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Variability in grassfire rate of spread

Wildfire propagation is inherently non-steady, although forecasts of their spread rely upon an assumption of pseudo-steady behaviour. We investigated the variability in rate of fire spread of wildfires in southern Australian grasslands, including the impact of landscape features on fire propagation. We characterised the non-steady nature of the fire propagation and found that peaks in forward rate of spread were on average 2.6 times higher than mean spread values. Discontinuities, such as roads, did not stop fires under moderate burning conditions but reduced the average rate of fire spread.

The dynamic nature of fire propagation

As a wildfire spreads across the landscape, the speed its head fire travels is non-steady, fluctuating over short to long time scales. These variations in rate of spread can be due to many factors, including changes in environmental conditions such as continuously varying winds, changes in fuel type and condition or topography. Each factor can produce cyclic or one-off fluctuations in fire propagation, with peaks (or troughs) in rate of spread being several times higher (or lower) than the average value over a fire run lasting 1–2 hours.

For practical purposes, operational fire spread models assume pseudo-steady state propagation in equilibrium with the prevailing conditions. A spread prediction is typically calculated for a period of 30 minutes or more, often aligned with the temporal resolution of weather forecasts, and does not try to describe short-term variations in fire propagation.

A set of observations from wildfires in pasture and winter crops (primarily wheat, barley and canola) was used to characterise variability in rate of spread and quantify the effect of barriers such as roads on the overall propagation of each fire (e.g., slowing or halting spread). All fires in the set occurred in western Victoria between 2021 and 2023.

Fire spread variability characterisation

Air observers' intelligence gathering tools (such as photography and video capture from forward and sideways facing cameras on aircraft) were used to map fire fronts. A fire run was discretised into propagation segments and their rate of fire spread determined. The non-steady nature of grassfire propagation was characterised by relating each segment's spread rate with the average value for the entire fire run. A dataset of six wildfires with more than 60 total fire spread segments was assembled.

Fire spread variability analysis

The McArthur Grassland Fire Danger Index varied between 12 (High) and 23 (Very High) for fires in the dataset. Rate of fire spread for all fires was found to be highly non-steady. The fastest segment fire spread rate in the dataset, 21.7 km/h, was 4.6 times greater than the average value calculated for the entire run of that fire. Across the dataset, the average maximum segment rate of spread was approximately 2.6 times the fire run average (Fig. 1).

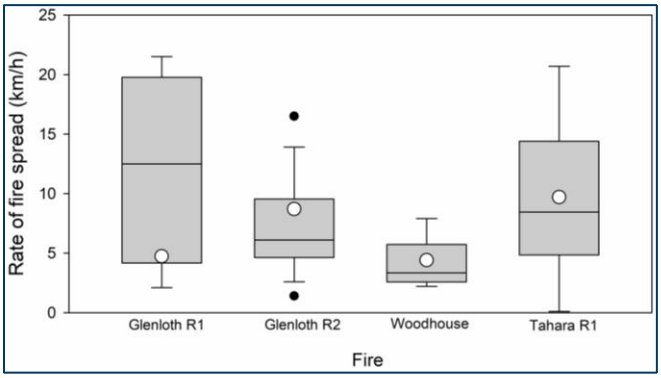

Figure 1. Variability in observed rate of fire spread for a sample of the wildfire runs used in the analysis. Open circles are the average for each fire run.

Very slow rates of spread were associated with periods where the headfire was held up by, but eventually crossed, a barrier (Fig. 2). We could not identify a clear acceleration trend in the segments downwind of a barrier once the fire breached it.

Effect of barriers on fire propagation

Of the 68 fire spread segments used in this analysis, a total of 41 segments had fire crossing, or breaching, barriers such as roads or other types of fuel breaks. Barrier characteristics varied from firebreaks and farm lanes, typically 3-m wide, to gullies (often with partially cured grasses) about 20 m in width. Firebreaks and roads ranged from poorly maintained to well-maintained with surrounding vegetation managed (e.g., cut or well grazed grass).

Under the burning conditions associated with the dataset, no road, firebreak or gully stopped a wildfire as such. We observed that most poorly maintained barriers up to 3.0 m wide did not impact propagation of a wildfire if it was spreading vigorously.

Management implications

Fire spread rates increased during periods of wind gusts, slowed down during wind lulls or when the flame front reached areas with low fire spread potential (e.g. creek lines), and was momentarily halted when roads or other barriers were of such a size that they limited propagation by reducing convective or radiative energy heat transfer. On average, the peak rate of fire spread was found to be almost three times higher than the typical (20-30 minute) average or predicted value.

Wider barriers, such as established roads 5–9 m wide, tended to significantly slow the overall wildfire propagation, and at times facilitated containment. When a wildfire reached such a barrier, the headfire would stop momentarily, with discrete ignition points observed to occur downwind of the barrier. It was observed that such ignitions could occur immediately or take minutes to materialise – up to ~10 minutes in some cases. This process was often repeated several times in the longer runs (e.g. Glenloth East fire, Fig. 4). This momentary halting of overall fire propagation and associated reduction in fireline intensity often allowed for successful containment of the fire at that location. However, we could not identify situations where any barrier, sometimes consisting of 15-m wide tracks, stopped a fire solely by itself.

Further reading

Cruz MG, Kilinc M, Gould JS, Anderson WR (2024) Observations of wildfire spread dynamics in southern Australian grasslands. *International Journal of Wildland Fire* 33, WF24095. (Free open-source access)

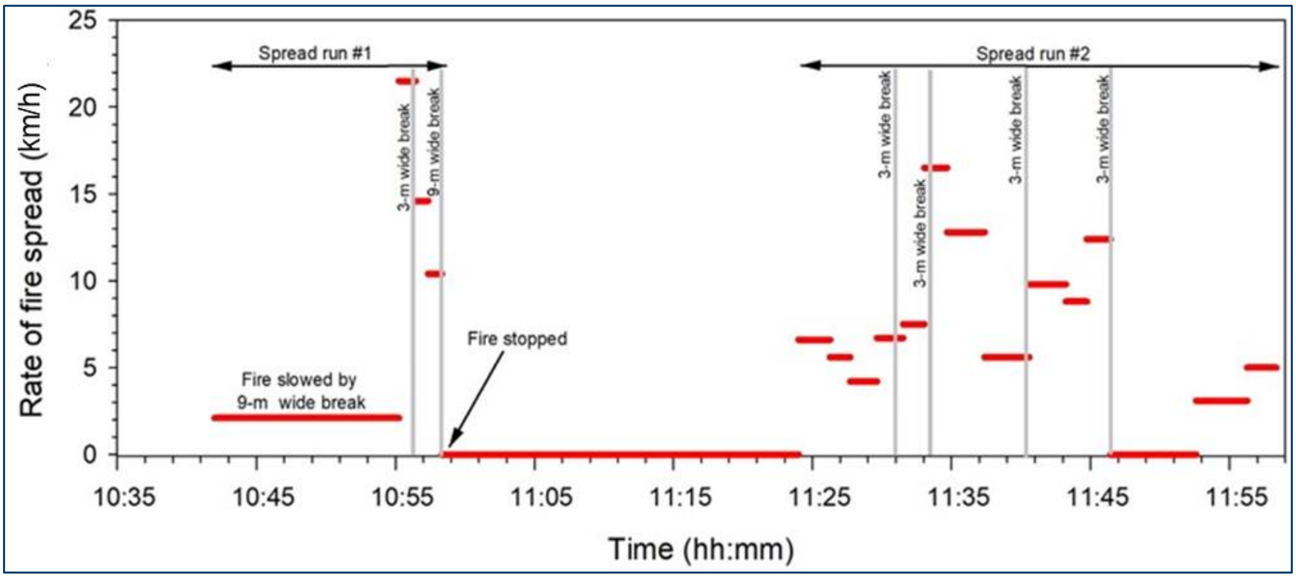

Figure 2. Variability in observed rate of fire spread in the Glenloth Road Fire. Red horizontal lines represent the average segment rate of fire spread; grey vertical lines represent barriers such as fire breaks.

FOR FURTHER INFORMATION

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