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STAND RECOVERY DYNAMICS AFTER THE 2003 WILDFIRES IN THE A.C.T.

Rick McRae*
ACT Emergency Services Agency, Canberra, Australia. rick.mcrae@act.gov.au

The 2003 wildfires were among the most intense extreme wildfires recorded in Australia. Post studies of these fires have significantly expanded global understanding of the drivers of extreme wildfires. A range of new scientific breakthroughs have resulted.

Being extreme wildfires (*sensu* Sharples, *et al*., 2016) they exhibited behaviour patterns unlike those of fires typical in that landscape. Then-unknown fire dynamics (vorticity-driven lateral spread) caused sheltered, mesic sites to burn more intensely that exposed, xeric sites. Forest types with long-recovery times after fire were burnt, in places at extreme intensities. It was clear from post-fire surveys that understanding the recovery process would be valuable for future landscape and bushfire risk management.

The vegetation recovery has been studied from a range of perspectives. Discussed here is an ecological longitudinal study of the structural recovery from a fire fuel perspective. Sampling addressed the main combinations of vegetation community and fire intensity class in 2003. Thirty-three study sites across the landscape (Figure 1) have been revisited since shortly after the fires and a wide range of physical parameters recorded. This parameter set allows assessment of stand recovery and spatial biomass and fuel configuration. Together these allow assessment of how fires might behave within the fuel structure, and the evolution of this over time provides insight into the return of wildfire risks on that landscape.

Introduction

Much has been written about the fires in the ACT on 18th January 2003. (See Barrett, 2006, Dold, *et al*., 2005, Fromm, *et al*. 2006, McRae, 2004a & Mills, 2005.)

A number of studies have explored the impact of the 2003 alpine fires on the vegetation in the ACT, NSW and Victoria (see Coates, *et al*., 2012, Doherty, 2014, Kitchin, *et al*., 2013 & Williams, *et al*., 2008).

This body of work has explored how a wide range of ecological parameters has evolved post fire. Most of the work has focussed on supporting future fire management – with an emphasis on landscape management. What has been under-represented is a quantification of the impacts on future protection of the community from wildfires, including potential fire behaviour and suppression difficulty.

From the outset, data collection aimed to provide a comprehensive description of stand configuration in a way that would allow a first-approximation estimate of flame propagation through the stand. However field inspection indicated that likely regeneration dynamics would make fuel dynamics and standard steady-state fire spread models at least partially inapplicable.

Data

The usual approach for handling the effects of fire on future fire risk to the community is to use an “Olsen Model” (Good and McRae, 1989) for fine surface fuel accumulation. For the ACT, implementation of such models has been discussed in Good & McRae, (1989) and Kessell

(1990). This model makes assumptions about the stand biomass and its dynamics. The rate at which the canopy sheds leaves, which become part of the litter layer, is held constant, while litter decomposition slowly build up, with an equilibrium reached after a characteristic number of years.

Where the fire intensity, and thus also the fire impact level, was extreme these assumptions were clearly not valid. There was a need to record data on the stand structure as it recovered from the fire. This data would support on-going risk assessments and also serve as a detailed record of the recovery trajectories of the vegetation.

Methods

As the typical fine fuel accumulation models were not necessarily valid, more broadly applicable methods were required.

A structural model was used (McRae, 2004b). This model assumes:

- Six zones or strata of vegetation, which may or may not carry flammable material.
- Convective flame heating and mass transfer of burning embers. Radiation in particular has no role.
- A logistic function to describe horizontal percolation.
- Flame size reflects the properties of the vertical array of fuel particles rather than fuel load. This is directly equivalent to fuel hazard ratings.
- Wind speed at any layer depends on the bulk wind, the proportion of total biomass above that layer and the fire's indraught.
- The convection and wind are in balance and that flame angles reflect this balance.

The model works for any vegetation type given an adequate description of the fuel geometry. The parameters for this description are, for each layer, i: i = 1 (highest) to 6 (surface).

- A stratum type: (C)anopy, (E)picormic regrowth, (W)oody stems, (R)egeration by seedlings or lignotuber, (T)all shrub layer, (S)hrub layer, (G)rasses, graminoids and herbs, (L)itter and (A)erated down timber.
- Maximum and minimum heights.
- A patchiness index, ranging from 1 for spatially sparse to 10 for spatially uniform.
- A complexity measure, showing the typical number of fuel elements vertically in the layers.
- A set of fuel hazard scores (Hines, *et al*., 2010).

The model produces site values, based on values for all the layers: Fuel Moisture Content; Fire Danger Index; maximum rate of spread; maximum flame height.

From time-to-time the field sites were visited and the parameters for each layer recorded. Photographs were taken. At times an exact revisit was not practical due to occasional disturbances such as the falling of dead timber stags. In such cases a nearby equivalent site was selected.

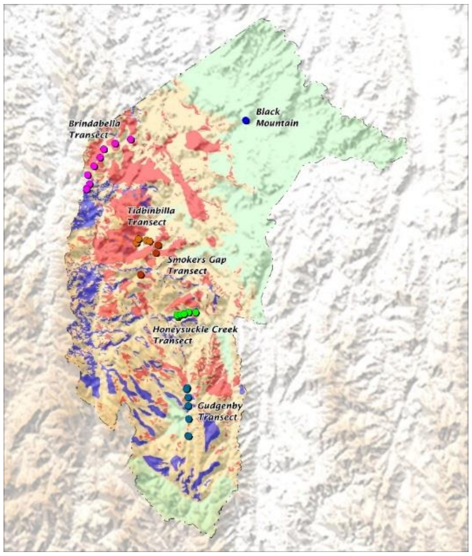

Figure 1. Field sampling points, grouped into transects. The background colours represent burn intensity class for the 2003 fires: red= blow-up fire event, orange = intense fire, blue = mild fire or grassfire, green = not burnt.

Figure 2. Early regeneration, showing shooting from lignotubers (left) and (right) epicormic regrowth. Regeneration from seedlings was typically slower to commence.

Findings:

Key outputs include:

- Canopy recovery processes. Some stands had their canopy unburnt, others replace the canopy *in situ* through epicormic regrowth, while yet others replace the canopy completely through seedling growth or lignotuberous regrowth (Figure 2). A lot of sites have fully returned to their pre-fire condition. These are primarily those burnt with a moderate intensity and those in Dry Sclerophyll Forest.
- Structural dynamics (Figure 3), including the emergence of the crown gap. When an emerging new canopy separates from shrub layers it creates a zone of lower friction that allows easier horizontal air flow, changing the wind profile significantly. Also, some structural layers have formed and decayed during the study to date. Foliage senescence is a key elevated fuel hazard source.
- Dynamics of fuel layers and their hazard scores. For a number of sites fine fuel recovery of the "Olsen Curve" type has not yet commenced, reflecting delayed onset of fuel accumulation during regeneration. After a significant delay, a number of sites are now showing raised fuel hazard scores (Figure 4). Bark hazard is typically low, due to (i) stags already clean of bark; (ii) regen not yet forming bark depth; and (iii) significant bark loss in 2003. A significant challenge for the fuel modules within steady-state fire spread models is how to assign a value to fuel age.

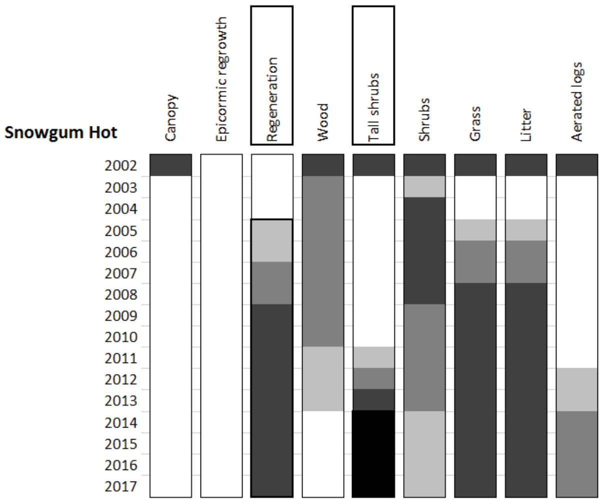

Figure 3. Example of structural dynamics for a typical hot burnt Snow Gum woodland stand. Two anomalous layers are highlighted – these will need to disappear before pre-fire conditions return. The decline of S as R builds-up indicates the return of the free air crown gap under the canopy.

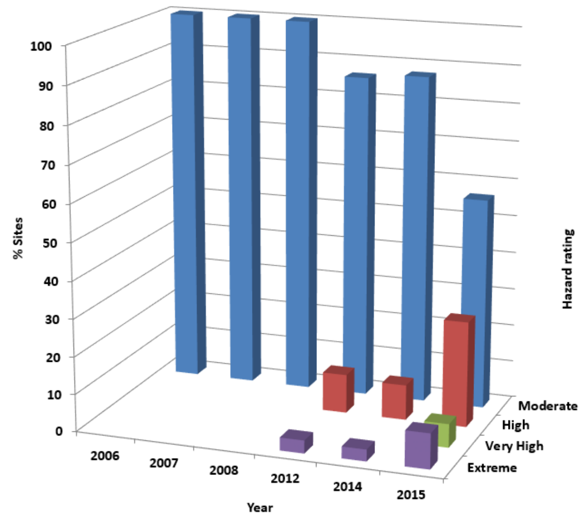

Figure 4. There was a commencement of raised Surface Fine Fuel Hazard (SFFH) after 2014 (11 years post-fire).

Figure 5. Dead stags above an intensely burnt Ash Forest stand.

Figure 6. Ash regeneration (background) is still impenetrable. Not only is access dangerous, but maintenance of situational awareness is impossible negating any safety planning. Note the dense anomalous shrub layer in the foreground.

Figure 7. Changes over a decade in the understorey of Snow Gum woodland burnt in mild conditions to protect a logistics base.

- Initial stages of the long-term decay of standing stags. Some mesic stands are still dominated by standing dead stags (Figure 5) and also have extreme stem density from canopy regeneration (Figure 6). Both processes make suppression operations there dangerous.
- Shrub layer dynamics. This includes shrub layer regeneration, transient anomalous extra shrub layers (Figure 6 and Figure 7), and layers of "invasive" fire adapted species.
- An assessment of the return of stand flammability. With structural data on all layers, including height, patchiness and element density, it is possible to apply a simple flame penetration model (McRae, 2004b). This indicates at which stage in the recovery process different layers may be involved in fires on days of raised fire danger. The nature of fire behaviour within stands can be anticipated (Figure 8).

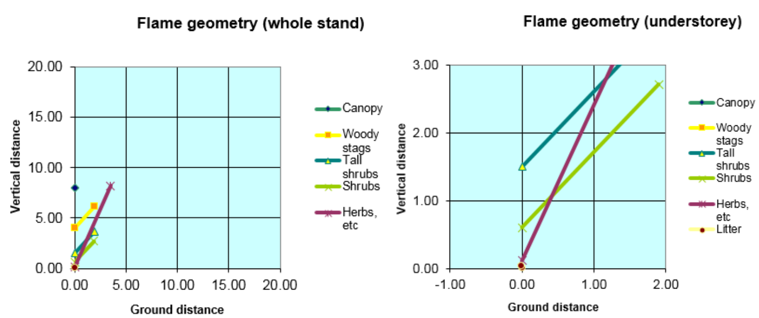

Figure 8. Modelled flame geometries for the current state of hot-burnt Snow Gum woodland, for a hot, dry and windy day on a steep slope.

Table 1. Distribution of fuel accumulation and fuel hazard scores.

Fuel accumulating?	% area	EFH	% area	SFFH	% area	FH	% area
Yes	42	Mod	1.9	Mod	29.5	Mod	5.4
Not yet	18	High	38.2	Mod/High	29.5	Mod/High	25.0
N/A	40	High/VH	4.5	High	0.2	High	9.8
		Very High	13.0	Very High	0.5	High/VH	4.5
		Extreme	2.3	Extreme	0.3	Very High	13.0
		N/A	40.0	N/A	40..0	Extreme	2.3
						N/A	40.1

- The distribution of recovery status across the landscape (Table 1) provides valuable guidance for managing bushfire risk.
- The documented recovery trajectories can be applied after future fires to better predict the time until return of wildfire potential.

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