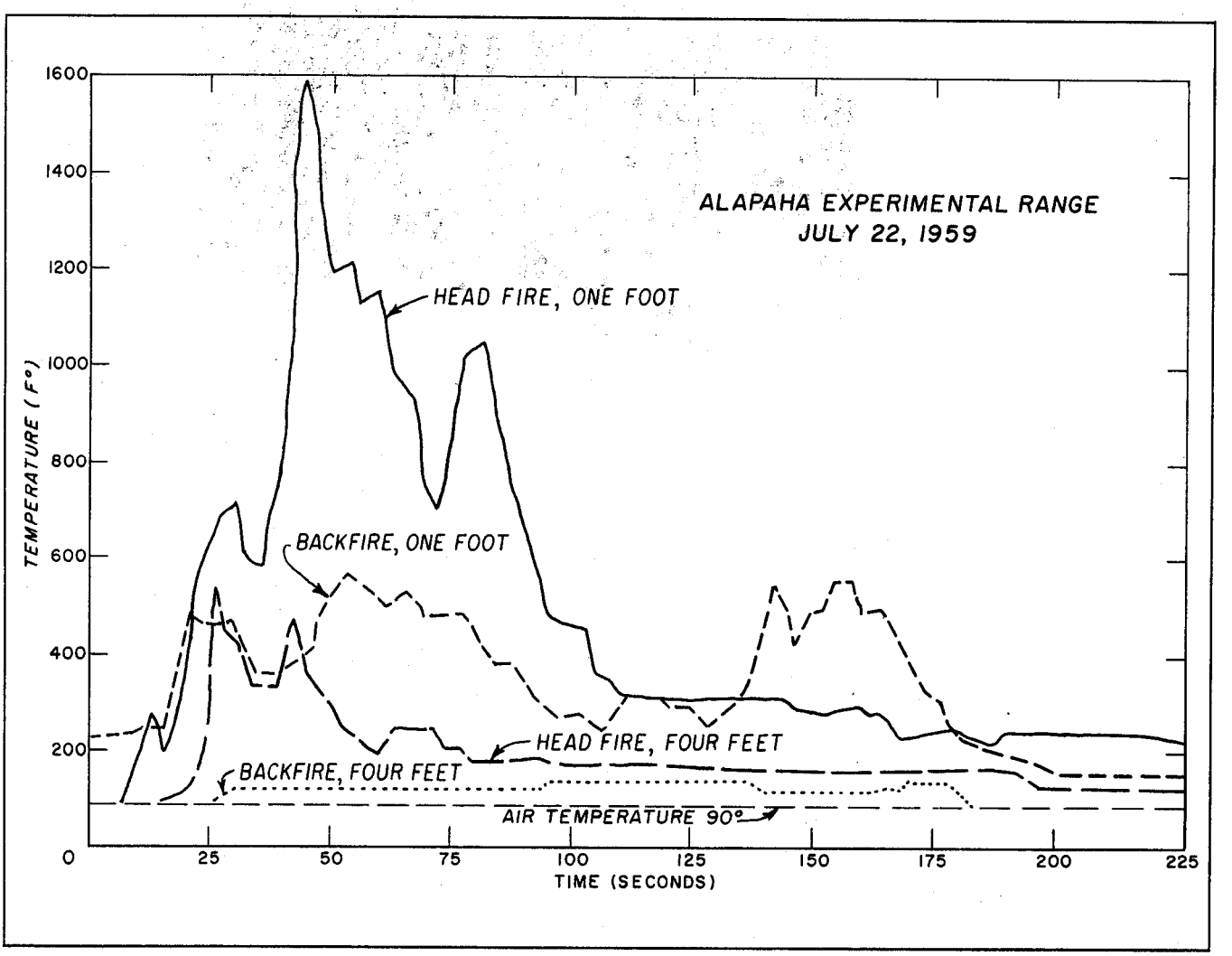
A plot of temperature against time represents one of a fire's most significant thermal characteristics. By measuring these relationships at different heights above ground, a three-dimensional, quantitative analysis of a fire can be made which in turn

---

1/ Lindenmuth, A. W., Jr., and Byram, G. M. Headfires are cooler near the ground than backfires. U. S. Forest Serv. Fire Control Notes 9(4): 8-9. 1948.

can be used to rate fuels according to heat yields. Vegetation damage should be closely related to a fire's time-temperature behavior if initial vegetation temperature is taken into account.

Many more fires in different fuels under different weather conditions must be measured before the energy release that takes place in wildfires can be estimated. Detailed and carefully documented studies are now in progress at the Southern Forest Fire Laboratory.



Temperatures developed by 5 head fires and 5 backfires in 8-year-old gallberry-palmetto roughs.

Lawrence S. Davis and Robert E. Martin
Southern Forest Fire Laboratory