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A rule of thumb for estimating a bushfire's rate of forward spread using just the speed of the wind

Predictions of fire propagation across the landscape are often used to support planning of fire suppression activities and warn communities of impending threats. However, in many situations there is little time or access to the necessary data to undertake detailed predictions of fire spread. We derived a simple rule of thumb that can be quickly applied to a broad range of fuel types: the rate of forward spread of an established bushfire is equal to approximately 10% of the average 10-m open wind speed.

The need for timely spread predictions

Fire behaviour models are at the core of the prediction of the propagation--the speed, direction and intensity--of fires burning in the landscape. Model predictions, driven by prevailing environmental conditions and adjustments made by a Fire Behaviour Analyst, are coupled with experience and interpretation to determine the location of the fire perimeter at given times. These simulations of fire propagation are then used to support fire suppression decision-making and alert communities threatened by the fire.

Throughout a fire season there will be numerous instances where there will be little or no time available to undertake a detailed prediction of fire propagation. Yet, an incident controller still needs to quickly make critical decisions regarding the potential behaviour and spread of the fire, particularly if lives are at risk. In such situations, simple, uncomplicated and quick to apply rules of potential fire behaviour are required.

New research to address the need

Rules of thumb are frequently used in fire emergencies to make estimations for fire management. We conducted an analysis of many observations of the spread rate of established high-intensity wildfires to investigate the existence and validity of a simple and scientifically credible rule of thumb for predicting bushfire propagation. These observations were sourced from published wildfire case study analyses made on fires burning in a diverse range of fuel types spanning temperate shrublands, Australian dry eucalypt forests, and North American conifer forests. The analysis utilised the prior knowledge that wind speed is the dominant variable driving the spread rate of fires under typical summer-like wildfire conditions (Fig. 1).

Figure 1. View of a fast approaching wind-driven bushfire from beneath the convection column.

What did we find from our analysis?

Regression analysis indicated that the rate of forward spread of the wildfires (ranging 0.3--10.5 km/h) was consistently about 8% of the average wind speed measured at 10 m in the open, irrespective of the general fuel type. However, because the calculation of 8% of the wind's speed does not readily lend itself to mental arithmetic, we tested the use of a nominal 10% value (i.e., the forward rate of fire spread is roughly 10% of the average 10-m open wind speed). The '10% wind speed' rule of thumb resulted in a mean absolute error of 1.11 km/h (Fig. 2).

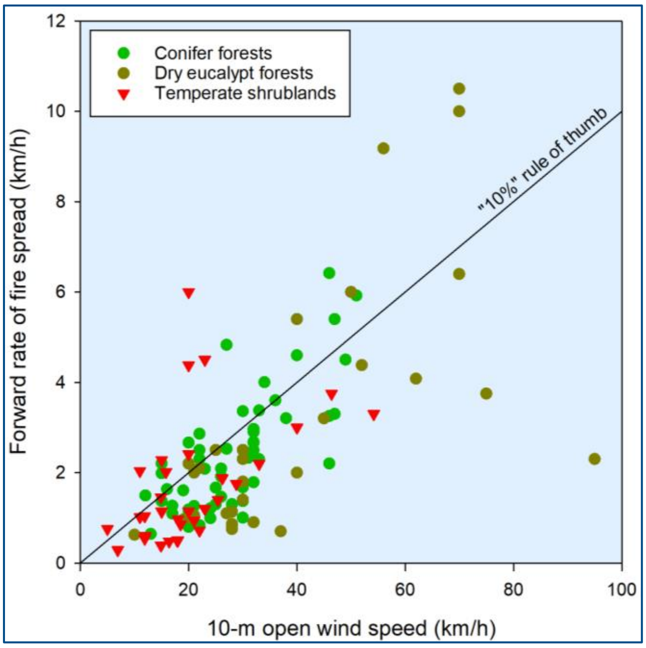

Figure 2. Scatterplot of observed rate of fire spread versus 10-m open wind speed for wildfires in conifer forests (green circles), dry eucalypt forests (olive circles), and temperate shrublands (red triangles).

Model error was analysed by considering a matrix of four distinct burning conditions: low (≤7.5%) *v*. high (>7.5%) fine dead fuel moisture content (FMC) and moderate (≤30 km/h) *v*. high (>30 km/h) wind speeds. Errors were lowest in the drier fuel conditions, irrespective of the associated wind speeds. For these conditions, the tendency to over or under predict the observed fire spread rate (i.e. the bias), was significantly reduced and the error in estimated fire spread rate was between 42–54% of observed, which is notably low given the uncertainty in the wildfire observations.

The rule of thumb tended to over-predict the spread rate of the fires burning under high fuel moisture contents, with the error being greatest for the high fuel moisture/moderate wind speed (i.e. the lowest spread rate) scenario.

Management implications

The main operational constraints of the rule of thumb are: (1) it requires the knowledge of the 10-m open wind speed, typically a forecast value or a current measurement at an appropriately located and maintained weather station; (2) it is only applicable to free-spreading fires burning over level to undulating topography or across drainages with alternating upslope and downslope runs; its suitability in purely upslope or downslope runs is questionable; and (3) it is not applicable to open grasslands where a higher rate of spread to wind ratio is to be expected.

This rule of thumb can help guide decision making when a situation is too complex or time-critical for a complete analytical solution. The 10% wind speed rule of thumb can certainly be used for the assessment of the potential for a wildfire to spread into peri-urban areas under Very High or higher Fire Danger Ratings if the time available does not allow for a more comprehensive fire spread simulation using current models and processes.

In this respect, the rule of thumb is most appropriate for those situations where it works best: under dry (≤7.5% FMC) and windy (>30 km/h) conditions when established fires spread at their fastest and time for predictions is short. Its use for moister burning conditions is not recommended, as over-prediction errors will dominate.

Despite the applicability of the rule of thumb, it should be noted that the most accurate fire spread predictions will continue to be made using the most appropriate fire spread models for the situation combined with high situational awareness and direct observations of fire behaviour.

Further reading

Cruz MG, Alexander ME (2019) The 10% wind speed rule of thumb for estimating a wildfire's forward rate of spread in forests and shrublands. *Annals of Forest Science* 76:44. doi: 10.1007/s13595-019-0829-8.

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