EXPERIMENTAL INVESTIGATION OF JUNCTION FIRE DYNAMICS, WITH AND WITHOUT WIND

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JUNCTION FIRES OCCUR WHEN TWO OBLIQUE FIRE LINES INTERSECT WITH ONE ANOTHER. THE INTERACTION OF THE TWO FIRE LINES MEANS THAT JUNCTION FIRES CAN EXHIBIT UNEXPECTED FIRE BEHAVIOUR, WITH ENHANCED RATES OF SPREAD IN THE VICINITY OF THE JUNCTION POINT. QUANTIFYING THESE INTERACTIONS IS ESSENTIAL FOR THE DEVELOPMENT OF NEXT GENERATION FIRE SPREAD MODELS, WHICH WILL ALLOW PREDICTION OF DYNAMIC FIRE PROPAGATION

BACKGROUND – SPOT FIRE COALESCENCE

Modelling the behaviour of spot fires that form ahead of the main region of a bushfire poses a significant challenge. As multiple spot fires coalesce with one another, they interact dynamically, and so behave in a way that is beyond the current predictive capability of operational fire spread models.

An important aspect of spot fire coalescence involves the case where two oblique fire lines intersect – such instances are referred to as 'junction fires' (see Figure1).

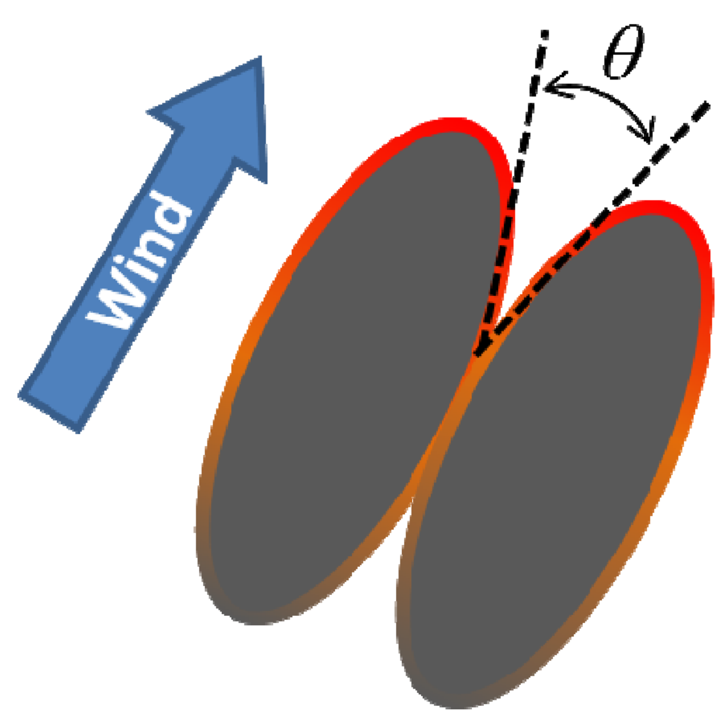

Figure 1: *Schematic of two wind-driven spot fires coalescing and forming a junction fire – indicated by the black dashed lines.*

Junction fires can exhibit high rates of spread at the point of intersection. The exact physical mechanisms that drive the enhanced rates of spread in junction fires are currently poorly understood, though convective and radiative interactions are likely candidates.

EXPERIMENTAL INVESTIGATION

To better understand the dynamics of junction fires, a number of experimental fires were conducted using the CSIRO Pyrotron. A number of intersection angles (θ) (see Figure 1) were investigated: 15°, 30°, 45° and 60°; and two different fire line lengths were considered: 800 mm and 1500 mm. Moreover, experiments were conducted in the absence of wind, as well as under the influence of a 1 m s^{-1} wind. All experimental fires were conducted using eucalypt litter with a fuel load of 1.2 kg m^{-2} and FMC of 4-6%.

RESULTS

Figure 2 shows an example of a junction fire spreading in the absence of wind. Of note is the fact that the fire spread inside the white ignition line is more pronounced than the fire spread outside the ignition line.

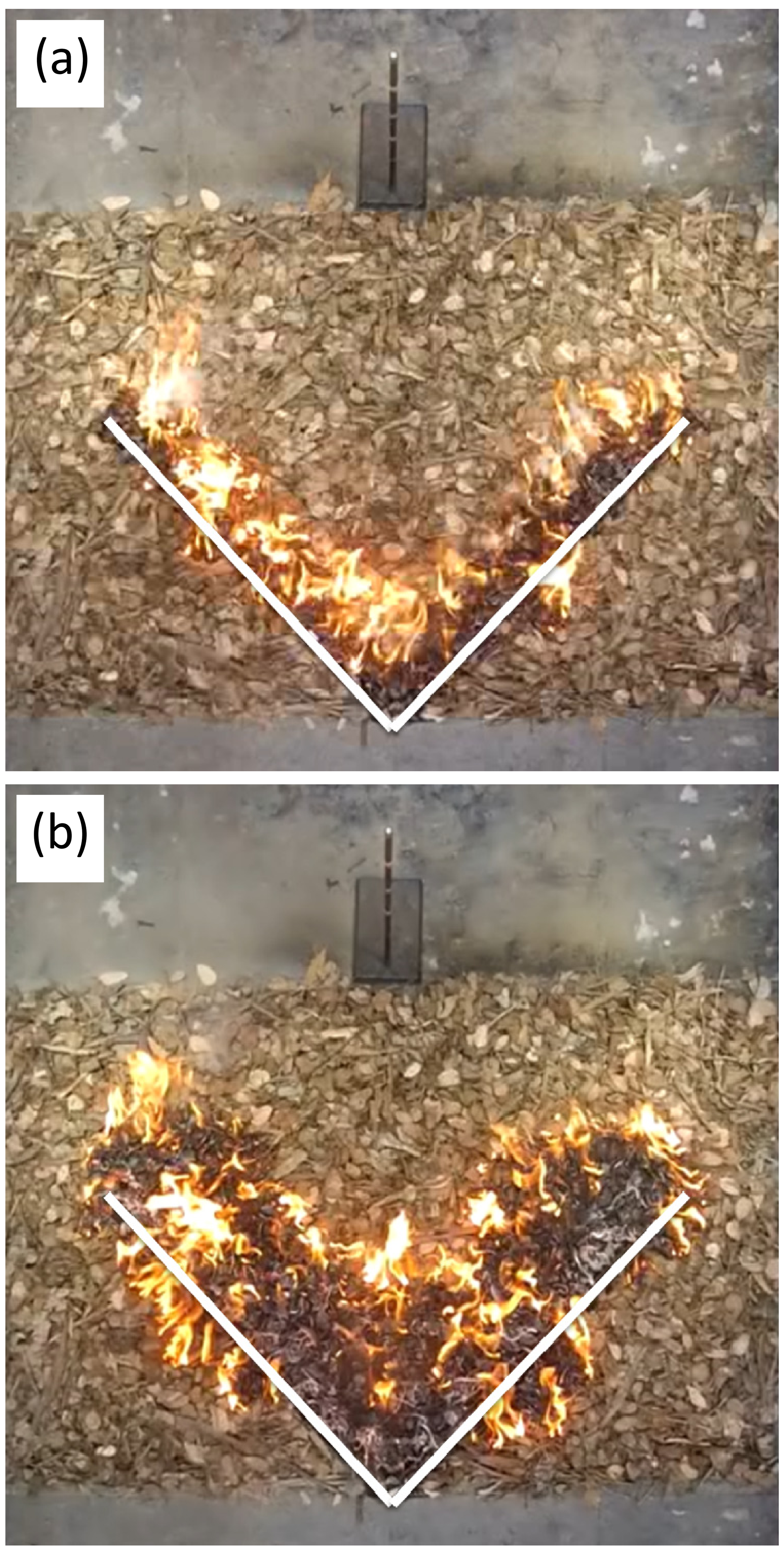

Figure 2: *Junction fire experiment with 800mm fire lines and no wind. The θ = 45° case is shown. The white lines indicate the position of the ignition line. Panel (a) shows the fire 10 seconds after ignition, while panel (b) shows the fire 30 seconds after ignition.*

ANALYSIS OF THE VERTEX SPEED

The speed of advance of the point of intersection of the two fire lines (referred to as 'the vertex') depends on the angle θ even if the two fire lines do not interact with one another. This cosec θ dependence forms a null hypothesis, which can be tested against for evidence of significant influence of fire line interaction on the vertex speed. The null hypothesis is represented by the dashed curve in Figure 3.

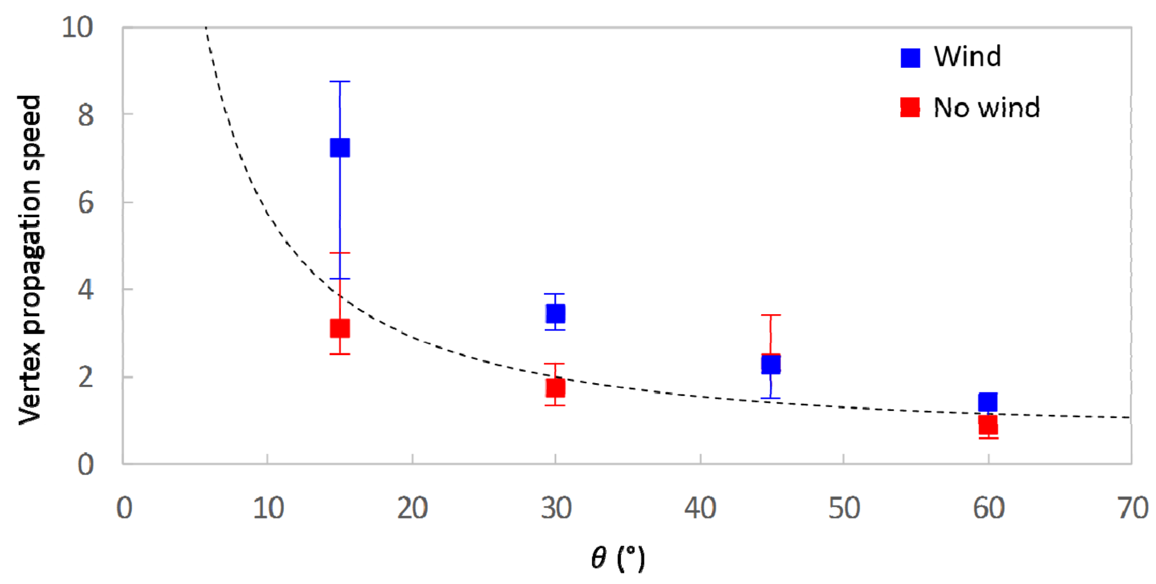

Figure 3: Plot of observed vertex speed *against* θ *for the wind and no wind cases. The black dashed line represents the expected vertex speed in the absence of fire line interactions.*

Figure 3 indicates that in the absence of wind fire line interaction has little effect on the vertex speed. In the presence of a 1 ms^{-1} wind, however, the figure indicates that the interaction between the wind and the fire lines does produce a significant enhancement of the vertex speed.

CONCLUSIONS

While there was evidence of fire line interaction slowing the advance of the fire outside the ignition 'V' line, the interaction did not produce a significant effect on the vertex speed inside the ignition 'V' line when there was no wind. In the wind-driven case, however, the vertex speed was significantly enhanced.

END USER STATEMENT

Dynamic propagation due to mass-spotting is a significant gap in current modelling capability. It's envisaged that when operationalised, this project will help address this gap for next-generation models.
Dr Simon Heemstra, Manager Community Planning, NSW Rural Fire Service.

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CSIRO UNSW AUSTRALIA SPOTFIRE PROJECT