SHORT-TERM IMPACT OF A MEGA-FIRE ON SMALL MAMMAL COMMUNITIES DURING PROLONGED DROUGHT

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Increased size, severity and frequency of wildfire is predicted as a consequence of prolonged droughts associated with climate change. In south-eastern Australia severe landscape-scale wildfires (mega-fires) have elicited a strong anthropocentric response due to the significant life and property impacts. However, the impact of mega-fires on fauna, habitat and subsequent management actions are poorly understood. Small mammals were surveyed to examine mega-fire impact using the post-2006 wildfire landscape of the Grampians National Park, Victoria, Australia. Long-term research sites were established with 9620 trap nights completed in autumn 2008 across thirty-six sampling units. Vegetation structure, floristics, fire severity, patch size and overall fuel hazard were measured to investigate correlations with changes in small mammal abundance. Two years post-wildfire, rapid resurgence of house mouse (*Mus musculus*) was detected, conversely the abundance of native small mammal species was severely impacted. No sampling category within the burnt perimeter provided superior refuge presenting potential conservation implications. A habitat vacancy model is introduced where small mammal recolonisation post-wildfire depends on a lack of isolation and connectivity of populations. Floristic and structural contributions of vegetation to higher overall fuel hazard areas are essential in maintaining diverse fauna assemblages. As such, prescribed burning or fire suppression tactics such as 'patching out' or 'burning out' require consideration when contributing to further reduction of complex habitat patches following fires.
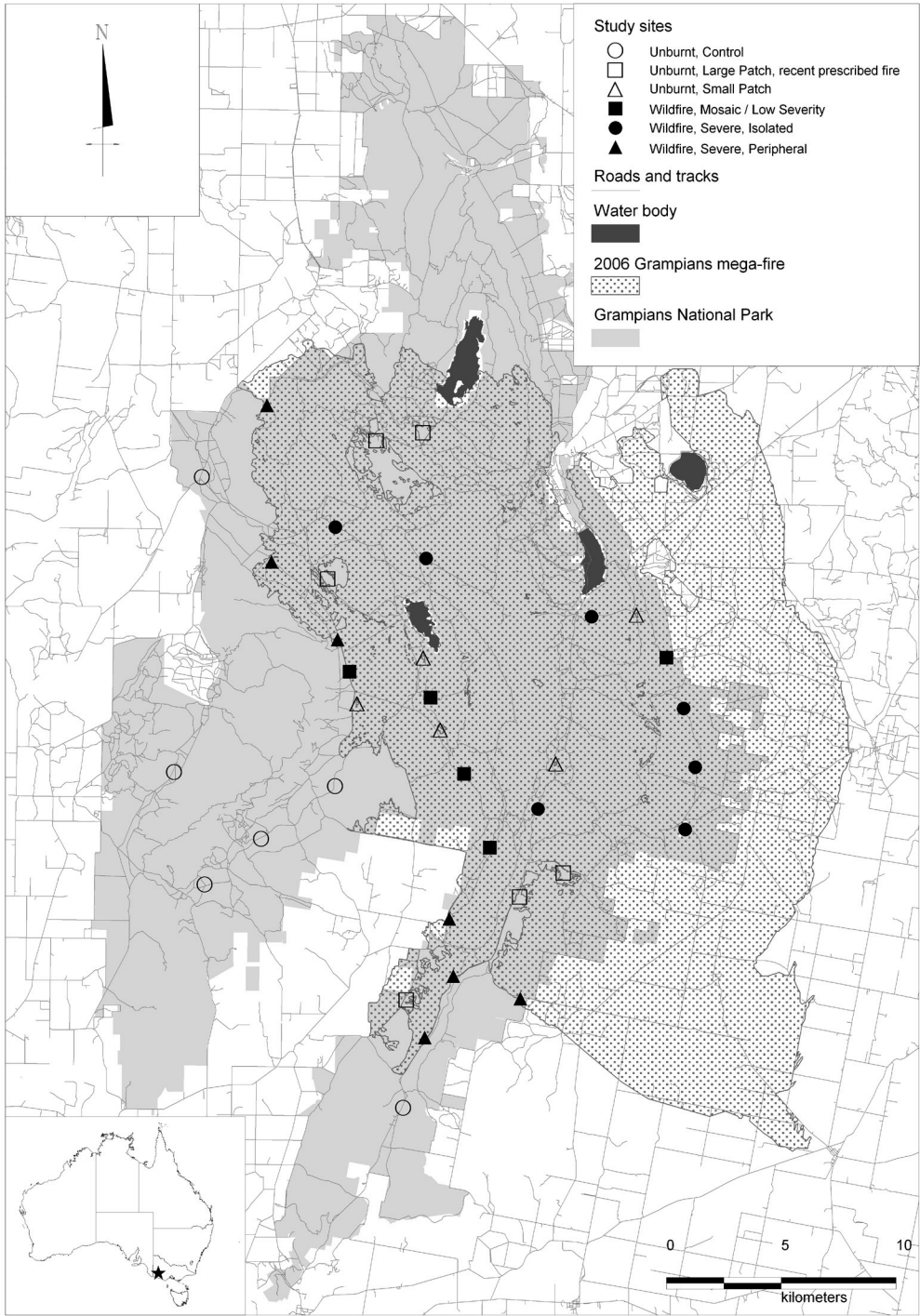
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Most research investigating the long-term impact of fire has largely focussed on flora (Clarke 2008) with faunal responses examined in a limited number of studies (Newsome et al. 1975; Fox 1982; Wilson et al. 1990; Letnic et al. 2005; Larsen et al. 2007). Furthermore, few studies have investigated the impact that severe landscape-scale wildfires, recently labelled mega-fires (Williams et al. 2011), may have on fauna when leaving landscapes that are homogenously severely burnt with minimal unburnt vegetation (Catling et al. 2001). In particular, small terrestrial mammals may be susceptible to mega-fires due to their dependence on the habitat value associated with vegetation structure (Fox 1982; Monamy & Fox 2000; Rees & Paull 2000). This is important when considering small terrestrial mammals provide ecosystem processes such as assisting nutrient cycling, soil water penetration, dispersal of seed and hypogeal fungi and act as food resources for forest predators (Converse et al. 2006; Monroe & Converse 2006).

The development of patchy fire mosaics has been hypothesized as creating differing successional habitat, patch size and connectivity (Clarke 2008).

Patchy fire mosaics therefore, have the potential to reduce isolation and create dispersal opportunities, and provide shelter, nesting, breeding sites and rich food resources for fauna (Fahrig 2003). These resources can significantly influence the ability of fauna to survive and re-populate burnt areas more rapidly than in large homogenously burnt areas (Newsome et al. 1975; Fisher & Wilkinson 2005; Letnic & Dickman 2005). Following mega-fire, dispersing individuals may not find suitable habitat to colonise with the long-term viability of fauna populations likely to be linked to the fate of individuals surviving in limited patches of un-burnt vegetation (Day & Possingham 1995; Fisher & Wilkinson 2005; McAlpine et al. 2006; Hannah et al. 2007).

While knowledge exists on individual species responses to fire and successional changes in vegetation structure, there is a critical knowledge gap associated with the impact of mega-fires on fauna. To mitigate against potential future impacts of climate change, mega-fire impacts require investigation as these events are expected to increase in scale, frequency and severity (Rosario & Mathias

Study sites

○ Unburnt, Control
□ Unburnt, Large Patch, recent prescribed fire
△ Unburnt, Small Patch
■ Wildfire, Mosaic / Low Severity
● Wildfire, Severe, Isolated
▲ Wildfire, Severe, Peripheral

Roads and tracks

Water body

2006 Grampians mega-fire

Grampians National Park

2007; Dunlop & Brown 2008). It is assumed that these wildfires will have a more pronounced impact on biodiversity than prescribed fire, exacerbating existing fragmentation effects with significant implications for the conservation and persistence of rare species (Gill 1999; Sinclair & Byrom 2006; Rosario & Mathias 2007; Clarke 2008).

This paper investigates the early, two year, post-fire response of small mammals to a mega-fire that occurred in 2006 at the Grampians National Park, Victoria, Australia. Lightning started the fire, burning 128 814 ha of public and private land affecting 80 873 ha, approximately 47%, of the National Park (Department of Sustainability and Environment 2006; Friends of the Grampians-Gariwerd 2007; Fig. 1). The period leading up to and post the fire had been one of the driest periods on record (Bureau of Meteorology 2012).

METHODS

Study Site
The Grampians National Park is an iconic, national heritage listed reserve containing a high level of floristic endemism and Ecological Vegetation Class (EVC) diversity (Tumino & Roberts 1998; Parks Victoria 2003; Commonwealth of Australia 2007). The Grampians is dominated by brown stringybark (*Eucalyptus baxteri*) heathy woodlands with rainfall varying with both latitude and altitude ranging north to south from 550mm to 700mm and up to 895mm in central mountainous reaches (Sibley 1967; Cayley & Taylor 1997; Tumino & Roberts 1998). Bushfires have been regular with significant fires occurring in 1851, early 1900's, 1939, 1942 and 2006 (Sibley 1967; Parliament of Victoria 2008). Rainfall in the decade prior to 2008 was lower than any previously recorded decade with four of ten years receiving extremely low rainfall (i.e. less than the mean -1sd) with nine of ten years receiving below average rainfall (Bureau of Meteorology 2012).

After the 2006 Grampians wildfire the Department of Sustainability and Environment procured detailed aerial imagery to map fire severity supported with field validation (Victorian Government 2006). Over 75% of the burnt area was classified as having the entire canopy removed or being severely scorched with complete loss of understorey. Approximately 16% was classified as moderate to light crown scorch. However, the fire weather conditions resulted in a large contiguous area being burnt with only 3.4% unburnt vegetation remaining in isolated patches within the burn perimeter.

To minimise potential sources of variation and confounding error in this study, a process of stratification and sampling unit selection criteria were applied. Thirty-six sample units were located within the National Park's fox poison baiting perimeter (to standardise for management actions) and were below 470 m elevation to mitigate against topographic influences. Sampling units were placed within the predominant Heathy Woodland EVC (with some areas of Sand Heathland) to reduce habitat differences and had 2 km between other sample units to enhance site independence.

The 36 sampling units were divided into two broad areas, areas burnt by wildfire (n=19) and unburnt (n=17). Three unburnt sampling categories consisted of i) control sites, ii) recently prescribed burnt large patches and iii) small patches (Fig. 1). Control units (n=6) were selected as reference sites, being at least 2 km from the wildfire perimeter and averaged 29.7 years post-fire (ranged from 12 years to no record) . Small patches (n=5) of unburnt vegetation averaged 5.7 ha in size (ranged 3.2–15 ha), were isolated within the wildfire perimeter and averaged 36.8 years post-fire (ranged from 3 years to no record). Large patches (n=6) averaged 345 ha in size (ranged 104.8–959.4 ha) and were prescribed burnt one to three years prior to the 2006 wildfire and did not re-burn. The three sampling categories in the area burnt by wildfire were i) peripheral, ii) isolated and iii) low severity (Fig. 1). Peripheral units (n=7) were located in 2006 fire affected areas of complete canopy loss or severe crown scorch within 300 m of the contiguous unburnt area and averaged 23.4 years post-fire prior to 2006 (ranged 11–44 years). Isolated units (n=7) were in 2006 fire affected areas of complete canopy loss or severe crown scorch at least 3km from the contiguous unburnt area and averaged 43.7 years post-fire prior to 2006 (ranged 23–69 years). Low severity units (n=5) were within 2006 fire affected areas of light to no canopy scorch with small pockets of unburnt ground vegetation occurring within them and averaged 19.6 years post-fire prior to 2006 (ranged 3–42 years).

Forest management records were not available for the Grampians, therefore historic practices such as

Fig. 1. Locality map of the Grampians National Park study site, extent of the 2006 severe landscape-scale wildfire (mega-fire) and distribution of sampling units. (facing page)

timber harvesting and forest thinning was not able to be considered as a potential source for confounding error when considering sample unit placement. Grampians fire history records date back to 1939 and GIS analysis indicates similar regimes for time-since-fire, fire interval and fire frequency across most sampling units. One exception exists, with recently prescribed burn large patch units having relatively young time-since-fire (approximately 4 years) compared to other unburnt sampling units (approximately 30 years).

Focal Patch Study

This research used the 'focal patch study' design presented by Brennan et al. (2002) that considers response variables are dependent on the landscape context, or characteristics surrounding the sampling unit. A focal patch is a discrete, non-overlapping landscape of contiguous and homogenous habitat surrounding a sampling unit. This approach addresses concerns that species movement may be larger than the sampling unit or patch size, patch quality can be variable at a small scale and interpatch movement can be influenced by the surrounding matrix cover types (Dunning et al. 1992; Brennan et al. 2002; Holland et al. 2004; Bender & Fahrig 2005).

A focal patch study approach, using strict non-random selection criteria increases the ability to extrapolate results from single sample units across a landscape (Brennan et al. 2002). The Victorian Government (2006) fire severity mapping combined with verifying sample unit placement in the field was essential to confidently position sample units in the landscape context of various sampling categories.

Small Mammal Trapping

Small mammal trapping was undertaken from April to July 2008. Trapping was conducted on a 2.25 ha (150 m x 50 m) trapping grid for four consecutive nights. Forty-nine 'Elliot' traps (330 x 90 x 100 mm) were laid at 25 m spacing's for a total of 196 trap nights per site. Sixteen wire cage traps (490 mm x 205 x 175 mm, hanging bait bucket design) were laid concurrently at 50 m spacing's providing a total of 64 trap nights per site.

Captured individuals were identified in the field to species level using Menkhorst and Knight (2001) and sexed and weighed. Each animal was uniquely identified with a numbered fingerling ear tag (model #1005-1, National Band and Tag Co., Newport, KY, USA) and released at the point of capture immediately

after processing.

Habitat Characteristics

Five, 10 m radius sampling plots were located at the centroid and mid-point of each of the four sides of the trapping grid to measure vegetation structure, simplified vegetation cover abundance (CA) and fuel hazard levels.

Vegetation structure was measured from five points at each of the five sampling plots (25 measurements per site) as hits of live and dead vegetation in 10 cm intervals along a two-metre pole to a maximum of 10 hits per interval. Simplified vegetation CA was measured (e.g. grass, sedge, Leptospermum, prostrate heath) and included logs (considered > five-centimetre diameter (Larsen et al. 2007)).

Detailed measurements were recorded for surface fine, near surface, elevated and bark fuel and used to determine overall fuel hazard in accordance with descriptions in McCarthy et al. (1999) and Department for Environment and Heritage (2006). Surface fine fuel was measured from five points at each of the five sampling plots (25 measurements/ site).

Statistical Analysis

Single factor analysis of variance (ANOVA) with post-hoc Tukeys test comparisons were conducted using SPSS (version 12) to determine significant differences in species richness and abundance between sampling categories.

To reduce the effects of colinearity within vegetation structure and simplified vegetation measures, Principal Component Analysis (PCA) data reduction with Kaiser Normalization were used to reduce the number of variables using a varimax rotation. Data with correlation coefficients < 0.6 or > -0.6 were considered independent factors. These reduced PCA data were used in ANOVA with post-hoc Tukeys test comparisons of habitat differences between sampling categories. The PCA predictor variables were used to examine correlations between response variables of small native mammal species richness and abundance, and house mouse (*Mus musculus*) abundance. These correlations used bivariate Spearmans correlation coefficient and two-tailed tests of significance with SPSS.

RESULTS

Small Mammal Trapping

Thirty-six sampling units across six sampling

Table 1. Small mammal trapping results by species for the Grampians National Park two years post mega-fire. Numbers against each species represent number of individuals, and percent of sites detected in parenthesis. * = introduced species. Native richness numbers represent mean ± standard deviation.

Area	Unburnt			Burnt (wildfire)			
Sampling category	Control	Large patch	Small patch	Severe, peripheral	Severe, isolated	Low severity	Total
Number of sample units	6	6	5	7	7	5	36
Agile antechinus	12 (68%)		5 (40%)		2 (29%)		19 (22%)
Yellow footed antechinus	1 (17%)						1 (3%)
Dusky antechinus	1 (17%)						1 (3%)
Common dunnart				2 (14%)			2 (3%)
Eastern pygmy possum					1 (14%)		1 (3%)
Sugar glider	1 (17%)						1 (3%)
Brush tailed possum		2 (17%)	1 (20%)				3 (5%)
Heath mouse	10 (68%)	1 (17%)		3 (14%)			14 (16%)
Swamp rat	1 (17%)						1 (3%)
Black rat*					2 (14%)		2 (3%)
House mouse*	1 (17%)	22 (83%)	47 (80%)	32 (71%)	140 (100%)	28 (80%)	270 (70%)
Native richness per site	1.38±0.52	0.52±0.21	0.89±0.40	0.49±0.18	0.53±0.20	0.00±0	
Total native Individuals	26	3	6	5	3	0	43
Total native Species	6	2	2	2	2	0	9

categories in the 2006 Grampians wildfire landscape were each trapped for four consecutive nights giving a total of 9620 trap nights (7252 Elliot nights, 2368 cage nights) yielding 471 captures of 315 individuals. Of the 315 individuals, 86% were introduced house mice and only 43 individuals were indigenous species (Table 1).

This study experienced extremely low captures of native small mammals (Table 1). A significant difference between native small mammal species richness and sampling categories was detected ($F_{5,30} = 3.70$, $P < 0.01$). The control category had significantly higher native species richness to all other sampling categories with the exception of small patches, (Tukey $P < 0.05$) with all other sampling categories showing no difference (Tukey $P > 0.05$). A significant difference between sampling categories for native small mammal abundance was detected ($F_{5,30} = 3.89$, $P < 0.01$). The control category had significantly higher species abundance to all other sampling categories except small patches (Tukey $P < 0.05$) with no significant difference detected between other sampling categories (Tukey $P > 0.05$).

The most abundant native species were agile antechinus (*Antechinus agilis*), 19 captures, and heath mouse (*Pseudomys shortridgei*; table 1), 14 captures. Due to the extremely low captures of most native species (Table 1), species specific analysis for native small mammals have only been presented for agile antechinus and heath mouse.

No significant difference in agile antechinus abundance between sampling categories was detected ($F_{5,29} = 2.383$, $P = 0.06$). The species was predominantly caught at the unburnt, control category (n=12 individuals) yet were detected at isolated (n=2) and small patch (n = 5) categories, displaying limited resilience to persist within the post-wildfire landscape (Table 1). No significant difference in heath mouse abundance was detected between sampling categories ($F_{5,30} = 1.39$, $P = 0.26$). Predominantly captured at the unburnt, control category (n=10), heath mouse displayed low levels of resilience in large patch (n=1) and peripheral categories (n=3).

A rapid resurgence by house mouse two years post Grampians mega-fire was detected in this study (table 1). House mouse abundance displayed a significant difference between sampling categories ($F_{5,30} = 4.55$, $P < 0.01$). The isolated category

Table 2. Correlation of native small mammal species richness and abundance (all species) and house mouse with habitat characteristics for the Grampians National Park two years post mega-fire. Data represents Spearman correlation coefficient with significance at * = 0.05 level in parenthesis.　　　　PC = principal component from data reduction analysis.

	Native small mammal abundance	Native small mammal species richness	House Mouse Abundance
Overall fuel hazard level	0.397(*)	0.415(*)	-0.358(*)
Structure PC 1, 0-100cm	0.391(*)	0.351(*)	-0.379(*)
Structure PC 3, 100-160cm	-0.043	-0.025	0.252
Structure PC 2, 160-200cm	-0.171	-0.149	0.143
Vegetation PC 1	0.154	0.174	-0.17
Vegetation PC 2	0.374(*)	0.347(*)	-0.404(*)
Vegetation PC 3	0.143	0.162	-0.156
Vegetation PC 4	-0.105	-0.129	0.011
Vegetation PC 5	0.106	0.114	-0.131

had higher house mouse abundance (n=140) than peripheral, (n=32), large patch (n=22) and control (n=1) categories (Tukey P<0.05) with no significant difference between isolated (n=140) compared to small patch (n=47) and low severity categories (n=28; Tukey P > 0.05). No significant difference existed between other sampling categories (Tukey P > 0.05).

Habitat Characteristics

Of the 13 simplified vegetation elements measured in this study, PCA reduced the data to five independent factors explaining 70% of the variation. The first vegetation factor demonstrated a positive association with cover of grass, sedge, *Allocasuarina* spp. and *Xanthorrhoea* spp. The second vegetation factor demonstrated a positive association with cover of log, wiregrass and *Hakea* spp. The third vegetation factor demonstrated an association of decreasing cover in *Acacia* spp. associated with increasing cover of *Leptospermum* spp. The fourth vegetation factor demonstrated a positive association with cover of bracken and *Banksia* spp. with the fifth vegetation factor demonstrating an increasing cover of prostrate heath with *Grevillea* spp.

Of the 20, 10 cm intervals from 0 to 200 cm PCA reduced the data to three factors explaining 82% of the variance. Structure factor one demonstrated a positive association between 0 to 100 cm vegetation intervals. Structure factor three demonstrated a positive association between 110 to 160 cm vegetation intervals and structure factor two displayed stronger associations between 160 to 200cm vegetation intervals.

No significant difference was detected between sampling categories for the first vegetation factor (grass, sedge, *Allocasuarina*, *Xanthorrhoea*; $F_{5,30}$ = 1.35, P = 0.27), third vegetation factor (decreasing *Acacia*, increasing *Leptospermum*; $F_{5,30}$, P = 0.32), fourth vegetation factor (bracken, *Banksia*; $F_{5,30}$ = 1.54, P = 0.21) and fifth vegetation factor (prostrate heath; $F_{5,30}$ = 1.52, P = 0.21). The second vegetation factor (log, wiregrass, *Hakea*) demonstrated a significant difference between sampling categories ($F_{5,30}$ = 3.13, P = 0.02) with increased cover of the second vegetation factor at control compared to peripheral and isolated categories (Tukey P < 0.05). No significant difference exists between control and other sampling categories (Tukey P > 0.05) with all other sampling categories statistically similar (Tukey P > 0.05).

No difference existed between sampling categories for structure factor three (100–160 cm; $F_{5,30}$ = 0.64, P = 0.67) or structure factor two (160–200 cm; $F_{5,30}$ = 1.54, P = 0.21). A difference was, however, detected between sampling categories for structure factor one (0–100 cm; $F_{5,30}$ = 4.71, P < 0.01) with a significant increase (Tukey P < 0.05) in the control category compared to low severity, peripheral and isolated categories (wildfire areas) yet similarity to large and small patch categories (unburnt areas; Tukey P > 0.05).

A significant difference was detected in overall fuel hazard between sampling categories ($F_{5,30}$ = 45.95, P = 0.01). The overall fuel hazard levels

were significantly higher in the control and small patch categories (Tukey P < 0.05) to all other sampling categories, yet no significant difference existed between the two (Tukey P > 0.05). Low severity category had significantly higher overall fuel hazard (Tukey P < 0.05) compared to severely burnt peripheral and isolated categories, but not significantly different to recently prescribe burnt large patches (Tukey P > 0.05). Large patches had higher overall fuel hazard compared to the isolated category (Tukey P < 0.05), but not statistically different to the peripheral category (Tukey P > 0.05) whereas isolate and peripheral categories were statistically similar (Tukey P > 0.05). Post-fire vegetation successional change has led to higher overall fuel hazard levels in the longer unburnt control and small patches, moderate levels in later successional large patches and lower fire severity categories with lower levels in the recent, high fire severity categories.

CORRELATIONS BETWEEN SMALL MAMMAL TRAPPING AND HABITAT CHARACTERISTICS

The response variables of native small mammal abundance, richness and house mouse abundance were all significantly correlated to various habitat characteristics (Table 2). Native small mammal abundance and native small mammal species richness had a significant positive correlation to the second vegetation factor (log, wiregrass, *Hakea*), vegetation structure below one-metre and increasing levels of overall fuel hazard (Spearman P<0.05; Table 2). These results suggest that both native small mammal species richness and abundance requires increasing vegetation structure below one-metre and *Hakea*, wiregrass and logs, that may create a variety of habitat niches and also increase the overall fuel hazard.

House mouse display preference for low vegetation cover with significant negative associations to vegetation factor two (log, wiregrass, *Hakea*), vegetation structure below one-metre and decreasing levels of overall fuel hazard (Spearman P < 0.05; table 2). This is the opposite response to that demonstrated by the native species.

DISCUSSION

Cockburn (1978) and Meulman (1997) suggest frequent fire regimes to maintain early successional habitat for heath mouse in the Grampians. However, in our study the species was captured at sites ranging from later (24 years), mid (nine years) and early (two to four years) successional post-fire sites, although not captured at severely burnt isolated sites. Although the species may take advantage of frequent fire regimes, our results suggest that the species may require unburnt, later successional habitat adjacent (< 300 m) to recently burnt areas to colonise.

The early 'boom' successional phase of house mouse as experienced in other studies post-wildfire (Newsome et al., 1975; Fox & McKay 1981; Fox 1982; Wilson et al. 1990) is significantly linked in this study to isolation from unburnt habitat and decreasing cover in vegetation. This study detected some of the lowest densities of house mouse at low severity burnt sites. In contrast, Wilson et al. (1990), in complex vegetation communities, found the greatest increase of house mouse in partially burnt sites with large numbers at all study sites until three years post-fire (maximum at two years) when the population decreased rapidly. Fox and McKay (1981) detected maximum numbers at 12 months post fire in open eucalypt forest on coastal sand plain, whereas Lindenmayer et al. (2008) experienced no post-wildfire boom in house mouse populations across six broad vegetation types.

The house mouse is a generalist omnivore and rapid breeder (Friend 1993; Sutherland & Dickman 1999). If able to survive the direct impacts of wildfire, possibly in sub-surface burrows, they can then take advantage of post-wildfire conditions. Whilst not an ideal situation to have an explosion of an introduced species, the role house mouse may provide as an important post-wildfire food resource for forest predators such as hawks, owls, reptiles and small dasyurids requires investigation.

Apart from the control category, no one sampling category appears more advantageous as a refuge than another, with no individual species displaying sampling category preference at this early successional time post-severe, landscape-scale fire. Importantly, no adequate explanation can be given for zero captures of native small mammals in low severity category that contained pockets of unburnt vegetation. These results are in contrast to the Wilson et al. (1990) study where numbers increased steadily at partially burnt sites compared to severely burnt sites up to three years post-wildfire.

Fox (1982) presents a habitat accommodation model where fauna recolonises based on response to vegetation succession and resource availability. This has led to a greater understanding of different

successional preferences of many small mammals to changing vegetation structure (Friend 1993; Sutherland & Dickman 1999). However, human induced land clearing has isolated many contemporary protected landscapes with wildfire exacerbating existing threatening processes (Tolhurst 1999; Clarke 2008; Dunlop & Brown 2008). A key assumption with Fox's (1982) habitat accommodation model is that species exist within the landscape or within range to colonise changing habitat.

In consideration of the results from this study, two hypotheses are presented for consideration by land managers after mega-fire. The first, a 'system normal' hypothesis, presumes that the landscape and fauna assemblages will recover as predicted in the habitat accommodation model. The second, a 'system distressed' hypothesis, presumes that the combined impacts of prolonged drought and mega-fire exacerbating existing threatening processes have implications to fauna assemblage recovery with potential for a 'habitat vacancy model' to exist.

The habitat vacancy model suggests that localised extinctions retract the distribution and abundance of species. Subsequent isolation of disjunct populations could result in habitat moving in and out of successional growth phases with some species missing recolonisation opportunities unable to colonise due to lengthy dispersal distances. If localised extinctions or isolation does not influence colonisation opportunities then the habitat accommodation model will persist. The habitat vacancy model could lead to potentially significant long-term impacts to faunal distributions and abundances across post-wildfire landscapes especially for rarer species. Species may become restricted to areas that provide sub-optimal habitat conditions, especially in prolonged drought scenarios. In addition, unknown changes to vegetation and habitat may occur due to the ecosystem services native small mammals provide with increased vulnerability of isolated populations to stochastic events and threatening processes such as predation and inbreeding.

The limited captures, lack of later successional species and potential localised extinctions from low severity sites of native small mammals from 8060 trap nights within the mega-fire perimeter of this study are presented to support the habitat vacancy model post-wildfire. Additionally, the model is supported by results in Wilson et al. (1990) where habitat that met key assumptions of floristic diversity for species presence failed to detect any animals. Fox and McKay (1981) detected local extinction at every study site up to 3 years post-wildfire for some species in open eucalypt forest. Lindenmayer et al. (2008) did not detect typical post-wildfire successional replacement of species in Heathlands. Although habitat may undergo successional changes, species persistence and recolonisation is reliant on the lack of isolation and connectivity of populations across the landscape. Further investigation is required to determine when localised extinctions and isolation have occurred and when measures such as translocations of small mammals are suitable to assist dispersal.

IMPLICATIONS FOR CONSERVATION

Mega-fires have significant impacts on ecosystems and the economy of communities with considerable interest in how to manage these events from both a biodiversity and asset protection viewpoint. Recommendations to increase landscape-scale prescribed burning (Parliament of Victoria 2008) and prescribed burning targets (Parliament of Victoria 2010) are assumed to contribute to managing both for biodiversity needs whilst also safeguarding against the anthropogenic effects of wildfire. However, both strategies require further scientific investigation and testing under mega-fire conditions. Recent prescribed burn large patches in this study did not contain any more small native mammals than any of the other sampling categories investigated. A consistent trend of increased species richness and abundance existed in small patches compared to recently prescribe burnt large patches. This is attributed to small patches having greater habitat complexity being of later successional development. Patches of later successional unburnt habitat may therefore provide important refuges across mega-fire landscapes to assist recolonisation and aid in preventing localised extinctions and isolation. To avoid a situation where habitat vacancy persists we must maintain the maximum number and size of complex, unburnt habitat patches within fire perimeters. Contemporary prescribed burning or fire suppression tactics such as 'patching out' or 'burning out' that reduce the number and size of complex, unburnt patches after the fire front has passed require review as these tactics may conflict with ecological objectives.

Although it is widely assumed that landscape mosaics are essential to the maintenance of a suite of faunal assemblages, the introduction of future prescribed fire regimes into the 2006 Grampians wildfire landscape and across the remaining unburnt

landscape needs to be undertaken with caution. The location, scale and timing of prescribed burns post-wildfire need to consider remaining fauna populations, the connectivity of these populations and species with later successional habitat requirements. Conflict between anthropogenic (fuel hazard management) and ecological needs (habitat complexity, connectivity and dispersal opportunity) may arise when managing for lower overall fuel hazard. Unfortunately, areas of higher overall fuel hazard also provide essential small mammal habitat components such as vegetation structure. For the maintenance of diverse small mammal assemblages we must, therefore, accept that there will need to be considerable areas of higher overall fuel hazard in the landscape.

ACKNOWLEDGEMENTS

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