Making Sense of Fire Weather

Brian E. Potter

A district ranger checks the local weather conditions and notes high windspeeds. In another district, the ranger sees low relative humidity is predicted for her area. A third ranger looks at the nearest upper-air report and finds strong wind shear and an unstable temperature profile. Which ranger or rangers should consider their observations as indicative of high weather-related fire risk?

The general public and fire managers alike commonly consider a variety of weather-related variables to be indicators of fire risk. These include surface air temperature, windspeed, and humidity. Fire managers and foresters may hear or believe that wind shear and stability also contribute to fire risk. While researchers repeatedly note that various conditions precede or accompany large wildland fires, they have not examined whether these same conditions are equally common on days when no fires occur or when only small or controllable fires occur. When fire managers know which weather-related variables discriminate typical weather conditions from weather associated with large fires, they can prepare for the possibility of a large wildland fire developing.

Methods Used

I analyzed data for 339 large wildland fires that occurred in the Continental United States from 1971 through 1984. Each fire burned 1,000 acres (400 ha) or more. I associated each fire with the nearest upper-air weather station and classified it according to its season (spring, summer, autumn, or winter). I dropped any station and season with fewer than five associated fires from the analysis. Figure 1 shows the number of fires for each station that remained.

When fire managers know which weather-related variables discriminate "large-fire" weather from typical weather conditions, they can prepare for the possibility of a large wildland fire developing.

For each fire day, I used statistical analysis of variance, a technique that indicates whether or not the fire and typical values are significantly different, to compare the following six measurements with "typical" values for the same station and season:

- Surface air temperature,
- Relative humidity,
- Dewpoint depression,
- Stability,
- Windspeed, and
- Wind shear.

Note that dewpoint depression is the difference between actual air temperature and dewpoint temperature. It is *not* the same as wetbulb depression, which appears on the psychrometric charts in many belt weather kits. Dewpoint depression is always greater than wetbulb depression.

Also note both the size of the wildland fires considered here and the location of the weather observa-

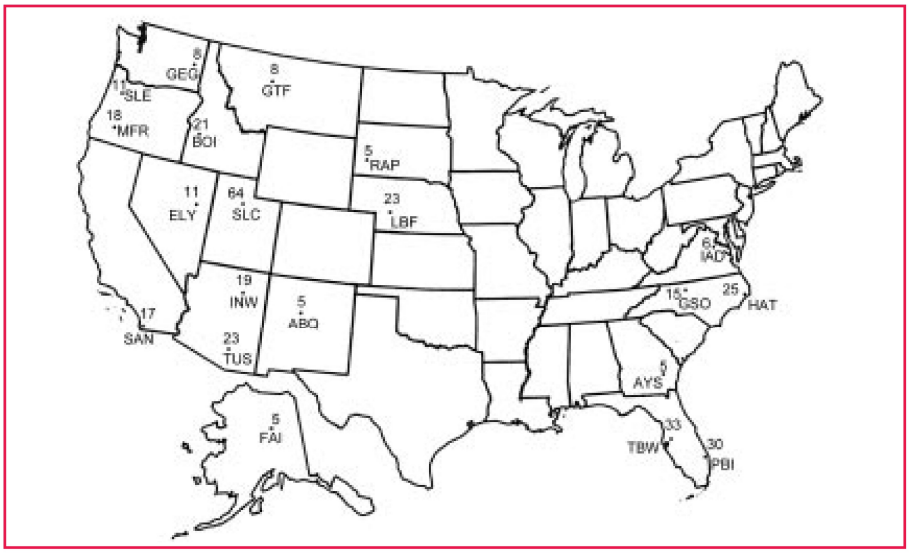

Figure 1—*Locations of stations used for this study and the number of fires over 1,000 acres (400 ha) associated with each station. Three-letter codes are weather station identifiers.*

Brian Potter is a research meteorologist for the USDA Forest Service, North Central Forest Experiment Station, East Lansing, MI.

tions. The fires are all large fires—the more numerous small fires may show stronger or weaker correlations with some of the weather variables. The observations indicate the weather conditions on a horizontal scale of about 62 miles (100 km). A fire, once started, begins to alter some of these conditions (such as wind), and onsite measurements of any weather variable may differ from measurements taken several miles away from the fire.

Results Found

The results of my analyses show that surface temperature and dewpoint depression are substantially higher on fire days than they are on a typical day for a given location and season. Relative humidity is considerably lower on fire days. Windspeed, wind shear, and stability did not show any significant differences between fire and nonfire days. In other words, it is the more straightforward and commonly known atmospheric properties—high temperatures and low air moisture contents—that most significantly contribute to weather-related fire risk. Thus, the answer to the question in the first paragraph is clear: The second ranger, who saw the forecast of low relative humidity, should be particularly alert to the possibility that the weather will contribute to the development of a large wildland fire.

In examining the six weather variables at individual stations, I found that neither fire-day stability nor fire-day wind shear showed any significant difference from typical values at any of the 20 stations tested. Windspeed proved significant at just two of the stations, relative humidity at four, surface temperature at seven, and dewpoint depression at ten (or half) of the stations. The stations where surface temperature was significant were all west of the Mississippi River.

While they are not a substitute for first-hand experience, these findings can be helpful to fire managers and district rangers. They suggest that the conditions that really matter are those at the surface—stability and wind shear may not be very good fire-weather indicators. Regardless of what part of the country you are in, dewpoint depression is a robust indicator of the weather-related fire risk. Relative humidity, which also measures the moisture in the air, is almost as good and more readily available in weather reports. As experienced fire managers know, even without any measurements or weather reports, they can use their own "senses" to get a good idea what the temperature, humidity, and windspeed are.

With weather measurements, however, fire managers can use the applicable Table 1 to quickly convert relative humidity and temperature to dewpoint depression. This Dewpoint Depression Table (shown both in Fahrenheit and Celsius) can be photocopied, laminated, and kept in belt weather kits for use at any altitude. ■

Table 1—*Dewpoint Depression Table (in both Fahrenheit and Celsius), which can be photocopied, laminated, and kept in belt weather kits. At any altitude, users can quickly convert relative humidity and temperature to dewpoint depression by consulting the applicable version of the Dewpoint Depression Table.*

Dewpoint Depression Table (Fahrenheit)

Temperature (°F)	Relative Humidity (%)							
	10	20	30	40	50	60	70	80
110	69	50	38	30	23	17	12	8
105	68	49	38	29	22	17	12	7
100	66	48	37	29	22	16	12	7
95	65	47	36	28	22	16	11	7
90	64	46	36	28	21	16	11	7
85	63	46	35	27	21	15	11	7
80	61	45	34	26	20	15	11	7
75	60	44	34	26	20	15	10	7
70	59	43	33	25	19	15	10	6
65	58	42	32	25	19	14	10	6
60	57	41	31	24	19	14	10	6

Dewpoint Depression Table (Celsius)

Temperature (°C)	Relative Humidity (%)							
	10	20	30	40	50	60	70	80
44	38	28	21	17	13	10	7	4
40	37	27	21	16	12	9	7	4
36	36	26	20	16	12	9	6	4
32	35	26	20	15	12	9	6	4
28	34	25	19	15	11	8	6	4
24	33	24	19	14	11	8	6	4
20	32	24	18	14	11	8	6	4
16	32	23	18	14	10	8	5	3
12	31	22	17	13	10	8	5	3
8	30	22	16	13	10	7	5	3
4	29	21	16	12	9	7	5	3