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Fire spread and its prediction in wheat crops

Wildfires in cropland areas represent a significant threat to lives and livelihoods. Recent devastating fires highlighted the need to better understand the behaviour of fires in common crops and to quantify the ability of current fire spread models to predict fire propagation in these fuels. An experimental burning study was conducted in wheat crops to address these research questions. It found that current grassland fire spread models satisfactorily predict the spread rate of fires in these crops.

Fire spread in croplands

Understanding wildfire dynamics in cropland areas and being able to forecast the likely development (spread direction, speed and perimeter location with time) of a fire is at the very heart of Australian fire agencies' mission to warn the public of the possible threat of fire impacting their location to avoid or minimise detrimental effects. No fire spread model has been specifically designed for use on fires in cereal crop fuels. Instead, the models developed for continuous grasslands (Cheney *et al.* 1998) have been used for this purpose but with no clear indication of how these models performed in such fuels.

New research to address the need

This research, a collaborative effort by the Victorian Country Fire Authority and CSIRO (Cruz *et al.* 2019), aimed to collect data on fire spread in wheat in different harvest states or conditions and to evaluate the performance of the existing operationally-used grassland fire spread models in this crop type.

A large-scale field-based experimental study was conducted in during late summer in Victoria. A total of 51 experimental fires in 50 m × 50 m plots were undertaken in three crop conditions (Fig. 1): *unharvested* (mature crop unharvested at the time of burning), *harvested* (crop harvested for kernels using typical harvesting procedures) and *baled* (crop harvested for kernels and straw). The Grassland Fire Danger Rating ranged between Low (Grassland Fire Danger Index (GFDI) of 14) and Severe (GFDI 71) with more than half of the fires conducted at ratings of Very High or greater grassland fire danger.

Figure 1. Comparison of flame structure of three experimental fires in different wheat crop conditions with similar prevailing weather; top: unharvested (GFDI 23.4), centre: harvested (GFDI 27.6) and bottom: harvested and baled (GFDI 26.7).

Findings

Average standing fuel load varied between 5.3 t/ha for unharvested wheat and 1.3 t/ha for baled wheat. Horizontally matted harvest debris between rows in the harvested and baled conditions averaged 2.3 t/ha. Observed rates of fire spread ranged 2.4–10.2 km/h. Rate of spread and flame heights differed significantly between crop conditions, with the unharvested condition yielding the fastest spreading fires and tallest flames, and the baled condition the slowest moving fires and shortest flames (Fig. 1).

The fire spread models of Cheney et al. (1998) for fire in grass fuels satisfactorily fitted the data after appropriately taking into account crop fuel structure: i.e., unharvested wheat ≈ natural pasture; harvested wheat (~0.3 m tall stubble) ≈ grazed or cut pasture; and baled wheat (<0.1 m tall stubble) ≈ eaten-out pasture. The Cheney et al. (1998) fire spread models predicted the wheat fire data with mean absolute percent errors of between 21 and 25% with low bias (Fig. 2), a result on par with the most accurate published fire spread model evaluations.

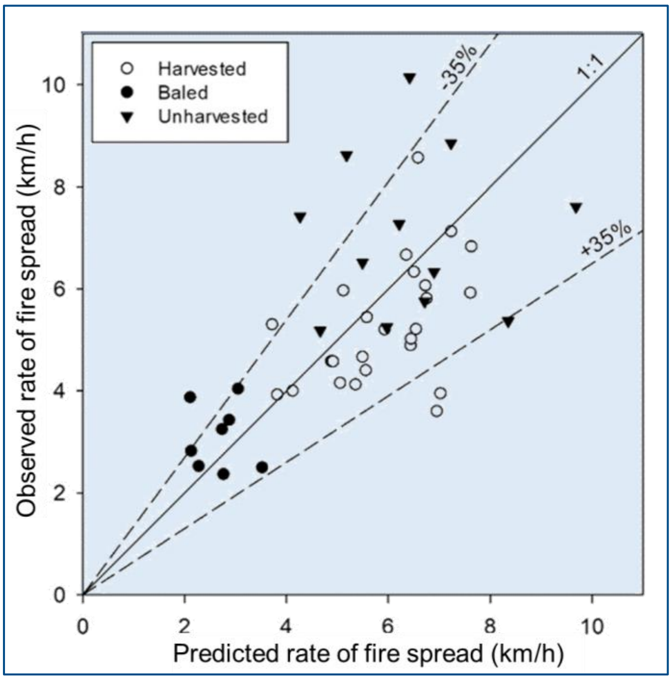

Figure 2. Observed versus rate of fire spread predicted by the Cheney et al. (1998) grassland fire spread models with the natural pasture condition used for the unharvested crop condition, grazed pasture condition used for the harvested crop condition and the eaten-out pasture condition used for the baled crop condition.

Management implications

The differences in fire behaviour observed in the different crop conditions can have a serious impact on fire suppression and firefighter safety. During harvest season, the landscape will be a mosaic of different crops in different conditions. Understanding the differences in potential fire behaviour as a fire spreads across such a landscape can be critical to determining the safest and most effective suppression actions and reducing overall economic impact. The greater flame heights of fires in unharvested crops will allow such fires to more easily breach roads and other barriers to fire spread such as paddock firebreaks and creeks, resulting in a greater potential for landscape-scale fire spread.

As many crop fires are started by machinery during harvest, knowledge of the differences in fire behaviour can be used to inform the pattern of harvesting within a paddock. Commencing harvesting at the down-wind end of the paddock will increase the probability that if a fire does start from the harvester, fire propagation with the wind in the harvested portion will be more manageable than if the fire burned into unharvested crops.

Differences in fire behaviour between the harvested and baled conditions suggest that baling, or simply harvesting to a lower height, could be used as a post-harvest fire mitigation method to reduce the speed and intensity of fires with a correspondingly greater potential for successful suppression and reduced landscape-scale spread.

Further reading

Cruz MG, Hurley RJ, Bessell R, Sullivan AL (2020) Fire behaviour in wheat crops – effect of fuel structure on rate of fire spread. *International Journal of Wildland Fire* 29, 258-271. doi:10.1071/WF19139.

References

Cheney NP, Gould JS, Catchpole WR (1998) Prediction of fire spread in grasslands. *International Journal of Wildland Fire* 8, 1-13.

Cruz MG, Hurley RJ, Bessel R, Sullivan AL. 2019. Fire behaviour in wheat crops. CSIRO Land and Water Client Report EP195825, Canberra ACT.

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