Reprint of Ed Brotak's & William E.. Reifsynder's :
Prediciting Major Wildland Fire Occurrence

During a drought period when the build-up index is very high, wildfires are common. On some days, these small fires quickly get out of hand, and some become major fires. Obviously, any forecasting method which could determine when these major fires were likely to occur would be most useful. The following details such a predictive scheme from readily available weather maps. No calculations are necessary, just recognition of certain clearly defined situations.

Using Weather Maps

The original data analyzed consisted of 52 fires, each burning 5,000 acres (2,000 ha) or more, in the Eastern United States from 1963 to 1973 (see fig. 1). Of particular concern were major fire runs, periods of time when the fire was probably uncontrollable due to the prevailing weather conditions. Figure 2 is an idealized surface map showing where these major fire runs occurred in relation to the existing fronts and high and low pressure areas. Certain regions were obviously prone to large fires.

The region immediately behind a dry cold front is the most dangerous. Strong, shifting winds are the apparent cause. Strong southerly winds ahead of the cold front can also cause control difficulties. Obviously, if significant precipitation occurs with the frontal passage, fire danger will not be great.

Another region of great danger is the warm sector of a strong low pressure area (as indicated by the cluster of runs to the east–southeast of the low in figure 2). There were two different types of low pressure areas involved with major fires. One was the Rocky Mountain low which produced dangerous fire conditions in the Plains and Midwestern States. The other kind of low was a storm which moved easterly through southern Canada producing dangerous fire conditions in the Great Lakes States and in northern New England. Major lows in the Eastern United States are almost always accompanied by precipitation.

If only the surface maps are available, then these dangerous situations can only be distinguished from other similar situations by a closer examination of the map.

Dangerous frontal situations will be characterized by strong winds, a tight pressure gradient, and little or no precipitation with the frontal passage.

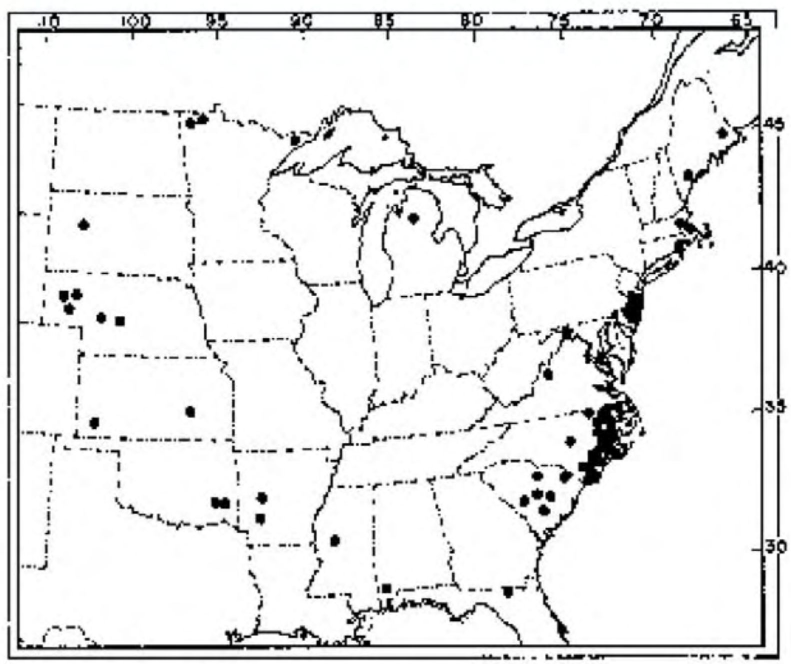

Figure 1—*Locations of all fires.*

When this article was originally published, E.A. Brotak was a research assistant and W.E. Reifsnyder was a professor of forest meteorology at the Yale School of Forestry and Environmental Studies, New Haven, CT.

* The article is reprinted from *Fire Management Notes* 38(2) [Spring 1977]: 5–8. It is based on *A Synoptic Study of the Meteorological Conditions Associated With Major Wildland Fires*, E.A. Brotak's Ph.D. dissertation at the Yale School of Forestry and Environmental Studies.

Fortunately, the development of major low pressure areas and the passage of strong cold fronts are normally associated with precipitation.

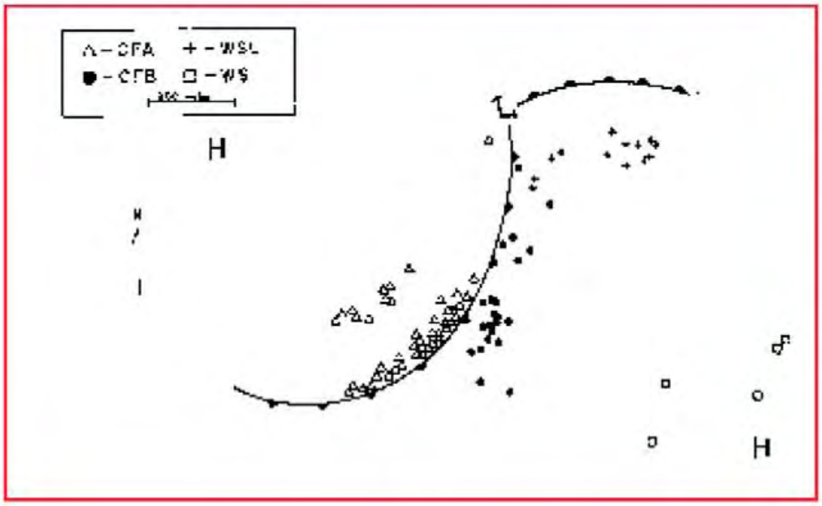

Figure 2—*Idealized surface map showing locations of all fire runs. (CFA = following cold frontal passage; CFB = preceding cold frontal passage; WSL = warm sector of low; and WS = warm sector of high.)*

Dangerous frontal situations will be characterized by strong winds, a tight pressure gradient, and little or no precipitation with the frontal passage. Dangerous conditions around low pressure areas usually depend on precipitation occurrence.

If the upper air maps are available, these dangerous situations are much easier to determine. Strong cold fronts are distinguished from weaker fronts by the presence of intense upper level troughs, readily apparent at the 500-millibar (~18,100 feet [~5,500 m]) level. The intensity of these troughs is determined by the radius of curvature which was usually 400 miles (640 km) or less for the study fires. Figure 3 shows that the most dangerous conditions are associated with the southeastern portion of the trough.

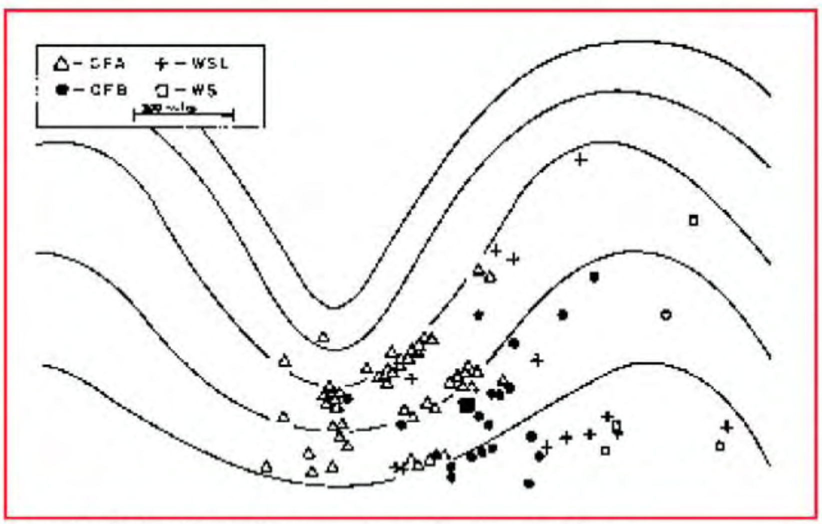

Figure 3—*Idealized 500-millibar map showing locations of all fire runs.*

The likelihood of precipitation is best determined from the 850-millibar (~4,900 feet [~1,500 m]) map. Significant moisture advection at this level in conjunction with an upper trough usually produces precipitation. Only if the dewpoint depression of the air at this level upwind of an area is 41 °F (5 °C) or more is precipitation unlikely and major fire occurrence possible.

Fortunately, the development of major low pressure areas and the passage of strong cold fronts are normally associated with precipitation. It is on those rare occasions when precipitation does not accompany these systems and fuel conditions are severe that major fire occurrence is likely.

Using Local Wind and Temperature Profiles

The preceding section describes the use of readily available weather maps for the routine prediction of major wildland fires. In this section, we shall describe how to use local wind and temperature profiles to determine dangerous fire conditions. For all 52 fires, wind and temperature data from the surface to 10,000 feet (3,050 m) were plotted and analyzed for one or two nearby first order weather stations for times just before and just after the fire's run. From these data, characteristic profiles were deter-

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mined which could be used as predictive models.

Strong surface winds are a prerequisite condition for major wildland fires. However, an examination of only the surface winds is not adequate for predictive purposes. Observed surface winds are not always representative of actual conditions. This is especially true in the morning when the nocturnal inversion often produces weak surface winds. If the winds above the inversion layer are strong, the potential for strong surface winds in the afternoon is great. Topographic effects can also produce seemingly low surface wind speeds, but again if the wind speeds above the surface are high, strong gusts can be expected at the surface.

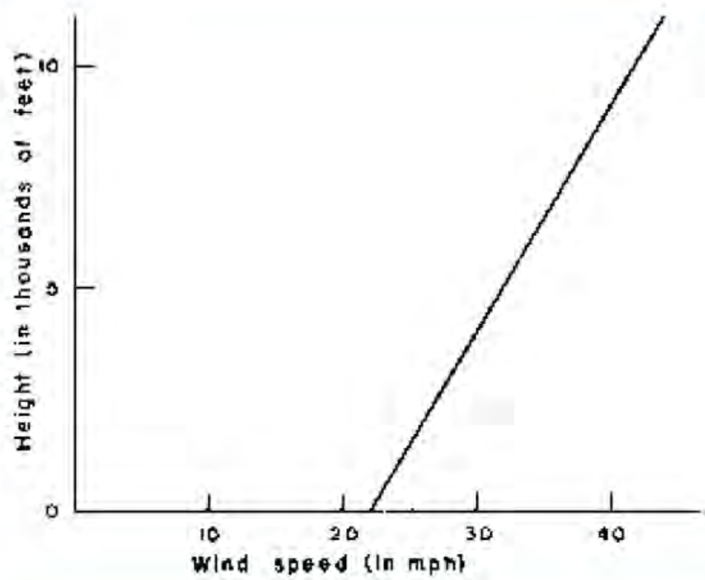

Figure 4—*Characteristic wind profile.*

A wind profile characteristic of most major fire situations is shown in figure 4. Surface wind speeds always reached 15 miles per hour (24 km/h) and are usually 20 miles per hour (32 km/h) or greater. Wind speeds at 10,000 feet (3,000 m) were almost always 40 miles per hour (64 km/h) or greater. The above figures can be considered as critical values for major fire occurrence.

The association of major wildland fires with low-level jets (wind maxima within 10,000 feet [3,000 m] of the surface where the wind speed is 5 miles per hour [8 km/h] greater than a thousand feet [300 m] above or below) was a significant finding of this research. A third of the wind profiles showed such a jet. Certain synoptic situations were more favorable for the jet's occurrence. Most frequent were the prefrontal jets, southerly wind maxima just ahead of the surface cold front. Another southerly jet was often noted in the warm sector of the common Rocky Mountain low pressure area. A postfrontal jet, a northerly wind maximum behind the surface cold front, occurred on a number of occasions. Low-level jets were also occasionally noted along the East Coast and seemed to be associated with the sea breeze front.

Although not a prerequisite condition, the occurrence of a low-level jet happens frequently enough, especially under certain patterns, to be an important factor. If present, the authors believe that the low-level jet will increase surface wind speeds and gustiness by downward transport of momentum. The importance of this, especially on the worst fire days, is probably to make bad conditions even worse.

It has long been believed that atmospheric instability was associated with major wildland fires. In an attempt to determine some characteristic values of this parameter, certain lapse rates were examined for each fire situation. Using the standard pressure levels given in the soundings, the lapse rates that were used were 950–850 millibar, 850–700 millibar, and 850–500 millibar.

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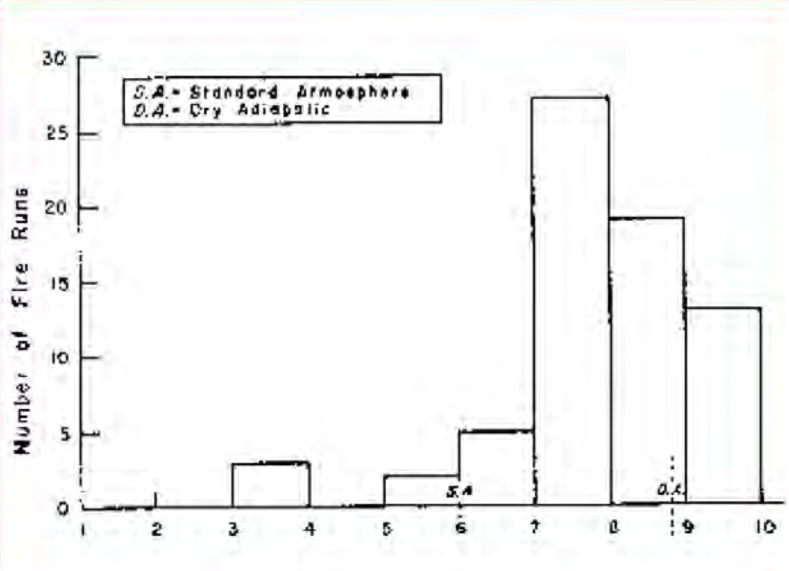

Figure 5—*950–850 millibar temperature difference for all fire runs.*

The 950–850 millibar (~2,000 feet to ~5,000 feet [~600 to ~1,500 m]) temperature (ΔT) avoids the variability of surface temperatures and the occurrence of surface based inversions, but is still greatly influenced by daily solar heating and is probably a local rather than macroscale parameter. As shown in figure 5, the vast majority of fires, 92 percent, occurred when the lapse rate between these levels was steeper than the standard atmosphere value (ΔT = 6.0 °C). Superadiabatic lapse rates were noted on a number of fires. Thus a temperature difference of at least 6.0 °C between the 950 and 850 millibar levels appears to be a necessary condition for major fire occurrence.

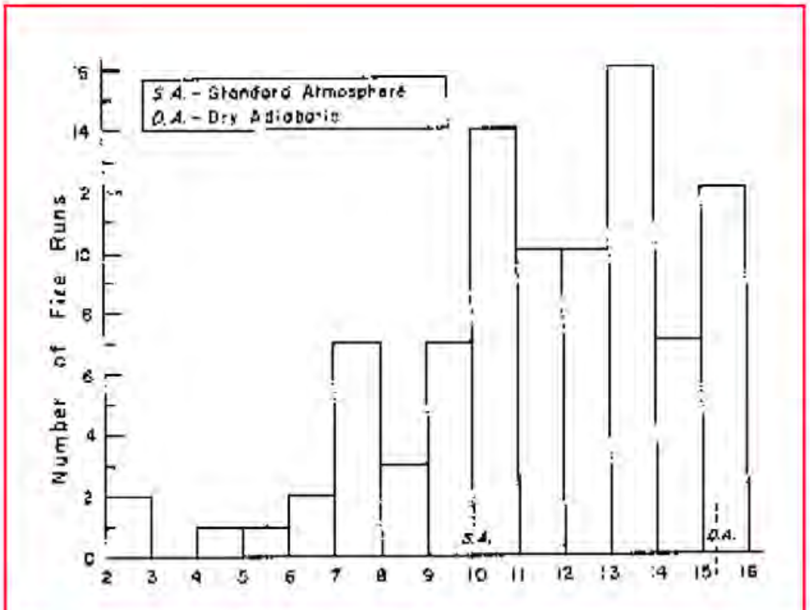

Figure 6—*850–700 millibar temperature difference for all fire runs.*

The 850–700 millibar (ΔT) depicts the lapse rate between ~5,000 feet (~1,500 m) and ~10,000 feet (~3,000 m), and the instability at those heights would probably be macroscale. As shown in figure 6, in general, a temperature difference of at least 10 °C is associated with major fires. This value is close to the standard atmosphere lapse rate. The 15.0 °C to 15.9 °C category encompasses the dry adiabatic lapse rate which is the maximum that could be expected for these heights.

The 850–500 millibar (ΔT) depicts the lapse rate between ~5,000 feet (~1,500 m) and ~18,000 feet (~5,500 m). A temperature difference of 26 °C is the standard atmosphere lapse rate. A temperature difference of 40 °C to 41 °C is the dry adiabatic lapse rate and would be remarkably unstable for

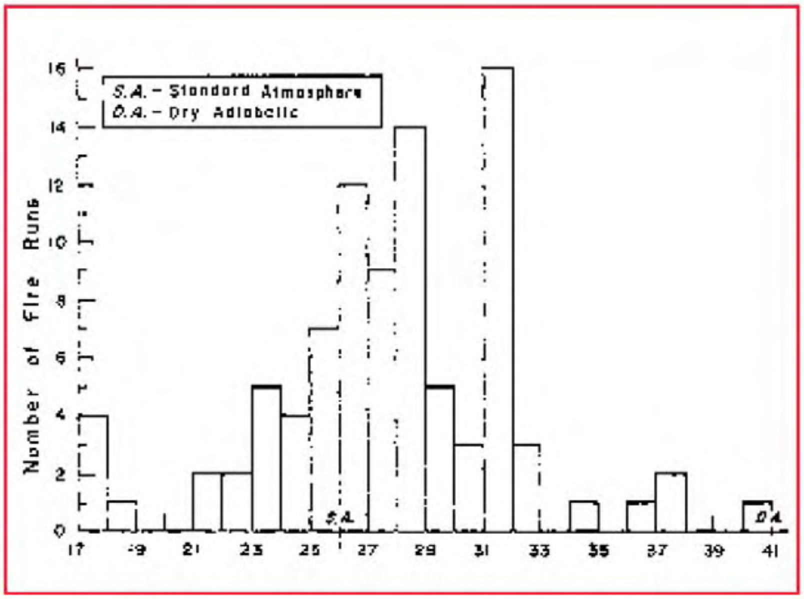

Figure 7—*850–500 millibar temperature difference for all fire runs.*

this level in the atmosphere. As shown in figure 7, about 75 percent of the fire runs occurred with a temperature difference of 26 °C or more.

Acknowledgment

The research project summarized here was supported by the Atmospheric Science Section of the National Science Foundation. ■

Special Note:

Since the printing of this document, NCDFR Fire Environment Branch now recognizes that the Brotak profile starts at 9 knots (`ly 10mph) at the surface and 34 kts (~ly 40 mph) at 10,000 ft. Wind profiles to the right of this line cause problems in fire suppression efforts. Also, the Bryam reverse wind speed profile is a major impact to forest fires as high as 3000 ft. The jet point can be at this altitude and be very troublesome for fire suppression crews……Gary M. Curcio, 2000.