Modernised fire mitigation program

Report by Adj. A/Prof Philip Zylstra, commissioned by Kinglake Friends of the Forest Inc.

An opportunity exists to modernise fire management in the area to accommodate more recent science, in accordance with the principles of adaptive management.

Issues of concern

Analysis of Departmental mapped fire histories for the forests covering the Kinglake area has shown that fire promotes a pulse of increased flammability as forests regrow (Zylstra, 2018). This is a widespread phenomenon termed *Disturbance Stimulated Flammability* driven by trends in growth and succession (Lindenmayer & Zylstra, 2023; Zylstra et al., 2023), and is initiated by both planned and unplanned fire, as well as other disturbances such as logging and thinning (Zylstra et al., 2022). This effect was evident during the 2019/20 fires in the east of the state, where on the worst days, crown fire was far more frequent in forests with a recent history of disturbance, compared to all older stands (Lindenmayer et al., 2021).

This has important implications for prescribed burning, as this form of disturbance may create a short-term advantage, but then impose a long-term increase in fire risk. Our concern is that any benefits of the short-term advantage may be too limited to justify the long-term cost of the practice. Following the 2009 Black Saturday fires, one analysis found that prescribed burns provided a small (15%) reduction in house loss, but only if conducted within 500m of houses (Gibbons et al., 2012). This study examined a subset of houses lost, but a subsequent analysis that examined all houses found that in fact, both house loss and the likelihood of crown fire close to houses *increased* if prescribed burning had been conducted within one km of the urban interface (Price & Bradstock, 2013). In addition, burning imposes immediate costs via smoke impacts that are far greater on a per-hectare basis than the effects of bushfire smoke (Borchers-Arriagada et al., 2021). For example, more deaths were attributed to a single week of prescribed burning in the Sydney area than have been recorded for all direct bushfire deaths in the same area (Broome et al., 2016).

In addition to these concerns, the current state of forest regrowth still contains a higher-than-average density of disturbance-stimulated species such as bracken and *Cassinia*, and prescribed burns in such forests will likely burn with greater flame heights and cause more scorch than expected. Crown scorch is an important consideration for vegetation, but also for the scale of Disturbance Stimulated Flammability that will be initiated by the burn, and as an indicator of fire impacts on arboreal fauna. For example, the only published evidence available for Greater Gliders states that prescribed burns causing any degree of crown scorch pose a threat to animals (McLean et al., 2018). Based on surveys we conducted in dry forests during November 2023 and models of thinning for these species (e.g. (Tolhurst & Burgman, 1994)), Dr Philip Zylstra used the state of the art fire behaviour model FRaME (Fire Research and Modelling Environment (Zylstra, 2021; Zylstra et al., 2016)) to calculate the likelihood of different levels of crown scorch that could be expected from prescribed burns as the forest ages. Although these results are based on limited data and projected growth trends, they do provide an improved understanding of the issue. The central finding was that prescribed burns are likely to cause some degree of scorch until at least 20 years have passed from the previous fire (Fig. 1).

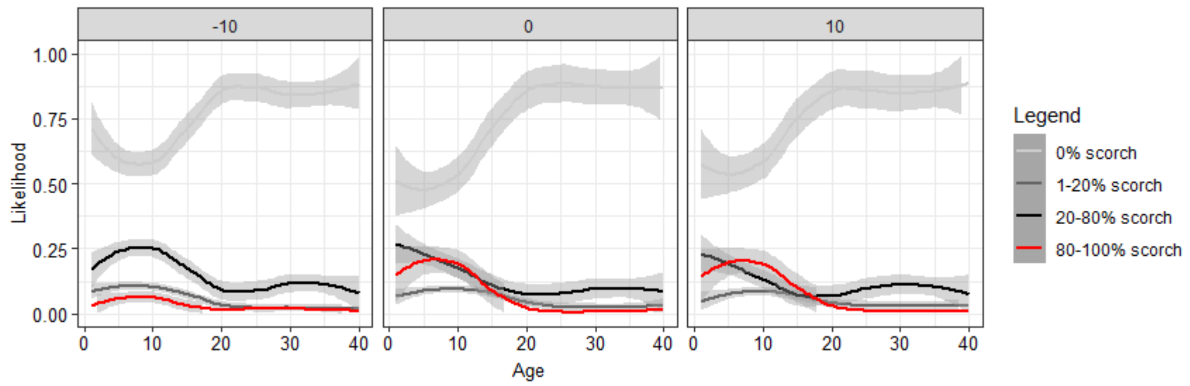

Figure 1 | Modelled likelihoods of canopy scorch for three different slopes. Lines show the smoothed likelihood of each scorch scenario occurring within the prescription, across the age range. Shading around each line shows one standard error.

Reasons for the lack of scientific adoption

Although these points have been published in high-quality peer-reviewed journals and conducted by world-leading experts, they have little to no influence on current fire management practice. All such complexity is assumed to be covered by the modelling conducted using Phoenix RapidFire, but this is not the case. Phoenix predicts fire spread as a function of fuel load, but the effect of fuel load on rate of spread has been comprehensively disproved (Burrows, 1999). Project Vesta work demonstrated empirically that the rate of fire spread and the height of flames were both determined by the height and cover of understorey vegetation (Cheney et al., 2012; Cruz et al., 2021), whereas most of the fuel load was present in surface litter which by itself could only produce "*a low-intensity state (henceforth called Phase I) associated with short flames*" (Cruz et al. 2021). Recent developments of fire risk modelling using Phoenix acknowledge that "*Improved fire behaviour models have been developed (Storey et al., 2021; Cruz et al., 2022) but these have yet to be fully operationalised and in most regions Phoenix is still used*" (Clarke et al., 2023). The first model cited here (Storey et al., 2021) found *no effect* of fuel load on fire spread, but did not investigate any other fuel-related drivers of fire behaviour. The second model (Cruz et al.) is the Vesta work we have just outlined, which concluded that "*the best fuel descriptor from the point of view of the operational prediction of fire spread is the height of the understorey fuels. This variable is defined as the average height of both the near- surface and elevated fuels weighted by their cover on a per area basis.*" Critically, the increase in the height and cover of understorey fuels promoted by prescribed burning is central to the issue of Disturbance Stimulated Flammability that we are raising here. If either of these two models that the authors acknowledge to be improvements were used, all support for prescribed burning would disappear.

Proposed solutions

Flammability trends can be characterised in three stages of 'Young' (very recently burnt) forest with low flammability, highly flammable 'Regrowth' forest typified by denser understoreys and sometimes less canopy cover, and low flammability 'Mature' forest where taller vegetation has been fully restored and the understorey has self-thinned. Two statistics are useful for management purposes in this regard – the number of years after fire for which the forest has ≤ the flammability of mature forest, and the number of years after fire until it reaches maturity. Most of the EVCs in the Kinglake area fall within the 'dry forest' classification in the Zylstra (2018) study. Dry forest has ≤ the flammability of mature forest for 2 years after fire, and reaches the mature stage by 19 years.

For the forests of Kinglake burned in 2009 then, these forests are now past their peak flammability and will reach a lower-than-average state of flammability by approximately the year 2028. Due to the current cover of bracken and other fire-stimulated understorey species, burning these forests in their current state will likely cause some degree of crown scorch over ~50% of the area even under careful prescribed conditions (Fig. 1). Based on historical trends, any benefit from such a burn will only last 2 years, and all progress in restoration toward a long-term low-flammability state will be undone.

Our proposed alternative is that as these forests have already passed through 13 years of increased fire risk (15 years less the 2 years of initially lower risk), they should now be protected from fire for the remaining 4 years until they begin to enter their period of lower risk. Fire risk will continue to decline after this point, creating a broad landscape of reduced fire risk.

An important component of excluding fire will be improved rapid detection and suppression. Significant technological developments are occurring in this area (Lindenmayer et al., 2022), but existing technology can already be brought to bear in the form of fire detection cameras that locate heat signatures and/or smoke. A well-designed network of such cameras that maximises view factors from each could be a cost-effective method to detect new ignitions at a pace that will enable much faster suppression. This needs to be supported by adequate resourcing of small plant/aircraft and remote-area fire fighters.

FRaME modelling can be used to better guide suppression decisions, by identifying thresholds within which techniques such as direct or parallel attack can be deployed. Developing these thresholds will require further field survey and modelling, but also improved intelligence regarding local weather conditions. To this end, we suggest the establishment of a weather station in the Kinglake area, as terrain effects can cause very different weather phenomena here than are reported for lower stations in the region. Ideally this would be established as part of the BOM network, but if this is not possible, a small weather station can easily be established to BOM standards. The main limitation to this and the establishment of smoke detection cameras is the location of suitable sites.

To further fortify the landscape, there may be a place for extremely frequent prescribed burns or mechanical clearing of the understorey, but we stress three considerations for these:

1. As disturbances such as these stimulate regrowth, they will only provide a net benefit if they are as close to the two-year period of frequency as possible.
2. Such intensive disturbance should only be conducted in tightly limited areas where fire fighters can be safely placed during an incident.

3. If located close to houses, mechanical means such as brush cutters should be considered in preference to burning, to minimise impacts from smoke and the risk of escape.

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