SOUTHERN Fire Exchange
Uniting Fire Science and Natural Resource Management

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FLAME DESCRIPTORS

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This is one of a series of fact sheets authored by Dale Wade, a prescribed burn researcher and specialist in the South for over 45 years. They are designed to meld current technology with Dale's unequaled experience with fire and science. The fact sheet series is available within the "Prescribed Fire" section at www.southernfireexchange.org/SFE_Publications/Fact_Sheets.html. The Southern Fire Exchange thanks Dale for these contributions from his wit and wisdom, which, in Dale's words, "was sharpened by the many people he worked with over the years."

The following three descriptors are used to characterize flaming combustion (Figure 1):

1) **Flame height** is the vertical distance from the base to the tip of the flames.
2) **Flame length** is the actual length of the flames from the tip to the midpoint of the flame footprint. Under no-wind conditions on flat ground, flame length equals flame height. Otherwise flame length will exceed flame height regardless of whether a fire is backing or heading.
3) **Flame zone depth** is the distance from the leading edge to the trailing edge of the flaming front measured at the base of the flames.

Byram (1959) established the mathematical relationship between flame height (wind speed = 0) and the depth of the flame-zone showing the dimensionless ratio was a straight line function of the weight of fuel burning per unit area. That means the more fuel burning in a square foot, the higher the flames will be and the deeper the flame zone.

From a physics standpoint, increasing wind speed will decrease flame height because the wind will bend the flames over. But in the real world, as wind speed increases so does rate of spread, which in turn increases fireline intensity. As more understory fuels are involved, flame height will increase accordingly (although it will be less than flame length). Wind pushing a headfire tilts the flames ahead toward unburned fuel, subjecting the fuel to increased radiant heat, thereby preheating it and raising it to ignition temperature (~500°F) more quickly than with no-wind conditions. This results in more rapid fire spread and as rate of spread increases, so does flame length and fireline intensity. In topography, the steeper the slope, the closer the flames are to the upslope fuel (Figure 2).

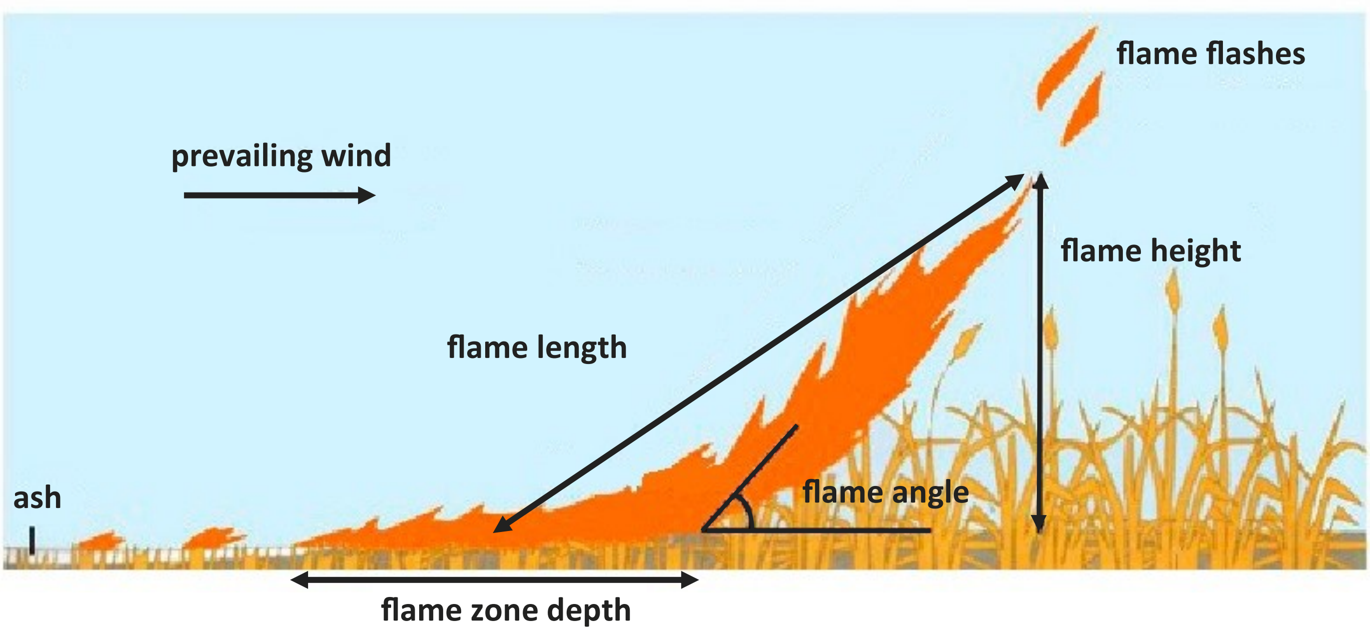

Figure 1. Idealized cross-sections of a surface head fire in grass fuels on level terrain. Figure modified from Alexander et al. (2009); originally in Cheney & Sullivan (2008).

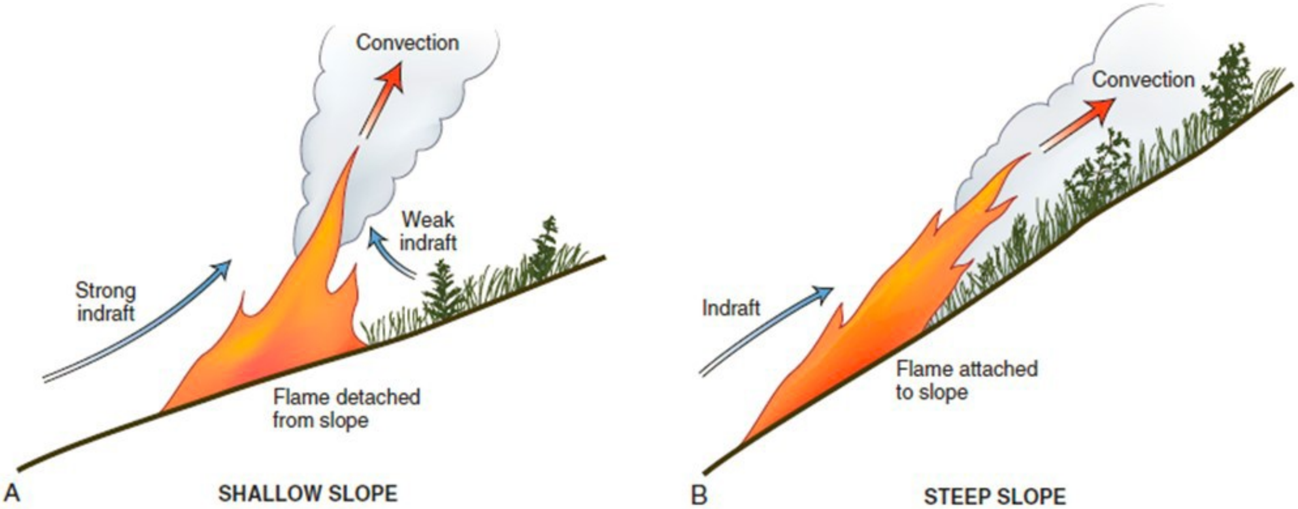

Figure 2. Effect of slope steepness on degree of flame attachment and convective heat transfer for shallow sloping (A) and steep sloping (B) terrain . Figure from Alexander et al. (2009); originally in Alexander et al. 2007, where it was adapted from Rothermel (1985).

Upslope wind bends the flames even closer to the slope surface resulting in even faster uphill spread. Wind speed has little effect on backfire rate of spread; even though flame length will increase, the flames lean back into the burned area.

Visually estimating flame length is usually as much a "guesstimate" as an estimate because flame length continuously changes in response to wind speed and the amount, size, continuity, and arrangement of fuel. When making notes to be included in the written evaluation of a burn, an approximation to the nearest ½ foot for flames less than 2 feet high, 1 foot for flames 2 to 10 feet high, and 2 feet for flames 10 to 15 feet high will suffice. Some burners also include the maximum length and height observed in parentheses directly following the average length and height with the notations "BF" for backfire and "HF" for headfire.

Flame characteristics such as height, length and flame zone depth vary with wind, slope and fuel loads and must be understood to assess and predict prescribed fire effects.

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