bushfire CRC

SOCIAL CONSTRUCT OF FUELS IN THE INTERFACE

FINAL REPORT FOR THE SOCIAL CONSTRUCTION OF FUELS IN THE INTERFACE (PROJECT ONE)

Ross Bradstock[1], Owen Price[1], Trent Penman[1], Sandra Penman[1], Nicholas Gill[2], Christine Eriksen[1,2], Olivia Dun[2], Chris Brennan-Horley[2] and Carrie Wilkinson[1,2]

Centre for Environmental Risk Management of Bushfires, University of Wollongong[1]

Australian Centre for Cultural Environmental Research, University of Wollongong[2]

UNIVERSITY OF WOLLONGONG

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Executive Summary

The number of houses at risk of wildfire continues to increase around the world and researchers continue to search for ways to minimise loss. Many people inhabit fire-prone areas across south eastern Australia and, despite the inherent risk of fire, choose to live in these areas for the amenity and lifestyle opportunities that these areas provide. This project was developed in order to identify and understand the features which residents' value most on their property and surrounds and if the same features contribute most to their bushfire hazard.

Risk reduction measures pose dilemmas for many residents on urban margins. Such people place a high value on living close to bushland, for a host of reasons (e.g. visual, recreational and cultural amenity). Conflicts may arise between risk reduction policies and activities in and around bushland margins and the amenity that people derive from living in these places. For example, the clearance of or permanent structural alteration of vegetation may diminish visual amenity for local residents. Risk management at the urban interface may involve inherent trade-offs between tangible (e.g. houses) and less tangible (e.g. human amenity, biodiversity) values. Such trade-offs may be difficult to evaluate objectively, though some promising initiatives exist (e.g. Morehouse et al.2010).

A major constraint on management of the interface is the disparity between policies targeted at pre-emptive hazard (fuel) reduction, typically promulgated by public fire management authorities, and the adoption and acceptance of such measures by the community. Such a disparity has been highlighted in recent research on peri-urban communities (Eriksen 2010, Eriksen and Gill 2010).

This project was aimed at addressing some of the questions arising from these potentially competing views. It employed a cutting edge combination of spatial and statistical analytical methods, resident interviews and elicitation. These confirmed and extended established approaches to the problem as previously employed in both Australia and overseas (e.g. the USA). The overall package of work was however, unique in dealing with quantitative determinants of risk of loss on the one hand and the viewpoints and impressions of residents concerning attitudes to their living environment and risk on the other.

A major fire occurred in the Blue Mountains in October 2013. This followed soon after survey work in adjacent communities had been completed in winter 2013. Thus the opportunity was taken to re-survey affected residents to assess their preparedness, in late December 2013

This report summarises the overall project in five major parts:

1. Analysis of historic house loss and development of a model for the probability of loss due to bushfire

   We developed our model of house loss building on the work of Gibbons *et al.* (2012), through the use of historic aerial images and house loss data across New South Wales between 2001 and 2009, as well as GIS analysis. Unlike the majority of previous work we considered multiple fire events across multiple seasons, and included houses both damaged and undamaged houses which were exposed to the same fire event.

2. The perception of bushfire hazard by residents in fire-prone communities, and how these relate to their values surrounding their properties

A questionnaire and follow-up interviews were used to determine the attitudes and values of the residents in our study. A photo ranking exercise was employed to determine their preferences for bushfire hazard, aesthetics and recreation. These methods followed established practices in the literature. This work was done during 2012 – 2013 in fire-prone communities in NSW and the ACT (Mt Wilson, Bilpin – Bowen Mountain, Wamboin). These communities varied in their demographic, economic and land use status.

3. Ethnographic methodologies for exploring residents' attitudes to their environment and bushfire management including use of mapping to define amenity perceptions of risk and actions for hazard mitigation.

   This revealed diverse and interrelated intra-property management activities and rationales at two scales (within 20 m and 100m from houses). The exercise provided insight into the assessments and decisions behind vegetation management activities regarding vegetation immediately fringing houses on private properties and representing bushfire hazard despite residents managing vegetation elsewhere on their property for hazard mitigation purposes.

4. A survey of community preparedness in Mount Wilson and Bilpin in the Blue Mountains, NSW was performed after the October 2013 State Mine Fire

   Practical and mental preparedness by individuals increased the capacity to cope. It also highlighted important points for improvement, particularly with regards to household decision-making during stress, caring for dependents and pets, and miscommunication between local RFS brigades and public messages from New South Wales Rural Fire Service Central Office.

5. How residents' identification of hazard relates to the probability of loss of their house due to bushfire, and if this conflicts with their amenity values

   We calculated the probability of house loss, given a fire, for each of the participants using the model developed in part one and combined the results with the attitudes and values from part two.

Key results

The best model to predict the risk of loss due to bushfire at a local scale contained positive effects of vegetation cover in the garden and slope and negative effects of distance to the nearest building and distance to the nearest waterbody. Although this model explained only 15% of variation in house damage, the difference in predicted probability between a best-case and worst-case house was 0.47, suggesting that risk could be effectively mitigated by providing a water-source, keeping the garden cover low and maintaining separation between houses.

Residents were able to distinguish between the levels of bushfire hazard. We found that residents' landscape preferences are consistent with existing landscape preference research; residents tended to prefer relatively open woodland or forest landscapes with good visual and physical access but with elements that provoke their interest. Overall, we find that resident's landscape preferences are consistent with vegetation management that reduces bushfire hazard and consequent risk to houses.

The spatial mapping and interviews suggested that amenity and hazard reduction activities were more likely to be in tension close to the house (20 m). Within 100m, most residents were undertaking some form of vegetative hazard reduction work, including those who kept vegetation close to the house. Hazard mitigation will vary spatially within properties in response to social and landscape context but is likely to be oriented to direction of highest fire threat.

In the communities exposed to the 2013 State Mine Fire, practical and mental preparedness by individuals, as well as community cohesion, enhanced the generally high capacity to cope. Nonetheless strong variations in house-hold level decision making were evident with much reliance being placed on direct experience by either householders or trusted community members. The welfare of children caused much anxiety and there was evidence that pets were not well considered before the event. Communication between local sources and authorities was an issue that caused concern among some residents.

We found that almost all residents correctly preferred a low-fuel, open forest in adjacent bushland for bushfire hazard. Most also preferred the low-fuel forest for amenity, meaning there is potentially little conflict between forest management goals for hazard reduction and amenity. The high level of appreciation of hazard may be due to experience with fire, since 77% of interviewees had experienced wildfire directly. However, most houses were exposed to adjacent fuel hazard levels that placed them at a relatively high level of potential risk. The results also indicate that there is a subset of residents who can accurately identify hazard but don't necessarily act on that perception.

Key implications

The work has uncovered new insights into: i) how biophysical factors at the interface affect risk of loss of property; ii) how people perceive hazard (fuel) and various measures of amenity, as determined by the state of vegetation; iii) how, why and where people act to mitigate hazard on their own land; iv) preparedness in typical rural and peri-urban communities, and; v) the disparity between perceptions of hazard and amenity and the actual risk to their own property.

The results confirm important insights derived from analyses of losses in the 2009 Victorian fires, namely that the state of vegetation in close proximity to buildings, along with the spacing or density of houses, has a crucial influence on risk of loss. Thus people have a considerable degree of ownership of hazard and risk. Their actions and choices can make a difference. These insights not only provide important new research findings but will also can potentially contribute to development of more effective strategies for enhancing preparedness. They also suggest a deeper role for education: where people choose to live in terms of environmental and developmental context has a considerable effect on risk. Assistance with informed choices in this regard may be beneficial.

A number of possibilities exist to explain the disparity, highlighted above, between perceptions of and preferences for hazard versus estimated risk.

First, people may be willing to knowingly tolerate the existence of hazardous vegetation on their properties because they perceive that the chance of fire reaching their property is low (i.e. likelihood is low). People may be, consciously or unconsciously, be trading of likelihood and hazard. Given that

formal estimation of likelihood (i.e. the chance of fires reaching property, particularly in adverse conditions) is somewhat neglected in current risk assessment and planning initiatives, such trade-offs may be occurring in a state of relative ignorance. Work to estimate likelihood and to convey the results to exposed and potentially vulnerable communities may be required to produce a more informed basis for action by residents.

Second, residents may not act on their hazard because of motivational barriers which might be psychological, practical or financial: what Eriksen and Gill (2010c) refer to as the 'dilemmas of everyday life". Further work will be required to test these hypotheses.

These suggestions to some degree are bolstered by the outcomes of the post 2013 fire survey. This highlighted how previous fire experience contributes to or detracts from practical and emotional preparedness and resilience. Perceptions and experience of risk may be a strong motivator for action. Nonetheless these findings need to be tempered by reality. Among all the other tasks required to live and enjoy their lifestyle, wildfire preparedness may be low on the list. Many of these residents may be amenable to maintaining their surrounding vegetation in an open, low fuel state, and this concurs with findings from the USA (McCaffrey *et al.* 2013a).

The key to improving preparedness may depend less on conventional education initiatives, no matter how well planned and executed, but more on providing assistance for them to take action.

1. The role of gardens, nearby houses, water-sources and topography on the likelihood of house destruction in NSW wildfires from 2001 to 2009

Sandra Penman, Owen Price*, Trent Penman, Ross Bradstock

Centre for Environmental Risk Management of Bushfires, University of Wollongong, Wollongong, 2522, Australia

*Corresponding Author

Abstract

The number of houses at risk of wildfire continues to increase around the world and researchers continue to search for ways to minimise loss. This study examines the determinants of house damage in 28 forest fires from New South Wales, Australia between 2001 and 2009 (309 houses lost or damaged), and is notable for the large number of fires, the use of undamaged controls and the statistical methods that assist the isolation of independent effects on house damage. We focussed on factors in the immediate vicinity of the houses since this zone is where differences between damaged houses and neighbouring controls must occur. A range of spatial measures of vegetation, nearby buildings, waterbodies and topography were derived for each house from Google Earth and Geographic Information Systems data. Principal component analysis was used to select a set of predictors that best represented the variation in these measures. The selected variables were applied to a generalised additive mixed model analysis to derive the best and supported alternative models to predict house damage. The best model contained positive effects of vegetation cover in the garden and slope and negative effects of distance to the nearest building and distance to the nearest waterbody. Although this model explained only 15% of variation in house damage, the difference in predicted probability between a best-case and worst-case house was 0.47 suggesting that risk could be effectively mitigated by providing a water-source, keeping the garden cover low and maintaining separation between houses.

Introduction

People inhabit fire prone areas around the globe where the risk to themselves and their property from fire is unavoidable and consequently significant losses occur. For example 173 lives and over 2000 homes lost in Black Saturday fires in Victoria in 2009 (e.g. Leonard *et al.* 2009; Gibbons *et al.* 2012; Price and Bradstock 2012), 76 lives and around 850 houses lost in Greece in 2007 (Bassi and Kettunen 2008), and over 2200 homes destroyed in California in 2007 (McCaffrey and Rhodes 2009). The number of properties in high risk areas is increasing (Hughes and Mercer 2009; Schoennagel *et al.* 2009), and this is partly because the features which make these areas attractive can also be the features that pose the highest risk (Eriksen and Gill 2010a). While we cannot eliminate the risk of loss due to wildfire we can endeavour to reduce it through understanding the factors that contribute to loss.

Many studies have examined house loss due to wildfire, with the majority of these being in response to a particularly bad fire season or event (Cole 1983; Wilson and Ferguson 1986; Ramsay *et al.* 1996; Bhandary and Muller 2009; Gibbons *et al.* 2012; Price and Bradstock 2013a). Most aim to characterise the features of houses which were lost, or the conditions in which they were lost. Few of these studies have considered controls (houses which were not damaged despite being exposed), studied multiple events or used statistical techniques that can determine the independent effects of interacting factors. These limitations may have contributed to some contradictory evidence about risk factors. Consequently, much uncertainty remains about the best means to mitigate risk and every fire presents further opportunity to improve our understanding of the complex factors influencing house loss in wildfires.

Much of the past research has focused on the actual structures that have been lost to fire. While house construction materials have been found to influence the probability of loss to varying extents in different fires (Cole 1983; Ramsay *et al.* 1996), Leonard and McArthur (1999) concluded that the construction material was less important than the standard of construction to prevent ember penetration. The standard of construction of neighbouring properties is also important. The density of buildings within 40-50 m, including sheds and other houses, affects the likelihood of loss through house to house transmission of fire (Cohen and Stratton 2008; Gibbons *et al.* 2012; Price and Bradstock 2013a). Other flammable objects near the house, including timber decks, woodpiles, gas bottles or fuel drums provide secondary ignition points thereby increasing the likelihood of loss (Wilson and Ferguson 1986; Ramsay *et al.* 1987). Similar studies have been conducted in the US where analysis of a fire event from Colorado in 2002 showed that vegetation density, the managed area around the house, distance to fire station and slope were the key determinants of house loss (Bhandary and Muller 2009). Analysis of house loss in California's Cedar fire of 2003 showed that that vegetation type had the largest effect (Brillinger *et al.* 2009).

Fuels in the grounds have been found to have a strong influence on the chance of loss to fire, with Cohen (2000) describing a zone of 30-40m around a house being key to the chance of a house igniting. House ignitions are unlikely if the flames or embers do not occur within this zone (Cohen 2000), so maintaining this area with low fuel loads and access for active defence would be desirable. There is also potential for house-to-house transmission within this zone as evidenced by the Lake Arrowhead fire in California in 2007 (Cohen and Stratton 2008). Gibbons (2012) found that tree cover within 40 m of the house and the type of garden (native or exotic) had a strong influence on house loss in the Victorian fires of 2009, with native plants increasing the probability of loss by ~ 0.15 and houses with high tree cover ~0.3 more likely to be lost than those without trees. Wilson and Fergusson (1986) found that the height of the vegetation within 40 m was important, but vegetation touching the house was not important. Ramsay (1987) found lower rates of house loss for gardens dominated by lawns compared to shrubs or trees in Victorian fires in 1983. In contrast to these studies Cole (1983) found that houses with trees around the house had lower rate of loss than those without in the 1968 Blue Mountains fires but higher rates in the Hobart fire of 1967.

Residents can improve the probability of survival of structures and themselves by undertaking suitable preparation (Wilson and Ferguson 1986; Ramsay *et al.* 1987; Blanchi and Leonard 2008; Whittaker *et al.* 2012) and defending their property from the approaching fire. Residents can increase the probability of the survival of built structures by 3 to 6 times when they stay and defend their property from wildfire (Wilson and Ferguson 1986; Ramsay *et al.* 1987; Blanchi and Leonard

2008; Whittaker *et al.* 2012). The evidence relating to fire agency suppression effectiveness or factors that aid suppression is largely missing.

In this study, we extend previous research by analysing the determinants of house loss from 28 previously unexamined fires from eastern New South Wales (NSW) occurring over nine years. Our analysis overcomes some of the limitations of many previous studies by examining multiple fires and years, including controls (houses which were not damaged) and using techniques that can identify the independent effects of many factors. We focus on the immediate surrounds of the house, including the nature of fuel in the garden and more broadly, the surrounding built environment, and topographic variables.

Methods

New South Wales (NSW) has experienced some of the largest losses of property in Australia, with major losses in at least 26 seasons in the past century (Ellis *et al.* 2004a). We examined all loss or damage to houses from all fires in forested areas of NSW in south-eastern Australia from the period 2001 to 2009, comprising 309 houses in 28 fires (Table 1.1, Figure 1.1). Most of the lost or damaged houses were in interface, intermix or rural settings (as defined by Radeloff *et al.* 2005), with only 4% in urban suburbs. These fires represent all house loss from fires over the period, other than five grassfires in the NSW western slopes and plains which were excluded because risk factors are thought to operate differently in grassfires compared to forest fires.

Our dataset consisted of damaged houses in the NSW Rural Fire Service (RFS) database, which is the result of post fire site surveys of all damaged houses. We augmented these with the nearest two undamaged houses for every damaged house. The nearest undamaged houses were chosen, rather than random houses, because they were most likely to have experienced similar fire weather and exposure as the damaged houses during the wildfire event. Each house was georeferenced, and houses excluded if they could not be accurately located or if aerial images were not available. The final dataset consisted of 927 houses, of which 64 were damaged and 245 lost to wildfire. To account for the difference in number, undamaged houses were given a weight of 0.5 in all analyses.

Google Earth imagery with a resolution of 10-20 cm was used to measure distances and counts of features surrounding each house. These measures included the cover of vegetation of the garden (low <10% cover, medium 10-30%, high>30%), distance and extent of vegetated patches, distance and number of other built structures and waterbodies (any open water visible in the imagery, length of driveway and amount of vegetation touching the house (see Table 1.2 for a full list)). We used the most recent pre-fire image except in a few cases where there was no pre-fire imagery of reasonable resolution, for which a post-fire image was used, usually an aerial image taken within two weeks of the fire. A geographic information system (GIS) ArcMap 10 (ESRI 2010) was used to calculate measures derived from mapped topographic, vegetation and cadastral data, including the number of houses, and extent of vegetation, forest and tree cover within 100 m of each house. The source data were a 1 second (~30 m) Digital Elevation Model (from Geoscience Australia), NSW Cadastre (NSW Government Land and Property Information Division, unpublished data), the combined vegetation map of NSW (Keith 2004) and the Sparse Woody Extent (version 6, 2009) dataset derived from Landsat 5 TM imagery (Furby 2002).

It was not possible to consider factors that operate at scales considerably larger than the distance between the damaged and undamaged houses, such as the amount of vegetation in the surrounding landscape because the study design uses damaged houses and the two closest undamaged houses as controls. Similarly, weather is not a relevant variable in this study because the neighbouring damaged and undamaged houses would have experienced the same meteorological conditions, at least as far as can be measured retrospectively. House construction variables were not included because this information was usually only available for the damaged houses. Note also that although all of the houses were within the final fire perimeter, not all were exposed to the fire. This is the case in most studies of house loss, and some studies have included houses outside the fire perimeter (e.g. Syphard *et al.* 2012), which affects the interpretation of results.

Analysis

As many of the available predictor variables were correlated, a principal component analysis (PCA) was conducted on the predictor variables for entire dataset to produce a set of uncorrelated variables describing variation in the data. We used principal component analysis (PCA) as an exploratory data technique to identify the best set of predictor variables to model probability of house damage. Variables were transformed, where appropriate, using either log or asin transformations prior to analysis. The factor loadings derived from the PCA indicate how much that variable contributes to each component. The single variable with the highest factor loading for each component identified in the PCA were used for subsequent analysis. Only components with an eigenvalue of >1 were considered. The selected variables were then used as predictors in a generalised additive mixed model (GAMM) analysis with house damage (undamaged = 0, damaged or lost = 1) as the response variable. All possible combinations of the predictors were tested, including all two-way interactions. To account for spatial autocorrelation 'Region' was incorporated as a random variable as there is likely to be regional variations which affect the risk of house loss, but are beyond the scope of this study; such as climate and vegetation types. Houses were assigned to one of eight regions: NW Sydney, SW Sydney, Southern Sydney, Southern tablelands, escarpment, South coast, North coast, Blue Mountains. The model with the lowest Aikaike Information Criterion (AIC) score was retained as the best model, with consideration given to any model that fell within two AIC points of this best model.

Variables pertaining to the vegetation immediately surrounding the house (garden cover, vegetation touching and overhanging the house) could only be measured for about half of the houses (429, including 143 damaged or lost) because the vegetation of interest was consumed during the fire so could not be identified on post fire imagery. Previous studies indicate that these are very important variables (Cohen 2000; Gibbons *et al.* 2012) so we conducted our analysis twice: firstly on this subset and again on the full dataset but with without these variables. We compared the AIC for the best model in the subset data and the best model identified from the entire dataset when applied only to the subset data. All analyses in this study were conducted in R 3.0.1 (R-Development Core Team 2013).

Results

Garden information subset

The PCA results using the subset data (429 rows) identified six key orthogonal components each containing a set of correlated variables (Table 1.2). Component 1 consisted of the cover of vegetation around the house, the distance to forest and the percentage of forest within 100m of the house which had the highest factor loading. Component 2 described the built environment where the house occurs, specifically the length of the number of structures within 50m of the house, the distance to the nearest structure, driveway length, with the highest factor loading attributed to the distance to the nearest house. Component 3 was made up of the variables which were not able to be examined in the full data set. Garden had the highest factor loading, with contributions also from vegetation touching the house and vegetation overhanging the house. Component 4 was topographic position with no other variables contributing to that factor. Component 5 described the presence of waterbodies in the landscape, in particular the distance to the nearest waterbody within 200m which had the highest factor loading with contributions from the number of waterbodies within 200m. Component 6 was entirely described by slope.

The variable with the highest factor loading from each of the components identified in the PCA were used for the GAMM analysis of house damage. One model was superior to all others (no other models within 2 AIC points of the best one). With this model, the probability of damage consisted of an interaction between house distance and slope, as well as the distance to the nearest waterbody (within 200m) and vegetation/garden cover within a 20m radius (Table 1.3a).

The interaction between the distance to the nearest house and slope indicates that houses which are close (within 7m) to their neighbours have an increased probability of loss as slope increases until the slope is around 10^{o}, after which point the probability of loss decreases (Figure 1.2). This interaction is much reduced when neighbouring houses are further away, with differences being negligible when neighbouring houses are 400m away (Figure 1.2).

The probability of damage increased from 0.261 where the nearest waterbody was 20m away from the house to 0.470 where waterbodies were ≥200m away (Figure 1.3). The mean probability of damage increased from 0.195 where garden/vegetation cover within a 20m radius of the roofline of the house was <10%, to 0.274 with 10-30% cover, and 0.366 where cover was ≥30% (Figure 1.4). It is worth noting that despite variation within each of these categories there is a general increasing trend. A house in the worst case (i.e. with high garden cover, neighbouring house 5 m away and a water source at least 200 m away) had a predicted probability of loss of 0.697 (95% ci 0.56-0.83), which could be reduced to 0.228 (95% ci 0.10-0.36) by addressing all of these issues (low garden cover, neighbouring house 200 m away and water source 5 m away).

Full dataset

The principal component analysis identified five key orthogonal components within the full data, (Table 1.3), which were the same as for the garden information subset except it did not include the sixth garden-related component. Component 1 described aspects of nearby structures and the length of the driveway and the variable with highest factor loading was distance to the nearest

house. Component 2 described the vegetation around the house and the percentage of forest within 100m of the house had the highest factor loading. Component 3 was a topographic group with the highest factor loading for topographic position. Component 4 was associated with waterbodies distance to the nearest waterbody within 200m had the highest factor loading. Finally component 5 was also topographic with slope as the only variable.

The variable with the highest factor loading from each of the five components identified in the PCA (Table 1.3) were used for the GAMM analysis of house damage. The best GAMM was very similar to that for the garden information subset except mapped forest within 100m cover was substituted for the missing vegetation/garden cover variable (Table 1.4b). The model predicted that the probability of damage increased by 0.13 when forest cover was increased from 0% to 100% (Figure 1.5). There were five other candidate models with an AIC score within 2 points of the best model. All of the candidate models included the same variables so they have not been considered further as they are adequately described in the best model.

We calculated the AIC score for the model identified from the full dataset when applied to the garden information subset. The difference in AIC score between this model and the best model from subsetted data was 10.43 points which indicates that the model using the garden information subset was a superior model.

Discussion

This study identified a number of factors that influence risk of house loss due to wildfire. By considering multiple fires, multiple years and varying magnitudes of house losses this study has been able to extend previous research in identifying consistent factors and removing idiosyncrasies of individual fires. The factors that best predicted house loss were an interaction between the distance to the nearest house and slope, the distance to the nearest waterbody and vegetation cover within 20m of the house, which we refer to as “garden”. Where garden cover was unavailable, the forest cover within 100m of the house was identified as the next best predictor, albeit not as good.

Our models identified an interaction between the distance to the nearest house and slope on house damage, where the probability of loss of a house which is closer to the nearest house increases as slope increases (Figure 1.2). The distance to house effect is consistent with previous work which identifies the role that houses have on providing fuel for house to house transmission of fires (Cohen and Stratton 2008; Gibbons *et al.* 2012; Price and Bradstock 2013a). The slope effect reflects increased fire behaviour (rate-of-spread, intensity and flame length) when a fire runs uphill and so this has a direct relationship to the radiant heat and likelihood of flame contact with the house (Price and Bradstock 2013b). The interaction between distance to nearest house and slope on the probability of loss may be a synergy of both these effects where slopes facilitate the transfer of heat or flame from a one burning house to another. Alternatively, it may reflect lack of access around the property which impedes suppression activities and the allocation of suppression resources.

The vegetation cover surrounding the house, represented by garden cover in the subset model and forest cover in the full dataset, was identified in both models reflecting the positive influence that nearby vegetation has on providing fuel for fire to expose a house. This general effect has been

demonstrated previously at different scales (Cohen 2000; Gibbons *et al.* 2012; Price and Bradstock 2012). The fact that garden cover was stronger than the nearby forest cover is presumably because it only considers the area immediately surrounding the house which is key to house ignition (Cohen 2000; Gibbons *et al.* 2012), and varies more between individual houses. Two other vegetation variables (the presence of vegetation touching and overhanging the house) had similar factor loadings to garden cover in the PCA analysis (Table 1.2). These three variables are all correlated in that houses with a high proportion of trees touching or overhanging the roof tend also to have a densely vegetated garden. This makes it difficult to distinguish exactly which component of vegetation poses the most risk. Garden cover and distance to neighbouring houses are factors that directly affect the radiant heat load on a house during a fire. This reflects findings in the USA which prioritise risk mitigation in the Home Ignition Zone, the area within 30 m of the house (Cohen 2001).

The distance to waterbody effect has not been identified in previous work. Waterbodies probably reduce risk because they are static water supply, potentially aiding suppression efforts. Unfortunately data on suppression activities are unavailable so cannot be explored further in this study. It is also possible that the waterbody functions as a non-flammable fuel break which may impede fire spread and/or decrease fire intensity at that point, but since the majority of these water bodies were <10 m wide this is unlikely to have had a major impact on the fire.

The models explained only a small proportion of the variation in house loss. This may be expected since the study did not examine house construction or wider landscape variables, both of which are known to influence house loss. It is also likely that a considerable proportion of loss is unpredictable due to the complex nature of fire spread and weather at the fire ground. Fire spotting (Cruz and Alexander 2013) may mean that the fire experienced at each house may be spreading from any direction while wind gusts and eddies may cause localised variation in fire intensity. Most of the previous studies also left a large proportion of variation unexplained (Gibbons *et al.* 2012; Price and Bradstock 2013b), which may also be due to fine-scaled variation in fire behaviour.

While this study provides useful information regarding the risk of house loss, three key elements are missing; specifically information on suppression activities, property preparation, and building standards of the houses examined. The limited evidence suggests that defended houses have much lower likelihood of being lost (Blanchi and Leonard 2008), but no data were available on suppression activities by residents or agencies for the houses in this study. Preparation of property for exposure to wildfire is believed to increase the chance of successful defence (Penman *et al.* ; Whittaker *et al.* 2012) but data on this were also unavailable. Building standards and materials of the houses considered may also enable better understanding of which houses were lost but this information was only available for the burnt houses (not the controls).

The relationships identified in this analysis have several applications under the framework of fire risk planning. Most simply, they provide an empirical basis for advice given to householders, for example about the risks from vegetation around the house or the benefits of water sources. The models suggest that a substantial risk reduction would be achieved by residents who take such action. The models could be converted into maps of risk if a suitable means were found to map the fine-scale features in the models (water-bodies and garden density). Such maps would quantify the likelihood of house loss given exposure to a fire (of unknown intensity). By combining such a map with other empirically derived maps of the probability of ignition and fire spread to the WUI, a total fire risk

map could be developed. The models can be used to estimate the benefit gained from altering any of the determinants (such as reducing garden density or increasing the separation between houses). Lastly, if the costs of different risk-reduction strategies were known, the models could be used to explore the cost trade-offs among different strategies. There is a growing body of evidence about the effectiveness of many aspects of fire risk management, and by combining all of the known relationships into a network model, a complete risk model can be built in which all trade-offs can be explored and optimal fire management strategies identified (Penman *et al.* 2011).

While the risk factors identified in this study are likely to be applicable to fires burning in different conditions and in different countries, the magnitude of their effect may not be so applicable. Much depends on the weather at the time. Most of the houses burnt in these fires burnt under severe but not extreme conditions (as mentioned the exact weather conditions at each house were unknown). There have been fires in Australia burnt under much more extreme conditions (e.g. Ash Wednesday 1983 and Black Saturday 2009), and under these circumstances the relative influence of the risk factors may change. For example, in the Black Saturday fires in Victoria, burning under catastrophic weather (temperature 47^{o}C, relative humidity < 10% and wind speeds > 60 km/hr (Cruz and Alexander 2013), there were very high ember loads and houses were lost up to 350 m from forested lands. Under these conditions, the fire is likely to influence the house from a greater distance, so perhaps the forest has an elevated influence in comparison to the garden. Similarly, caution is required to apply our findings to other fire prone regions of the world such as Mediterranean Europe or the USA where fire weather can be extreme. Nevertheless, our results contribute usefully to the global body of evidence that the immediate surrounds of the house is a crucial zone influencing house loss in wildfires.

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Table 1.1 Wildfires causing house loss in New South Wales between December 2001 and December 2009, as used in this analysis

Year	Month	Fire Name	Latitude	Longitude	Houses damaged	
					Lost	**Total**
2001	Dec	Appin Road	-34.408059	150.669894	24	27
		Blackadder/Dirty Creek	-29.983949	153.158672	2	2
		Burragorang Complex	-34.185599	150.440081	12	16
		Grahame Creek	-33.481775	150.70759	10	13
		Lawson Road 2	-33.698402	150.62647	18	25
		Serendipity	-29.253452	153.313380	3	3
		Warragamba/Burragorang	-34.185599	150.440081	33	38
		Mckenzies Complex	-30.892034	152.417577	1	1
		Penrith Complex	-33.827599	150.636419	5	5
2001-2	Dec-Jan	Hylands	-35.086472	150.420499	28	30
2002	Feb	Burke River	-34.55498	150.68594	0	1
	Oct	Mount Carmel Fire	-34.046951	151.012583	10	19
		Racecourse Road	-32.873307	151.380168	7	12
		T-Ridge	-29.699560	152.679207	1	2
	Nov	Willow Vale	-34.424499	150.492891	4	12
		Killingsworth*	-32.977313	151.568156	2	2
	Dec	Baulkham Hills Complex	-33.531876	151.047828	78	84
		Blackheath Glen Fire	-33.672846	150.334858	1	4
		Cambridge Ave	-34.021325	150.951421	2	4
2004	Oct	Bangalee Scout Fire	-34.849472	150.558655	1	2
2006	Jan	Quarry	-33.496804	151.285033	4	10
		Short Point	-36.895472	149.928548	0	1
		Jailbreak Inn*	-34.864062	147.718302	11	11
	Sept	Charcoal Road	-33.508872	150.916786	1	1
		Dormitory Hill	-33.611701	150.892647	1	2
		Wollondilly Complex	-34.154656	150.529175	4	9
		Nerrindillah Creek	-35.220732	150.484440	1	1
2007	Oct	Oyster Cove	-32.753469	151.964409	2	2
2009	Aug	Romney Park Fire	-35.401450	150.410021	1	1
	Sept	Bush alight Burrill Lake	-35.368137	150.453408	1	1
	Dec	Tea Tree Creek	-35.737576	149.266029	9	9
		Gumin Homestead*	-31.254491	148.860627	1	1
		Old Gundagai Road*	-34.555636	148.187503	2	4
		Walla Walla Rubbish Tip*	-35.822353	146.974821	5	5
		Ournie*	-35.991871	147.981027	6	6
Total					**290**	**366**

* denotes grass fire not included in this study

Table 1.2. Principal component analysis (PCA) loadings for components (1-6) for subset data (n = 429). Loadings indicate the correlation between the component and each variable. Only loadings > 0.7 are shown and the highest loading for each component is in bold.

Variable	Transformation	1	2	3	4	5	6
Variables measured from aerial imagery							
Minimum distance to any patch of vegetation >1ha	log			0.550			
Length of the driveway (from house to public road)	log		0.752				
Distance to the nearest house	log		**0.863**				
Distance to the nearest structure	log		0.722				
No. of structures within 50m of the house	log		-0.832				
Distance to the nearest waterbody within 200m						**-0.821**	
No. of waterbodies within 200m	log					0.769	
Garden/vegetation cover within 20m radius				**-0.834**			
Vegetation touching the house				-0.819			
Vegetation overhanging the house				-0.786			
Variables calculated through GIS							
Distance to the nearest house which has been damaged by fire	log		0.630				
Housing density within 100m			-0.614				
Distance to mapped forest	log	-0.866		0.123			
Distance to mapped vegetation patch >= 500 ha	log	-0.618					
Percentage of mapped Forest within 100m	asin	**0.938**					
Vegetation cover within 100m	asin	0.911					
Vegetation cover within 100m including smaller fragments, trees, etc		-0.686					
Altitude (m)	log				0.754		
Topographic position (valley=1, hilltop=100)	asin				**0.840**		
Slope (degrees)	log						**-0.845**
Proportion variance explained		0.177	0.178	0.118	0.079	0.07	0.056

Table 1.3. Principal component analysis (PCA) loadings for components (1-5) for the full dataset (n = 927). Loadings indicate the correlation between the component and each variable. Only loadings > 0.7 are shown and the highest loading for each component is in bold.

Variable	Transformation	1	2	3	4	5
Variables measured from aerial imagery						
Minimum distance to any patch of vegetation >1ha	log					-0.656
Length of the driveway (from house to public road)	log	-0.785				
Distance to the nearest house	log	**-0.883**				
Distance to the nearest structure	log	-0.735				
No. of structures within 50m of the house	log	0.847				
Distance to the nearest waterbody within 200m					**-0.838**	
No. of waterbodies within 200m	log				0.743	
Garden/vegetation cover within 20m radius						
Variables calculated through GIS						
Distance to the nearest house which has been damaged by fire	log	-0.701				
Housing density within 100m		0.739				
Distance to mapped forest	log		-0.872			
Distance to mapped vegetation patch >= 500 ha	log		-0.621			
Percentage of mapped Forest within 100m	asin		**0.931**			
Vegetation cover within 100m	asin		0.903			
Vegetation cover within 100m including smaller fragments, trees, etc			-0.679			
Altitude (m)	log			-0.852		
Topographic position (valley=1, hilltop=100)	asin			**-0.86**		
Slope (degrees)	log					**0.82**
Proportion variance explained		0.233	0.205	0.091	0.088	0.077

Table 1.4. Model estimates tables for the best models of the probability of house damage: a) The subset data; b) The full data.

a) Subset data, n = 429

PARAMETRIC COEFFICIENTS				
Variable	**Estimate**	**Std. Err**	**T**	**P**
Intercept	-0.1300	0.104	-1.253	0.211
Garden Cover : Low	0.6402	0.179	3.573	0.000
Garden Cover: Medium	-0.0063	0.187	-0.034	0.973
SMOOTH TERMS				
Variable	**Edf**	**Ref.df**	**F**	**P**
S(Distance to house,slope)	9.632	9.632	3.145	0.000
S(Distance to water)	1.000	1.000	9.552	0.002

b) Full data, n = 927

PARAMETRIC COEFFICIENTS				
Variable	**Estimate**	**Std Err**	**T**	**P**
Intercept	-0.0732	0.069	-1.059	0.29
SMOOTH TERMS				
Variable	**Edf**	**Ref.df**	**F**	**P**
S(Distance to house,slope)	9.297	9.297	6.082	0.000
S(Distance to water)	1.000	1.000	25.313	0.000
S(% Forest 100m radius)	1.000	1.000	6.815	0.009

Figure 1.1. The location of the fires in NSW, with forested vegetation also shown.

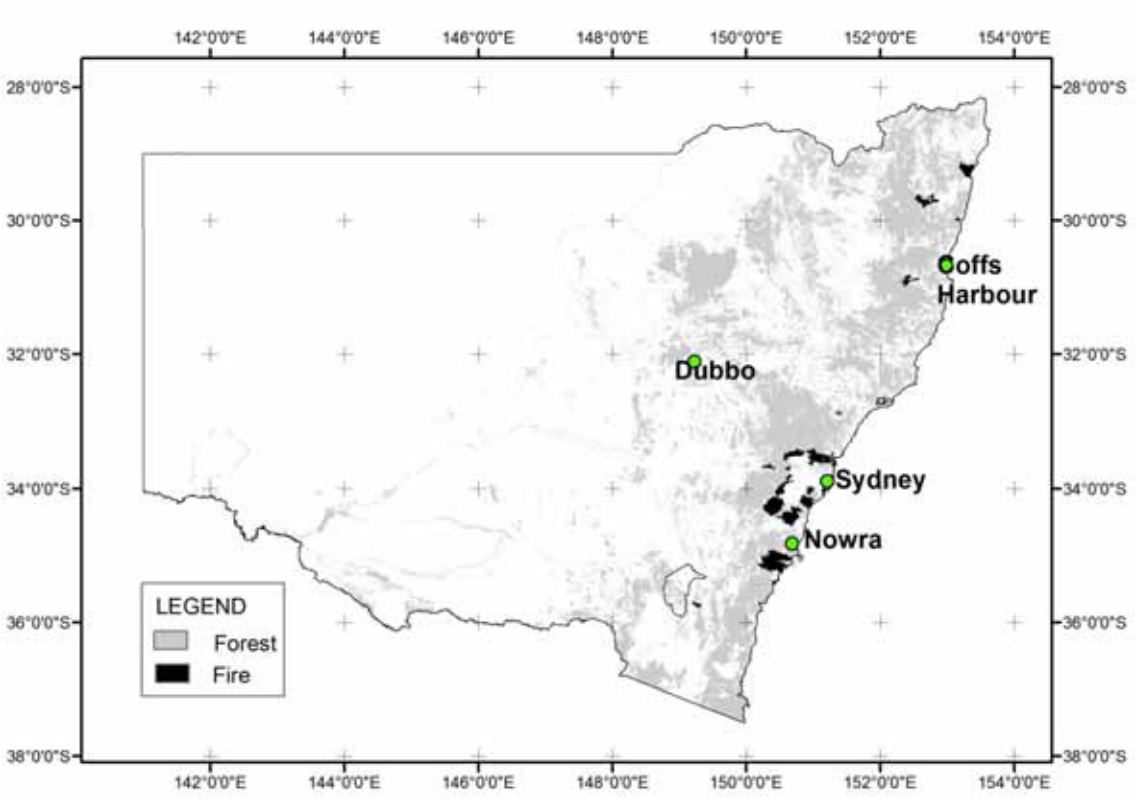


Figure 1.2. Modelled interaction of slope and distance to nearest house on the probability of damage (subset data).

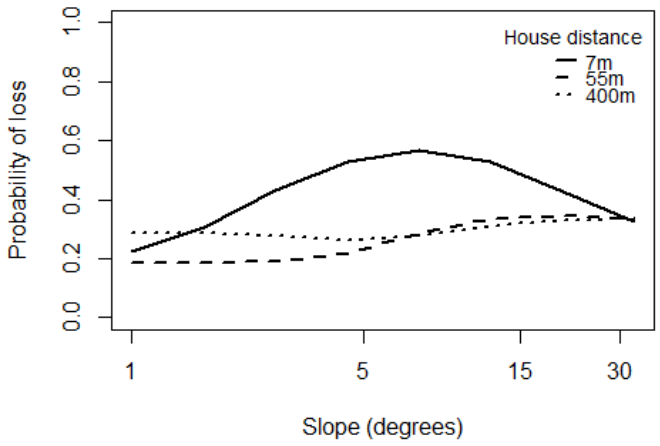


Figure 1.3. Modelled relationship of distance to waterbody on the probability of damage (subset data).

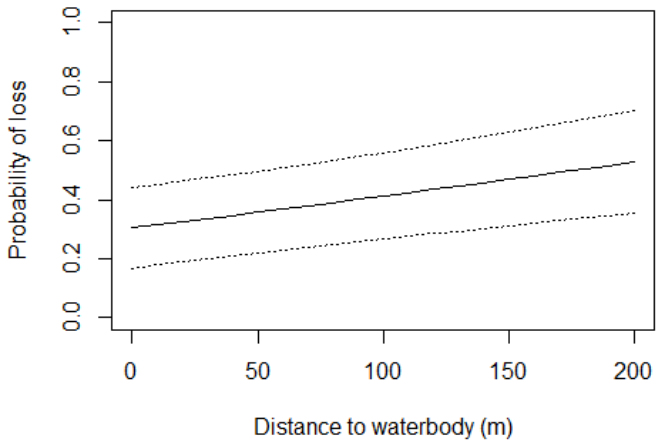


Figure 1.4. Modelled effect of garden/vegetation cover within 20m radius of house (subset data); Low <10%, Med 10-30%, High >30%.

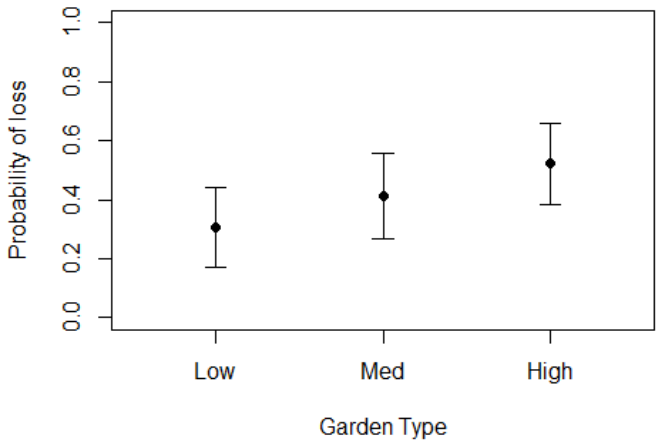
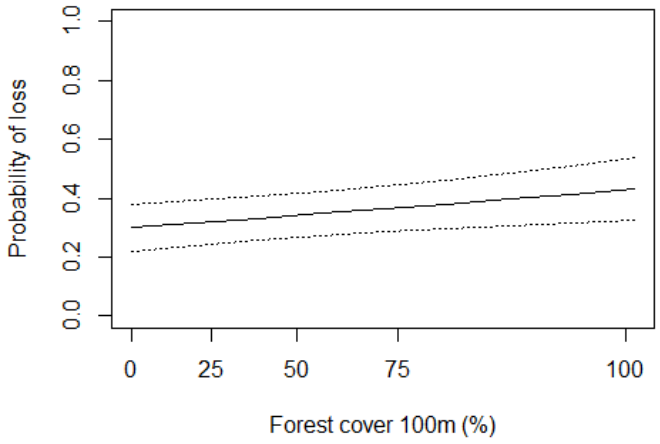


Figure 1.5. Modelled relationship of distance to forest cover within 100m on the probability of damage (full dataset).



2. Visual prompts: Eliciting amenity and bushfire hazard mitigation preferences in fire-prone landscapes of NSW, Australia

Nicholas Gill, Olivia Dun, Chris Brennan-Horley and Christine Eriksen

Australian Centre for Cultural Environmental Research (AUSCCER), University of Wollongong, NSW 2522, Australia

Abstract

In this study we elicit resident views on landscape preferences regarding amenity and bushfire hazard management in high amenity areas of eastern New South Wales, Australia. We provide insights into resident and landowner vegetation preferences in areas where properties neighbour large areas of native vegetation, such as contained in national parks, or exist within a matrix of cleared and vegetated private and public land. In such areas, managing fuel loads in the proximity of houses is likely to reduce the risk of house loss and damage. Our research investigated how resident preferences for vegetation appearance and structure related to varying fuel loads, particularly with respect to the density of understorey vegetation and larger trees. Like Ryan (2012), rather than simply talking or asking about management options via a survey or interview as is in much fuel management research, we adopted a visual approach. We used ranking and photo-elicitation as part of a broader interview. A visual approach aids in focusing on outcomes of management interventions rather than on the particular fuel management interventions. Our research expanded on Ryan's work by using the same photo scenes to firstly derive residents' perceptions of amenity and secondly, residents' perceptions of fuel hazard. We find that residents' landscape preferences are consistent with existing landscape preference research; residents tend to prefer relatively open woodland or forest landscapes with good visual and physical access but with elements that provoke their interest. Overall, we find that resident's landscape preferences are consistent with vegetation management that reduces bushfire hazard and consequent risk to houses.

Key Words: Bushfire, wildfire, landscape preferences, fuel management, amenity

Introduction

Increasing numbers of residents in Australia are opting, often for lifestyle reasons, to settle in peri-urban areas directly bordering large areas of bushland of forest (wildland) or in rural areas where significant areas of native vegetation remain or are regenerating (Gill *et al.* 2010; Abrams *et al.* 2012). These areas are commonly referred to as the wildland-urban interface (WUI) or rural-urban interface (RUI) (e.g. (Gill and Stephens 2009), particularly in the USA. Large parts of south-eastern Australia both outside, and on the fringes of, metropolitan areas have been the focus for much of this settlement (Burnley and Murphy 2004; Luck *et al.* 2010). These same regions, encompassing New South Wales, the Australian Capital Territory, Victoria, South Australia, and Tasmania, are

particularly prone to fire at the WUI/RUI[1] (Gill and Stephens 2009). Over the past one and half decades, in this region of Australia alone, there have been over 200 lives lost and nearly 20,000 people requiring immediate assistance during a period of emergency because of wildfires (EM-DAT 2014) . Most notable has been the significant loss of 173 lives resulting from the February 2009 fires in Victoria (Penman *et al.* 2014). Residents are drawn to live in such locations for their amenity, recreational and environmental values (among others), but face the increasing risk of bushfires and potential loss of housing or human life as a result (Eriksen and Gill 2010b). This raises a question of how residents manage landscapes in order to meet their amenity aspirations weighed up relative to their perception of bushfire hazard and risk. Eliciting residents' landscape preferences using visual prompts are potentially a useful way to explore this.

Literature on landscape preferences has identified common landscapes characteristics that humans tend to prefer. Broadly speaking, people tend to favour landscapes characterised by open forest or woodland that retain sufficient elements to generate interest or anticipation. In often separate, but sometimes overlapping work, researchers have also investigated residents' views regarding vegetation management for fire risk reduction purposes. This work has shown mixed results that vary socially and geographically (Nelson *et al.* 2005; McGee 2007; McCaffrey *et al.* 2013b), however, in general, it has found that residents are amenable to management actions such as vegetation thinning and prescribed burning.

Residents in fire-prone lands can reduce their probability of loss by adequately preparing their houses and properties for potential bushfire threat. However, evidence suggests that, despite being aware of bushfire risk, many residents still fail to prepare adequately for wildfire or underestimate the risk they are exposed to (Cotrell *et al.* 2008; Paton and Wright 2008b; Eriksen and Gill 2010b; Ryan 2012). The reasons for lack of preparation by residents living in bushfire-prone areas can come down to "the juggling of everyday procedures, dilemmas, and tradeoffs between social, cultural, environmental and economic issues" rather than a lack of bushfire risk awareness per se (Eriksen and Gill 2010b). Preparation involves a broad spectrum of activities including having equipment such as pumps ready, development of the physical and mental capacity among residents to defend their property from fire, and preparing conditions on the ground (see (Penman *et al.* 2013a).

A key aspect of preparing conditions on the ground includes vegetative fuel management around assets such as houses. Fuel loads or hazard in the area immediately surrounding houses has been shown to be a key factor for potential property loss to fire (Penman *et al.* 2014). (Penman *et al.* 2014) in their review of work by Cohen (2000), Gibbons (2012), Wilson and Fergusson (1986) and Ramsay (1987) indicate that vegetation type, composition and density within a zone of 30-40 metres from a house or building structure have an influence on rates of property loss. Thus, an important option in bushfire risk reduction is hazard reduction: i.e. removal and/or reduction the amount of vegetation close to or in the vicinity of houses in the form of vegetation clearing, thinning or removal through either mechanical means, grazing or prescribed burning.

[1] For simplicity we will refer to the WUI in the remainder of this paper as it is more commonly used in the literature. However, we note that it does not fully describe the range of landscapes in our case study area, particularly those characterised by a more complex matrix of land covers on both public and private land such as Wamboin and to a lesser extent in Bilpin.

Experience from the USA and Australia indicate mixed reactions by residents to hazard reduction or management for fire purposes, particularly on public land and in national parks, but also with respect to mandatory hazard reduction on private property (Winter and Fried 2000; McCormick 2002; Winter *et al.* 2002; Brunson and Shindler 2004; Ellis *et al.* 2004b; McGee 2007; Gill and Stephens 2009). This has prompted a greater focus on studies which seek to elicit resident preferences for vegetation management *techniques* on lands that require fuel reduction for fire purposes, with a notable increase in research about social science aspects of fire hazards since around the turn of this century (Brunson and Shindler 2004; McGee 2007; McCaffrey *et al.* 2013b). What is largely absent from both work on fire hazard and risk perception and on vegetation management techniques, is investigation into resident assessment of, and preferences for, the landscapes that can *result* from management interventions for fuel reduction. Some recent US research (Nelson *et al.* 2005; Ryan 2012) on this issue and insights from other landscape preference research for forestry and urban park management suggests the value of visual methods to investigate landscape preferences for hazard reduction.

This study adds to this growing body of literature and is concerned with vegetation management to reduce hazard and the consequent risk of property loss during wildfire. It encompasses vegetation management on both private property and neighbouring public lands. The overarching aim of this study is to elicit and explore the vegetation management preferences of residents living in areas bordering national parks and in rural fire-prone settings by providing visual prompts of different fuel hazard levels in scenes of tree-dominated landscapes. It draws on four study sites of New South Wales and is based on a photo elicitation exercise conducted during interviews with seventy-nine residents on sixty-three properties. We explore resident preferences regarding the appearance and structure of different vegetation arrangements in the landscape. In particular, aesthetic, recreational, and bushfire hazard perception dimensions of these preferences we examine. In eliciting resident responses to different vegetation management scenes depicted in photos, we gain insights into the trade-offs between amenity and bushfire hazard reduction and risk mitigation and into the extent to which hazard reduction measures may align with the amenity that residents derive from the landscape around their houses.

Landscape Preferences and Vegetation Management at the Wildland-Urban Interface

There is a long history in landscape research of investigating human preferences for landscape composition and structure (Kaplan and Kaplan 1989). This research has its roots in environmental psychology and its methodologies continue to influence research on resident preferences for vegetation management for fuel reduction at the WUI (Ryan 2012). This research tends to elicit landscape preferences via surveys or highly structured interviews that seek expression of these preferences in response to a series of carefully chosen or manipulated photos that show landscape scenes containing features such as trees, open areas, shrubs and pathways in configurations that provide contrasts in vegetation structure and composition. For example, open and grassy areas under a forest canopy in comparison to the same or a similar area being shrubby and closed to access. There is often a park or open space management orientation to the research and the same scene may be chosen or digitally manipulated to show the results of different management options (Tahvanainen *et al.* 2001). Such research has shown that the visual elements of such research are

key to gauging vegetation and management preferences and, by implication, any subsequent resident or open space user engagement (Tahvanainen *et al.* 2001; Ford *et al.* 2009 ; Ryan 2012). With visual information, respondents are able to more effectively appraise the *results* of management, and are less prone to react on the basis of an existing disposition towards a particular intervention such as mechanical thinning of forest.

There are at least two general frameworks and concepts that continue to influence and inform the general findings from landscape preference research and its application to fire and fuel management at the WUI. In their influential work, Kaplan and Kaplan (1989) based their framework on what they called two human needs – understanding and exploration. They argue that the need to understand, to be able to make sense of what is going on, means that landscape preferences will be greater when environmental attributes facilitate comprehension. Further they argue that humans also have a need to find out what is going on in their surroundings and thereby acquire knowledge, understanding, and familiarity. Accordingly, preferences will be greater where environmental attributes facilitate exploration. The key environmental attributes of their framework are (Kaplan and Kaplan 1989, p.52-56):

- Complexity – the number of different visual elements in a scene; how intricate the scene is; its richness
- Coherence – provides a sense of order and direct attention; coherence is enhanced by anything that helps organise the patterns of brightness, size, and texture into a few major units.
- Legibility – a legible space is one that is easy to understand and to remember; there is a promise of a capacity to comprehend and function effectively
- Mystery - there is a promise that one could learn more by walking into the scene, something not immediately apparent from the original vantage point.

This framework was proposed by Kaplan and Kaplan as a conceptual guide and to suggest that these various attributes may be present to varying extents in preferred scenes, not that any will, might or should be optimised. For example, they suggest that a scene that is high in coherence but low in complexity may be clear and simple but also boring. The framework has been extensively applied and tested - with variation among attributes, studies, and approaches to testing - and has been found to offer significant, if variable, insights into landscape preferences (Herzog and Kropscott 2004; Stamps 2004; van der Jagt *et al.* 2014).s

A second influential and potentially overlapping framework is prospect-refuge theory, proposed by Appleton (1975). As with Kaplan and Kaplan (1989), Appleton proposes that humans are predisposed to favour certain landscapes to meet certain, innate needs. Appleton's formulation of this was that humans will favour those landscapes that offer prospect (an open view) and refuge (protection) as these places offer an aid to survival by providing a point from which to observe, respond, and defend (prospect) or protective spaces (refuge). Actual landscape preferences arise from the judgements that people make about the relative extents of indirect or secondary prospect and refuge offered by a place or setting - i.e. that which can be appraised by observing a scene from a vantage point. This approach has been used in work that deploys photographs to test the role of concepts such as mystery (Hagerhall 2000), and particularly for studies of perceptions of safety and danger in urban areas and parks (for example, Andrews and Gatersleben 2010).

The general findings from landscape preference research are clear and consistent over time and generally across countries and cultures (Gatersleben 2008). While expertise, knowledge, and association with industries such as forestry, has been shown to influence preferences, the evidence for this can be variable (Ryan 2012); an observation also made for the influence of demographic variables on vegetative fuel management preferences in WUI areas of the USA (McCaffrey *et al.* 2013b). People tend to prefer scenes that are half open forest or woodland, scenes that might be described as park-like and relatively easy to see through and walk through (providing visual and physical accessibility). Scenes that are too open or too 'blocked' by dense understorey vegetation tend not to be preferred, consistent with prospect-refuge theory and with work that has set out to test the Kaplans' framework (Herzog and Kutzli 2002; see Dandy and Van Der Wal 2011 for a consistent but more qualified qualitative study). In terms of ground cover, preferences tend to favour relatively uniform or short ground textures, people tend not to prefer scenes with much dead wood or other material on the ground (Kaplan and Kaplan 1989; Williams and Cary 2002; Tyrväinen *et al.* 2003; Lothian 2004; Ryan 2012). This is consistent with the observation that research generally finds that residents prefer scenes that they perceive to be natural but where the scene is the result of management intervention: 'residents prefer managed forests, but prefer them without visible traces of human activity. Often, forests are thought to be in 'a natural condition' even when they are managed' (Tyrväinen *et al.* 2003, p.136). This has implications for vegetation management for fire fuel reduction, expanding the fuel management options that can meet residents' desires for landscapes they perceive as natural.

Overall, these findings about preferred landscapes are consistent with findings from perceptions of fuel management at the WUI and with official recommendations regarding fuel management around houses. Fire agencies in Australia issue standards for creating Asset Protection Zones (APZs), areas of reduced fuel on private land surrounding built assets such as houses, indicating that it is one of the most important ways to reduce the level of fire hazard to a property (NSW Rural Fire Service 2006). The aim of an APZ is to minimise bush fire fuels "such that the vegetation within the planned zone does not provide a path for the transfer of fire to the asset either from the ground level or through the tree canopy" (NSW Rural Fire Service 2006, p.3). In their advice to residents on how to reduce risk in APZs, the (NSW Rural Fire Service 2006), outlines that generally, the greater the density and flammability of vegetation, the greater the fire hazard, but that reduction of fuel does not require removal of all vegetation. With respect to vertical arrangement and structure of vegetation in the landscape, the (NSW Rural Fire Service 2006), recommends[2]:

- ground fuels such as fallen leaves, twigs (less than 6 mm in diameter) and bark should be removed on a regular basis
- grass needs to be kept short and, where possible, green
- removing or thinning understorey plants, trees and shrubs less than three metres in height
- removing more flammable species such as those with rough, flaky or stringy bark
- planting or clearing vegetation into clumps rather than continuous rows
- pruning low branches two metres from the ground to prevent a ground fire from spreading into trees

[2] Selected information from the *Standards for Asset Protection Zones* (NSW Rural Fire Service 2006) has been extracted here to highlight relevant points relating to vertical arrangement and structure of vegetation in the landscape, further detailed advice about managing fuels (including non-vegetative fuels) in asset protection zones can be found in the Standards.

- trees should be pruned or removed so that there is not a continuous tree canopy leading from the hazard to the asset
- tree crowns should be separated by two to five metres and a canopy should not overhang within two to five metres of a dwelling
- native trees and shrubs should be retained as clumps or islands and should maintain a covering of no more than 20% of the area

APZs are located wholly within private land. Landholders are not permitted to clear vegetation on neighbouring public land, such as national park land, without written approval (NSW Rural Fire Service 2006). Thus residents must rely on external authorities for fuel management of on public lands. In a recent review, McCaffrey et al (2013b) reviewed 64 articles on public acceptance of fuel management, finding that, in general, there was a high level of public support for thinning and prescribed fire activities on *public lands* with a high fire risk, especially in the WUI. This support was mediated by a range of factors - views about fuel management are not independent of broader social contexts. These factors include trust in agencies as identified by Winter et al (2002) who find that residents will generally support fuel management if it is well-planned, if it includes some citizen participation, if the responsible agency is well resourced, and if the scope and setting of the area to be treated is manageable. Further, trust will be generated in part by agencies meeting residents' expectations that agencies seek out and take into account local values, context, and experiences (McCaffrey *et al.* 2013b). In southern California, Gardner et al (1987) found support for fuel management in public land, amid resident expectations that it is the responsibility of public land management agencies rather than themselves. This focus on public land is in contrast to our study which explicitly considers residents' views about management of their own property as well as that of neighbouring land, including any public land, where relevant. Moreover, while many of our interviewees did neighbour publicly owned land such as national parks, this was not universal, and interviewee properties were located in a matrix of various land tenures and landcovers.

The relevance of the two approaches highlighted above, the Kaplans' preference framework and Appleton's prospect-refuge theory, is illustrated in a recent study by Ryan (2012), who used landscape preferences and photographs of forests to explore preferences in relation to the consequences, as evident in forest structure and composition, of fuel management by fire and thinning. In general, respondents most preferred those scenes with relatively open forest and little or no understorey and tended to favour management that removes understorey rather than more established trees. These preferred scenes were described by respondents in terms such as 'neat', 'open', 'good for people and forest'. One scene that received a moderately positive ranking and which retained some understorey was described by respondents as 'some overgrowth but managed' and as a 'good clearing with ground covers for wildlife' (Ryan 2012, p.63). Less preferred scenes had more and better established understorey or wood debris on the ground and were perceived in terms such as 'overgrown' and 'fire threat'. Ryan's (2012) study is one of few to use photo prompts to specifically explore residents' views on the results of different fuel reduction measures. This research intends to build on Ryan's work by also using photos to explore residents' views on fuel hazard, but additionally using the same photo prompts to assess residents' sense of amenity with respect to aesthetic and recreational value and management of their own property.

Our intention in this study is not to formally test and apply the Kaplan and Kaplan's *understanding and exploration* framework nor Appleton's *prospect-refuge* theory as is commonly done in

quantitative landscape preference and environmental psychology research. Rather, our aim is to use these frameworks and their attributes as heuristic devices in our analysis of interviewee rankings of photographs and the reasons they gave in the interview for their rankings.

Methods

The research presented in this study was conducted across four study sites in New South Wales (NSW): Mount Wilson and Bilpin in the upper north-western part of the Blue Mountains, Bowen Mountain, a Sydney suburb located at the interface with the northern Blue Mountains, and Wamboin, located along the border of NSW and the Australian Capital Territory (ACT). Mount Wilson and Bilpin were selected because they contain high proportions of lifestyle-oriented residents living on rural properties that fringe large, rugged, and heavily vegetated areas of national park, representing a significant bushfire risk. These northern Blue Mountains settlements were selected over better known southern Blue Mountains settlements, such as Katoomba or Springwood, which are dominated by suburban development, because they contain a diverse range of human communities, including farming as well as urban enclaves and rural lifestyle blocks. Bowen Mountain was subsequently selected as a suburban contrast to Mount Wilson and Bilpin, yet it was still a site in the same region that also fringes a large area of national park. Wamboin was selected as another area with high levels of lifestyle-oriented rural land ownership and for its value as a contrasting site to the other three areas in terms of its mixed vegetation composition (open grassland and grassy woodland as well as denser bushland) but also because there was evidence that the area had been revegetated both actively by residents and also as a result of the retreat of grazing. Wamboin is characterised by poor soils, grassland landscapes (partly a legacy of its pastoral history) and scrubby bushland environments.

During May and June 2013, a total of 65 interviews were conducted across all four study sites (see Table 2.1). These participants were recruited in a variety of ways. Local Rural Fire Brigades were an important initial way to learn about the range of residents and management practices, and identify potential initial interviewees and possible areas to focus on for recruitment - based for example on varying exposure to bushfires to topographic factors. We also attended community events, advertised in local newspapers and community newsletters, conducted letter box drops ourselves and/or paid Australia Post to do so, and door knocked in specific areas. We also recruited via snowballing from interviewees. Although, as for (Brenkert–Smith *et al.* 2006p. 63), we tended to find it hard to recruit people who do nothing with respect to hazard and risk reduction. In combination, these approaches allowed us to recruit people beyond contacts initially provided by the Rural Fire Brigades and to recruit a range of residents.

From these 65 interviews, four clusters of neighbouring (or near-neighbouring) properties, amounting to 18 interviews and 20 properties, have been identified for more detailed qualitative analysis. Two of these clusters fall within the responsibility of Wamboin Rural Fire Brigade, namely four properties in Bywong and six properties along the eastern edge of the area, near the town of Bungendore. The two other clusters fall within the responsibility of the Mount Wilson/Mount Irvine Rural Fire Brigade, namely four properties on the southern side of Mount Wilson and a further six properties on the northern side of Mount Wilson. Any resident quotes presented in this study are from research participants residing within these four clusters. For the purpose of the photo

evaluation and elicitation exercise discussed in this study, the exercise was conducted in 63 out of the 65 interviews.

Table 2.1. Summary of interviews conducted in all four study sites.

	WAMBOIN	BOWEN MOUNTAIN	BILPIN	MOUNT WILSON	**TOTAL**
Number of Interviews Conducted	21	9	17	18	**65**
Number of Residents Interviewed	29	15	26	26	**96**
Number of interviews where property was main residence of interview respondent	20	9	17	13	**59**
Number of interviews where property was secondary residence of interview respondent	1	0	0	5	**6**
Number of interviews where interview respondent was property owner	21	9	17	17	**64**
Number of interviews where interview respondent was renter	0	0	0	1	**1**

Engaging with residents consisted of four components conducted in sequential order (see Figure 1): a pre-interview questionnaire followed by a face-to-face interview that included an interactive mapping exercise, a photo evaluation exercise, and a walking tour of each resident's property. The spatial mapping component formed the main part of the face-to-face interview and is addressed in the paper "Investigating Residents' Bushfire Hazard Mitigation and Amenity Values through Interviews, Qualitative Mapping, and Property Walks". This paper concentrates on the results of the photo evaluation exercise activity. To conduct the photo evaluation exercise, we employed a ranking exercise and photo-elicitation. Our primary aim was not to generate quantitative preference data akin to that generated in much landscape preference research (for example Tyrväinen *et al.* 2003; Ryan 2012) but to use photo-elicitation as a means of exploring residents' preferences and assessments of risk in greater depth. Photo elicitation involves inserting photos into interviews to tap into 'deeper elements of human consciousness' than those evoked by words alone (Harper 2002, p.13), thereby eliciting not only 'more' information but different information from respondents. This is because photography is never just a matter of reading off the content of the image. The message being read does not simply reside in the image, waiting to speak to us - rather 'it is humans who speak to each other…readers of an image can consider both content and context (Banks 2001, p.10). Photo elicitation can be used simply as a tool to facilitate a more conversational narrative between a researcher and interviewee (Banks 2001; Waitt *et al.* 2009). Its utility, however, goes beyond this relatively pragmatic role. It also contains the potential generate a conversation that is open to the interviewee's interpretation of a scene, that allows them to connect their experiences and observations and bring them into the dialogue, that may cause them to reflect on their own assumptions and beliefs, and in which the researcher may have their own assumptions about the

content and meaning of the photo challenged, prompting further questions and analytical reflection (Banks 2001; Beilin 2005; Gill *et al.* 2009; Brickell 2011).

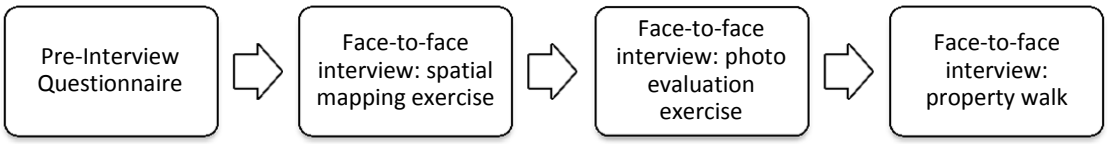


Figure 2.1 - Flow process of interview with residents participating in amenity research for the "Co-existing with Fire: Risk and Amenity Project"

As one part of a larger interview, residents were presented with five alternative images of the way vegetation can appear in the landscape labelled A through E (images are provided in results section of this study). The images were photos of tree-dominated areas taken by the researchers in the actual study site locations during scoping visits in early phases of the research project. There was a set of five images representative of the vegetation landscape in Wamboin and a separate set of five images representing vegetation landscapes typical for the three Blue Mountains study sites (including Bowen Mountain). Images were selected to show increasing vegetative understorey in each progressive scene with the idea of both representing increasing fuel hazard as well as representing the possible consequences of vegetation management such as prescribed burning, clearing, or thinning.

During the interview, the five images were laid out in front of residents in random order and it was explained that the research participants were to rank the photos from their most preferred to least preferred in three separate ways: according to their aesthetic, recreational and hazard mitigation preferences. After each ranking took place, residents were requested to explain the rationale behind their ranking and/or what it was about a particular photo that they liked or disliked. In addition, as a result of experience in the earlier Wamboin interviews, in the Blue Mountains we added an additional question. In this question we asked interviewees which of the photos most corresponded to what they would aim for as an outcome that balanced hazard and amenity on their own property. Full ranking data for the exercise is in Appendix One.

For the 63 interviews in which the photo evaluation exercise was conducted, 79 people completed the exercise (see Table 2.2). This was because couples being interviewed commonly opted to complete the exercise separately because they had differing ideas about which photos appealed to them and how they saw fuel hazard in the landscape (although differences between couples on the latter point was not as common as having different preferences for aesthetic or recreational purposes).

Table 2. Summary of number of photo evaluation exercises completed in all four study sites.

	WAMBOIN	BOWEN MOUNTAIN	BILPIN	MOUNT WILSON	**TOTAL**
Number of Interviews Conducted	20	8	17	18	**63**
Number of Residents Photo Exercise Rankings	22[i]	12[ii]	22[iii]	23[iv]	**79**

[i] Two couples opted to complete the exercise separately; [ii] Two couples opted to complete the exercise separately; [iii] Five couples opted to complete the exercise separately; [iv] Five couples opted to complete the exercise separately

If residents required clarification of what was meant by aesthetic, we would explain we wanted them to rank the photos purely in terms of which vegetation state they liked to look at, for example, if they imaged sitting on their veranda or looking out their window. If residents required clarification of what was meant by recreation, we would explain we wanted them to rank the photos according to an activity they enjoyed doing, for example, going for a walk or horse ride. If residents required clarification of what was meant by preference for hazard reduction, we explained that we would like them to rank the photos according to which image made them feel most safe to least safe with reference to fuel hazard.

There are some limitations to our visual methods. Choosing the photos to manage and encompass a range of possible variables such as light as well as vegetation structure and composition was difficult. Landscape preference studies generally use larger numbers of images, however, as the photo evaluation was only one part of the interview, we were restricted in the number of images we could use. We also did not have access to scenes that could illustrate the outcomes of various management options while holding other variables more or less constant. We did explore with local Rural Fire Brigades whether there were places in their areas that we could use to generate such images but this did not prove possible. We also considered local photo collections that were offered by RFS brigade members. This, however, introduced other variables such as composition style, angle of view, and image aspect ratios. Ultimately, the five photos in each area were chosen from our own photos largely on the basis of being representative of the range of vegetation appearance in the areas balanced with the extent and character of the understorey vegetation and openness.

In terms of data analysis, the photo rankings data has been interrogated both qualitatively and quantitatively. In order to conduct qualitative analysis of what residents were saying about their photos rankings and preferences, interview transcriptions were entered into an NVivo 10.0 project. The transcript text was then coded in two ways. The first iteration coded parts of the text where a particular image ‘A’, ‘B’, ‘C’, ‘D’ or ‘E’ was being discussed regardless of what was being said about the image (each letter was represented as an NVivo node). The second round selected text that could be coded according to the nodes:

1. Reasons for preference for an image
2. Reasons for lack of preference for an image
3. Reasons for perceiving an image as safe
4. Reasons for perceiving an image as unsafe
5. Rationale for aesthetic ranking
6. Rationale for recreational ranking
7. Rationale for bushfire risk mitigation ranking

The first four codes were for managing and analysing interview data where interviewees were talking about particular images. Codes five to seven were used for managing and analysing interview data where interviewees were talking about the images as a set when explaining their overall preferences. For example, interviewees would sometimes describe the rationale or thinking that lay behind their overall preferences and photo sorting, rather than necessarily talking about a particular image.

The NVivo nodes could then be opened and cross referenced against other coding using the ‘View Coding Stripes’ feature in NVivo. As an example, this could then yield an interviewee’s reason for

preferring photo C or reason for perceiving photo E as unsafe when the same piece of text had been coded to both nodes. A spreadsheet containing all the raw results allowed us to instantly see how each particular resident had ranked the photos being discussed as well as filter the data according to, for example, which particular residents had selected a particular photo as their most preferred.

Results and Analysis

Tables 2.3 and 2.4 present the results from the photo evaluation exercise alongside the relevant photos used as visual prompts for each site. Some clear trends are indicated. The most relevant and clearest trend is that the majority of participant respondents (91% in Wamboin, and 88% in the Blue Mountains sites) agree as to which arrangement of vegetation in the landscape constitutes the highest fuel hazard; photo E in both sites. This is clear evidence that residents are able to recognise fuel hazard in the landscape, particularly according to understorey structured in tree-dominated landscapes. Other trends are that there was a tendency for residents to prefer more open landscapes (for example, photos C and D in the case of Wamboin and photos A and B in the case of the Blue Mountains sites) for both aesthetic and recreational purposes. The reasons for this are diverse and are fleshed out further in Table 2.5 and the analysis discussion. Preferences were also expressed and defined by what residents did not prefer (see Table 2.6) and are discussed in further detail in the analysis section.

Table 2.3. Blue Mountains Photos		**Number of People Selecting Photo (n=57)**
First preference aesthetically	A:	12
	B:	20 ⇦ Most preferred
	C:	10
	D:	4
	E:	11
Second preference aesthetically	A:	9
	B:	15
	C:	10
	D:	17 ⇦ Most preferred
	E:	6
Last preference aesthetically	A:	24
	B:	0
	C:	2
	D:	3
	E:	27 ⇦ Least preferred
	Nil:	*1*
First preference recreationally	A:	17 ⇦ Most preferred
	B:	17 ⇦ Most preferred
	C:	6
	D:	2
	E:	15
Second preference recreationally	A:	7
	B:	23 ⇦ Most preferred
	C:	8
	D:	17
	E:	2
Last preference recreationally	A:	21
	B:	0
	C:	3
	D:	5
	E:	28 ⇦ Least preferred
First preference for hazard reduction mitigation	A:	50 ⇦ Most preferred
	B:	4
	C:	0
	D:	0
	E:	0
	Nil:	*3*
Second preference for hazard reduction	A:	3
	B:	48 ⇦ Most preferred
	C:	2
	D:	1
	E:	0
	Nil:	*3*
Last preference for hazard reduction	A:	1
	B:	0
	C:	0
	D:	4
	E:	50 ⇦ Least preferred
	Nil:	*2*

Table 2.4. Wamboin Photo Results		**Number of People Selecting Photo (n=22)**
First preference aesthetically	A:	2
	B:	3
	C:	10 ⇦ Most preferred
	D:	1
	E:	6
Second preference aesthetically	A:	2
	B:	2
	C:	6
	D:	8 ⇦ Most preferred
	E:	4
Last preference aesthetically	A:	13 ⇦ Least preferred
	B:	1
	C:	0
	D:	2
	E:	7
First preference recreationally	A:	2
	B:	3
	C:	13 ⇦ Most preferred
	D:	2
	E:	2
Second preference recreationally	A:	3
	B:	3
	C:	4
	D:	11 ⇦ Most preferred
	E:	1
Last preference recreationally	A:	9
	B:	1
	C:	1
	D:	0
	E:	11 ⇦ Least preferred
First preference for hazard reduction	A:	8
	B:	9⇦ Most preferred
	C:	5
	D:	0
	E:	0
Second preference for hazard reduction	A:	6
	B:	6
	C:	8 ⇦ Most preferred
	D:	1
	E:	0
	Nil:	1
Last preference for hazard reduction	A:	2
	B:	0
	C:	0
	D:	0
	E:	20 ⇦ Least preferred

Amenity Preferences

In terms of first preferences for aesthetic and recreation, the ranking results are quite clear. In both Wamboin and the Blue Mountains, the top two preferences are those photos that are relatively open and, in at least three of them, "park-like". These are photos A and B in the Blue Mountains and photos C and D in Wamboin. Photos A and B in the Blue Mountains effectively represent two versions of a similar scene. Photo A is of large trees and is highly managed and mown, while photo B is of a similar scene but less managed: the grass is longer, there is a small amount of plant litter on the ground and some understorey species, particularly tree ferns, have been left in place. In Wamboin, photo C represents an equivalent scene to photos A or B in the Blue Mountains in terms of openess and patterning of the larger trees While Photo C also ranks relatively highly as the second aesthetic preference in Wamboin (Table 2.4), the most aesthetically preferred second Wamboin photo is photo D, a photo that does have more understorey than photo C, but is still relatively open.

In explaining why certain photos were preferred, interviewees indicated they liked these photos for their visual and physical accessibility. They could see through the vegetation and felt they would be able to easily move through it. As one interviewee said about photo Blue Mountains photo A, 'I can see through, I feel safer in that sort of view. I mean I could walk anywhere'. Quotes reflecting these views are in Table 2.5, which shows why interviewees tended to prefer the more open scenes such as Wamboin photos C and D and Blue Mountains photos A and B. Blue Mountains photo B was most preferred overall in that area for its more natural and less managed appearance – in the words of one interviewee, it has 'the best of both worlds'. Interviewees saw it as containing a balance between a natural appearance, as represented by the remaining understorey and the less mown appearance relative to photo A, and accessibility and openness that appealed to them visually and for access. As one interviewee noted, for Blue Mountains photo B (and A) in contrast to photos D and E 'they're not hidden, things are starting to get very hidden there'. Some interviewees also made positive comments about the fact that Blue Mountains photo C appears to have open ground discernible beyond the foreground vegetation. Some similar comments were made regarding Wamboin photo B. This theme of visibility and an ability to perceive and locate oneself in a broader setting was also evident in how people talked about Wamboin photos C and D. For example with respect to C one interviewee said, 'so you could see where you were walking and you wouldn't have to bash your way through…it felt like it had a balance that I liked'. Others talked about the liking the shape of the older trees in photo C and also about being able to sit and have a picnic. For photo D, relatively open but with more shrubs, interviewees continued to like the ability to see through the vegetation, for example one said, 'Okay, well that's getting to have more understory but it still has the openness of the trees. And you can see through the trees'. Despite the openness, these photos hold interest for the interviewees and contain potential for finding and enjoying the things that they value, such as for the interviewee who values Wamboin photo C for its potential as an accessible place with bird watching possibilities (Table 2.5).

Table 2.5. Photos themes and quotes regarding residents' more preferred photos		
Themes	**Points about why photo was more preferred**	**Quotes**
Visual openness	• Ability to see through the trees • Openness of the trees • Not too open	'Well, because it's got mature trees. And it's got some scope for looking through the trees. And it's got a small amount of understorey. So you could see where you were walking and you wouldn't have to bash your way through…it felt like it had a balance that I liked' (Wamboin Photo C) 'because the undergrowth's gone, you actually see further into it. And you actually, you've got more of that vista, I guess, because you can see more' (Blue Mountains Photo B).
Accessibility	• Relatively easy to walk through • Features of interest or to attract engagement	'It was the combination of natural bush plus some cleared area. It's not a jungle. So you could walk through it quite easily ' (Blue Mountains Photo B) 'for grandkids, you've got a lot more options for recreation' (Blue Mountains Photo B) 'I think you see lots of birds in that environment and it would be easier to see them. It would be easier to walk around into' (Wamboin Photo C)
Texture	• Not too smooth • Not too uniform • Not too manicured	'Yeah, stark and sort of uninviting (Blue Mountains Photo A). At least that's sort of got the tree ferns there, the grass is a little longer' (Blue Mountains Photo B) 'I like a little bit of understorey and I like the older trees in it' (Wamboin Photo C)
Habitat or Perceived Naturalness	• Environmental values • Conformity to a valued image of indigenous nature • Environmental interests	'This I like because it looks fairly natural, but still it has the tree fern and the ferns and these fish ferns or birds' nest ferns they are' (Blue Mountains Photo B). That's a sort of birdie environment that is certainly, and this one which I suppose draws me to them a bit more' (Wamboin Photo C)
Interest	• Promise of something interesting • Everyday engagement is straightforward	'I'd probably be drawn to maybe something more easy to interact with' (Blue Mountains Photo B) 'That's like something that's developing and it would be nice to see how that develops over time' (Wamboin Photo C)
Appearance and Aesthetics	• Form of the trees • A pleasant place to be • Patterns, light and shading from vegetation structure	'This just looks like a nice gentle, sunny, aesthetically pleasing place to be' (Blue Mountains Photo B). 'Yeah, I quite like that because it's got the, I don't know it's got this nice shapes in the trees, different' (Wamboin Photo C).
Perceived Fire Safety	• Fuel loads are not high • Access for fire-fighting is possible	'That's a bit too clear for me from an aesthetic point of view but from a fire point of view, good (Blue Mountains Photo B) 'And if you're going to fight a fire, you've got to be able to access it' (Wamboin Photo C).

Table 2.6. Photos themes and quotes regarding residents' less preferred photos		
Themes	**Points about why photo was less preferred**	**Quotes**
Lacking Visual Openness	• Inability to see through trees	'visually looking through it, you won't see anything or be able to move through it once it gets up to its full height.' (Blue Mountains Photo E)
Inaccessibility	• Lacking ease of movement and requiring concentration to look out for danger (either walking hazards or hazardous wildlife) • Difficult for accessing in fire situation	'not so much E. It's just too full on. Yeah hard for us to do what we want to do which is walk around and not have to keep watching out for snakes and thinks as we walk. Just to be able to be able to get the bigger picture rather than having to concentrate where you're actually stepping.' (Wamboin Photo E) 'That one's a bit more hard to transverse, probably, and probably harder to fight a fire in.' (Blue Mountains Photo E) 'You just can't get in. You can't get in there and do anything. Just from the point of view of walking through there, you can't access it.[…]. I've been in this, or worse than that. You can't win. I was out there yesterday trying to get through a creek and getting scratched up.' (Blue Mountains Photo E)
Texture	• Too uniform • Too boring • Too stark • Lacking understorey or too much understorey • Lack of species richness, diversity and complexity	'had too little understorey.[…] That's right because there shows to me there's nothing interesting that's happening at the near level. The trees are interesting; particularly here I think the trees are interesting. But there's not going to be any small flowers. There's not going to be any creepers. There's not going to be anything. [Wamboin A] And that one's [Wamboin E] way too much.[…] Photo E way too much. I can't imagine walking through that.' (Wamboin Photos A and E) 'I probably like A least because of the just the regular nature of the [trees]. […] And I think a lot of it was a reaction to the shape of the trees. And that's all that sort of straightness. […]One of the things with A is it's very similar looking..[…]And I mean that just looks a bit boring.' (Wamboin Photo A as discussed by a couple) 'I find that a bit too clipped and park like for me' (Blue Mountains Photo A).
Habitat and Perceived Naturalness	• Hazardous wildlife habitat e.g. for snakes and leeches • Sense of foreboding created by too much nature • Environment appears damaged	'E looks inhospitable because I couldn't walk through. It would be full of snakes and other goodies.' (Wamboin Photo E) 'A looks a damaged environment' (Wamboin Photo A) 'I wouldn't go near it because I'd be terrified of snakes or leeches or something like that.' {Blue Mountains Photo E) 'I rank this one the least because, although it's very natural and obviously I like things with natural, they're a bit forbidding.' (Blue Mountains Photo E)

Blue Mountains photo B, while still open and accessible, contained more elements of interest relative to Blue Mountains photo A. Photo A was ranked last aesthetically and recreationally by a significant number of interviewees (Table 2.3). Interviewees who did not rank photo A first tended to make comments such as 'I find that a bit too clipped and park like for me' or noted that it was too 'manicured', 'too stark', 'too cleared', or words to that effect (Table 2.6).One noted that that relative to photo E, photo A lacked the interest he was looking for when out for a bushwalk. To some extent such views were qualified where alternative users were envisaged. For example, in contrast to one interviewee who saw photo B as holding interest for grandchildren, another who ranked photo B as their first preference also noted that photo A would be preferable if you're going to be having a family picnic – 'Oh, it may change, oh, yes, if you were going to be having a picnic with children around'. This view about the value of photo A for activities such as picnics or kicking a ball around with kids was also noted by interviewees who did rank photo A as their first preference.

The photos with more understorey such as Blue Mountains photos C, D, E were generally less preferred on aesthetic and recreational grounds. Speaking to a theme of the ability to have immersive contact with native vegetation, one interviewee said of Blue Mountains photo E, 'once it's like this it's much harder to interact with' (Holland interview). Interaction of a more vigorous nature is possible in such vegetation and one interviewee said if they wanted an adventure in the bush, they'd choose photos such as Blue Mountains photo D with relatively dense understorey. People are however, not looking for adventure in their daily life on their properties and so tend to prefer the scenes that are going be easier to access and move around in. Notwithstanding this, as Tables 2.3 and 2.4 show, there is some preference among interviewees for the photos with more understorey such as Wamboin photos E and Blue Mountains photos D and E. In Wamboin, this was largely due to the greenness of the understorey which appealed to some interviewees – 'I don't mind the understorey here, looks quite lush'. In the Blue Mountains, interviewees again either liked the healthy appearance of the dense understorey of photo E or were able to picture themselves still able to move through photos D and E; in the case of E, if there were a track for bushwalking. In such cases, these views on aesthetic and recreational grounds were not necessarily associated with an absence of awareness of the fire risks presented by such scenes.

With some qualification as above, aesthetic and recreational preference tended to decline with increasing understorey. As Tables 2.3 and 2.4 show, in the Blue Mountains images least preferred aesthetically and recreationally are photos D and E respectively. In Wamboin photo E is the least preferred recreationally and the least preferred aesthetically is a somewhat different photo, photo A, which has almost no understorey, has some leaf litter, and is composed of relatively dense young trees which people did not find attractive. Apart from Wamboin photo A, and notwithstanding some of the positive comments about the understory above, photo E also was ranked low in aesthetic and recreational preference (Appendix 1). The reasons for disliking these photos are generally the reverse of the reasons for liking the more open images above. These reasons as summarised and illustrated in Tables 2.6 are lack of visual and physical accessibility – i.e. these are scenes that one cannot see into and through very easily and which would be hard to move into and around. Moreover, on top of these reasons are those of a perception of uniformity and a lack of things of interest as well more negative perceptions of danger such as from snakes and other creatures, one interviewee going so far as to describe Blue Mountains photo E as 'forbidding' and another labelling Wamboin photo E as 'inhospitable'.

Table 2.7. Resident perspectives on bushfire risk mentioned during photo evaluation exercise

Themes	Points about why photo was considered safe or unsafe (relative to other photos)	Quotes
Safe(r) with respect to bushfires	Minimal fuel loads: Minimal groundcover and understorey Cleared undergrowth Younger and thinner trees Sparser tree spacing Open canopy Accessible for firefighting purposes Area exhibits signs of already having been burnt	'No rubbish on the ground, well not much.' (Wamboin Photo B) 'Cleared, no undergrowth, easy to, you could get a vehicle into there. This one similar, you've got a cleared area with denser scrub at the back.' (Blue Mountains Photos A and B) 'there's no understorey, and not so much canopy either.' (Wamboin Photo A) 'it looks safer…as far as fuel load goes' (Blue Mountains Photo A) 'seems a lot of leaf vegetation on the ground, but pretty low, not likely to catch alight those ones [Wamboin Photo C]. But that's already been burnt [Wamboin Photo A] so it's probably a tossup between those.[…] And then I'd probably go that way. Very marginally yeah. Still C [is the safest].[…] I think probably with these being a bit sparser, the trees [Wamboin Photo C].' (Wamboin Photos A and C) 'They're not fatter trunks or bigger trees, it's a big canopy. And so it's again that. That just means the fire goes through quickly. There isn't much there.' (Wamboin Photo A) 'that would be the lower risk in the sense that it's already been burnt out.' (Wamboin Photo A) 'And if you're going to fight a fire, you've got to be able to access it.' (Wamboin Photo B and C) 'minimal fire risk, you can, it's more open.' (Wamboin Photo B)
Unsafe with respect to bushfires	High fuel loads, particularly in terms of understorey vegetation growth Potential future vegetative growth a fire hazard	'E has the risk that when it gets dry that nice green stuff is going to be a fire risk. So I saw, that's when I said last, looked at it first and I thought, "Fire risk," when I saw E; not because it's fire risk now, but it will be when it becomes dry.' (Wamboin Photo E) 'This one's just the undergrowth. Fuel loading on those is pretty high.' (Blue Mountains Photo E)

Bushfire Hazard Reduction Preferences

In Wamboin the first preferences for hazard reduction (i.e. those scenes for which people feel safest) were the relatively (but variably) open scenes of photo A, B, and C. The least preferred image was photo E, the scene with the most understorey. The two interviewees who ranked Wamboin photo A as their least preferred photo on the basis of bushfire risk, did so on the basis of what they perceived as relatively large amounts of flammable leaf litter. In the Blue Mountains almost all interviewees ranked the open forest photos A and B as their preference for bushfire risk mitigation and photo E, the photo with the most understorey, was almost unanimously ranked as the least preferred. Table 2.7 summarises interview data for these preferences. In general, people ranked their preferred images on the basis of relatively low fuel loads due to relatively low amounts of understorey and groundcover as well as fairly open tree spacing. Such photos were also perceived as accessible should firefighting need to occur and in the case of Wamboin photo A, it was perceived to some extent as an area that may already have been burnt and therefore had relatively low fuel loads. Conversely, those scenes perceived as relatively high hazard were assessed largely as such due to high fuel loads due to the presence of understorey.

However, while residents tended to rank their preferred scenes for bushfire risk mitigation based on the decreasing to increasing fuel loads they could detect in the five images, this did not necessarily equate to residents thinking such scenes were safe during bushfire. For example, one resident in Wamboin ranked their preference for bushfire mitigation A, C, B, D, and E (A being the safest to E being the least safe) for the sake of completing the exercise, but promptly indicated that they would not feel safe in the scenes they had picked:

> *"Well, I suppose either that one [Photo A] or this one [Photo C], because there's no understorey, and not so much canopy either. …But I don't like either of those [Photo A or C]. I don't feel very comfortable in either of those….I don't like the feeling of either of them. When you say with fire, I mean if you were to be in that environment in fire…I'd move!...it's [Photo C] got a bit more going on for fire. Yes, it has. But not as much as these [Photo D and E] or even that [Photo B]…That's [Photo B] got a fair bit of scrubbery and stuff underneath there. I'd be fairly uncomfortable if I lived closer than several hundred metres from that [Photo C] anyway…Yeah, to any of this. I wouldn't want any of this around the house [referring to all photos]…[I'd want it] far enough away to feel out of, not to feel threatened by the radiant heat if it all goes up, but I mean if it's coming towards you, anywhere's too close with that amount of vegetation. If it's going past you, you'd want several hundred metres at least."*

A further example from a resident in the Blue Mountains (whose ranking from most safe to least safe was Photo A,B,C, D, and E) indicates how residents struggled to see a potentially safer photo for bushfire purposes in amongst the photos provided:

> *"that's obviously the most safest [Photo A]… Well, these rough barked trees [Photo B], you know, they can burn really easily. Oh well, I suppose that one's [Photo E] got the most undergrowth, hasn't it, the most fluffy stuff and dead-looking things? There's not a lot to choose between those, is there? But this will change. If this doesn't get burnt this will change, because there's tree ferns in there, there's probably rainforest trees coming up. None of these things stay the same; they're all shifting anyway. But it's not an easy question to answer."*

These examples indicate that while residents could provide a ranking of the photos based on fuel loads, they did not necessarily perceive the images as safe in a bushfire context. In both examples, the interview

participants were long term residents and with prior experience of fire as well as thorough knowledge about plants. Overall this shows that a photo evaluation exercise can be useful for understanding a residents' ability to understand the relative fire threat of different scenes, but a ranking alone is not sufficient to indicate how residents perceive fire safety in the landscape.

Overall Resident Vegetation/Landscape Preferences

In Blue Mountains interviews we also asked interviewees which scene represented their overall preference with respect to balancing risk and amenity on their own property. In other words we were asking them to consider, and sometimes explicitly did so as a result of queries regarding the question, what kind of vegetation structure and composition they would be satisfied with on their own land to meet both amenity and bushfire hazard reduction goals to an acceptable extent. The results of this are shown in Table 2.8.

Table 2.8. Overall photo preference balancing fire risk and amenity – Blue Mountains (n=43)	
A	12
B	17
C	2
A or B	4
B or C	5
B or D	1
D	1
E	1

Seventy-seven percent (n = 33) of the interviewees in the Blue Mountains selected photos A or B as representing management outcomes for their property that they would be satisfied with. Ten interviewees were unable to make a definitive preference choice; these interviewees responses are therefore shown in the rows 'A or B', 'B or C', and 'B or D'. Five of these were wavering between photos B and C, both photos with open spaces and relatively low fuel loads. This indicates the extent to which this is a potentially difficult question for interviewees. It asked them to weigh up, and possibly engage in compromises across, a range of values, rhazard perception, and management goals for their property, as well as the extent to which they are willing to put resources such as time and money into achieving certain outcomes relative to other uses of those resources. It suggests the value of discussions about goals and options between fire agencies and residents.

In summary, the results of photo evaluation exercise and associated interview material are that:

- Interviewees generally prefer open, park-like scenes composed of relatively large trees with little or no understorey.
- There was a preference for scenes that had small amounts of sparse understorey or some other manifestation of rougher texture such as unmown grass, rather than 'manicured' uniformity.

- In these respects, interviewees tended to prefer scenes that conformed to an ideal of apparently unmanaged 'nature' even where it is a result of management intervention.
- Interviewees ranked scenes that had relatively large amounts of understorey and could not easily be seen through lower in preference.
- Where scenes provided high levels of visual and physical accessibility, they tended to be more preferred or, where photos were not highly preferred but contained some element of access, these aspects of the scenes were commented on favourably.
- Aesthetic appearance of the vegetation is important – as evident in preferences for larger trees, 'shapely' and widely spaced trees, and comments about the sense of it being pleasant to be in a particular scene.
- Scenes that had relatively high levels of fuel hazard, particularly as evident in understorey and ladder fuels, tended to be ranked lower in preference, including on bushfire risk grounds.
- Those scenes with relatively low levels of fuel hazard, particularly as evident in understorey and ladder fuels, were preferred on both aesthetic or recreational grounds, and on bushfire risk mitigation grounds.
- Perceptions of bushfire hazardperceived in the photos were common across all study areas and for the large majority of interviewees, almost unanimously so in the Blue Mountains.

These results are consistent with the key elements of both the Kaplans' (Kaplan and Kaplan 1989) framework and Appleton's (1975) prospect-refuge theory and with the broader findings about landscape preferences outlined above. That is, interviewees prefer relatively open scenes that are neither wholly open such as open farmland, nor 'blocked' too much by understorey. In Appleton's terms, interviewees prefer scenes that offer prospect – i.e. what is there or might be there can be, or most likely can be, seen due to the openness of vegetation – and a certain level of refuge – i.e. there is a likelihood that one could successfully conceal oneself, the scene is not totally open.

The Kaplan's framework of complexity, coherence, legibility, and mystery can also be applied to our results and the relative role of these components can be seen in the rankings and comments of interviewees. Table 2.9 provides a summary of how interviewees preferred or did not prefer things according to these four framework components.

Table 2.9. Interviewee Preferences and the Kaplans' Framework	
Framework Component	Evidence from Preference Ranking and Interviews
Complexity	- Interviewees preferred scenes with some complexity as represented by interestingly shaped and spaced larger trees. - Interviewees preferred scenes that had some complexity as represented by at least some rougher grass and sparse understorey. - Interviewees did not prefer scenes with what looks like undifferentiated and substantial understorey. - Interviewees commented negatively on scenes that were simple in composition (e.g. Wamboin A, Blue Mountains, A)
Coherence	- Interviewees preferred scenes in which the spacing of the larger trees provides an irregular but pleasing arrangement. - Interviewees preferred scenes in which the trees were interesting but overall had enough similarity to provide coherent patterns and some sense of order. - Where too much order was perceived (e.g. Blue Mountains A) this could reduce preference ranking.
Legibility	- Interviewees preferred scenes or scene characteristics that would allow them to easily move around, see where they were going, retain a sense of perspective and location, and undertake activities such as fire management/response. - Interviewees preferred scenes or scene characteristics that facilitated straightforward everyday interaction. - Interviewees did not prefer scenes or scene characteristics that made it difficult to spot hazards.
Mystery	- Interviewees preferred scenes in which all, or at least most, was not revealed at first glance. - Interviewees preferred scenes that offered the potential to find or observe things they were interested in or which offered the potential of various things to do or see.

Overall, the most highly preferred photos, photo B in the Blue Mountains and photo C in Wamboin could be characterised as having moderate complexity, moderate coherence, a relatively high level of legibility, and a low to moderate level of mystery.

Conclusion: Implications for Bushfire hazard Reduction

This study aimed to provide insights into resident and landowner vegetation preferences in areas where properties neighbour large areas of native vegetation, such as contained in national parks, or exist within a matrix of cleared and vegetated private and public land. In such areas, managing fuel loads in the proximity of houses is likely to reduce the risk of house loss and damage. Our research investigated how resident preferences for vegetation appearance and structure related to varying fuel loads and structures, particularly with respect to the density of understorey vegetation and larger trees. Like Ryan (2012), rather than simply talking or asking about management options via a survey or interview as is common in much fuel management research, we adopted a visual approach using ranking and photo-elicitation as part of a broader interview. A visual approach aids in focusing on outcomes of management interventions rather than on the particular techniques that may be used to manage fuels. While we weren't able to include images from different stages of management (eg. to include wood debris on the ground) as Ryan (2012) did, our images did encompass key elements of vegetation that influence preferences for landscape appearance. Our research also expanded on Ryan's work by using the same photo scenes to firstly derive residents' perceptions of amenity and secondly, residents' perceptions of bushfire risk.

Our findings are generally consistent with previous US research (McCaffrey *et al.* 2013b) that suggests that management that results in relatively open vegetation with some but limited understorey is likely to be acceptable to most people, if not preferred. Our results show that such landscapes are preferred on aesthetic, recreational, and bushfire risk perception grounds. To the extent that people are able to separate aesthetic, recreational and risk in allocating their preferences, our results show that the amenity gained by residents from the landscapes around their houses is generally consistent with management of native vegetation to reduce bushfire hazard and risk . They also show that people are able to identify the relatively high hazard scenes and those depicting lower hazard. Another way of looking at how these results are relevant to management is to also look at the characteristics of preferred scenes that interviewees commented on. These characteristics may be present in different ways in various photos. For example, relative openness and associated visual and physical accessibility was a characteristic of the most preferred photos. Some less preferred photos had these characteristics to a lesser degree but this was nonetheless commented on favourably by interviews. For example, photo D in the Blue Mountains (second ranked on aesthetic grounds) has more understorey than the most preferred photos but also has openness in the foreground and the suggestion of open space beyond the trees and shrubs. Similarly, the presence of at least some textural roughness in the most preferred photos as a result of unmown grass and limited understorey, was noted by interviewees when present in varying ways in other photos. Open landscapes containing elements of interest to people are generally preferred but the way in which these elements may be potentially present can vary. This suggests there is unlikely to be one way to manage landscapes that in some combination reduce hazard and meet residents' aesthetic and recreational preferences to an extent that is acceptable to them. Rather,

these results suggest a range of potential landscapes elements that people prefer that can explored in developing management scenarios.

One implication for management is that there is a chance for agencies to potentially reframe fuel reduction activities as an issue also about achieving landscape preferences. Agencies working in communities where fuel risk reduction is necessary could engage with residents by acknowledging risk reduction needs to be done, but expanding dialogue to also ask residents about precisely what it is about the vegetated landscape that they prefer. This could reframe fuel reduction activities as a means of also achieving landscape preferences which (as our data has shown) can include relatively open spaces, thus achieving dual goals of increasing safety vis a vis bushfire, but also enhancing a sense of amenity that bushland environments provide for local residents.

A photo evaluation exercise is a method that has potential use for agencies to promote dialogue about fuel management with residents in fire-prone areas. In undertaking such an exercise, it would be useful to select photos or create targeted images that reflect relevant formal fire-related guidelines such as those issued for establishing asset protection zones or undertaking fuel hazard assessments. Moreover, such photo evaluation exercises are likely to be more valuable and have more success if locally contextualised; images should reflect the actual vegetation, topography, and overall landscape for the residential communities being targeted. The use of photos provides a chance for residents and agencies to visualise the landscape before it is altered. Photos can help to prompt discussion that identifies which aspects of vegetation in the landscape residents are willing to alter or see altered for hazard mitgation and which aspects residents will not willingly compromise for hazard mitigation purposes. Further, the use of photos allows residents to be exposed to different means of, and ideas about, vegetation management for fuel reduction purposes, ideas that they may not have previously thought about. Demonstrating different mechanisms of achieving fuel reduction (such as via the use of fire or mechanical means) by using visual aids such as photos may also help agencies to arrive at the best means of undergoing fuel reduction activities without putting residents offside. For example, if agencies wish to reduce fuel in the landscape and encourage residents to do so, then using photos to consult with residents in advance regarding potentially preferred means of achieving fuel reduction may help to give residents a sense that they have some choice and say in how the landscape is managed for an inevitable activity.

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Appendix

Photo Ranking Data

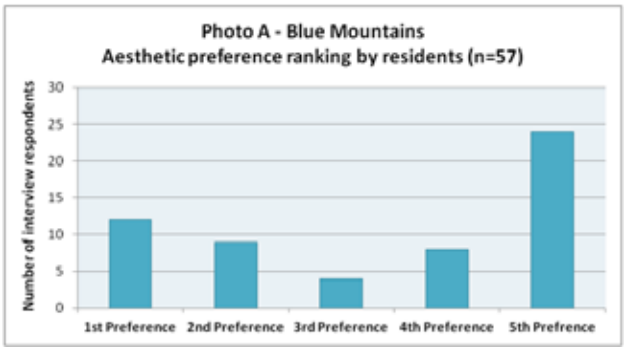
Photo A - Blue Mountains
Aesthetic preference ranking by residents (n=57)
Number of interview respondents
0
5
10
15
20
25
30
1st Preference
2nd Preference
3rd Preference
4th Preference
5th Prefrence

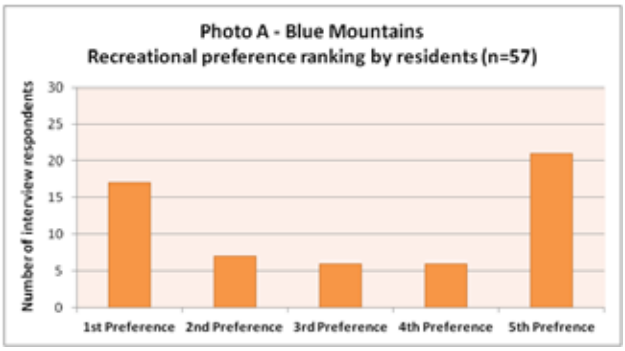
Photo A - Blue Mountains
Recreational preference ranking by residents (n=57)
Number of interview respondents
0
5
10
15
20
25
30
1st Preference
2nd Preference
3rd Preference
4th Preference
5th Prefrence

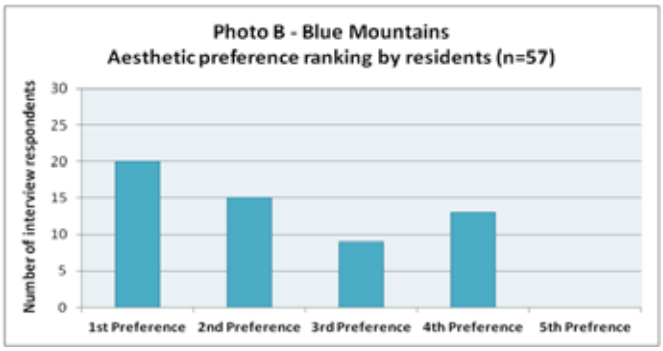
Photo B - Blue Mountains
Aesthetic preference ranking by residents (n=57)
Number of interview respondents
0
5
10
15
20
25
30
1st Preference
2nd Preference
3rd Preference
4th Preference
5th Prefrence

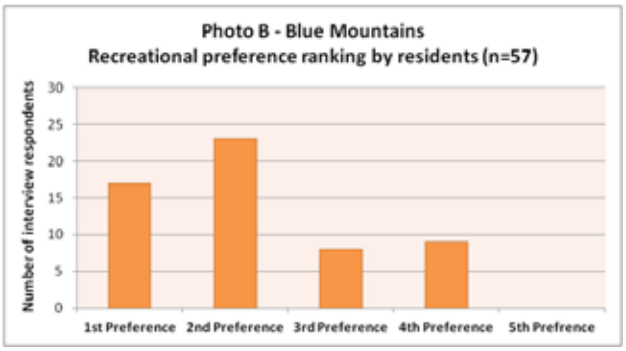
Photo B - Blue Mountains
Recreational preference ranking by residents (n=57)
Number of interview respondents
0
5
10
15
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25
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1st Preference
2nd Preference
3rd Preference
4th Preference
5th Prefrence

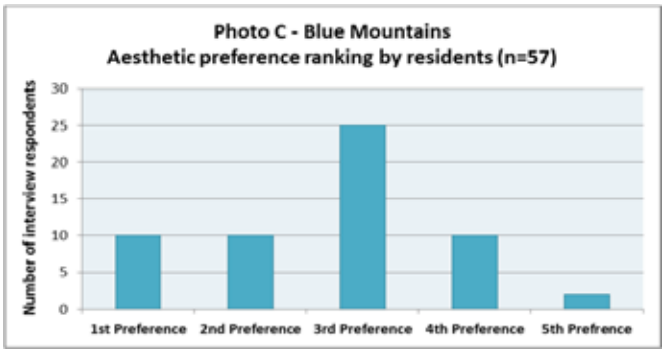
Photo C - Blue Mountains
Aesthetic preference ranking by residents (n=57)
Number of interview respondents
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1st Preference
2nd Preference
3rd Preference
4th Preference
5th Prefrence

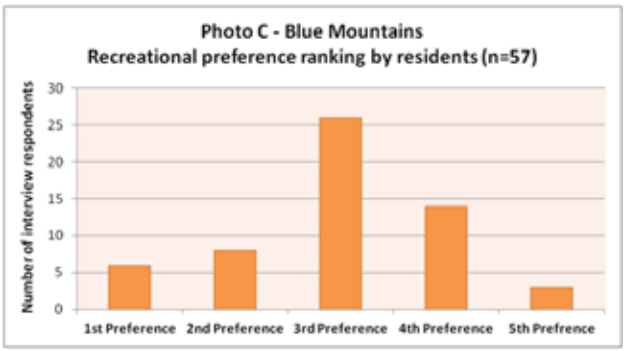
Photo C - Blue Mountains
Recreational preference ranking by residents (n=57)
Number of interview respondents
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1st Preference
2nd Preference
3rd Preference
4th Preference
5th Prefrence

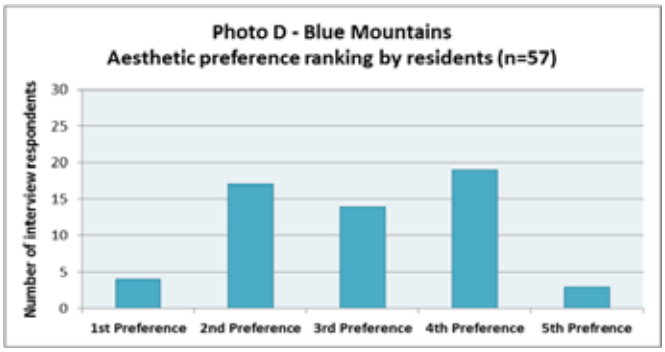
Photo D - Blue Mountains
Aesthetic preference ranking by residents (n=57)
Number of interview respondents
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1st Preference
2nd Preference
3rd Preference
4th Preference
5th Prefrence

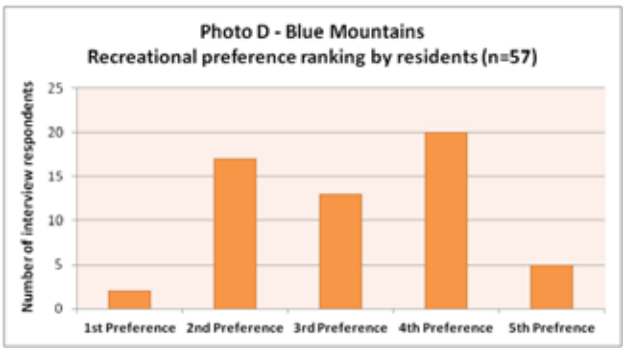
Photo D - Blue Mountains
Recreational preference ranking by residents (n=57)
Number of interview respondents
0
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1st Preference
2nd Preference
3rd Preference
4th Preference
5th Prefrence

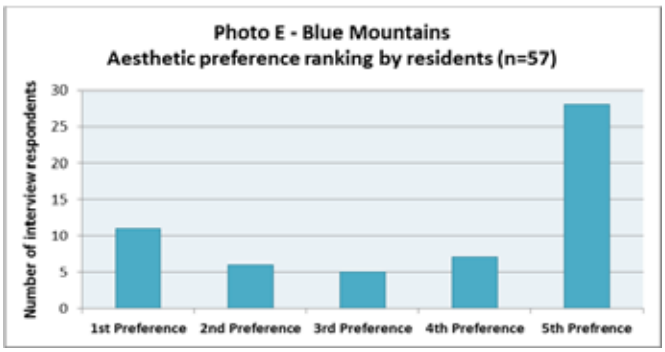
Photo E - Blue Mountains
Aesthetic preference ranking by residents (n=57)
Number of interview respondents
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1st Preference
2nd Preference
3rd Preference
4th Preference
5th Prefrence

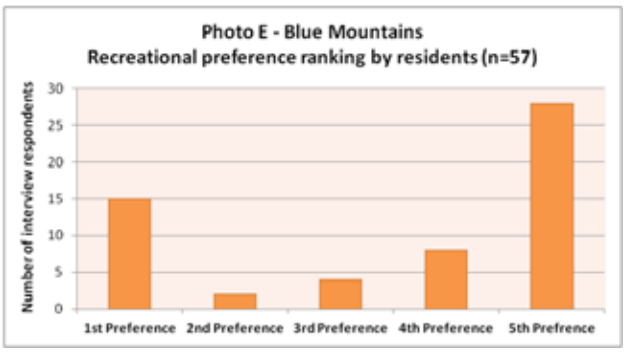
Photo E - Blue Mountains
Recreational preference ranking by residents (n=57)
Number of interview respondents
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1st Preference
2nd Preference
3rd Preference
4th Preference
5th Prefrence

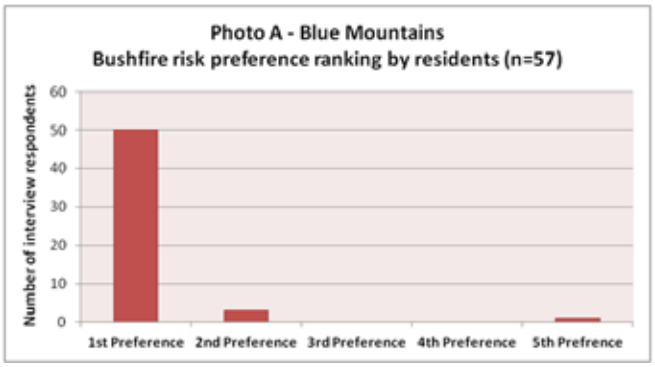
Photo A - Blue Mountains
Bushfire risk preference ranking by residents (n=57)
Number of interview respondents
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10
20
30
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50
60
1st Preference
2nd Preference
3rd Preference
4th Preference
5th Prefrence

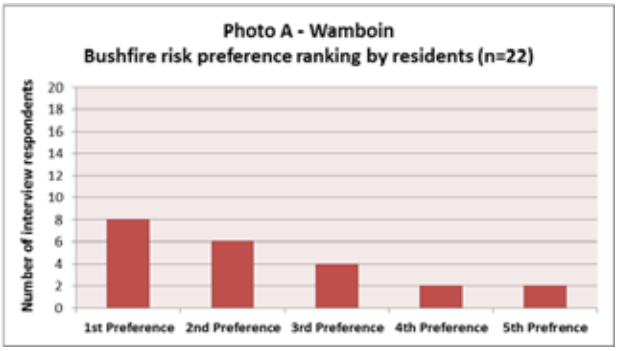
Photo A - Wamboin
Bushfire risk preference ranking by residents (n=22)
Number of interview respondents
0
2
4
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12
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1st Preference
2nd Preference
3rd Preference
4th Preference
5th Prefrence

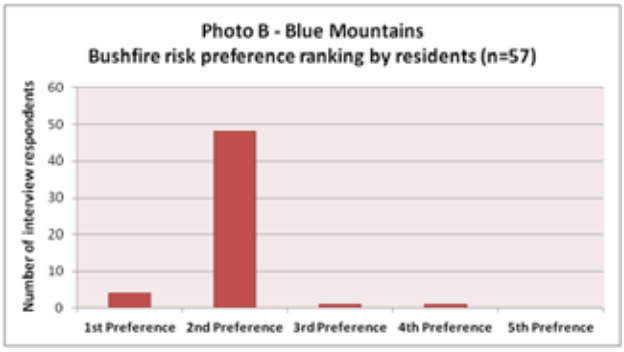
Photo B - Blue Mountains
Bushfire risk preference ranking by residents (n=57)
Number of interview respondents
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10
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60
1st Preference
2nd Preference
3rd Preference
4th Preference
5th Prefrence

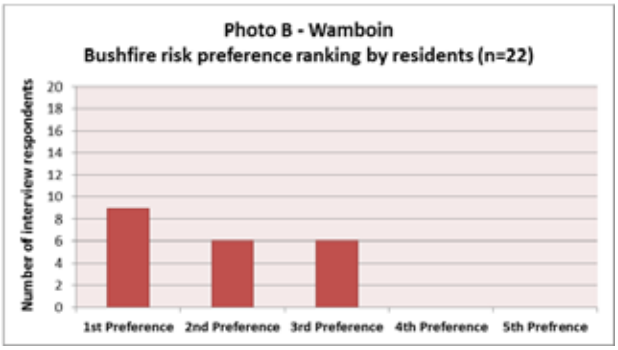
Photo B - Wamboin
Bushfire risk preference ranking by residents (n=22)
Number of interview respondents
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1st Preference
2nd Preference
3rd Preference
4th Preference
5th Prefrence

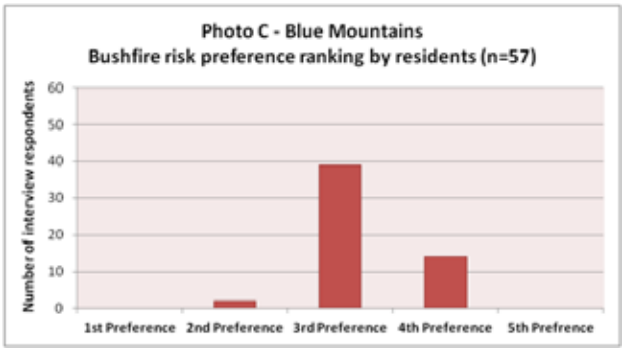
Photo C - Blue Mountains
Bushfire risk preference ranking by residents (n=57)
Number of interview respondents
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10
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1st Preference
2nd Preference
3rd Preference
4th Preference
5th Prefrence

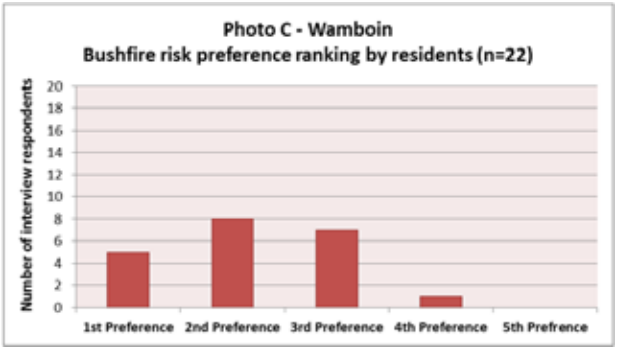
Photo C - Wamboin
Bushfire risk preference ranking by residents (n=22)
Number of interview respondents
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1st Preference
2nd Preference
3rd Preference
4th Preference
5th Prefrence

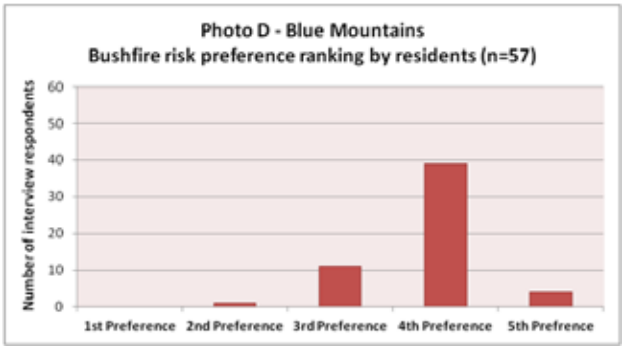
Photo D - Blue Mountains
Bushfire risk preference ranking by residents (n=57)
Number of interview respondents
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1st Preference
2nd Preference
3rd Preference
4th Preference
5th Prefrence

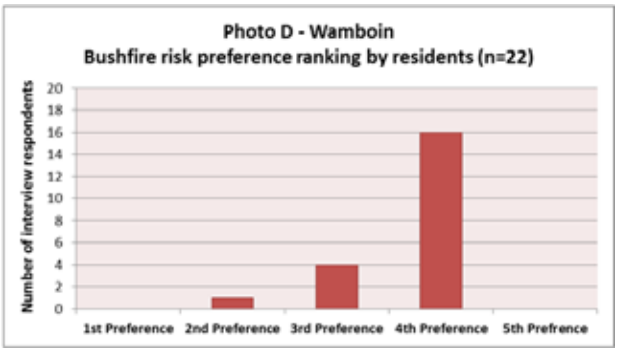
Photo D - Wamboin
Bushfire risk preference ranking by residents (n=22)
Number of interview respondents
0
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1st Preference
2nd Preference
3rd Preference
4th Preference
5th Prefrence

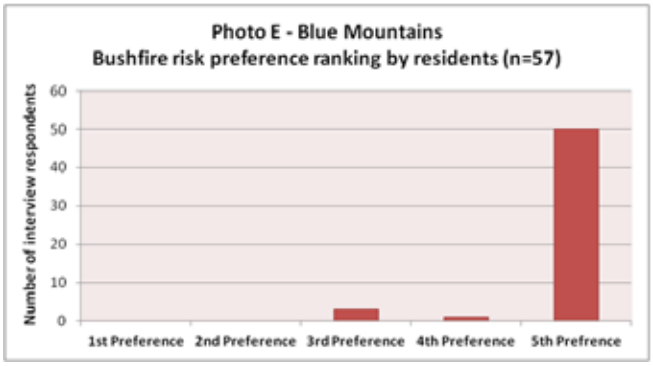
Photo E - Blue Mountains
Bushfire risk preference ranking by residents (n=57)
Number of interview respondents
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1st Preference
2nd Preference
3rd Preference
4th Preference
5th Prefrence

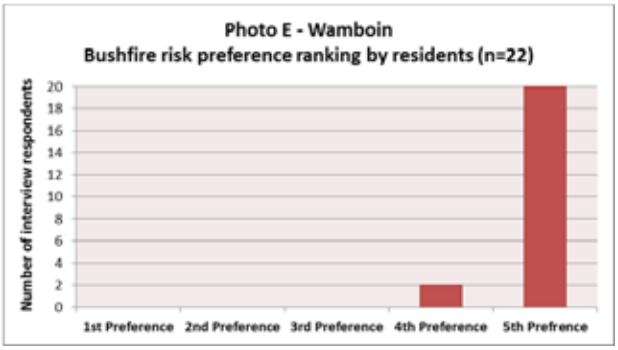
Photo E - Wamboin
Bushfire risk preference ranking by residents (n=22)
Number of interview respondents
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1st Preference
2nd Preference
3rd Preference
4th Preference
5th Prefrence

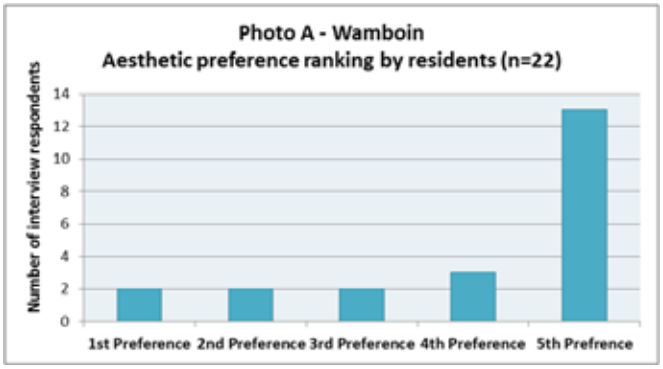
Photo A - Wamboin
Aesthetic preference ranking by residents (n=22)
Number of interview respondents
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12
14
1st Preference
2nd Preference
3rd Preference
4th Preference
5th Prefrence

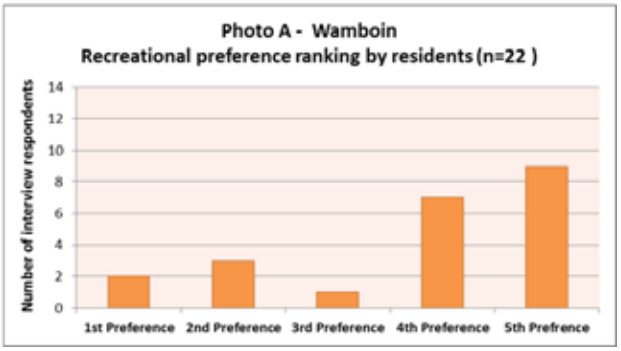
Photo A - Wamboin
Recreational preference ranking by residents (n=22)
Number of interview respondents
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1st Preference
2nd Preference
3rd Preference
4th Preference
5th Prefrence

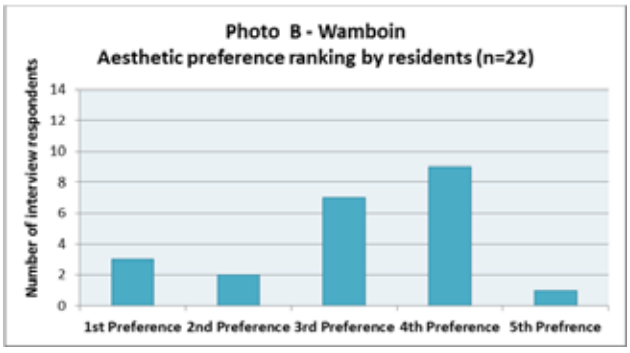
Photo B - Wamboin
Aesthetic preference ranking by residents (n=22)
Number of interview respondents
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1st Preference
2nd Preference
3rd Preference
4th Preference
5th Prefrence

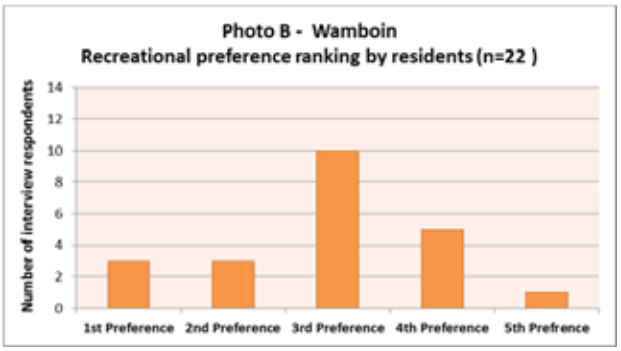
Photo B - Wamboin
Recreational preference ranking by residents (n=22)
Number of interview respondents
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1st Preference
2nd Preference
3rd Preference
4th Preference
5th Prefrence

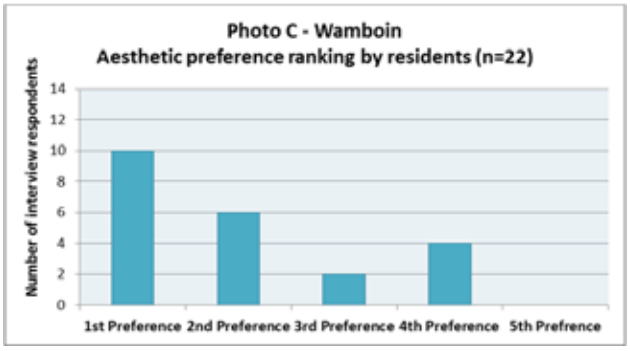
Photo C - Wamboin
Aesthetic preference ranking by residents (n=22)
Number of interview respondents
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1st Preference
2nd Preference
3rd Preference
4th Preference
5th Prefrence

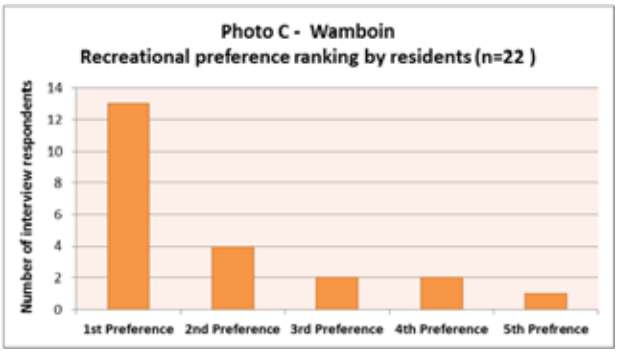
Photo C - Wamboin
Recreational preference ranking by residents (n=22)
Number of interview respondents
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1st Preference
2nd Preference
3rd Preference
4th Preference
5th Prefrence

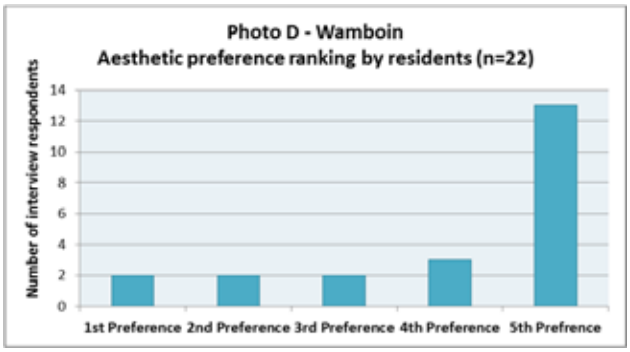
Photo D - Wamboin
Aesthetic preference ranking by residents (n=22)
Number of interview respondents
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1st Preference
2nd Preference
3rd Preference
4th Preference
5th Prefrence

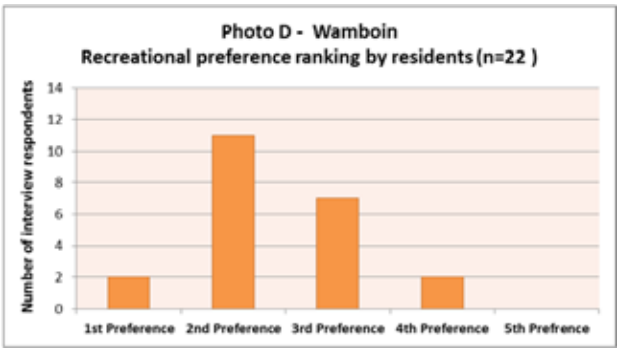
Photo D - Wamboin
Recreational preference ranking by residents (n=22)
Number of interview respondents
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1st Preference
2nd Preference
3rd Preference
4th Preference
5th Prefrence

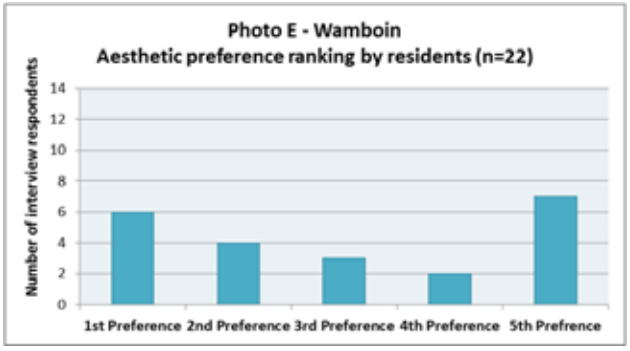
Photo E - Wamboin
Aesthetic preference ranking by residents (n=22)
Number of interview respondents
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1st Preference
2nd Preference
3rd Preference
4th Preference
5th Prefrence

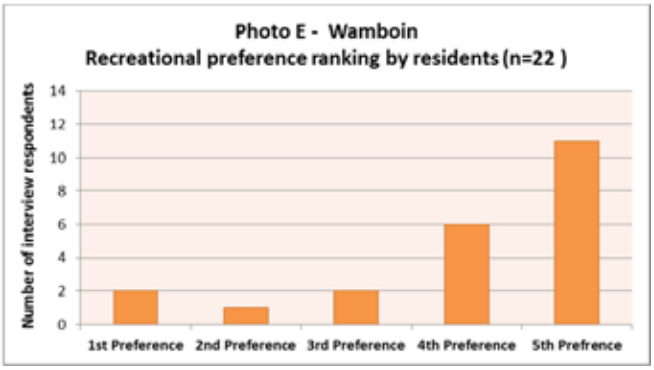
Photo E - Wamboin
Recreational preference ranking by residents (n=22)
Number of interview respondents
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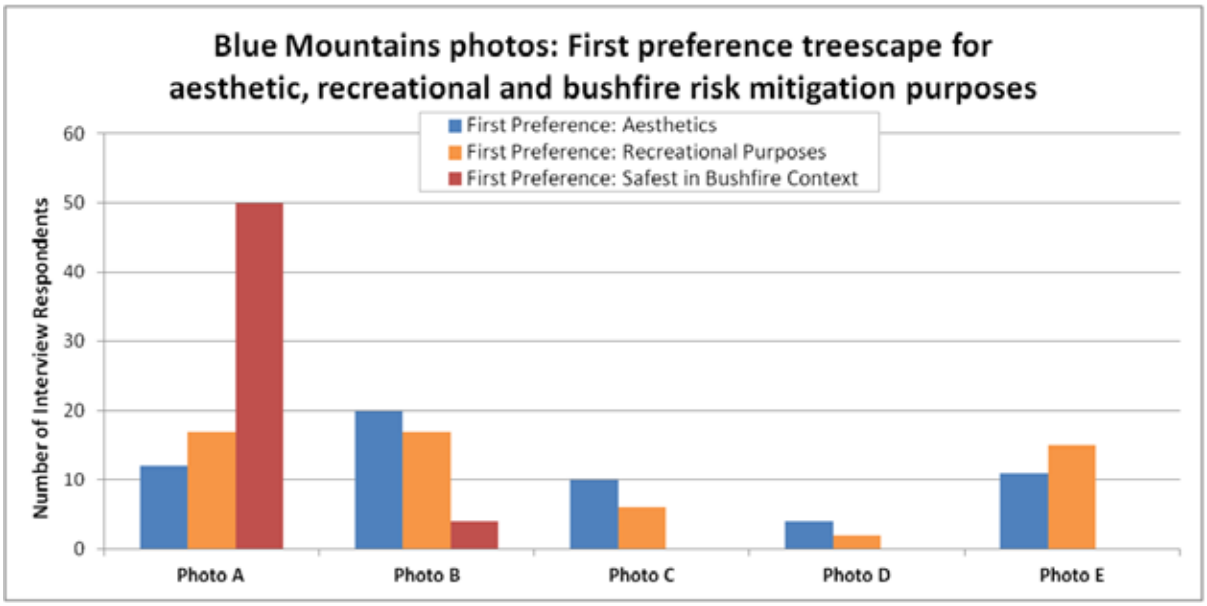
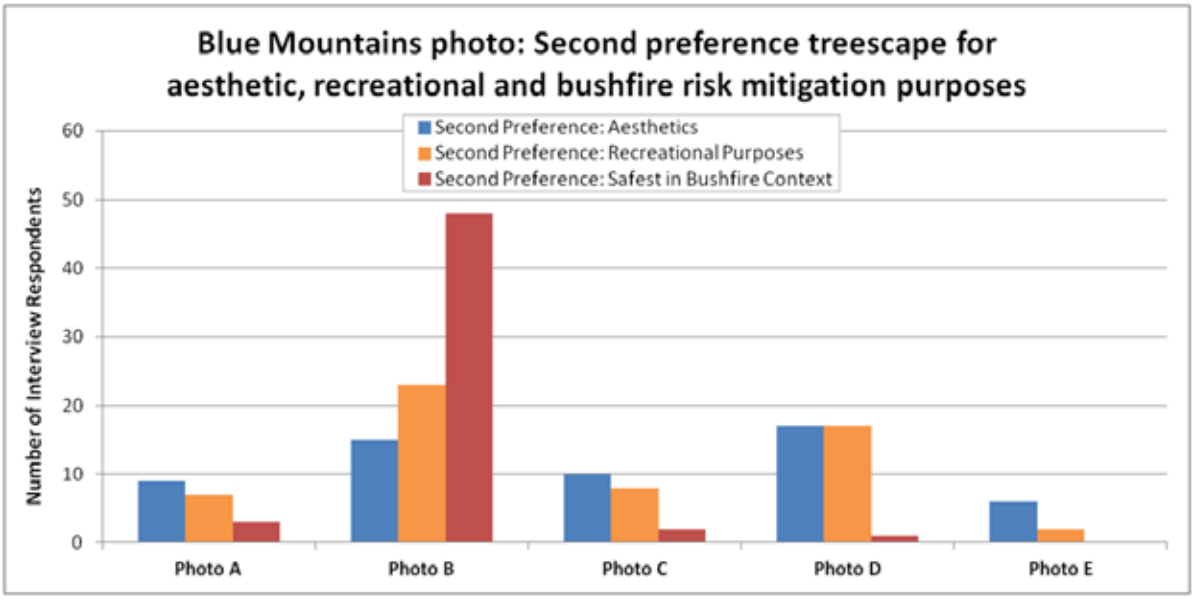
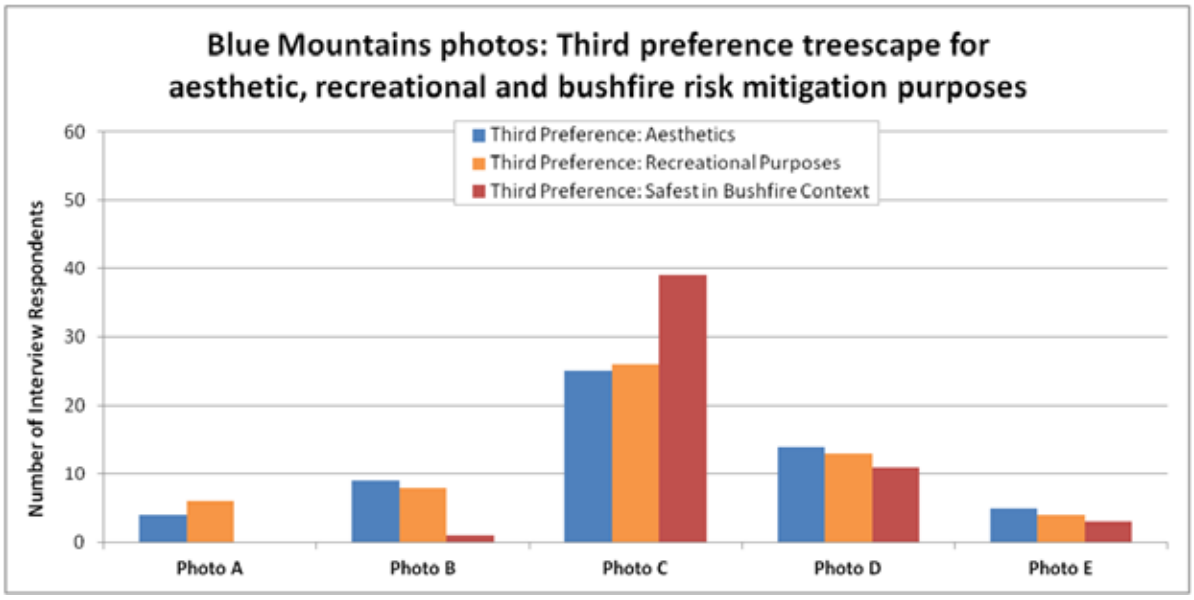
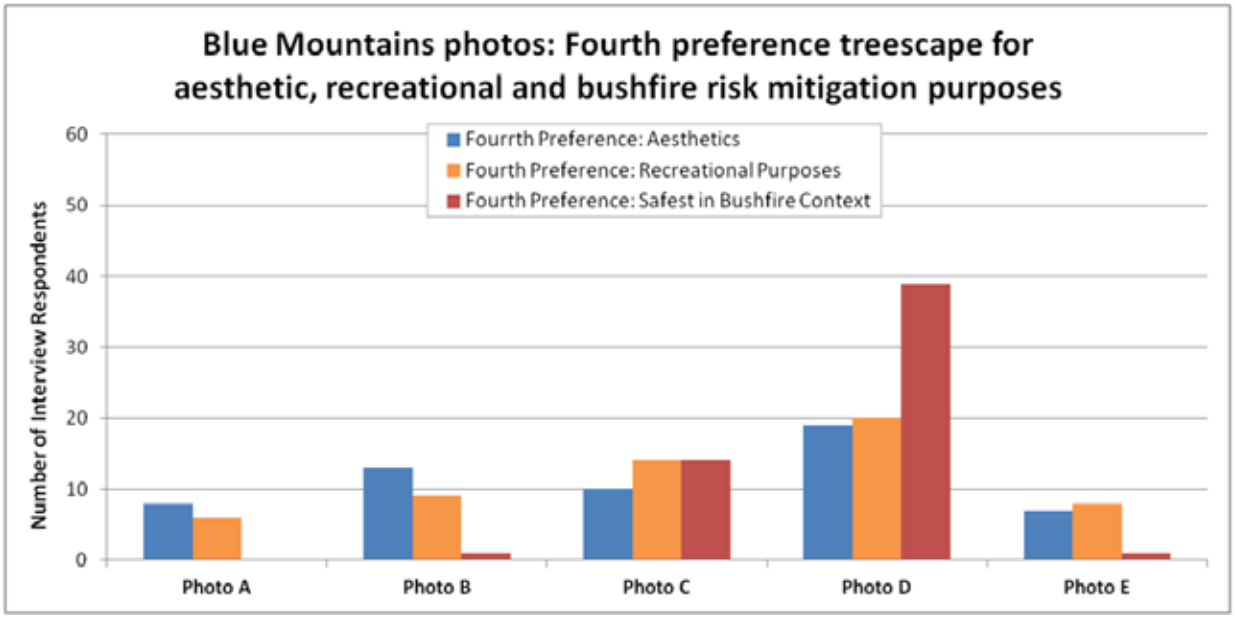
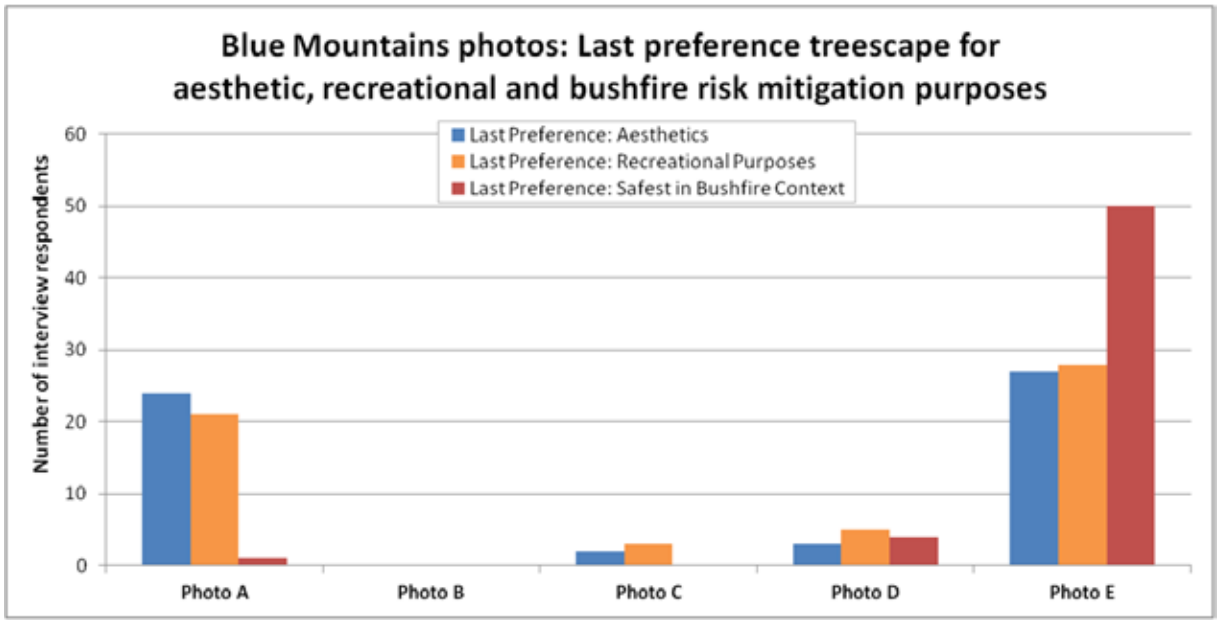
1st Preference
2nd Preference
3rd Preference
4th Preference
5th Prefrence

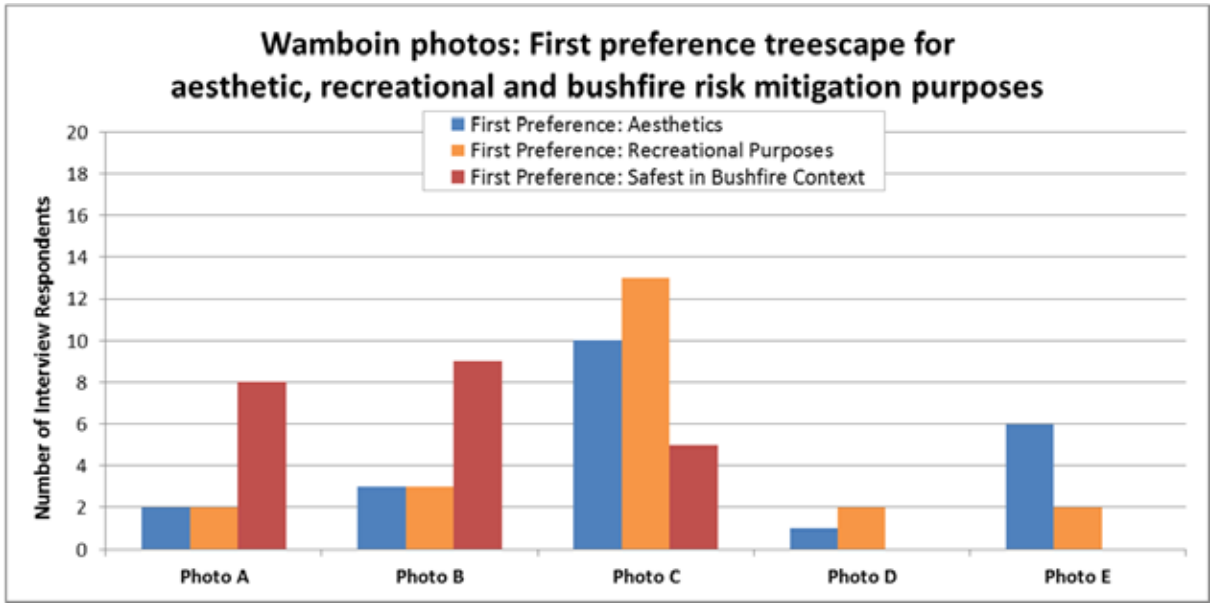

Blue Mountains photos: First preference treescape for aesthetic, recreational and bushfire risk mitigation purposes
First Preference: Aesthetics
First Preference: Recreational Purposes
First Preference: Safest in Bushfire Context
Number of Interview Respondents
60
50
40
30
20
10
0
Photo A
Photo B
Photo C
Photo D
Photo E


Blue Mountains photo: Second preference treescape for aesthetic, recreational and bushfire risk mitigation purposes
Second Preference: Aesthetics
Second Preference: Recreational Purposes
Second Preference: Safest in Bushfire Context
Number of Interview Respondents
60
50
40
30
20
10
0
Photo A
Photo B
Photo C
Photo D
Photo E


Blue Mountains photos: Third preference treescape for aesthetic, recreational and bushfire risk mitigation purposes
Third Preference: Aesthetics
Third Preference: Recreational Purposes
Third Preference: Safest in Bushfire Context
Number of Interview Respondents
60
50
40
30
20
10
0
Photo A
Photo B
Photo C
Photo D
Photo E


Blue Mountains photos: Fourth preference treescape for aesthetic, recreational and bushfire risk mitigation purposes
Fourrth Preference: Aesthetics
Fourth Preference: Recreational Purposes
Fourth Preference: Safest in Bushfire Context
Number of Interview Respondents
60
50
40
30
20
10
0
Photo A
Photo B
Photo C
Photo D
Photo E


Blue Mountains photos: Last preference treescape for aesthetic, recreational and bushfire risk mitigation purposes
Last Preference: Aesthetics
Last Preference: Recreational Purposes
Last Preference: Safest in Bushfire Context
Number of interview respondents
60
50
40
30
20
10
0
Photo A
Photo B
Photo C
Photo D
Photo E


Wamboin photos: First preference treescape for aesthetic, recreational and bushfire risk mitigation purposes
First Preference: Aesthetics
First Preference: Recreational Purposes
First Preference: Safest in Bushfire Context
Number of Interview Respondents
20
18
16
14
12
10
8
6
4
2
0
Photo A
Photo B
Photo C
Photo D
Photo E

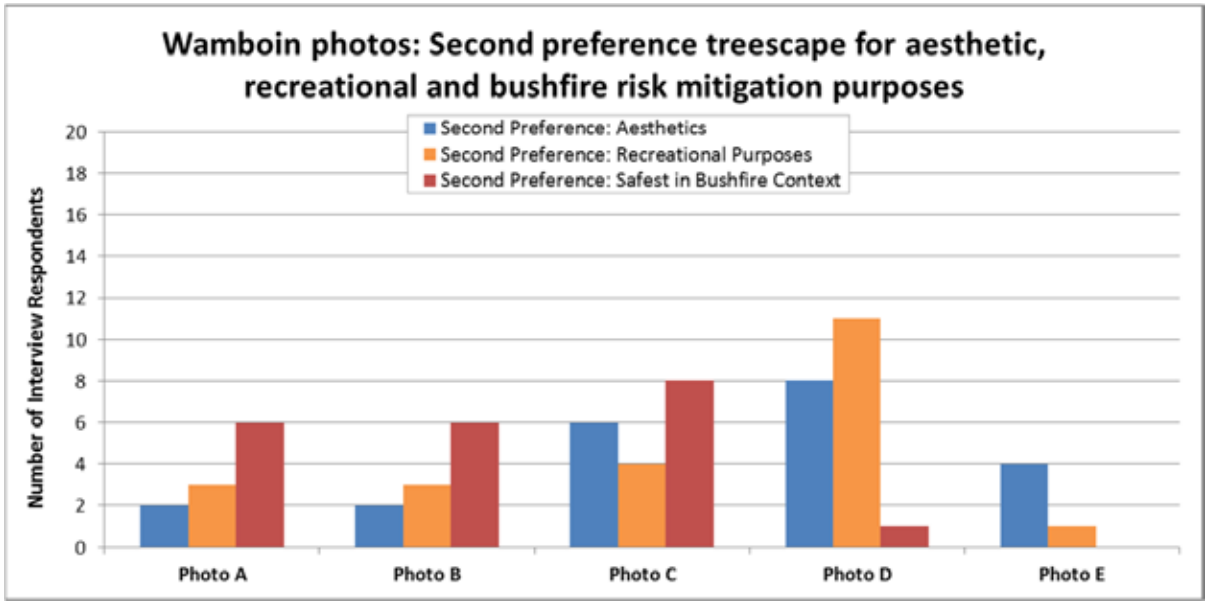

Wamboin photos: Second preference treescape for aesthetic, recreational and bushfire risk mitigation purposes
Second Preference: Aesthetics
Second Preference: Recreational Purposes
Second Preference: Safest in Bushfire Context
Number of Interview Respondents
0
2
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Photo A
Photo B
Photo C
Photo D
Photo E

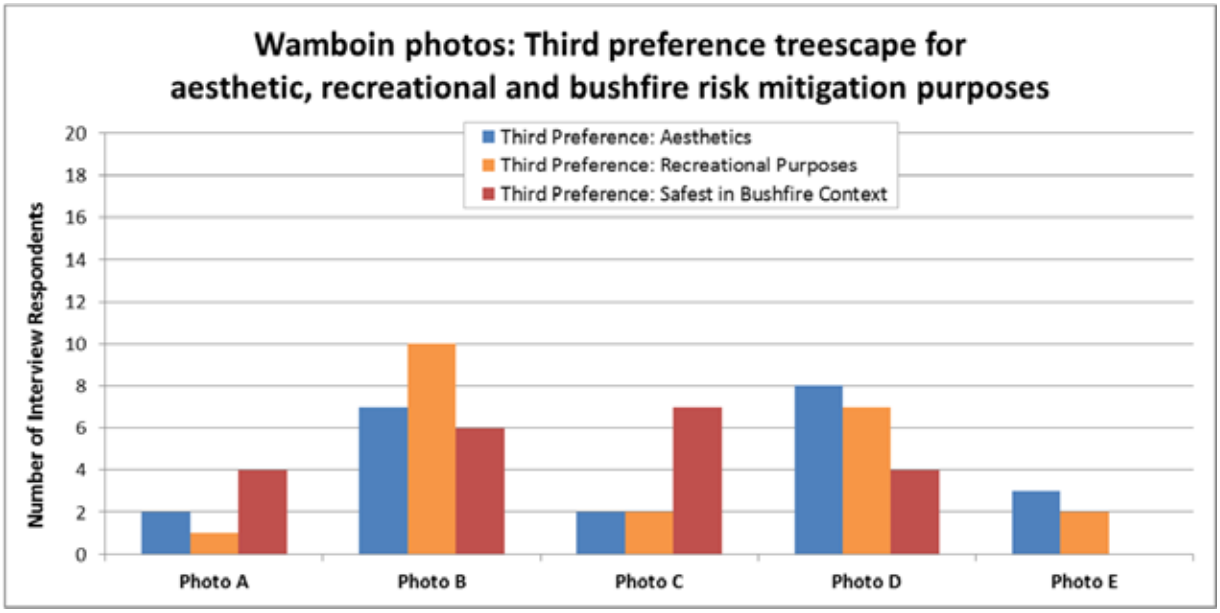
Wamboin photos: Third preference treescape for aesthetic, recreational and bushfire risk mitigation purposes
Third Preference: Aesthetics
Third Preference: Recreational Purposes
Third Preference: Safest in Bushfire Context
Number of Interview Respondents
0
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Photo A
Photo B
Photo C
Photo D
Photo E

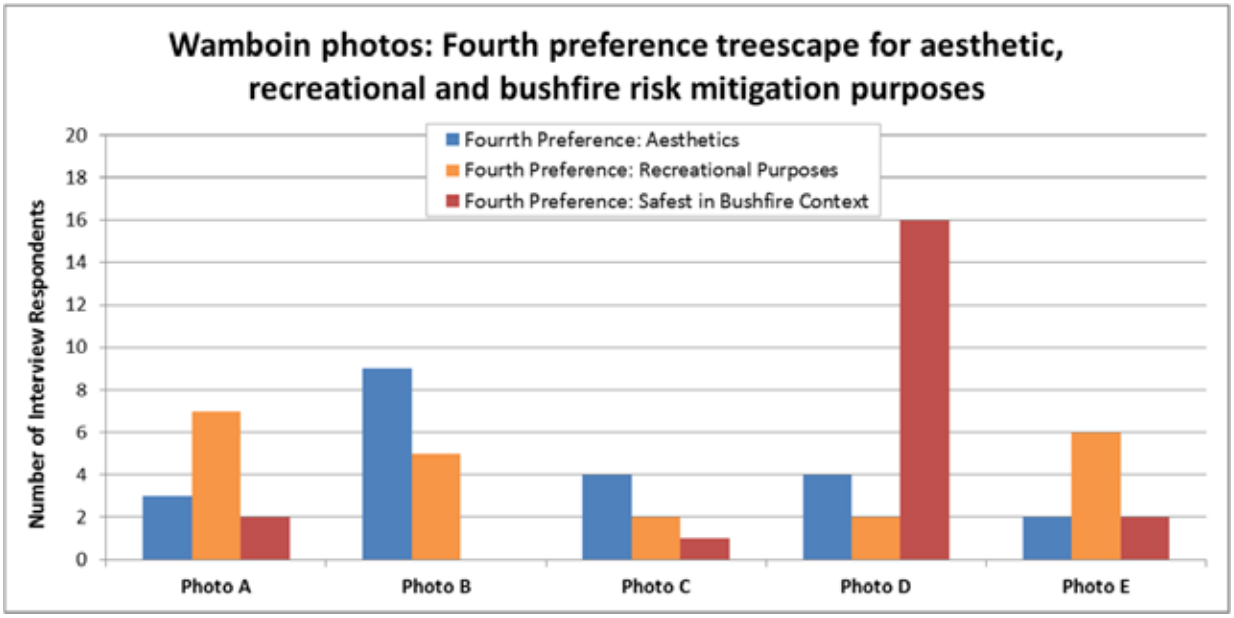
Wamboin photos: Fourth preference treescape for aesthetic, recreational and bushfire risk mitigation purposes
Fourrth Preference: Aesthetics
Fourth Preference: Recreational Purposes
Fourth Preference: Safest in Bushfire Context
Number of Interview Respondents
0
2
4
6
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Photo A
Photo B
Photo C
Photo D
Photo E

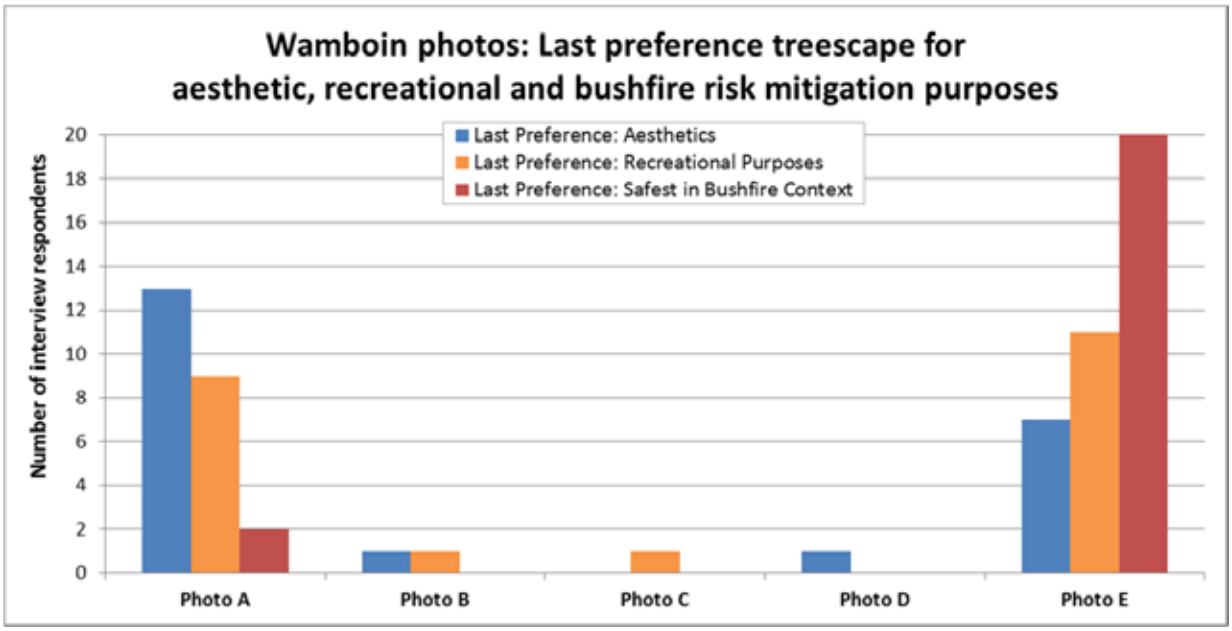
Wamboin photos: Last preference treescape for aesthetic, recreational and bushfire risk mitigation purposes
Last Preference: Aesthetics
Last Preference: Recreational Purposes
Last Preference: Safest in Bushfire Context
Number of interview respondents
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Photo A
Photo B
Photo C
Photo D
Photo E

3. Exploring the nexus between wildfire hazard, risk mitigation and amenity value in rural forest communities of NSW

Trent Penman[1], Nicholas Gill[2], Olivia Dunn[2], Christine Eriksen[2], Christopher Brennan-Horley[2], Sandra Penman[1], Owen Price[1], Ross Bradstock[1]

1: Centre for Environmental Risk Management of Bushfires, University of Wollongong, NSW 2522, Australia.

2: Australian Centre for Cultural Environmental Research (AUSCCER), University of Wollongong, NSW 2522, Australia

Abstract

Increasing numbers of people are living in the Wildland Urban Interface around the world and consequently the risk of house loss from wildfire is increasing. It is important to understand how residents manage this risk. We used a photo-elicitation exercise to identify preferences for the state of fuel (hazard) and amenity among 65 rural houses in NSW Australia, and compared the responses to an independently derived risk probability for each house. We investigated whether residents can adequately identify hazard, whether there is a conflict between such perceptions and amenity or recreation values and, whether the resident's values are related to the predicted fire risk for their property.

We found that almost all residents correctly preferred a low-fuel, open forest in adjacent bushland. Most also preferred the low-fuel forest for amenity, meaning there is potentially little conflict between forest management goals for hazard reduction and amenity. The high level of appreciation of hazard may be due to experience with fire, since 77% of interviewees had experienced wildfire directly. However, most houses were exposed to adjacent fuel hazard levels that placed them at a relatively high level of potential risk. Hazard levels in one community in general and adjacent to some residents in particular, who rated lifestyle value highly, were sufficient to result in particularly high potential risk. The results suggest that these residents can accurately identify hazard but don't necessarily act on that perception. In some cases this is because actions that would reduce hazard and consequent risk would compromise their amenity. Possibly such results may also emerge from competing priorities: the dilemmas of everyday life.

Introduction

Wildfire or 'unplanned fire' has resulted in significant loss of property and lives in most fire prone regions of the globe (Gibbons *et al.* 2012; Gill *et al.* 2013). Devastating losses were experienced in 2007 in California, USA with 2200 houses lost (McCaffrey and Rhodes 2009), approximately 850 buildings in Greece (Bassi and Kettunen 2008) and more than 2000 houses in the 2009 Black Saturday fires in Victoria, Australia in 2009 (Leonard *et al.* 2009; 2009 Victorian Bushfires Royal Commission 2010). In addition to the initial impact , wildfires can have considerable longer term economic impacts on communities, local business and production (e.g., agriculture and forestry) (Ganewatta 2008). Societal impacts continue for decades. For example, many residents suffer post-traumatic stress from wildfire many years after the fire event has occurred (McFarlane *et al.* 1997; Langley and Jones 2005; Papadatou *et al.* 2012). Minimising the damage of wildfires to people and property will therefore have a range of economic and social benefits. While fire management agencies attempt to protect property and lives with fire suppression resources, there are insufficient funds and resources to protect every house from destructive wildfires (Gill 2008; Gill and Stephens 2009).

Residents can improve the probability of survival of structures as well as their own survival by undertaking suitable preparation (Wilson and Ferguson 1986; Ramsay *et al.* 1987; Blanchi and Leonard 2008; Whittaker *et al.* 2012). While the determinants of the risk of house loss are varied, there is much evidence that the zone immediately around the house is critical, including the construction and condition of the house itself (Leonard and McArthur 1999), the garden (Penman et al, this report, (Wilson and Ferguson 1986; Cohen 2000; Gibbons *et al.* 2012) and to a lesser extent the vegetation in the surroundings up to 1 km away (Price and Bradstock 2013b). Adequate preparation involves preparing and maintaining the house and grounds, purchase and maintenance of equipment and the development of an appropriate survival plan (McLennan *et al.* 2013; Penman *et al.* 2013b). Preparing the house and grounds reduces the fuels on and around the structure(s) to decrease the probability of the structure igniting from embers and to reduce the severity of fire behaviour on or around the structure (Gill 2005; Blanchi and Leonard 2008; McGee 2011; Gibbons *et al.* 2012).

Only a small proportion of residents adequately prepare for wildfire (Paton *et al.* 2006; McLennan *et al.* 2012), despite the demonstrated importance of preparation for the survival of people and property. This lack of preparation is often attributed to residents failing to see the risk to their property from wildfire (Paton and Wright 2008a; Gordon *et al.* 2010) which is considered to be more common for residents new to an area that may not have experienced wildfire (Cottrell *et al.* 2008). Other residents have a strong understanding of hazard and risk, but elect not to prepare because they prefer the amenity and recreation opportunities of a "natural" environment (Daniel *et al.* 2003; Nelson *et al.* 2005). For these people vegetation that poses a high hazard and consequent risk to their lives and their property also has high amenity value. Thus there is a direct relationship between the amenity value hazard and fire risk that involves a potential conflict of values. A third group of people understand the risk but do not prepare because logistic barriers prevent action: the 'everyday dilemmas of life'(Eriksen and Gill 2010a).

Development of a fundamental understanding of the reasons why residents fail to prepare for wildfire is required for fire management agencies to more effectively conduct community

engagement. Appropriately targeted strategies are more likely to be adopted and result in decreased risk for residents and their properties. For example, where residents are aware of hazard and risk but have failed to prepare, programs should target assisting people to prepare rather than raising their awareness. In this study, we examine the attitudes to hazard and fire risk by conducting semi-structured interviews with residents in four at-risk communities in New South Wales (NSW). We analysed their responses in the context of an independently derived empirical assessment of the actual fire risk at their properties. Specifically, we asked the questions:

1. Can residents adequately identify vegetation in a hazardous condition?
2. Is there a negative relationship between resident's perception of hazard and amenity or recreation?
3. Do the things that a resident values most about their property increase the hazard and consequent predicted fire risk?
4. Does the ability of a resident to perceive hazard correspond with the actual potential risk to their own property, as reflected in the state of its vegetation?

Methods

Survey

The research was conducted in four communities in New South Wales (NSW), Australia (Figure). Three of the communities (Mount Wilson, Bilpin and Bowen Mountain) were adjacent to the Blue Mountains World Heritage Area (BMWHA), an extensive area of dry sclerophyll open eucalypt forests on steep sandstone-shale terrain. Small pockets of rainforest, heath and grassland also occur throughout the park (Keith 2004). A large and complex urban interface exists between the BMWHA and urban areas challenging fire managers who seek to balance a range of ecological and cultural values, as well as reduce the risk of house loss at the interface (NSW National Parks and Wildlife Service 2004). The fourth community (Wamboin) was selected as a contrast site. Wamboin was once dominated by grazing, but has in part regenerated to native grassy woodlands.

A total of 65 semi-structured interviews were conducted across the four study sites during May and June 2013. Participants were recruited through local NSW Rural Fires Service contacts, attendance at community events, advertisements in local newspapers and community newsletters, letterbox drops, door knocking and through interviewees passing on contact details for other residents. Prior to the interviews, residents were asked to complete a questionnaire. The questionnaire gathered demographic data, details about their prior experience with wildfire, and the extent to which the resident valued peace & quiet, space & privacy, being close to nature, view & scenery, sense of community, bushland &/or forest and lifestyle. The interviews were used for a broader project and here we only focus on a small component of the work. The survey method is described in more detail in Section 2 of this report.

As part of the interview, we used a photo evaluation exercise to elicit quantitative preference data (Tyrväinen *et al.* 2003; Ryan 2012). During the interview, residents were presented with five images of the way tree-dominated vegetation can appear in the landscape (see tables 2.3 and 2.4). A different set of images were used for the Blue Mountains and the Wamboin communities that took

into account the differing vegetation communities in these two areas. Images depicted a tree-dominated area with varying vegetative understorey which is related to fuel hazard (Hines *et al.* 2010). When the five images were laid out, research participants were asked to rank the photos (A to E) from their most preferred to least preferred in relation to three values – aesthetics, recreation and hazard. Photograph A represented the most open vegetation (minimal ground layer vegetation with and no shrubs), with vegetation density increasing across the pictures to a maximum in photograph E. The images relate to the Overall Fuel Hazard Guide (A would be rated as 'low', E as 'extreme'), which is a visual assessment method commonly used by fire management agencies in Australia (McCarthy *et al.* 1999). It is worth noting that while the photos in the Wamboin set depict increasing levels of hazard, they do not reach the rating of 'extreme' as examples of this condition were unable to be found in this vegetation type.

Analysis

Correlations were used to examine the relationships between preferences of aesthetics, recreation and hazard for each of preferences (A to E). We used the Kendall tau rank correlation as the data were non-parametric. Due to the multiple comparisons within the data set, we adopted a Bonferroni adjustment. There were five comparisons within each pair, therefore we used a p-value of significant at p=0.01 (i.e., 0.05/5). All analyses were conducted in the R statistical package v3.0.2 (R-Development Core Team 2011).

An empirically derived probability of loss (potential risk) was calculated for each of the houses by applying a statistical model of house loss from fires across NSW in the years between 2001 and 2009 (see section 1 of this report). That analysis examined the local factors (up to 200 m from houses) that influenced the probability of loss from 35 different fires (including fires in the Blue Mountains), comprising 309 damaged houses and 618 unburnt controls. The derived model predicted house loss as a function of slope, distance to the nearest house, distance to the nearest waterbody and the cover in the garden (low, medium, high). These same variables were calculated for the 65 houses in this study using a combination of Geographic Information Systems and Google Earth Imagery and these values were applied to the model to predict the likelihood that each house would be damaged if a fire occurred.

A generalised linear modelling framework was used to model predicted risk of loss values against the preferences of hazard, amenity and recreation, as well as the values residents placed in their property. We only used the first preferences of hazard, amenity and recreation from the photo exercise as preferences two through to five are correlated with the first preference. Values for peace & quiet, space & privacy, being close to nature, view & scenery, sense of community, bushland &/or forest and lifestyle were recorded on a five point scale and converted to a continuous variable. Due to the strong relationships between these estimated "values", we used a principal components analysis (PCA) to reduce the number of predictors. PCA seeks to create orthogonal factors based on existing relationships within the data. Only PCA factors with an eigenvalue of greater than 1 were used in the analysis (Johnson and Wichern 1988). Variables which contribute to a factor have a loading greater than 0.7 or less than -0.7. Those with loadings between 0.6 to 0.7 or -0.6 to -0.7 are considered to contribute weakly to the PCA factor.

We considered all possible combinations of the PCA factors, photo preferences for hazard, amenity and recreation and the survey area. Survey area was included as a fixed variable in all models as there are known regional differences in the predicted probability of loss. Preferences for recreation and amenity were highly correlated (Table 3.1) and not included in the same model to avoid the effects of multi-collinearity (Chatterjee *et al.* 2000). A best set of models was identified using Akaike's Information Criterion (AIC) (Akaike 1973) which balances model complexity with model fit. All models falling within 2 AIC points of the best model, i.e. the model with the lowest AIC were considered (Burnham and Anderson 2002).

Results

Identification of hazard

All respondents were able to rank the images in the photo evaluation exercise in a way that corresponded to their actual, assessed fuel hazard status: i.e. images with lowest fuel hazard score were ranked as 'low hazard' (Figure). Over 90% of respondents in the Blue Mountains selected the lowest hazard option, with the remainder selecting the second lowest (Figurea). In Wamboin, 80% of respondents selected A or B with the remainder selecting image C. A broader distribution of preferences was seen for both aesthetics and recreation (Figureb and 3.2c).

Hazard vs amenity/recreation

No relationships were found between the rankings of hazard and either aesthetics or recreation for preferences A to E (Table 3.). In contrast, there were significant positive correlations between the preferences of amenity and recreation for preferences A to E (Table 3.).

Risk and amenity/recreation trade-offs

The mean predicted probability of house loss (given the hypothetical occurrence of a fire) for the 65 houses was 0.43, but there was a considerable difference in this estimate of risk among the communities (Figure.3), with Bowen Mountain showing higher risk than the other three (mean values: Bowen Mountain 0.64, Mt Wilson 0.43, Wamboin 0.41 and Bilpin 0.36). The differences in the values for Bowen Mountain compared to the other communities were the close proximity of houses in the Bowen Mountain site (median distance 8 m compared to 150 m for other sites) and higher vegetation cover within 20m of the house (8/9 with 'high' garden cover compared to 35/59 for other sites) as seen in Figure.

The PCA identified three unique variables explaining a total of 64.1% of the variation in the data (Table 3.2). The first PCA factor (hereafter PCA1) correlated negatively with the values residents place in views from the property (loading = -0.798) and weakly with the values of nature (loading = -0.691) and community (loading = -0.651). The second PCA factor (hereafter PCA2) was positively correlated with the values of peace and quiet (loading = 0.885) and weakly with space and privacy (loading = 0.633). The third PCA factor (hereafter PCA3) was positively correlated with the values of lifestyle (loading = 0.896).

Six models were included in the best set based on AIC. When compared with the Bilpin properties, probability of loss was significantly higher for Bowen Mountain ($p<0.001$), Mount Wilson ($p<0.001$) and Wamboin ($p=0.021$). All models included a significant positive relationship with the probability

of loss and PCA3 which represents lifestyle. That is, the higher the residents ranked lifestyle values on their property the higher the probability of loss. All other variables except the first preference for aesthetics were included in one or more models in the best set; however the relationships were not significant.

Discussion

In this study residents could accurately identify increasing fuel hazard when presented with photos of varying fuel arrangements from their local vegetation type. This contrasts with some previous studies where an inability to perceive hazard and risk is considered the major barrier to residents adequately preparing for wildfire (Paton and Wright 2008a; Gordon *et al.* 2010). The ability to identify hazard in our study may be due to previous experience with fire. In fact, 91% of these residents had seen fire burning vegetation and 77% had experienced fire directly (their house was threatened by in the past or they had helped to defend a neighbour's house), and this is a much higher level of experience than in some of the studies that found poor hazard or risk perception (Gordon *et al.* 2010). Alternatively media reports from recent catastrophic fire events, advertising, or engagement activities within their local communities may have helped to raise awareness of wildfire hazard and risk. There was a broader distribution of preferences relating to the hazard photos in Wamboin compared to the Blue Mountains, which was probably due to less variable vegetation in Wamboin which resulted in little difference in hazard between the Wamboin pictures A-C.

Despite the awareness of hazard, most houses in this survey were at relatively high potential risk if a fire occurred. This is despite the fact that 56% of residents had received formal advice about hazard on their property. This is illustrated by the aerial image of the Bowen Mountain community (Figure 3.4), which has dense housing located on a steeply sloping ridge-top with many houses within the forest. This raises the question of why people might live in a such a situation when they recognise hazard and consequent potential risk. It is quite possible that residents can recognise that they live with high fuel hazard without considering the fire risk to be high if they think that the chances of fires occurring there are low. It is also possible that the residents in this study could identify hazard in a general sense (i.e. as in the photographs) without recognising high levels of hazard specifically on their own property.

Residents' preferences for minimising hazard from the photos had no statistical relationship with the photos they preferred for either aesthetics or recreation. Approximately half of residents preferred the less vegetated photographs (A or B) for both recreation (46%) and aesthetics (49%). However, photograph E (denser vegetation) was preferred by 17 residents for recreation and by 15 residents for aesthetics, and this is the main reason for a lack of correspondence between hazard and amenity preference. Thus there is broad agreement that open vegetation is good for both amenity and hazard reduction, but for about one quarter of the residents there is a conflict between amenity and hazard.

The statistical modelling of the probability of house loss identified study area and high lifestyle values as consistent factors influencing risk. Lifestyle priorities have previously been found to have a

major influence on choices to prepare for wildfire risk (Eriksen and Gill 2010a). Given that residents could understand hazard, this may indicate that hazard is not their highest priority when making decisions on how to manage their property. It seems that their value for lifestyle overrides their perception of either hazard and/or risk. However, the majority of variation in hazard was not explained by the models, so other factors are also at play.

A number of possibilities exist to explain this disparity. First, people may be willing to knowingly tolerate the existence of hazardous vegetation on their properties because they perceive that the chance of fire reaching their property is low. Second, residents may not act on their hazard because of motivational barriers which might be psychological, practical or financial: what Eriksen and Gill (2010) refer to as the 'dilemmas of everyday life". Among all the other tasks required to live and enjoy their lifestyle, wildfire preparedness may be low on the list. Many of these residents may be amenable to maintaining their surrounding vegetation in an open, low fuel state, and this concurs with findings from the USA (McCaffrey *et al.* 2013a). Thus, the key to improving preparedness may rely less in educating people about how to reduce hazard and more in in assisting them to take action. In other words, people know what to do, but everyday dilemmas prevent them from doing so. Assistance with overcoming the barriers might be of greatest benefit.

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Table 3.1: Correlations between fuel hazard, amenity and recreation preferences from the photo-elicitation exercise.

Hazard vs amenity	Hazard vs recreation	Amenity vs recreation
R = 0.063, p= 0.470	R = 0.012, p= 0.891	**R = 0.487, p< 0.001**
R = 0.146, p= 0.095	R = 0.118, p= 0.179	**R = 0.423, p< 0.001**
R = 0.113, p= 0.200	R = 0.130, p= 0.139	**R = 0.263, p= 0.003**
R = 0.097, p= 0.268	R = 0.077, p= 0.384	**R = 0.339, p< 0.001**
R = -0.014, p= 0.871	R = 0.000, p= 1.000	**R = 0.356, p< 0.001**

Table 3.2: PCA loadings for the features which residents value about their properties. For each value, residents scored the importance of that value for their lifestyle from Low to Very High.

Personal values of property	1	2	3
Peace and quiet	-0.209	0.885	-0.137
Space and privacy		0.633	0.529
Being close to nature	-0.691	0.243	0.179
View/scenery	-0.798	0.134	
Sense of community	-0.651	-0.438	
Bushland and/or forest	-0.464		0.265
Lifestyle	-0.17		0.896

Table 3.3: The best set of models to predict the calculated fire risk from the GLM analysis. Among the terms, Study Area is Wamboin, Bilpin, Bowen Mountain or Mount Wilson, PCA 1, 2 and 3 refer to the PCA variables identified in Table 2.2 and Rec1N refers to the first preference for recreation from the photo-elicitation exercise. Column DAIC gives the delta-AIC, the difference in Akiaike Information Criteria between the best model and each other model. The DE column gives the residual deviance.

Mod	DAIC	DE
Study Area + PCA3 + Rec1N	0	56.92017
Study Area + PCA3	0.383865	55.1741
Study Area + PCA1 + PCA3 + Rec1N	0.406266	58.0494
Study Area + PCA1 + PCA3	1.681324	55.69591
Study Area + PCA3 + Risk1N + Rec1N	1.989357	56.92781
Study Area + PCA2 + PCA3 + Rec1N	1.999859	56.92027

Figure 3.1: Location of the study areas in NSW.

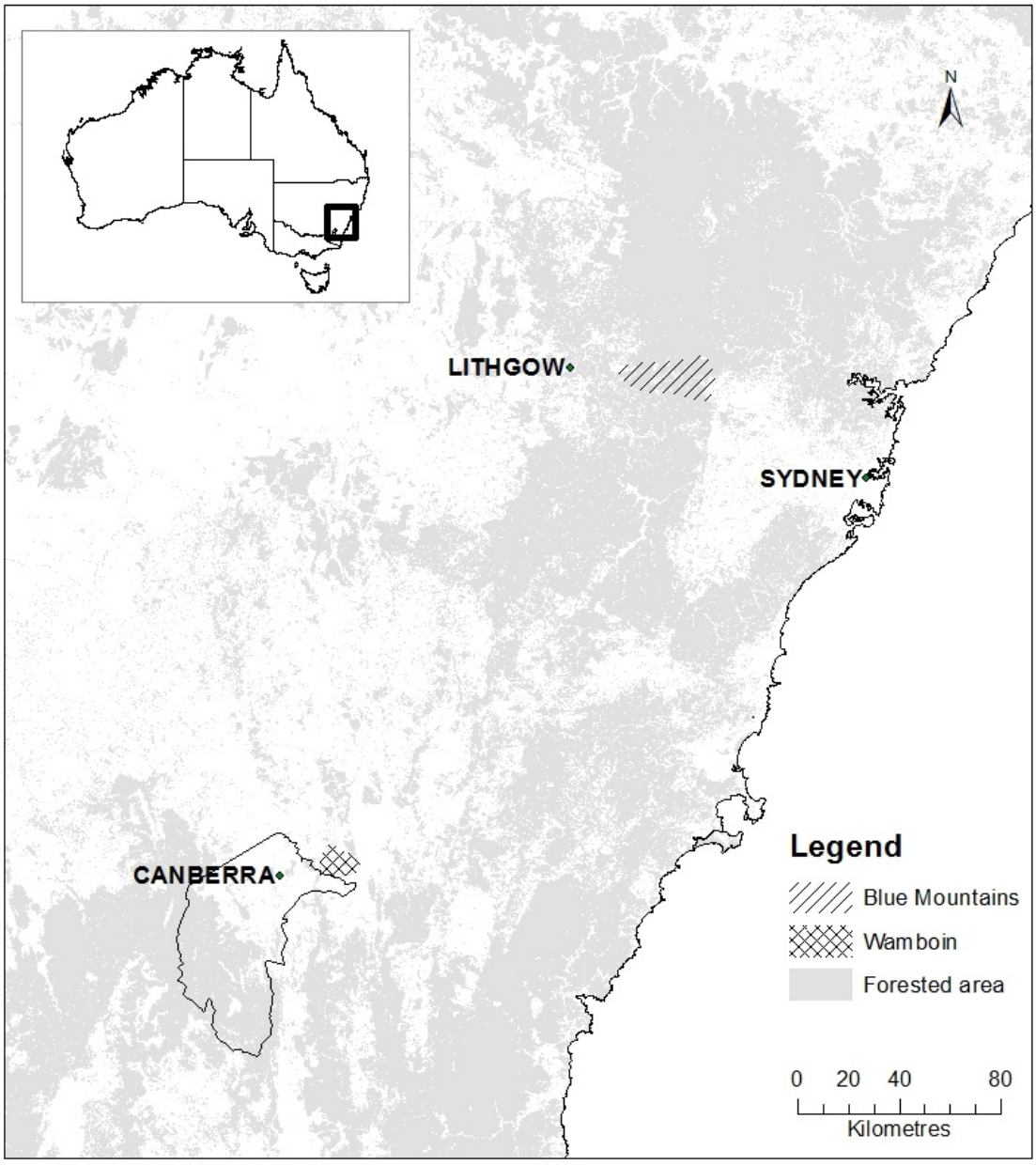


Figure 3.2: Distribution of the first preferences from the photo-elicitation exercise for participants for a) hazard, b) aesthetics and c) recreation

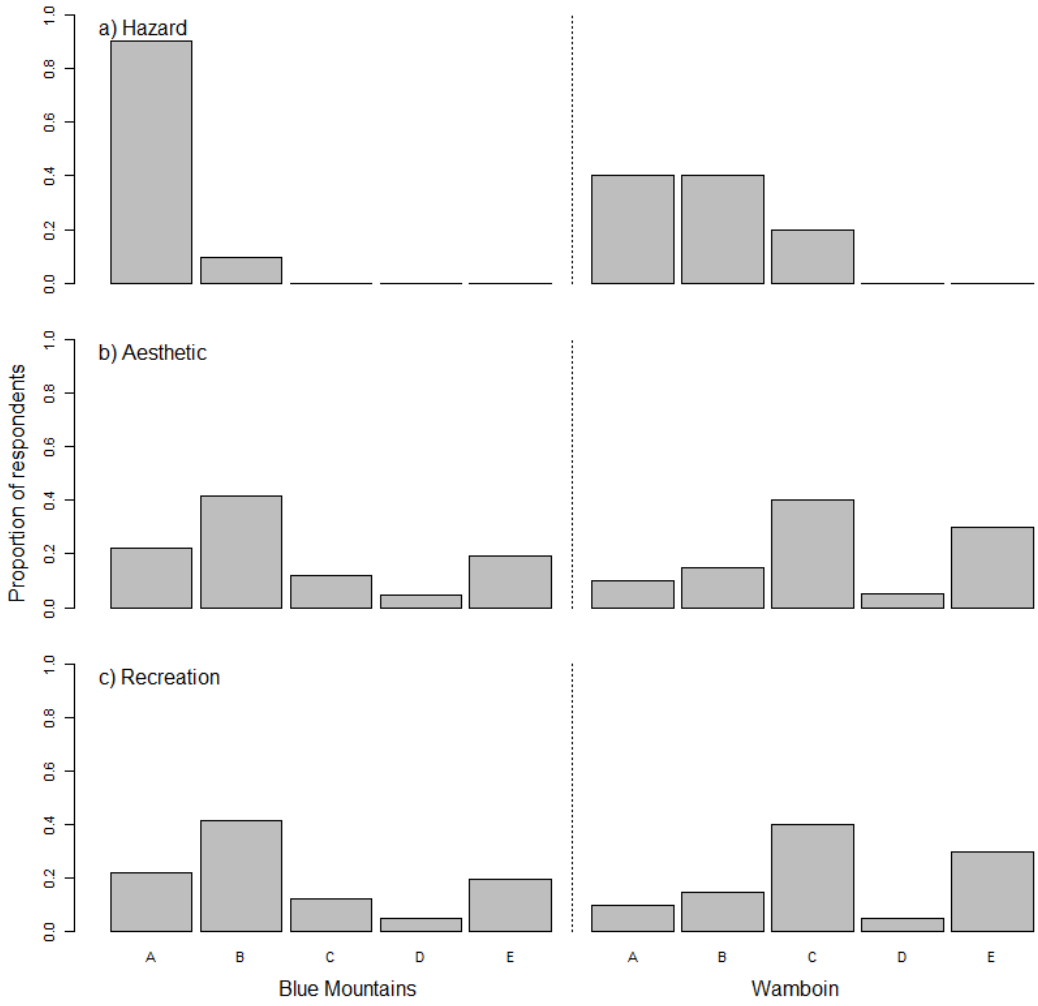


Figure 3.3: Risk of loss from fire of each property interviewed. The risk estimate is conditional on a fire occurring adjacent to property.

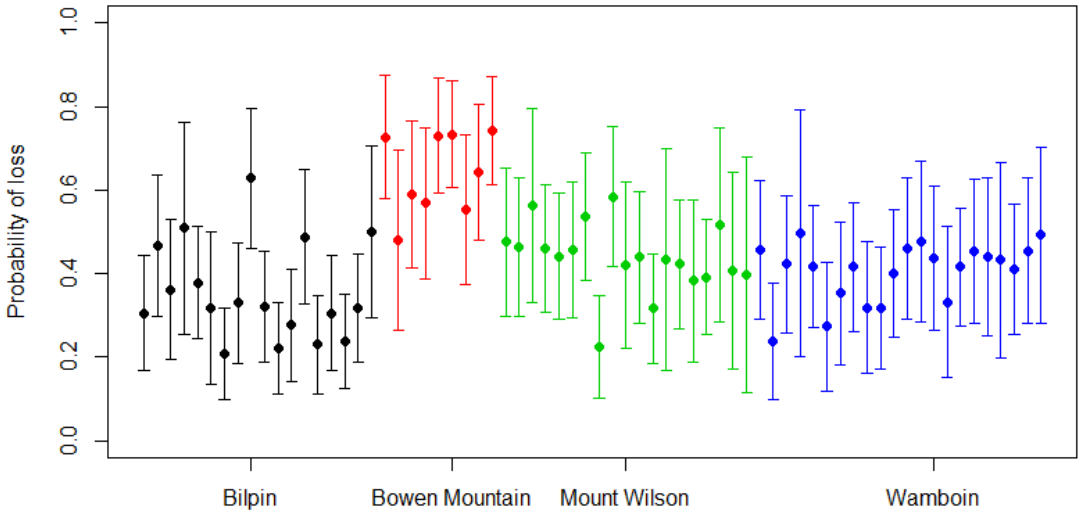
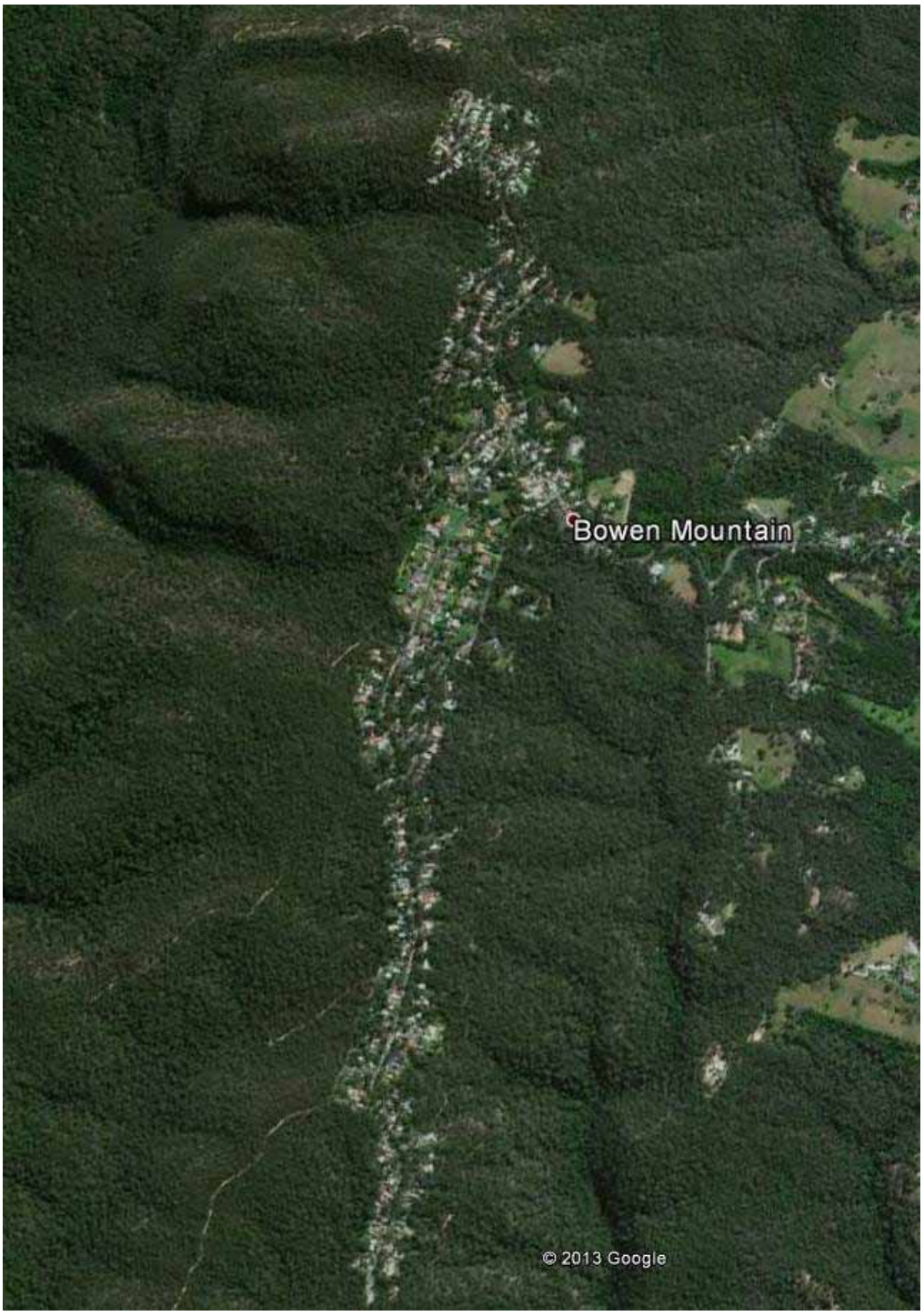


Figure 3.4 The Bowen Mountain community (courtesy Google Earth).



4. Lessons from the State Mine Fire: a post-fire analysis of preparedness and risk in the Blue Mountains, NSW

Report Authors
Carrie Wilkinson[a,b], Christine Eriksen[a,b,] and Trent Penman[b]

Interview Team
Christine Eriksen[a,b], Olivia Dun[a], Nicholas Gill[a] and Carrie Wilkinson[a,b]

[a] Australian Centre for Cultural Environmental Research, University of Wollongong
[b] Centre for Environmental Risk Management of Bushfires, University of Wollongong

Abstract

This report chapter presents a post-fire analysis of community preparedness and risk in Mount Wilson and Bilpin in the Blue Mountains, NSW in light of the October 2013 State Mine Fire. It examines: a) on-ground damage caused by the bushfire, as described by residents; b) examples of successful property defence due to preparedness measures; and c) insights into what did or did not go to plan, and the reasons why. The report concludes that practical and mental preparedness by individuals, as well as community cohesion, increased coping capacity. Yet, it also highlights important points for improvement, particularly with regards to household decision-making during stress, caring for dependents and pets, and miscommunication between local RFS brigades and public messages from New South Wales Rural Fire Service Central Office.

Introduction

Approximately 100 bushfires burnt across eastern New South Wales (NSW) during October 2013. This included six major bushfires (NSW RFS 2013A), three of which burnt uncontained for a number of weeks through the Greater Blue Mountains region. These were some of the largest fires seen in the area so early in the annual fire season. This chapter provides a post-fire analysis of the largest fire that burnt uncontained in the north-western area of the Blue Mountains region for nearly two weeks.

On Wednesday October 16th, a live ordnance training exercise at Marrangaroo Army Range, near Lithgow, accidentally sparked a fire that became known as the 'State Mine Fire' (NSW RFS 2013B). On October 17th strong westerly winds coupled with high temperatures resulted in a fast moving fire, which travelled east over 25 km in one day. It burnt for nearly another two weeks through large parts of the northern region of the Blue Mountains National Park as well as the Wollemi National Park between Lithgow and Mount Tomah. At various stages through this fire, thousands of people in Lithgow were evacuated and the communities of Bell, Bilpin, Berambing, Clarence, Dargan, Hartley Vale, Mount Irvine and Mount Wilson were also affected. When the State Mine Fire was brought

under control on October 29th, it had burnt over 55,000 hectares of bushland (NSW RFS Blue Mountains District 2013). Preliminary reports state that three houses and seven other buildings were destroyed in the bushfire and two were significantly damaged (NSW RFS 2013C). No human lives were lost.

Whilst the damage incurred by the communities impacted by the State Mine Fire was small when compared to the Blue Mountains communities of Springwood, Winmalee and Yellow Rocks affected by the Springwood Fire (also in October 2013; see Appendix A), the loss of three homes, several sheds, cars, machinery, fencing, gardens and other assets cannot be downplayed. That these communities escaped relatively unscathed is a subject of much discussion. It is therefore important to liaise with the affected communities to understand the extent and efficacy of their preparations, their actions on the day, and what agency information was effective (or not). Learning from these events means that awareness and education initiatives prior to a fire and management responses during a fire can be improved for the future. Specifically, this study reports on:

1. The on-ground damage caused by the bushfire, as described by residents
2. Examples of successful property defence due to preparedness measures
3. Insights as to what did or did not go right for residents during the fire and the reasons why.

Methods

Recruitment and sampling

This study sought to better understand the experiences of residents across two communities affected by the State Mine Fire: Mount Wilson and Bilpin in the upper north-western part of the Blue Mountains, adjacent to the Blue Mountain World Heritage Area. Mount Wilson and Bilpin were selected as the sites for this study for three reasons:

1. Research had been conducted with residents in both locales during May-June 2013 as part of the broader managing risk and amenity project reported in Chapters 2 and 3.
2. Experience of fire amongst residents is relatively high: it became clear through the initial round of interviews in May-June 2013 that a large number of the participants have been paid or volunteer members of fire management agencies and many have first-hand experience with bushfires. This reflects the fire-prone nature of the environment the participants live in, resident interest in the issue of bushfire management, and the fact that local Rural Fire Service (RFS) brigades are the main hub of social connectivity in these small communities. Resident interest in bushfire management can also, in no small part, be attributed to the high visibility and extensive community engagement practices of the local RFS brigades. This paper focuses on the experiences of individual landholders rather than the local RFS as a whole, whose volunteers fought to defend the communities from the approaching fire fronts.
3. The timing and duration of the fire threat – the Mount Wilson community was impacted by the bushfire almost immediately after first knowledge of the threat, whereas Bilpin residents

remained on 'high alert' for a number of weeks and were never truly impacted by the bushfire, in a physical sense at least. Given the vastly different timings wherein these communities came under threat, these case studies provide an opportunity to compare different experiences of the same fire event.

Emails were sent to the research participants in Mount Wilson and Bilpin who were already engaged with the "Co-existing with Fire: Managing Risk and Amenity" project, seeking their interest to participate in a follow-up interview. The purpose of this second interview was to learn about residents' direct experience of the October 2013 bushfires. Questions were structured to elicit a comprehensive, chronological narrative and covered the following themes:

1. Actions in the lead up to the fire
2. Actions during the fire: leave early, stay and defend, or wait and see
3. Reflections in the aftermath of the fire.

More broadly, the semi-structured interviews sought to gain insight to residents' preparations, communications and information sourcing, and identification of risk prior to, during and following the fire. With the participants' permission the conversations were audio-recorded and later transcribed for data analysis purposes.

Over three days in December 2013, a total of 18 interviews with 23 people were conducted at 18 properties across the two study sites (see Table 4.1). Eight properties were within the responsibility of the Mount Wilson/Mount Irvine Rural Fire Brigade: six of these were on the northern side of Mount Wilson and the other two properties were on the southern side of the village. The remaining ten properties were within the responsibility of the Bilpin Rural Fire Brigade: seven properties were on the northern side of Bells Line of Road and three on the southern side of Bells Line of Road in Bilpin. This report contains excerpts from all 18 interviews. Five interviews were with couples and the remaining interviews were with an individual resulting in a total of 23 participants. Any resident quotes presented in this study are from these 23 research participants. To protect the identity of participants, residents from Bilpin are coded as B# and residents from Mount Wilson are coded as W#.

Table 4.1: Summary of interviews conducted in the two study sites

	Mount Wilson	Bilpin	Total
Number of interviews conducted	8	10	18
Number of Residents Interviewed	9 (5 women/4 men)	14 (4 women/10 men)	23 (9 women/14 men)
Number of residents commuting to work (or other activities) three or more days a week	2	5	7
Number of residents for whom Mount Wilson/Bilpin is a secondary residence	2	0	2
Number of residents who are current member of their local RFS brigade	9	4	13

Data analysis

In order to conduct narrative analysis of residents' experiences of the State Mine Fire, interview transcriptions were analysed using NVivo 10.0 qualitative data analysis software program. The transcripts were coded under three head nodes and a number of sub nodes according to identified aspects of on-ground damage to property, successful property defence due to preparedness measures, what went right and what did not go to plan during the fire, and the reasons why.

Results and Discussion

Summary of on-ground damage from the bushfire

Bilpin

Residents of Bilpin reported no loss of life or damage to property by the bushfire. As the following residents described, Bilpin was largely spared from the worst of the fire because of timely changes to the weather, which saw the fire slow in speed and intensity.

> *So, we were well and truly ready. But as it turned out it wasn't necessary because the fire came in very, very passive, you know, gentle fashion by the time it got to us, thanks to the weather.* (B8)

> *It stalled here at 3 o'clock in the morning because it got quite cold when everyone was here. And they could control it; it was like a creeping giant really, just going through the night.* (B5)

The additional time to prepare, afforded to residents and the local RFS brigade by the weather change enabled a range of extensive back burns to be implemented around the township. Because of the back-burning the bushfire never reached property boundaries, "the fire actually never got to the property boundaries before something was started, like a back-burn was started" (B9). Notwithstanding this, two residents reported some minor spot fires and damage to lawns from falling embers, but it was unclear whether these embers were from the bushfire or from back burns conducted adjacent to properties.

Mount Wilson

The impact of the fire on Mount Wilson was much more pronounced than in Bilpin. Given the events of October 17th, when the fire moved with great speed and intensity, residents of Mount Wilson had less time to prepare than those in Bilpin. Notwithstanding the loss of two houses, several sheds and vehicles in the area, residents interviewed also reported extensive damage to gardens and fencing, as well as other assets (namely firewood and timber slabs), from the bushfire. The following section describes the nature of these losses in greater detail.

Gardens

Participants reported damage to specific features of their gardens including the destruction of non-commercial orchards, seedlings, irrigation and minor structures such as walkways and ornamental ponds. W4 reported the loss of a walkway and a 40 tree orchard in addition to extensive damage to garden beds and two large ornamental ponds through direct flame contact. The pond contained fish (all of which perished) and burnt, dead leaves choked the water filter.

W8 reported extensive garden damage to a secondary property, the building site of a new home. For the majority of time wherein the fire was impacting Mount Wilson/Mount Irvine, W8's property was unmanned. Consequently, the grounds sustained considerable damage with the loss of a number of fruit trees, berries and native seedlings, presumably from radiant heat and/or flame contact. There was also damage to woodchip mulch in the gardens and to well-established plants; including cherry and maple trees that were "singed a fair bit" (W8).

Vegetation

In addition to the more specific accounts of garden damage, summarised above, several participants spoke explicitly of damage to the general profile of vegetation on their property. For example, W4 reported a large number of dead and damaged eucalyptus trees on the property which required removal and W6 reported damage to tree ferns.

Further to this, having witnessed both exotic and native species burning and identified which plants posed a threat to them during the course of the fire, some participants said they would replant the damaged parts of their garden (or redesign their garden/property as a whole) to make it safer by planting less flammable species.

Although W4 described damage to both native and exotic vegetation on the property, W4 discerned that the eucalypts were especially threatening when on fire, pouring out oil and spitting flames. W4 observed that although "the North American exotics" burned, they burned a lot slower. W4 credits a past decision to remove native plants (in particular, tea tree) from the garden and replant with exotic species with reducing the spread and intensity of the flames and, hence, the damage inflicted on infrastructure.

Similarly, W6's experience of defending the property from the flames and embers of burning vegetation has prompted a rethink of the design and composition of the garden space closest to their house (which was not directly impacted during this fire event). Reflecting on the intensity with which tree-ferns burned and recovered, W6 discussed landscaping the immediate garden to encompass a buffer zone, "we might take all those ferns out and put a lawn in… they [ferns] burn and so that's bringing the fire closer to the house".

Fences

By all accounts, the residents of Mount Wilson suggest that the damage to fences was extensive throughout the community. Indeed, several participants spoke explicitly of damage to fences on their own properties. The experiences of two participants provide significant insight into the effectiveness of clearing land between bushland and properties when recounting the way the fire approached and spread via unkempt, densely vegetated fence-lines. As W8 observed, although the

fire burned along the fence lines bordering a number of paddocks, the middle of these paddocks did not burn. With nothing to burn in the paddocks, the fence-lines provided a way for the fire to move rapidly and spread from property to property. As W9 similarly observed, the fire approached their property via the fence, "It was coming into our place. It came through the fence and it burnt all the ferns and things. Then it stopped where [we] had cleared but kept burning along the bottom from where [we] hadn't cleared".

Sheds and Water Tanks

Residents refer to the destruction and damage of at least 3 sheds in Mount Wilson. Of the residents interviewed for this study, only one reported damage to substantial infrastructure with the destruction of a shed (containing a vehicle) and two plastic water tanks from direct flame contact. It is inferred by another resident involved in fire fighting efforts at the property, that the destruction of the shed and water tanks was a result of flame contact as firewood stacked against the structures ignited.

Firewood and Timber Slabs

Stores of firewood, of varying sizes, were destroyed on a number of properties in Mount Wilson. W8 lost a considerable amount of firewood and timber slabs at great financial cost. As an active firefighter during the event, W8 could not justify sparing the resources or manpower to defend the timber:

> *I wasn't really happy about leaving, but I had to leave the shed up there. And I would have preferred for someone to stay there and look at it 'cause it was still flaring up in spots and all the timber was alight… And a couple of times I went back and put stuff out. And I think a couple of other people went back and put stuff out. But I just didn't have, we didn't have the resources to leave anyone there.*

W4 also noted the loss of a large quantity of firewood. The close proximity of this firewood to the shed, described previously, was instrumental to its destruction.

Vehicles

> *It took a long time before that shed [came down]. It burned for hours and we could hear the tyres popping on the truck in there.* (W4)

Participants described the destruction of several cars during the fires. Three residents recalled seeing burnt out cars in Mount Irvine. Of the residents interviewed in this study, W4 was the only resident to have personally lost a vehicle to the bushfire. As noted previously, the shed that was destroyed contained a truck.

Houses

None of the residents interviewed in this study sustained damage to their houses. Rather, participants spoke of two houses destroyed in Mount Irvine. Of these, participants infer that one was a homestead of considerable local historical significance. The number of houses damaged, but not destroyed, by the bushfire was not clearly discernible from our discussions with residents.

Notwithstanding this, the majority of participants identified Danes Way, Mount Irvine, as being the worst affected, with property losses and damage concentrated in this area.

Roads

All participants described problems with road access and movement throughout the community during and immediately following the fires. W8, however, was the only participant to explicitly describe the damage to roads. W8 describes fallen trees and destroyed guard rails, "It was just chaos, there was just trees all over the road and, you know, you couldn't drive along the road. You had to go up and over the banks and through, the guard fences were all demolished, and it was just a mess."

Successful defence due to preparedness measures

As previously described, Bilpin was largely spared from the worst of the fire because of timely changes to the weather which saw the fire slow in speed and intensity. The additional time to prepare afforded to residents and the local RFS by the cooler, calmer weather enabled a range of extensive back burns to be undertaken around the township, particularly those properties backing onto the Blue Mountains National Park which were identified as being most vulnerable. Because of the back-burning and the weather changes the bushfire never reached property boundaries. Further to this point, the preparedness measures of Bilpin residents were also supplemented by the assistance of a large number of out-of-region and interstate fire fighting crews,

> *They had fire trucks posted on every property all the way up the road!* (B6)

> *It was surprising how many resources were found. I mean, you know there would be up to 50 units here at times.* (B9)

> *I was ready, but the fire brigade did such a good job, I mean they were here and we had our pump ready to go, hoses ready, but we didn't even start our pump. They had four pumps, they had four fire trucks and about 20 fire fighters surrounding our property and in our property.* (B8)

Whilst the preparedness measures undertaken by Bilpin residents appear to have been extensive, well tested and rehearsed, the timing of the fire, efficacy of the back burning, availability of resources, and the preparations made at a community level meant that individual residents were never truly tested by the bushfire practically. The emotional strain was greater, however, due to the worry and uncertainty associated with a predicted (but abated) worsening of weather conditions.

As illustrated in the preceding section, the Mount Wilson community was impacted by the bushfire with a number of residents sustaining damage to their property. By all accounts, the fire impacted Mount Wilson earlier than forecast and, as such, residents' physical and mental preparedness measures were put to the test.

The following section is divided into three parts. The first two sections, examine the efficacy of community and individual preparedness measures respectively, in the successful defence of life and property in Mount Wilson. The final section examines the role of emotional preparedness in the successful defence of life and property across both study sites.

Successful defence due to community preparedness – Mount Wilson

Fire-trails

The successful defence of a number of properties were credited, by and large, to the access and lines of defence provided by the region's extensive network of fire-trails. Given that there were considerable delays in the arrival of earthmoving equipment to "dust off" the fire trails, according to several participants, the fact that most of the trails had been well maintained and could be utilised immediately was essential to early fire-fighting and back-burning efforts.

Further to this point, participants also made reference to the efficacy of informal fire-trails (namely garden paths or poorly formed access roads) in the defence of their individual properties. W2, for example, made a point of showing the interviewers how the fire stopped at the downward slope side of a garden path running through the property, parallel to the house. Although poorly maintained the path was used by the RFS to launch a back-burn against the creeping flank of the fire. When walking along the path with W2 two months after the fire, the interviewers noted that the path divided the areas that burnt/did not burn on the edge of the rainforest/eucalypt interface on W2's property.

Hazard reduction burns

Two residents who were active members of the RFS spoke of a number of hazard reduction burns conducted around Mount Irvine and Mount Wilson in the six weeks to eighteen months preceding the October 2013 bushfire. W8 described how the fire front/flank moved up from the valley to under Mount Irvine Road, but reduced in intensity as it ran into areas of a previous hazard reduction burn: "…so that [the fire] ran into the hazard reduction, so it just sat there and did nothing. It burnt- it re-burnt but it didn't do it with any intensity. So that helped us."

Demanding resources early

> *Yeah, if I hadn't been screaming for resources at 3 o'clock in the afternoon we probably wouldn't have had any resources. (W8)*

Having heard about the fire via word of mouth on the morning of October 16th, W8, acting in the capacity of a senior fire fighter, contacted the RFS's regional office and followed the fire's progress that afternoon. Drawing upon years of experience and an in-depth working knowledge of the local topography and the region's fire regime, W8 recognised that there was a good chance that the fire could come to Mount Wilson/Mount Irvine earlier than initially predicted. W8 requested machinery (a bulldozer and grader) that afternoon so that the local RFS could start preparing their fire trails. This request was followed up a number of times on the 17th, but although promised, the machinery did not arrive until the morning of the 18th, after the fire front had been through. This reflects the trying circumstances under which the RFS was managing and resourcing two other major fires (Springwood and Mount Victoria), in addition to the State Mine Fire.

Despite the delay with the machinery, there were multiple references to crews and trucks arriving 'in the nick of time' to defend properties:

> *And we were very fortunate that a strike force from Hornsby showed up in the middle of this… And they were assigned out here, out to the end here, and they got out and they defended all these properties around the end here … And so we were very fortunate to have them and they did a great job out there.* (W5)

> *But it still kept coming, which surprised me given that the wind was against it, it still kept coming. But that's because it's coming up a slope and there's so much fuel. So it was just more this trickling fire coming through that just wouldn't stop until Valley Heights [brigade] turned up with a lot of water.* (W9)

> *They had a couple of tanker trailers, and they were doing their best but they were starting to lose the battle. And National Parks turned up with a couple of their units. And the National Parks were, sort of, at the same stage, they were starting to lose the battle and struggling, and then the Hornsby guys turned up and they were very glad to see the Hornsby guys 'cause they just needed that back up at that point. So they put two of them straight to work there. I think one of them went up to the other house, or two of them up to the other house, and then they took one of them down the bottom at [name]. It's black right to the walls of [name]. They're very lucky they didn't lose the house.* (W8)

With the timely assistance provided by crews from the National Parks and Wildlife Service, Hornsby and Hawkesbury brigades, several properties were narrowly saved along Mount Irvine Road. All research participants from the Mount Wilson cluster praised W8's forward thinking and early demands for resources with saving multiple houses and the village as a whole.

Back-burning

A number of participants described the extensive back-burning operation conducted in the valley over two nights. W1's house overlooked one of the larger back burns conducted in the area, lit from the Northern Fire Trail, and W1 considered the back burn to be extremely effective in protecting the town, especially if the wind had redirected the fire:

> *The whole of the Northern Fire Trail was back burned down into the valley... And that was all night Thursday night probably, and Friday, in the early hours of Friday morning and then throughout Friday. But then to meet that [the fire] it was burnt down into the valley. So even if the wind did come much more directly from the north in those succeeding days it would have been running into areas that had been back burned. So that would have meant that this whole area through here had been made safe by that back burning.*

Communications and networking: community cohesion

> *We had our community Christmas party last night and it was very interesting some of the statistics that came out of that, but also the comments about how Mount Wilson and Mount Irvine had got a reputation with the RFS management about how this community was the*

> *best organised in terms of preparation. It was both a coincidence and good management that we'd actually had our pre-season bushfire meeting two weeks before [the fire] and we'd gone through all the responsibilities of the street coordinators, the community engagement officer, the fire brigade operating, the guys in the yellows, they had their preparation.* (W1)

The methods of community engagement utilised by the Mount Wilson/Mount Irvine RFS brigade appear to have been instrumental to the preparedness and successful defence of individual properties as well as the village as a whole during the State Mine Fire. Through a network of Street Coordinators[3] the Mount Wilson community circulated knowledge of each other's preparedness, whereabouts on the day and actions during the fires. This made a difference when dealing with the expected as well as the unexpected.

Compared with the information reaching the community via official NSW RFS channels, the Blue Mountains Fire Control and popular media (TV and Radio), the information communicated via the Mount Wilson RFS Community Engagement Team was more context-specific and up to date. The team kept the community informed through their website, email status reports and recorded messages, and also served to counter the hype from popular media. The breadth and efficacy of the community engagement strategy employed during the fires was summed up by the Community Engagement Officer for the Mount Wilson/Mount Irvine RFS during the State Mine Fire:

> *Every morning [the Brigade Captain] gave a briefing to the crews and I would sit in on that. [The Brigade Captain] had a better idea of where everything- you know, what was happening around us. And so I would then write that up for the website and email residents, about 80% of the residents are on email and website and then the Street Coordinators would pass the message onto those who weren't on internet in the area.*

The combination of multiple communication methods such as phone messages, internet and word of mouth compensated for times when the power was down or properties were inaccessible. This mixed methodology helped to "fill the gaps" whereby those in the community who were more isolated or without internet access were accounted for and could still be informed via word of mouth. Further to this last point, W8 described communication difficulties within the RFS at an operational level**.** Contact with crews in the field was at first complicated by poor radio reception. As a way of combating this, W8 described the efficacy of driving around and visiting crews and showing them how to access fire trails and adapt to local conditions, etc. rather than just giving them a map and leaving them to their own devices.

Successful defence due to individual preparedness – Mount Wilson

Active intervention – vegetation

[3] The Street Coordinator network is an initiative of the Mount Wilson/Mount Irvine RFS (2011). Street Coordinators are volunteers who are on hand to provide residents with local information to assist them to make decisions. In addition, Street Coordinators are responsible for updating the Brigade on the whereabouts and intentions of people in their area and the conditions at their properties. Street Coordinators are expected to be the "first port of call for obtaining local information" during a fire.

Several participants spoke of how designing and/or maintaining their property consistently over the long term contributed to their overall feeling of preparedness leading into the October 2013 fire season. W4 and W9, for example, were aware of the risk posed by vegetation when designing their house and had factored this into the landscaping of their immediate surrounds.

W4's property, for example, includes an Asset Protection Zone (APZ), which exceeds the requirements of local council. When building the house in 2009, W4 cleared dense, eucalypt vegetation 50 – 70m away from the house. Further to these preparations and the maintenance of the APZ, W4 credits more recent modifications to the grounds with saving the house during the State Mine Fire. W4 credits removing native plants, in particular tea tree, with reducing the spread and intensity of the flames and, hence, the damage inflicted on infrastructure. W4 emphasised how clearing the vegetation across the fence made all the difference, as that was the direction the fire came from. Without having cleared on both sides of the fence W4 doubted they would have been able to stop the fire reaching the house. W4 described how the fire 'sat' at the fence line for a while before suddenly swooping through the crowns of the eucalyptus trees surrounding the garden and disappearing over the hill.

W9 were similarly aware that they were building in an area vulnerable to bushfire. According to W9, their house is in an identified 'flame zone'. Consequently, their Development Application was sent to the RFS for comment with recommendations that they clear a 40m APZ, which they have maintained. More recent preparations to their property included clearing a number of large eucalypts from their northern boundary following a severe wind storm in 2011. The husband had been particularly vigilant in keeping vegetation under-control on the north-western boundary of their property ever since. They consider the clearing of the northern perimeter as key to the successful defence of the house during the fire. As W9 [the wife] explained,

> *[My husband] was sort of walking down the fence line because as you can see it came through the fence but it stopped where he cleared… And that was fantastic; that really helped. Because if it got into, you know, if we still had all that undergrowth at the front there that would have been a bit scary and it would have been more difficult to put out.*

Other participants spoke of modifying vegetation on their property because of the fire risk. A number stated that these modifications had been undertaken in light of the realisation that a fire would most likely approach their property from the north/north-west. W1, for example, removed a number of eucalypts to the northwest of the house. W1also regularly slashes the vegetation on the downward, northerly slope side of the property, beneath the house. W7 was conscious that by clearing the bracken and tea tree close to the house, the garden design provided some support to the defence of the house when unattended: "I'm pretty clear. It's bush there, but immediately around the house it's clear and it's all non-combustible material. So the property has been developed to be as resistant to fire as possible".

Housing design

Understanding that they live in a high-risk zone, W4 and W6 spoke explicitly of building their houses to be fire resistant. In addition to the APZ noted previously, W4 identified sprinklers on the roof, a refuge room and thick, fire resistant windows as features included to enhance the architectural

integrity of the house during a fire. The sprinklers were used and the windows, whilst not tested, were found to be essential to the defence of the house (especially given that the single-pane glass on the shed melted with the radiant heat). W4, however, noted that when they sought shelter during the passing of the fire front they did not do so in the refuge room. The refuge room had been built on the north-western side of the house, facing the fire front:

> *We couldn't use the bushfire refuge room because it was facing the fire front. Interesting. So I have a whole room down here, but the fire was here and so it should have been on the other side of the house, and since the fire will most likely come from the north, north-west again if it comes, the room was built on the wrong side of the house. But I never realised that. I thought you'd fight the fire and back up into it and get in the room with the fire door, right? But no, you'd run around and shield yourself with the house if it's coming that way, and so the entrance should have been on the other side.*

Having moved from Sydney to Mount Wilson with no previous experience of fires or living in a bushfire prone area, W6 was acutely aware of how the danger of building in a high fire risk zone could be compounded by lack of personal knowledge and experience. Consequently, they designed their house to withstand fire, should they choose to leave or, in the more likely scenario, should they not be there to defend it: "I was travelling a lot and so I could be- often in January I'd be away for two weeks in the middle of January and I thought, I want a house that you can lock up and just leave". One feature of the fire-resistant design was the inclusion of window shutters. Interestingly, despite this preparation, the shutters were not used during the main fire threat, as they could not be pulled down without electricity (and the local power was disconnected early on).

Equipment – maintained and operational

All bar one participant interviewed in the Mount Wilson cluster, possessed a substantial quantity of fire-fighting equipment that was generally accessible and of good quality.

W1 was particularly well prepared in terms of equipment with fire-fighting hoses, a petrol-operated generator, a pump on the water tanks capable of maintaining high pressure, four access taps and gutter plugs. W2 also had a number of fire-fighting hoses and had made deliberate modifications to the storage of this equipment and pump to make access easier. As part of their survival plan, W4 maintained and checked their fire-fighting equipment regularly and by chance detected faults with the pump, sprinklers and hoses on Thursday morning, which were fixed before the fire front hit that afternoon.

Resources – water

Given the long dry spell preceding the October fires, a number of participants recalled concerns regarding water supply. In some cases, decisions to stay and defend or leave a property came down to the amount of water available. W5 alludes to the tension between accessibility and defendability when describing the defence of one particular property with a prolific water supply,

> *So we had the Cat 1 [tanker] sitting down behind [W4] and interestingly, W8 said to me later that [they were] really ambivalent about putting the truck in that location or whether it was a good place. He said, "I only got confident that it was the right place when we could plumb into [W4's] water supply and we had tonnes of water available. And as soon as I knew we*

could plumb into their water supply and we had tonnes of water available" he said "I had no reservations at all".

RFS membership

Several participants described how experience and knowledge gained through membership of the RFS (at both administrative and operational levels) contributed to their sense of preparedness and successful property defence during the fire. The W9 household, for example, reflected on how their work with the RFS prompted them to remove trees that were close to their house,

> *We hadn't been too particular about it because we like the trees, we didn't want to get rid of them but then having lived here and having joined the brigade and work of the RFS, we started to realise after a while that perhaps we did have a few too many trees too close to the house.*

W9 further described how work as the local community engagement officer resulted in a survival plan and checklist, which was consulted during the fires. The RFS gives volunteers PPE, equipment, access to resources, firsthand experience and a greater understanding of fire, its impacts and what needs to be done.

Last minute 'tune-ups' - clearing vegetation

Overall, residents were conscious that the greatest risk to their properties was from the density and type of vegetation in the immediate vicinity. A recurring theme in our conversations with participants was that the most common action taken immediately before the fire directly threatened their houses was to 'tidy-up' vegetation. With the exception of one participant, who was absent during the first week of the fires, all participants indicated making last minute preparations to their properties by clearing vegetation away from their houses and property boundaries. Participants sought to create or "tidy-up" an asset protection zone, chiefly around their houses but also around other assets (such as sheds). This included clearing leaf litter and other kindling slashing paddocks and raking mulch away from the house,.

Successful defence due to emotional preparedness – Mount Wilson and Bilpin

The following section explores the emotions residents of both Mount Wilson and Bilpin went through before, during and after the fire. More specifically, we look at what factors enabled residents to cope better mentally (or not) with the fire, and what factors contributed to their sense of emotional preparedness.

Pre-fire: the <u>assumption</u> that the RFS would be on hand

Although not a widespread sentiment, three residents inferred that the assumption that RFS volunteers and fire fighting equipment would be on hand in their time of need contributed directly to their ability to cope with the potential fire threat, and heavily influenced their decision to stay and defend. Interestingly, all three of these residents were from the Mount Wilson sample. Of all the participants interviewed in this study, W2's decision to stay and defend, perceived level of

preparation, and ability to cope emotionally, was the one most influenced by the assumption that the RFS would be on hand at the time of need:

> *Look, something in your brain sort of takes over going like "Okay, this is what's happening. We're just going to pace around. People will turn up. I've got my…", you know, you don't have time to really sort of go into a panic. "There's nothing else I can do now. I've got the water. I know how to…" you know. I'm sure people will be here if it's really - as they were - if I was really seriously threatened imminently with something.*

These assumptions arguably blinded this participant to inadequacies in both the practical and psychological level of preparedness.

During the fire: the <u>actuality</u> of the RFS being on hand

With the exception of W8 who, for the most part, partook in the defence of other properties as a member of the RFS, all Mount Wilson participants reported the presence of RFS personnel and equipment at their property, actively engaged in fire-fighting activities, at some point during the fire. For several residents, their actions and emotional preparedness were heavily dependent upon the presence and practical support provided by the RFS volunteers at their property:

> *At one point [name] sent me in the house with a flashlight for water for the firemen and a pitcher, and I'm in the dark, and as I'm in the dark trying to get the stuff I realised that I've been sent on an errand; you know, when you know somebody gives you something to do to make you busy?... I wonder if it was just keeping me out of the way and keeping me a bit busy. So I might have thought I was calm; maybe you have to ask [them]. Their quote to me was, "You were shitting yourself!" [Laughter].* (W4)

> *About every half hour until, I don't know, 1:00 am or 2:00 am or something, I just walked around with a torch and made sure there were no spot fires. Went down the drive. And as I say it was quite nice because every now and then I could see the fire truck. I'd look over to [neighbour's] place and I'd see a truck, I'd see the truck there, and then, "That's good". [Laughing]* (W6)

> *I'd been by myself all day and as the threat gets closer and closer it's always nice to know that there's somebody else there.* (W1)

Seeing, or working alongside, the RFS as personnel fought fires, back-burned or patrolled in the vicinity of their properties contributed to residents' ability to emotionally cope when the fire threat seemed imminent.

Although RFS resources were more plentiful in Bilpin than Mount Wilson, interestingly, Bilpin residents reported RFS personnel on site with less frequency. For those who did encounter RFS personnel working in the area immediately surrounding their properties, participants voiced similar emotions of relief and comfort:

To be honest as the fires were coming I was breathing a sense of relief when I could see them starting to back burn because I knew that the only way to fight fire is with fire and you can't back burn if conditions aren't favourable so it all sort of come to us really. (B8)

I: *In hindsight what do you think was the main factor in allowing you to avoid the fire and to stay here?*
P: *The firies [sic], without a doubt.* (B12)

Previous experience with fire

Having previously experienced fires, mainly in the capacity of volunteering for the RFS, contributed to the emotional preparedness of ten participants. B8 and W9, in particular, drew on their previous fire-fighting experience when coping with the October 2013 fire:

But I've grown up in Bilpin my father in law was the captain of the fire brigade so you kind of, for a local you know, you tend to know what to do and what not to do. It's, the people I am most concerned about are those who have not grown up in the bush and they've come from the city, they want a tree-change and they find themselves overwhelmed by the scenario. We've seen lots of fires come and go over the years and my wife grew up here, she's a third generation, our kids are third generation in the local school. So we've seen fires come and go on a regular basis. (B8)

I've been through big fires like this, but working in district office, and I also worked down at head office for the Victorian fire and, you know [name] has been on crews, you know when we had the Lawson Long Alley Fire in 2006 for instance that came up along Bell's Line, and that. So we had sort of that little bit of understanding of fire. (W9)

Previous fire experience, however, was not beneficial to every participant's sense of emotional preparedness. Indeed for B13, memories of past fire experience were nearly the undoing of the wife during the October fires. B13 became "frazzled" and distressed during the fire, wanting to evacuate when recalling memories of experiences in the 1967 Hobart bushfires, as the following dialogue between the couple [P1 – husband, P2 - wife] and the interviewee shows:

I: *And you're plan, at some point you were going to evacuate?*
P1: *No.*
I: *No, you were always going to stay and defend.*
P2: *Yeah, but it was me. I got- I think I just started to get frazzled. And I think- I always say to [P1], "It's that experience of 1967 in Hobart". That just that memory was coming back to me and I thought "ooohhh".*
P1: *But once we'd worked out the Mount Tomah thing [fire], took a couple of cars up there.*
P2: *I was alright then.*
P2: *So we came back to our stay and defend [plan].*

Although not speaking from personal experience, W1 similarly gives insight into the negative impact of previous fire experience on emotional preparedness. W1 describes how the past fire experiences of one woman caused considerable anxiety during and following the October 2013 fire:

> *A woman I was speaking to from Mount Irvine who was saying that even though their house wasn't threatened that because of the fact that two houses were lost in Mount Irvine and that they had experienced serious fires, more serious than Mount Wilson has in the past, that she was still upset about it and, you know, it was still affecting her.*

Survival plans

Having some form of 'plan' in place - regardless of whether it was written, mental, discussed or rehearsed – was essential to the physical and emotional preparation and successful defence of life and property during the October bushfires. Seven households explicitly described the centrality of a survival plan (either written or mental) to their preparedness during the October bushfires. Plans described by participants included: designating roles for household members during the fire, identifying fall-back routes and places of last resort, communicating how to use equipment to visitors and consulting lists for preparing property and packing. Behind the development and utilization of these plans was an understanding that during a fire, pressure and panic can result in poor decision-making:

> *I was quite pleased that I had a written one [plan] and lists, because I feel when the pressure's on its kind of hard to concentrate a bit but because I'd thought about it and where things should go…* (W9)

> *In the past, the first time this ever happened to me I packed the most ridiculous things ever and then after the fire event I went to unpack the car and I couldn't believe what stupid things I'd put [in there] and all the most important things I'd left in the house because I was panicked and made bad choices. So I said I'd never ever do that again.* (B4)

All seven of these households reported having significant experience with bushfire prior to October 2013. Although B8, as a case in point, dismissed their preparations as "just common sense", it is evident that B8 had a comprehensive household survival plan in place. Drawing on generations of knowledge and experiences as a Bilpin, "local" their plan accounted for different scenarios whereby embers may get into the house or spot fires may take hold in the grounds. B8 had planned to station family members both within and outside the house to mitigate potential ember attacks.

It is interesting to note that the success of almost all participants defence plans hinged on being present at their property to perform final 'tune-ups' to the house and grounds once the threat of fire became apparent or immediate. It was not clear from the interviews whether several of these participants had made provisions in their plans for how their house would be defended should they (or the RFS) not be there at the time. This is particularly interesting given comments made by all residents in Mount Wilson about running out of time to complete all the tune-ups to the grounds (clearing vegetation especially) and testing of fire fighting equipment, as they would have liked:

But we'd been overseas and had been here very little in the previous three months and so all of the winter leaves, you know, left over from autumn, all the kindling that was there, all of the leaves that had fallen around the shed and around the water tanks, you know. I mean there's mess still here that I never got down to clean up. So you could see that it was really needed, so I had a mad day on [the] Thursday just working so hard to try to get to all of the stuff. (W1)

I: Would you stay again in the future and defend?
P: Oh yeah, had I not been here we would have lost the house.
I: Yes.
P: But not that it was me defending it. But just having the ability to turn on the, I don't have automatic sprinklers, right, so just having the ability to turn it on and monitor it and put out all those ember attacks and move everything away. (W4)

For three residents, their Mount Wilson property was either their secondary residence or they commuted to work/other activities three or more days a week; it was largely by chance that they happened to be in Mount Wilson on the day of the fire to make those last minute tune-ups so central to the planned defence of their homes.

Household separated – partners and dependents

The decision to leave early or to stay and defend was a point of contention for five households across both study sites. Central to their debates was the question of separating household members; usually with one partner remaining at the property whilst the other would leave with any children or dependents in their care. Of the five households identified as having argued about leaving early or staying and defending three were households with young children. Given that there were only three households in this study with young children the fact that all three engaged in this debate is noteworthy. Looking at how these debates were resolved, and the resulting actions taken by the households, provides insight into how separating household members can contribute both positively and negatively to individuals' emotional preparedness and resilience.

The B1 household, for example, was very conflicted as how best to protect their children, themselves and their property, particularly given that both adults were actively involved in the RFS during the fire. Despite initially planning for the whole household to evacuate together, ultimately only the children were evacuated. This was not only because they both were working on the fires but also because there were concerns about the defendability of the house given the lack of water resources available:

So we stayed here for Saturday and Sunday and [name] and I were just swapping off trucks, so he was on the night and I was on the day, always swapping around so there was always one of us here. Um, but yeah, Monday and Wednesday were set to be the worst days and you know by Sunday we still hadn't had the delivery of water. And we both were needed on the trucks so neither of us could stay here to defend the house. So we just decided to evacuate them [the children].

It wasn't until the family was safe that B1 felt comfortable and emotionally equipped to tackle the fire as volunteers with the RFS, relinquishing responsibilities for their children for the time being. This was a sentiment shared by W8. Although not originally planned, having momentarily left the village his wife and infant child were unable to regain access during the fires. As an active fire fighter during the event, W8 reflected on how not having to worry about his wife or child as contributing to his ability to emotionally cope with the fire:

I1: *In retrospect, what do you think about them not being here then?*

P: *Well, it made things a bit easier. Just a little, you know, one less worry for me, I guess. Like, I'm not too concerned about this property, like, it's defendable. But it's very hard with the little one at this age to be actually, you know, able to do too much.*

B1 and W8 felt more emotionally prepared knowing that their children and partners were essentially out of harm's way. Interestingly, the third household did not share this sense of relief and relinquished responsibility. B11's concerns for his family went beyond the immediacy of the fire; he was also concerned about the impact of separating the household on the well-being of his disabled daughter not used to change. Whilst he cedes that, given the fire threat, it was necessary to evacuate his wife and children, the anxiety caused by the separation detracted from his emotional preparedness:

> *She was a bit reluctant to go. I mean to me, with [my child], if you've got to go, you just go. But [my wife] was a bit reluctant and I think on the third time where I suggested she go, you know, I had to just say to her, "I don't want to have to fight you and that fire." So you know, it just got too hard. And so I think after that she was much better about it and she realised, because yeah, a lot can happen very quickly.*

The welfare of partners and young children was central to the reasoning behind the decision as to when to stay or go and was at the crux of many participants' sense of emotional preparedness and resilience during the fire.

Alone and isolated – low emotional preparedness and resilience

Those who were completely alone and/or had no regular contact with RFS personnel or access to local information during the fire reported low levels of emotional preparedness and resilience. W6 reported feeling "abandoned" when she was home alone during the fires. Without power and thereby access to the internet, mobile or landline phone, W6 felt isolated from the community as she was unable to tap into the main sources of communication and information transfer utilised by the local RFS: she could not view the local brigade's webpage, access her emails or call the fire shed. W6's only sources of information – local or otherwise – for the most part, was through word-of-mouth via her immediate neighbours, intermittent updates from her husband, an active volunteer firefighter (W5), or from visually gauging the location of the fire by the smoke column:

I: *Where were you getting your information from at that time?*

W6: *No, I wasn't getting any. Because the phones had gone out, and the power had gone out, and we've got a wireless network in our house, and so when the power goes down I don't*

have any internet, and so usually you rely on your phones. The phones went down, and you sort of think "Oh I've got to keep the mobile for something that I really need it for".

W5: So I was driving up the drive about once an hour and telling her what was going on.

W6: Yeah, but this was at night. But during the day, and I mean as I say I didn't see him, he left in the morning and I never saw him until half past six/seven at night…And I wasn't so much scared as- I wasn't really scared because I didn't know what was going on really. But it was more that I'd really like to know. And I didn't want to go anywhere. I felt an obligation to stay here because I had people phoning in a bit [mobile]. And also I thought, "Well if [he] comes back and I'm not there", sort of thing. And as I say the one time when I was going to go somewhere, it was probably a good thing he did turn up because I wouldn't have got through, or I wouldn't have got far before I realised I couldn't go anywhere. Yeah, it wasn't really scary. It was more like, yeah, "abandoned" is the best feeling. I just felt abandoned. And it's silly. I mean [he] was doing what he had to do. I mean it's not a logical response and I'm quite used to being by myself.

W6's experience was similar to that described by two other participants out of the 23 residents interviewed in this study. This might be a reflection of the overall level of efficacy of well-established community engagement networks, as well as procedures by the local RFS brigades in both communities, as described previously in this report.

What did or did not go to plan for local residents

Went to plan	Why?	Didn't go to plan	Why?
Time to prepare	Although the fire moved faster than expected, residents in both Mount Wilson and Bilpin reflect that they had some time to prepare for its impacts - in particular to make last minute 'tune-ups' to their properties on October 16th.	**Time to prepare**	Fanned by strong winds and hot temperatures the State Mine Fire moved at unprecedented speed on October 17th. The communities of Mount Irvine and Mount Wilson were impacted suddenly and simultaneously with RFS volunteers struggling to resource and defend both villages as well as their own properties.
Resources and equipment	Timely – Although resources (in particular earth moving equipment) were scarce at first, in Mount Wilson especially, residents described multiple accounts of crews and resources turning up to defend properties "in the nick of time". Bilpin residents reported ample out-of-region and interstate fire fighting resources actively deployed in their community	**Resources and equipment**	Equipment failure – various forms of equipment failure impeded individual preparations. Community wide power outages affected landline, mobile and internet capability. Several participants ran into problems with their fire-fighting equipment. Problems encountered included: not knowing how to use a pump, not having alternate power

	during the fire.		to operate pumps when the electricity was cut, generators failing, field radios without reception, hoses without sufficient reach, unsuitable places of last resort (including a poorly designed bunker) and having window shutters which could not be deployed manually.
Access	Property accessible and manned– Having the homeowner (or RFS) on site prior to and during the fire to make last minute 'tune-ups' and/or actively defend the property was crucial to the successful defence of houses and other assets.	**Access**	Property inaccessible and unmanned, movement restricted by roadblocks – Access to properties was restricted by roadblocks at various times. This stopped both the flow of fire-fighting equipment and personnel as well as information throughout the area. Access was restricted by both fallen trees and police. Residents reported that properties threatened in Mount Irvine and Danes Way were essentially inaccessible as the fire front passed.
Communications	Community engagement – Generally, the Mount Wilson/Mount Irvine RFS brigades methods of community engagement were praised by residents as being comprehensive and effective in ensuring the community was kept informed throughout the fire. Using a combination of web-based, face-to-face and telephonic communication methods the majority of residents felt connected and up to date with proceedings at a local level. Residents of both communities felt comfortable and confident approaching the local RFS at the fire shed for updates.	**Communications**	Community engagement – Significant communications problems were reported across both case-study locations in terms of "mixed messages" from miscommunication between the local RFS, Central Office and other relevant stakeholders such as NSW Police, NPWS and the SES. These (mis)communication issues were substantially greater for Bilpin residents than Mount Wilson residents. Only one Mount Wilson resident alluded to interactions with police; she commented that there was little consultation and cooperation between the local RFS and police, resulting in misunderstandings, frustration and panic for some members of the community. 12 of the 14 Bilpin residents interviewed critiqued the text messages from Central Office inferring that they evacuate. They reported that these

			texts and their interpretation by residents, police and local RFS members caused considerable distress and anxiety.
	Street Coordinators – An initiative of the Mount Wilson RFS, selected residents had the resources, training and knowledge of procedures needed to ensure that everyone within their neighbourhood was accounted for and informed. Street Coordinators were instrumental in keeping those outside the scope of the RFS' main channels of localised communication (email and website) informed, either via phone calls or word of mouth. Residents across both communities spoke of keeping informed via word of mouth.		Street Coordinators – An initiative of the Mount Wilson RFS, residents reported that the Street Coordinator role was not taken seriously by some residents nor was it recognised or understood by police. In one participant's experience as a Street Coordinator, he found it difficult to juggle preparing his property with his obligations to keep other residents informed. This was compounded by his two counterparts in the role being overseas at the time.
	Local RFS Website – By all accounts the Mount Wilson RFS website was one of the main and most trusted sources of up to date information used by the Mount Wilson community, both near and far. The website content was described as accessible, timely and sufficiently localised. Being able to access the local RFS website as a source of information was important to the emotional and practical preparedness of several participants.		Isolation – Although kept informed initially through word-of-mouth, as the threat worsened and more RFS personnel were engaged in fire-fighting operations, residents in both communities who stayed at their properties without power and/or who had limited access to the internet, email or mobile, had little contact with RFS personnel and up-to-date local information. Most relied on sight and periodical contact with neighbours and family members in the RFS. For Bilpin residents, media hype surrounding the fire was not satisfactorily countered by the local brigade; several residents lamented that the Bilpin Brigade's website and email system was sporadically down – sources of information which had been proven invaluable and effective in the past.
Neighbouring properties	**Although some residents reported issues with the maintenance of neighbouring properties, others described good working relationships with their neighbours as central to their**	**Neighbouring properties**	**Several residents spoke of being concerned by the lack of preparedness of neighbouring households. The risk posed by these unkempt neighbouring**

	survival plan. One resident was able to supplement his water supply by tapping into his neighbours during the fire. Two other participants reported mowing neighbours lawns and tidying vegetation around the properties of absentee residents prior to the fire's impact.		**properties was further compounded in a number of cases when the homeowner was absent during the fires. The risk posed by neighbouring properties, including National Park lands, was something which residents couldn't mitigate as part of their personal bushfire survival plan.**
Help on hand	As previously discussed, several participants' plans and levels of physical and emotional preparedness hinged on the assumption that RFS resources and personnel would be on hand to support them during the fire.	**Fatigue**	A number of the more elderly participants in this study described feeling fatigued. They reflected that they were surprised by this at the time and commented that they had not planned on how physically and emotionally drained they would be by the event.
Active intervention	Relates to long-term efforts to maintain house and grounds. Examples included maintaining APZ, clearing trees and slashing undergrowth from specific sections of the property (such as at interface of neighbouring properties or NP) and house design. The overwhelming majority of participants across both communities reported substantially modifying and maintaining changes to their grounds and/or house to enhance the resilience of their property to bushfire.	**Pets and Dependents**	**Of the ten households in the sample with pets or livestock, seven inferred that they had not really considered how to care for pets should the house be impacted or evacuated; pets were essentially an afterthought to the household survival plan.**

Conclusion - Key Findings and Future Research

Key Findings

> *Look, there were so many aspects of that fire that we were so lucky about. I mean, a couple of houses and sheds and one thing or another. There were so many things- if the timing had been a bit different the village could have gone. People could have been killed, you know, all sorts of things.* (W2).

The successful defence of life and property in Mount Wilson and Bilpin can, in part, be attributed to luck: lucky that people were at home at the time to make last minute tune-ups, lucky resources and crews turned up when they did, lucky the weather changed when Mount Wilson was low on manpower, lucky the fire never reached Bilpin with the speed and intensity with which it approached Mount Wilson and destroyed houses in Mount Irvine, given so many residents were low on water. However, when we look at the damage, the preparedness measures, what went right and what went wrong for residents during the State Mine Fire it is clear that:

a) Practical and mental preparedness by individuals, as well as community cohesion, increased coping capacity
b) There are many lessons still to be learnt, particularly with regards to:
    i. Household decision-making during stressful situations – trigger points varied greatly from drawing upon previous fire experience, only trusting communications and warnings of local brigade members, smoke or wind direction, to arguments with spouses
    ii. Caring for dependents and pets – children were the cause of much emotional distress in the lead up to the fire and pets appeared to be an afterthought in individuals' survival plans
    iii. (Mis)communication between local RFS brigade sources and public messages from RFS Central Office: a source of anger and confusion for many residents which also appeared to discredit certain sources of information and methods of communicating.

Damage

Bilpin was spared from the worst of the fire because of timely changes to the weather, which saw the fire slow in speed and intensity. The additional time enabled residents to make a range of 'tune-ups' to their property and for the RFS to enforce a network of back burns around the township. Because of the back-burning and the weather the bushfire never reached property boundaries. Further to this, the preparedness measures of Bilpin residents were largely supplemented by the assistance of out of region and interstate RFS crews. Therefore, whilst the preparedness measures undertaken by Bilpin residents may have been extensive, well tested and rehearsed, the timing of the fire, efficacy of the back burning, availability of resources and preparations made at a community level meant that the individual resident was never truly tested by the bushfire, at least in a practical sense, and no damage was sustained.

Damage in Mount Wilson was, for the most part, restricted to gardens, vegetation and fencing. The loss of three houses in the area however, goes to show just how destructive the fire could have been were it not for timely weather changes and a high level of community and individual preparedness.

It may be inferred from the interviews, that the damage incurred by the community during the fires - in particular the destruction of property at Mount Irvine - can be attributed to three interrelating factors. First, and foremost, the speed and unpredictability with which the fire moved. Secondly, a lack of resources to adequately protect Mount Irvine and Mount Wilson simultaneously. Finally, and to a far lesser extent, a degree of un-preparedness on the part of the individual landholders concerned. The interplay of these factors on the day when Mount Irvine and Mount Wilson were impacted, and the house losses incurred, is summed up by W8. In reflecting on the fires from an RFS operational perspective, W8 commented:

> *We just didn't have the resources to do that, because we were trying to resource Mt Wilson and Farrah Road and Smiths Road. And we just didn't have the bodies to put out there. Usually, you sort of expect to get hit in one spot or a couple of spots, not the whole lot in one hit. And that was what, you know, it just stretched us out from one end to the other and we*

just didn't, didn't get up, and you know, by the time we got to Mt Irvine, we just didn't have the resources to, and we didn't have Mt Wilson over resourced either. We were pretty short there, but it didn't come up in there either, but it's easy to say that in hindsight.

It was clear that residents had largely accepted the extent and nature of the damage and loss of property in the area. As one participant reflected, "I haven't heard any suggestion that more could have been done in any way to save those particular houses" (W1). The fact that the community had a clear plan in place and knowledge of each other's preparedness, planned whereabouts and actions prior to and during the fires made a difference for dealing with the expected as well as the unexpected losses and damage, both personally and within the broader community.

The damage is not perceived as a result of a lack of community preparedness, particularly given the long-term planning and preparedness measures established by the local RFS such as the street-coordinator network. Rather, any sense of animosity (of which very little was expressed) was more to do with factors out of the hands of the local community, such as the weather and external resources shortages. Community engagement practices established and overseen by the local RFS, and an overall sense of community cohesion were important factors in making them more resilient and accepting of the losses incurred.

Successful property defence due to preparedness

A large number of the participants across the study sites have been paid or volunteer members of fire management agencies and many have first-hand experience with bushfires. This experience and interest in bushfire management was clearly reflected in the high level of preparedness of households from the Mount Wilson cluster, where all nine of the residents interviewed were current members of the local RFS brigade in either a fire-fighting, community engagement or administrative capacity.

In terms of broader, community-wide preparedness, residents most commonly cited back-burning as the most effective measure for successfully defending properties. Given the centrality of workable fire-trails to back-burning operations, the fact that the network was extensive and that most of the trails had been well maintained and could be utilised immediately was essential. The importance of well-maintained fire-trails to the defence of property was all the more pronounced given the delays in the arrival of earth-moving equipment to 'dust-off' the trails and the short notice with which the fire impacted the community.

In terms of role of individual preparations in the successful defence of properties, the most effective preparedness measure was long-term efforts to clear vegetation around the house and borders of the property. From the experiences of two residents in particular, whose properties were impacted by the bushfire, the preparation and maintenance of an APZ was fundamental to the successful defence of their houses during October 2013. One went so far as to say that had the vegetation not been cleared, the house would almost certainly have been lost (see Figure 4.1).

Figure 4.1: The successful defence of this property from the bushfire was attributed to the creation and maintenance of the APZ.

Notwithstanding the vast array of practical preparedness measures undertaken at both a community and individual level, it was clear that physical preparedness alone is not enough to adequately prepare an individual for a fire. Central to the successful defence of properties during the October 2013 fires was a level of emotional preparedness. Residents of both Mount Wilson and Bilpin reported a spectrum of feelings from distress, anxiety, abandonment, fear and fatigue to calm, reassurance and confidence during the almost two-week ordeal. A range of factors contributed to residents' ability to cope mentally (or not) with the fire; the most widely reported of which was the visible presence of RFS personnel in the immediate vicinity of their house. For several residents, their actions and emotional resilience was heavily dependent on the presence, practical support and local information provided by RFS volunteers.

What went right for residents during the fire

Aside from the efficacy of clearing vegetation away from the house, the two most commonly reported factors were time for preparing and access to property. The success of almost all participants defence plans hinged on final 'tune-ups' once the threat of fire became apparent. Of the 8 participants who were not at home at the time the fire threat became apparent, 7 succeeded in returning to their property, with varying degrees of difficulty. Residents thereby potentially placed themselves in unnecessary danger by returning home whether into or through the danger area.

What went wrong for residents during the fire

There are some distinct differences between Mount Wilson and Bilpin residents. For Bilpin residents, the two most commonly reported problems were water shortages and (mis)communications. Given

that 9 of the 18 households[4] interviewed in this study identified water shortages as being a critical factor that influenced their decision-making during the October bushfires, future research or community engagement initiatives may consider how residents value and utilise water in the months preceding the official bushfire danger season.

Although significant communications problems were reported across both case-study locations in terms of the local RFS liaising with and working under the direction of Central Office (and other relevant stakeholders such as NPWS, Fire and Rescue NSW, NSW Police, SES). These issues with communication were substantially greater for Bilpin residents than Mount Wilson residents. At an individual level, several participants in Bilpin expressed concern and anger over suggestions that they could be forcibly evacuated. It was explicitly stated and inferred that residents and the local RFS should have greater autonomy over the management of self and property. B10 was especially vocal in critiquing outside interference:

> *I mean the locals up here are sick of it. We're sick of the outside interference. You know in this place here I'm not scared of a fire. You know if one came through here now it wouldn't be a problem and yet the only problem would be the police turning up and dragging you out.*

According to Bilpin residents, non-context specific decision making by Central Office caused considerable problems for residents and firefighters on the ground. The communication issues described by Bilpin residents could be a result of the greater degree of "outside interference" in local fire-fighting operations, as the threat posed to the township existed over a longer timescale during which 193 properties were destroyed in the Springwood Fire.

For residents of Mount Wilson, the most commonly described problem was equipment failure. Failing to plan for power outages during the fire meant many residents were unable to power pumps, deploy window shutters, charge phones or access the internet for information. Not knowing how to use equipment, having hoses without sufficient reach, or tanks without the right fittings were also problems reported by Mount Wilson participants. Interestingly, just three households from our sample of 18 stated explicitly that they regularly checked their fire-fighting equipment. This was reflected in the large number of participants across both sites that reported having to repair equipment in the lead up to the fire.

Future Research

Considering the findings in this report, together with issues highlighted in research more broadly (AJEM 2014; Eriksen 2014; AJEM 2013), further research is recommended into:

1. How RFS volunteers juggle responsibilities to their brigade, to their families and to the preparation/defence of their properties;
2. How neighbouring properties challenge or benefit personal preparedness;
3. How households with dependents plan for and cope with fires;

[4] 5 households Bilpin; 4 households Mount Wilson

4. How previous fire experience contributes to or detracts from practical and emotional preparedness and resilience; and
5. How better to prepare for pets and animals during bushfires.

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Appendix A

Building impact analysis: Habitable dwellings and other buildings damaged or destroyed by bushfire, October 2013(table adapted from NSW RFS 2013).

	House (Habitable Dwelling)		Other Building (Shed, Business etc.)	
Fire location	*Damaged*	*Destroyed*	*Damaged*	*Destroyed*
Hank Street, Port Stephens	6	0	6	8
Hall Road, Balmoral	2	2	0	10
Rutleys Road, Wyong	3	3	4	15
Linksview, Springwood	109	193	0	0
State Mine, Lithgow	1	3	1	7
Mt York, Mt Victoria	1	7	0	0
Total	122	208	11	40

5. Investigating Residents' Bushfire Hazard Mitigation and Amenity Values through Interviews, Qualitative Mapping, and Property Walks

Nicholas Gill, Chris Brennan-Horley, Olivia Dun

Australian Centre for Cultural Environmental Research (AUSCCER), University of Wollongong, NSW 2522, Australia

Abstract

This paper reports on the qualitative methodology for the amenity component of the "Co-existing with Fire: Risk and Amenity Project" and also presents empirical results to demonstrate how the methodology has been applied. The qualitative approach employed ethnographic research methods to explore residents' attitudes to their environment and bushfire management. This approach was underpinned by identifying and mapping key cultural values contributing to amenity using aerial imagery of resident properties, computer tablet technology, and GIS mapping. Overall results reveal diverse and interrelated intra-property management activities and rationales at two scales – the immediate vicinity of the house (within 20) and in the garden or native vegetation at or within 100m from the house. When managing vegetation on their property residents take into account the topography of the landscape, knowledge of fire behaviour and the particular fire threat to their property, as well as multiple amenity drivers such as attracting birds around the house, creating wildlife corridors, providing privacy from neighbours, gardening activities, creating recreational spaces, or encouraging particular plant species while removing others. Using spatial mapping revealed how, where, why and whether or not such vegetation management drivers overlapped. This provided insight into the assessments and decisions behind vegetation management activities regarding vegetation immediately fringing houses on private properties and representing bushfire hazard despite residents managing vegetation elsewhere on their property for hazard mitigation purposes.

Key Words

Bushfire (wildfire); qualitative mapping; vegetation management; amenity values; wildland-urban interface (WUI)

Introduction

The "Co-existing with Fire: Risk and Amenity Project" set out to test a new spatial method to assess residents' sense of amenity at the wildland-urban interface (WUI)/ rural-urban interface (RUI)[5] and determine its potential usefulness and applicability to fire risk research. This paper therefore has a

[5] For simplicity we use the term 'WUI' in the remainder of this paper but note that it does not fully describe the range of landscapes in our case study area.

dual purpose. It mainly reports on the qualitative methodology for the amenity component of the research project, but also presents some empirical results to demonstrate how the methodology has been applied. The qualitative approach employed ethnographic research methods to explore residents' attitudes to their environment and bushfire management. This approach was underpinned by identifying and mapping key cultural values contributing to amenity using aerial imagery of resident properties and computer tablet technology.

The overall purpose of the amenity component of the research was to provide a spatial basis for investigating amenity implications for bushfire risk mitigation to address the overarching question: *How do residents' senses of amenity at the WUI, as evident in values relating to elements of the natural landscape, influence their perceptions of appropriate vegetation management and bushfire risk?* The specific aims were twofold. Firstly, to use maps to understand how and where residents perceive bushfire hazard and amenity on and around their properties. Secondly, to understand vegetation management approaches being taken by residents close to their house and around their property to account for both amenity and/or bushfire risk mitigation considerations. Following a brief review of the existing state of knowledge relating to these aims, detailed discussion of the methodological approach undertaken is provided before some results addressing these two specific aims are discussed and a conclusion that reflects on the usefulness of the mapping exercise is provided.

Literature Review

Bushfire Hazard Mitigation by Property Owners

An important influence on this study and approach was incorporating a spatial approach to investigate resident bushfire hazard mitigation activity and amenity that could contribute to, and build upon, existing research in this area. Findings from existing research about bushfire hazard mitigation by residents at the WUI have highlighted the effectiveness of engagement activities such as one-on-one consultations, property evaluations, and community meetings that are attentive to local context and needs (Brenkert-Smith, 2011; McCaffrey et al., 2013). This study aimed to explore how a mapping tool would assist identifying and discussing property management activities, amenity values, and bushfire hazard mitigation and their interrelationships with a view to the potential utility of such a tool for fire agencies.

There has now been considerable, predominantly USA-based, research on resident preparedness and bushfire hazard mitigation (McCaffrey et al., 2013). Much of this research has sought to investigate the role of individual and collective social factors such demographic variables, length of residence, community networks and capacity, experience of fire, and perception of hazard and risk. These studies vary in their findings, for example Champ et al. (2013, p.833) conclude that 'some of the literature has suggested a positive relationship between perceived risk and risk-mitigating behaviour, whereas other studies found no relationship'. However, and despite a common view among managers that residents do not undertake sufficient mitigation and resist doing so (for example, Reams et al., 2005), a general finding from this research is that the majority of residents are aware of bushfire hazard and undertake some action to mitigate it (McCaffrey et al., 2013). For example, Paveglio et al (2014) found, with some variation, that at least around half of their survey respondents had undertaken a range of mitigation measure such as removing or thinning trees and

other plants up to 100 feet from their houses. Schulte and Miller (2010), McFarlane et al (2011), and Halliday et al (2012) report higher proportions, 84%, 61-92% and 70-80% respectively, of residents undertaking some form of vegetative management for hazard mitigation (for more general but consistent findings see also McGee and Russell, 2003)6.

The actual decision to implement vegetative or other mitigation measures on risk or hazard grounds can be dependent on a wide range of factors including individual variables such as hazard and risk assessment. However, perception of risk or hazard is a necessary but not sufficient factor for action. Accordingly, bushfire research has increasingly contextualized 'hazard-related decisions by expanding considerations of the experiences, perspectives, and behaviours of those living in and owning property in fire-prone areas' (Brenkert-Smith, 2011, p.194). McCaffrey (2013, p.17) summarises these considerations as the 'social context in which mitigation options were considered; trade-offs with other amenity values such as aesthetics or provision of wildlife habitat; perceived effectiveness of risk reduction activities; and individual capacity to implement actions (e.g. time, money, physical ability)'. Moreover, as McCaffrey (2013) notes, residents are not always undertaking mitigation activities for fire related reasons. Routine garden maintenance such as lawn watering and mowing or garden design and landscaping according to aesthetic considerations are often done anyway, while more difficult mitigation tasks such as tree thinning may be done as well but by lower proportions of residents (Brenkert–Smith et al., 2006; Bright and Burtz, 2006; McCaffrey et al., 2011; McGee, 2005)

One of the key factors in resident's decision to mitigate by managing vegetation is how they value landscape elements that may be vulnerable or hazardous and which also provide amenity of some sort (Schulte and Miller, 2010). In WUI areas, the amenity provided by vegetation, the presence of wildlife, greenery, gardening, views, proximity to nature, and privacy is a key element in the decision to purchase property in such areas and a key driver of how people manage their property and create new homes or comfortable, relaxing second residences (Abrams et al., 2012). The landscapes on the properties are key sites for expressing themselves and their identities in the landscape (Nelson et al., 2004). Gardens are key sites of recreation, contact with nature, and for the expression of personal aesthetics (Head and Muir, 2007). Further, many residents at the WUI desire proximity to 'nature' and often have conservation ideals as an important aspiration underlying property ownership in such areas (Abrams et al., 2012; Gill et al., 2010). For these reasons, a common assumption, and borne out in some research, has been that bushfire hazard mitigation through vegetation management is likely to be in conflict with residents' sense of amenity and with their desired property aesthetics. For example, Cohn et al (2008) found that residents were reluctant to invest in vegetative hazard mitigation for aesthetic or lifestyle reasons, while McCaffrey et al (2011) and Collins (2008) review a range of potential conflicts between vegetation management for hazard reduction and for other goals such as habitat provision that have been identified in previous research. In 2008, Collins (2008) suggested that the evidence at that time supported the view that WUI residents generally did not reduce bushfire hazard via vegetation management, preferring to manage vegetation for aesthetic and other amenity reasons. More recently, McFarlane et al (2011) found a perception that vegetative mitigation work will reduce 'connectedness to nature' among Canadian WUI survey respondents.

[6] Note, these figures are generally from self-reporting surveys and are not based on systematic field recording of management activities by researchers or trained assessors.

However, other research has suggested that such findings may themselves obscure complexities in how residents weigh up amenity values and make decisions about bushfire hazard mitigation in valued environments around their homes and elsewhere on their properties. In contrast to the general research findings he identified at the time, Collins (2008, p.519) found 'tentative evidence' among Arizona WUI residents that 'amenity values may be compatible (rather than conflicting) with household hazard mitigation'. Such a finding had been foreshadowed in an earlier paper by Nelson et al (2004) who find compatibility between some of their respondents' amenity and aesthetics preferences and managing vegetation for bushfire hazard reduction. They further suggest that the variation in what constitutes 'natural' for residents opens up considerable opportunity for exploring compatibility between amenity values (e.g. a desire for proximity to nature and 'natural' views from the house) and hazard reduction more generally among residents. In other survey based work, Bright and Burt (2006) and Schulte and Miller (2010) also found that aesthetic concerns were not necessarily at odds with vegetation management for hazard reduction. Bright and Burt (2006, p. 182) in fact found that, for one of their two identified groups of landholders (those who tended to be less individualist, more community-oriented, less anthropocentric, and more biocentric), creating 'defensible space' had 'enhanced aesthetic benefits' such as creating a 'nice-looking neighbourhood' and 'improve[ing] the appearance of property'. More recently, McCaffrey et al (2011) in multisite interview-based work similarly found that aesthetics was an important motivator for vegetative hazard mitigation activity for about one quarter to one half of interviewees across their study sites, including interviewees for whom a natural setting and privacy were important. They conclude that 'home protection activities, including vegetation management, do not inherently conflict with the reasons why people choose to live in more natural areas' (McCaffrey et al., 2011, p.486).

It seems therefore that amenity plays an important role in resident decisions about hazard mitigation and that management for amenity can also achieve hazard mitigation goals. Despite the research referred to above it remains the case that relatively little is known about residents' perspectives on the vegetative hazard mitigation activities and their implementation on their properties (Brenkert-Smith, 2011), certainly in Australia. Moreover, it has been suggested that positioning residents as either adopters or non-adopters of hazard mitigation activities can obscure the range of variously adopted and implemented activities that residents engage in (Brenkert–Smith et al., 2006). Further, research to-date has at least two limitations. First, there is no spatial element to investigations of resident activities beyond a simple reference to distance from house. In their recent survey of Montana residents Paveglio et al (2014), did include a diagram showing distance-defined zones up to 100 feet from a house site, and they asked respondents if they had performed certain mitigation activities in each zone (see also Brenkert-Smith et al., 2012). This is a step forward but effectively treats the landscape surrounding the house as a uniform plane, undifferentiated by topography, vegetation, amenity, likelihood of fire, access, land use, and so on. Such spatially homogenising treatment is implicit in the existing research discussed above and risks missing details of any intra-property decision-making and activities, any variability in this, and the rationales for any such variability. All of these themes potentially speak to issues in the literature such as differential clearance around houses and residents' perception that hazard has been reduced to their satisfaction by certain actions on their property even if vegetation remains in the vicinity of the house that may be judged hazardous by an assessor. Second, as Nelson et al (2004) point out, and as we allude to above, WUI property management is driven by diverse, flexible, and sometimes complex social and cultural factors, aspirations, ideals of rural life or life close to nature, and home-

making processes (see also Abrams et al., 2012). Vegetation is more than fuel, it is a key element in how, why, and through which WUI residents live and make the landscape a home. In the quantitative research on hazard mitigation, this depth and significance is, albeit necessarily for the methodology, reduced to deployment of aesthetics and amenity in terms of brief survey questions about such things as 'nice-looking neighbourhoods' or 'naturalness' – a notoriously fuzzy and flexible concept. In the qualitative research too, aesthetics and amenity and relevant interview results tend to be discussed briefly and without elaboration of the resident values or aspirations that underpin them nor of any sense of how they, and the presence or absence of related management activities, might vary spatially within a property. Thus, as suggested by Nelson (2004), there remains significant scope to investigate resident amenity and mitigation activities and to provide managers with findings that will assist them to grapple with the complexities and variations in residents' sense of nature and amenity and how these might be consistent, or at least more consistent, with reduced hazard. Specifically, then, our spatial approach will enable us to address questions such as:

- To what extent do the USA-based findings regarding vegetative hazard reduction around houses apply in Australia?
- To what extent can a more explicitly spatial approach further help document and understand the range of hazard reduction strategies by residents?
- To what extent can our spatial and interview-based approach help us to investigate the interaction of hazard perception, amenity, and mitigation activities to provide greater depth of understanding of the role of issues such as aesthetics and a desire for 'naturalness'.

Consistent with the findings elsewhere in this project that fuel loads immediately around the house (within 20m) and in the vicinity of the house (up to 100m) are a key factor for potential property loss to fire, we address these questions by examining residents' decisions and management actions in these zones.

Mapping Qualitative Data

A suite of interchangeable terms – mental mapping, cognitive mapping, place mapping and qualitative mapping – are used to describe the use of maps for stimulating and grounding discussions around a particular area of interest. The power of this mixed-method approach lies in its ability to not only allow maps to act as a prompt and tool for gathering geographic data but also to permit collection of narrative responses. The mental mapping tradition has long used hand-drawn maps to understand how individuals make sense of the physical world through way-finding (Lynch, 1960) and emotional attachments to place (Tuan, 1975). Qualitative Geographic Information Systems (GIS) extends on this tradition, integrating ethnographic data including annotated mental maps, narratives and photos for database storage and cartographic visualisation in context with more traditional GIS data about the physical landscape (Elwood and Cope, 2009).

In developing our tool for mapping resident perceptions of hazard and amenity we appraised instances in the literature where maps and GIS have been deployed for researching perceptions of bushfire hazard and landscape preferences. A range of approaches varying in technical capacity were found, ranging from traditional paper-based mental mapping discussions through to custom software applications.

Beilin and Reid (2014) used a place mapping exercise, where respondents used multiple coloured pens to draw upon a blank sheet. They found this approach a constructive tool for engaging the community and for understanding the underlying social and ecological values associated with landscape, home and fire hazard. As they are conducted on a blank page, mental maps are easily deployed and highlight the role of memory in defining both social and ecological worlds. For our research we were interested in extending on memory-focussed mapping by providing aerial imagery to prompt respondents about particular landscape and property features. Responses drawn upon aerial images could be georeferenced for later GIS collation and analysis.

Taking a computational and spatial approach to data collection and analysis, Carver et al. (2009) developed custom software for mapping place-based values. Their laptop software provided a mouse-operated spray can tool for participants to highlight regions upon a static image of the Mission Mountains landscape, Montana, USA. Questions were asked about five separate layers of value – wildlife, access, cultural and scenic – indicating a successful deployment of a digital, layer-based approach with research participants. However developing software-based tools presented resourcing implications for our project design. We did not have the requisite skills in computer programming, but still wished to use a digital layer-based strategy for post-interview GIS analysis. Additionally, we sought a degree of zoom control on each map to foster discussion about individual plantings and vegetation management decisions within 100 metres of properties.

Cacciapaglia et al. (2011) also used a spray can mapping tool for charting special places and preferences in vegetation management in the WUI of the Kootenai National Forest, Montana USA. A key finding was that preferences toward fuel management can operate at greater spatial scales than the map area being discussed, or were based on aspatial perceptions. Therefore mapping tools must provide multi-scalar choices (for example, property, surrounds and regional maps) rather than relying on a single image. Additionally, in the Montana research the mapping exercise was not introduced until later in the interview, indicating that starting a mapping exercise early on may aid in grounding discussions. Also, mapping out the spaces of everyday property activities such as gardening, planting or clearing may serve to further spatialise vegetation management discussions.

Methodology

The main approach for the amenity research aspect of the “Co-existing with Fire: Risk and Amenity Project” project was to conduct interviews with residents living in peri-urban areas directly bordering fire-prone pasture, bushland or forest (wildland), particularly in south-eastern Australia. Four study sites were selected for this research and fell into two areas of New South Wales (NSW): the Blue Mountains (Figure 5.1) and Wamboin (Figure 5.2). The selection process for these sites as well as the recruitment of residents within these sites has been outlined in the chapter ‘Landscape preferences, amenity and bushfire risk in New South Wales, Australia’ elsewhere in this report. Census demographic and dwelling status data (Table 5.1) indicating the mix of residents in these the four study site areas also contributed to our site selection process.

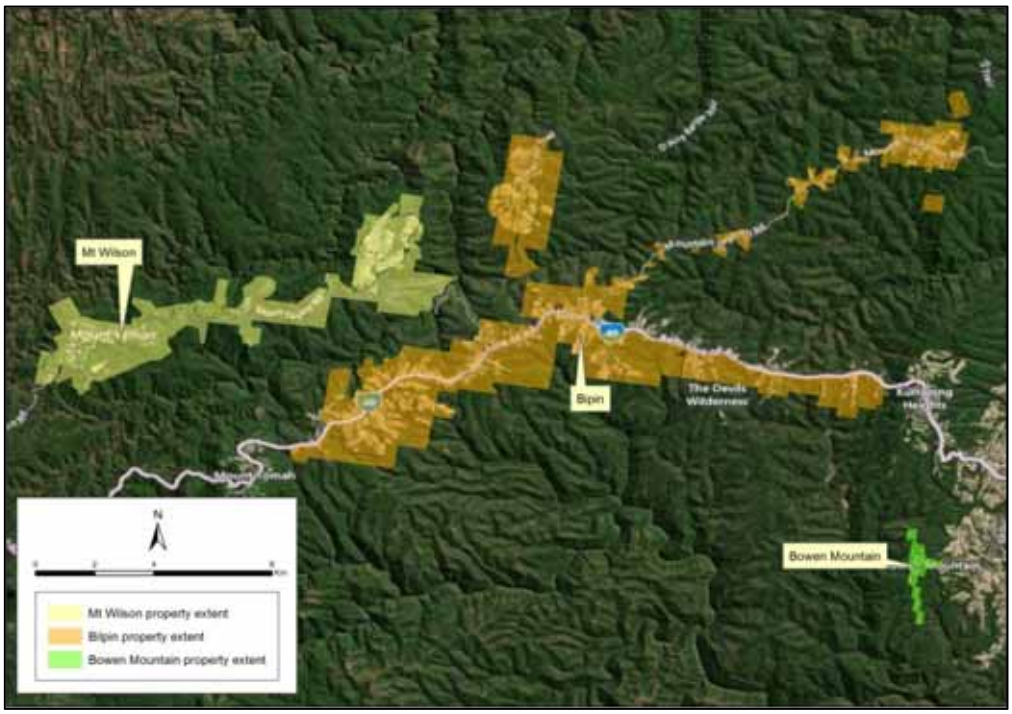

Figure 5.1 - Blue Mountains study areas – Mt Wilson, Bilpin and Bowen Mountain

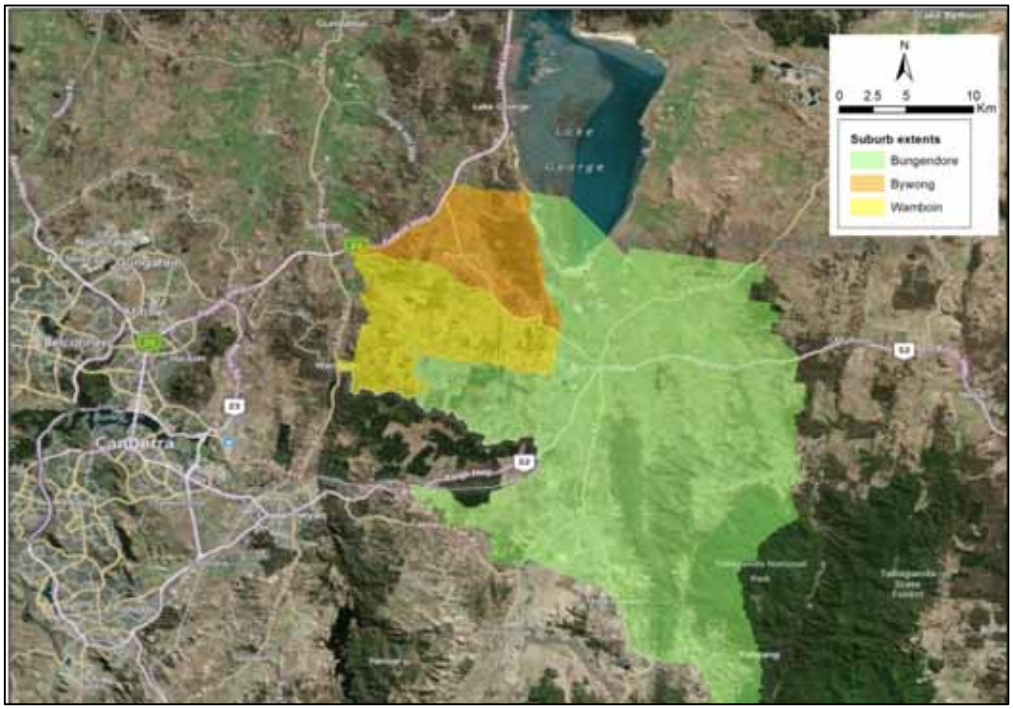

Figure 5.2 - Wamboin region study areas – Wamboin, Bywong and Bungendore

Engaging with residents consisted of four components conducted in sequential order: a pre-interview questionnaire (see Appendix 1) followed by a face-to-face interview that included an interactive mapping exercise, a photo evaluation exercise, and a walking tour of each resident's property (Figure5.3). The spatial mapping component formed the main part of the face-to-face interview. The purpose of engaging with individual residents/landowners was to gain insight into the following more specific research questions:

- *What are the important elements of the landscape for property owners at different scales, what are the values attached to them, and how do they relate to each other?*

- *What is the role of the broader landscape7, if any, in shaping what they value and defining those elements that are of value?*

- *How does their sense of amenity manifest itself spatially?*

In order to address these specific questions interviews were designed such that residents would be able to tell us what they like about the natural environment they live in (hence research methods: pre-interview questionnaire and all aspects of the face-to-face interview), at what scale this 'liking' occurs (hence research method: spatial mapping exercise component of the face-to-face interview), and how this influences how they think vegetation should be managed or indeed how they do manage it (hence research methods: photo elicitation exercise and property walk component of the face-to-face interview). This mix of methods allowed us to understand what is valued/perceived by residents in the landscape both vertically (the photo elicitation and property walk in particular helped us to understand what residents valued about vegetation height, vistas/views, and the hinterland landscape) and horizontally (mapping on aerial photos in response to specific questions aided our understanding of the spatial distribution of values, activities and concerns across the physical landscape).

In order to understand an individual resident's sense of amenity it was important to provide a means to allow them to discuss what they value in the landscape on their property as well as beyond their property boundary. An underlying driver for taking a multi-scalar approach (i.e. asking residents what they value both within and beyond their property bounds) was because there can be a relationship between the way residents think about and manage vegetation on their individual property based on how their property is located, situated and oriented within the broader landscape/natural setting; and, the visual appearance of the surrounding area/area beyond the immediate residence. We wanted to explore this relationship in our research while being open to the possibility that for some residents, the landscape beyond their immediate house and garden may play no role in the way they think about or manage vegetation on their property. This is in addition to recognising other non-scalar factors at play in how they think about and manage the vegetation on their property.

As an example, some issues that we were interested in included; if a resident has a view (from their house) of a forest in the hinterland or near-distance that they value, then how important is the understorey in constituting that view and/or how does that affect the way they think about and manage vegetation that is closer to their house? As another example, if a resident really focuses on the garden around their house, to what extent is any bush and its structure beyond that important in framing the garden as a valued element? Overall, our research was about the visual landscape – what people see, experience living in a place – and how this affects how they perceive elements of the vegetative landscape and how they think it should be managed. In this way, the spatial component of the research was crucial in aiding our understanding.

[7] Broader landscape = street, neighbourhood, public spaces, viewshed, parts of rural properties beyond house/garden envelope

Wamboin	Bilpin	Mt Wilson/Mt Irvine	Bowen Mountain
A commuter belt	*Mix of permanent residents/second home owners (weekenders)*	*Mix of permanent residents/second home owners (weekenders)*	*Suburbia at the edge of the Blue Mountains*
~ 1200 people • **median age: 44** • **94% occupied private dwellings** • **6% unoccupied private dwellings** • **commuter belt for Canberra** • **no recent fire history** • **green groups/sustainability focus** • **not many youth (according to brigade members)**	~ 800 people • 71.4% occupied private dwellings • 28.6% unoccupied private dwellings (census) • mix of permanent residents and second home owners/weekenders • recent fire history • not so apparent that there are green groups/focus, farming/orchardist history •	~ 250 people • 71.4% occupied private dwellings • 28.6% unoccupied private dwellings • mix of permanent residents and second home owners/weekenders • very elderly population • fire history one of near misses (no properties lost) • gardening culture and green focus	~ 1450 people • median age: 35 • 91.2% occupied private dwellings • 8.8% unoccupied private dwellings

Table 5.1 - Demographic and dwelling occupation data for the four research study sites (Sources: Australian Bureau of Statistics, Census of Population and Housing 2011 and personal communications from Rural Fire Service Brigades)

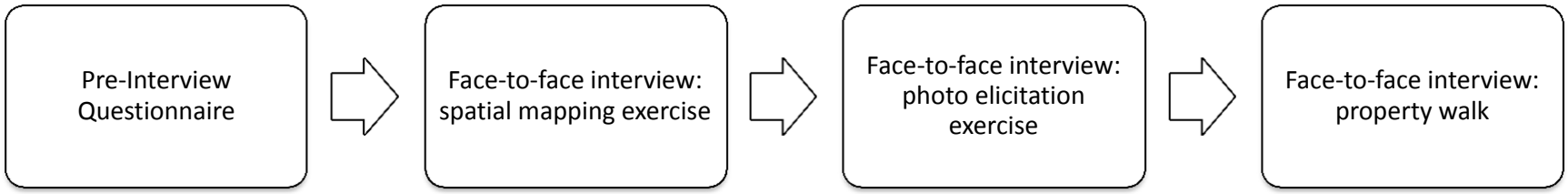

Figure5.3 - Flow process of interview with residents participating in amenity research for the "Co-existing with Fire: Risk and Amenity Project"

Development of Spatial Method

With respect to the interactive spatial mapping exercise, we wanted to present residents with a physical map or image of their property on which they could identify and mark out features relating to vegetation and values on their block of land. A range of computer software applications for both field use and post-interview processing were explored, beginning first with low-tech paper maps and multiple coloured pens followed with scanning and georeferencing into GIS. Whilst tactile and legible at a regional scale, our decision to investigate property-level vegetation management issues meant that existing 1:25000 topographic maps were often not at a fine enough resolution to pick out individual garden features. Producing our own custom-scale aerial image printouts was canvassed, but the ability to mark up these maps with coloured pens required a new map for each colour, which would have proved unwieldy in the interview setting. This suggested the utility of a GIS-based (Geographic Information System) approach using digital qualitative spatial and interview data collection.

We therefore turned next to using GIS with aerial imagery as a backdrop. Whilst GIS software packages can control map extents and pan around the data frame easily, they lack an intuitive drawing capacity and were thereby deemed too finicky for use with respondents without prior exposure to GIS. Instead, computer tablet technology, via the use of an IPad, proved most suitable for its paper-like drawing capacity (Figure **5.4**), portability and potential for digital image manipulation skills available through affordable photo and image editing applications (apps). After initially investigating a number of apps we settled upon Sketchbook Pro for IPad (Figure 5.5) for the following reasons:

- Allowed for an aerial image to be loaded in as a base layer
- Layers could be added in to hold responses for different questions and could be turned off and on (i.e. made visible or invisible) at will
- Intuitive drawing interface could be used with a finger or a pen-like stylus, also with erasers and shifting pen sizes
- Resulting layers could be exported in a format suitable for GIS transfer

As the baseline aerial photo was a static image, we were limited in how closely the map could be zoomed before the image would become too pixelated. A work-around involved loading three maps – property, surrounds and regional – each at a relevant scale for the property under investigation (Figure 5.6). In this way we could capture perceptions of not only on-property activities, values and concerns, but also those that may be playing out over a wider space in the local area. Deploying three maps at each interview did place pressure on preparations in that we ensured all aerial imagery base layers were loaded onto the iPad before we arrived, rather than pulling down imagery from the web at the time of interview.

Trialling the Spatial Method

The interview questioning and mapping method was trialled in Wollongong in December 2012. We picked three properties that backed onto a public reserve and asked questions about the use of that space, what they valued about the reserve, and if they had any concerns about it. Residents in our trial were able to use the iPad, either drawing with the supplied stylus or with their finger and were able to locate their properties and orientate themselves to the map. Following the interviews we were satisfied that the technological side of the interview would succeed in the field. The iPad data gathered from interviews was also successfully transferred into ArcGIS to create the map in Figure 5.7.

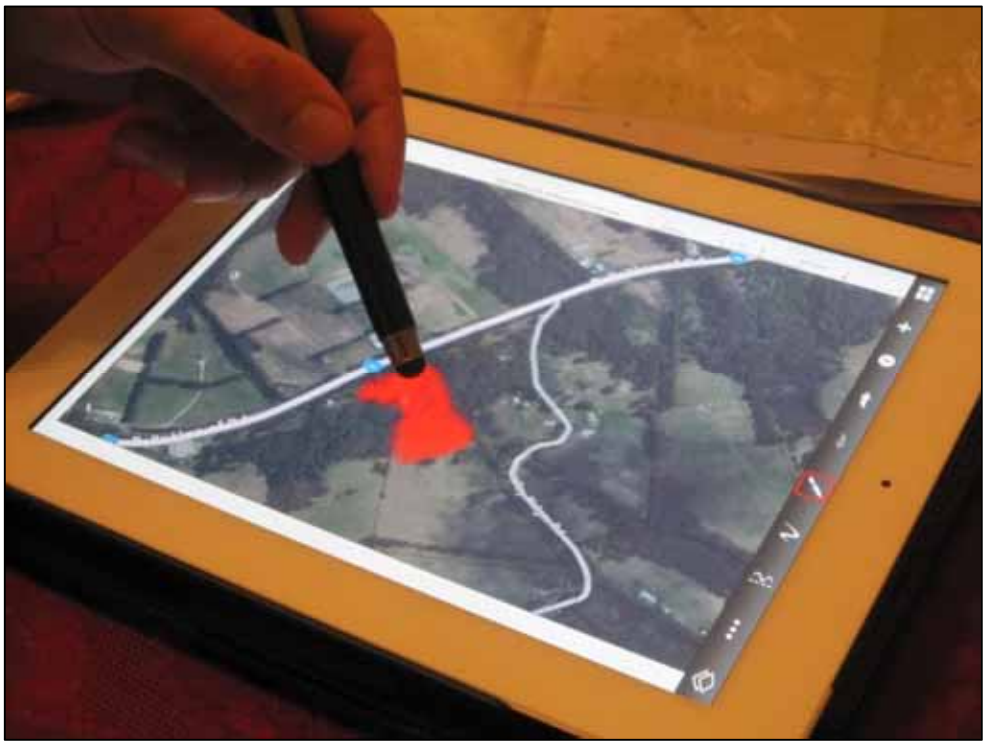

Figure 5.4 – The IPad's paper-like drawing capacity was useful for allowing residents' to mark out features

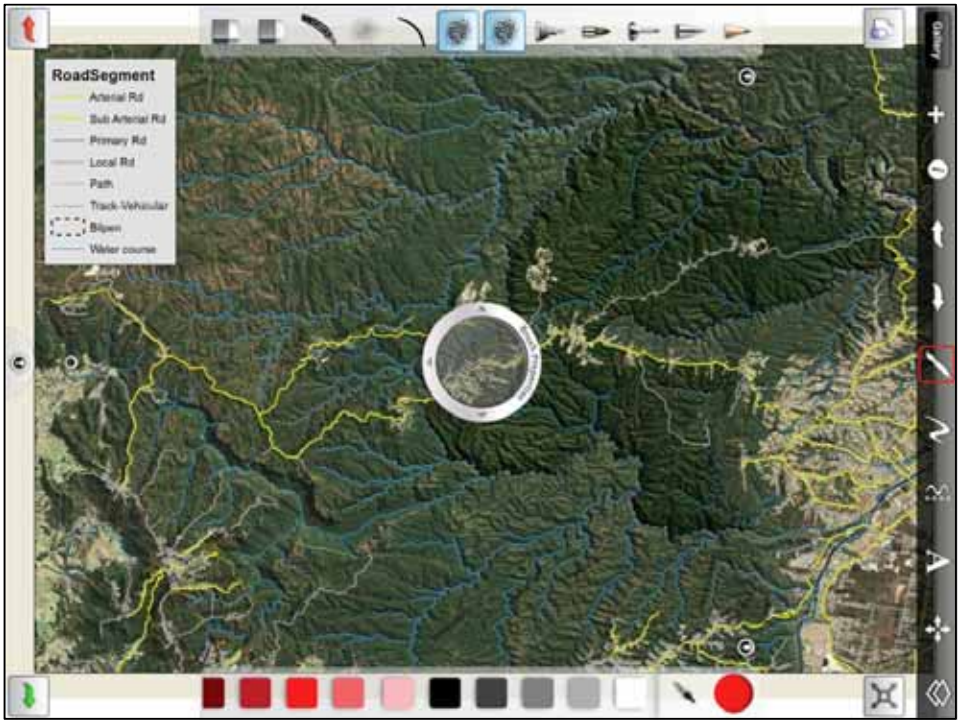

Figure 5.5 – Sketchbook Pro software showing different drawing tool options and aerial base-layer image to draw upon

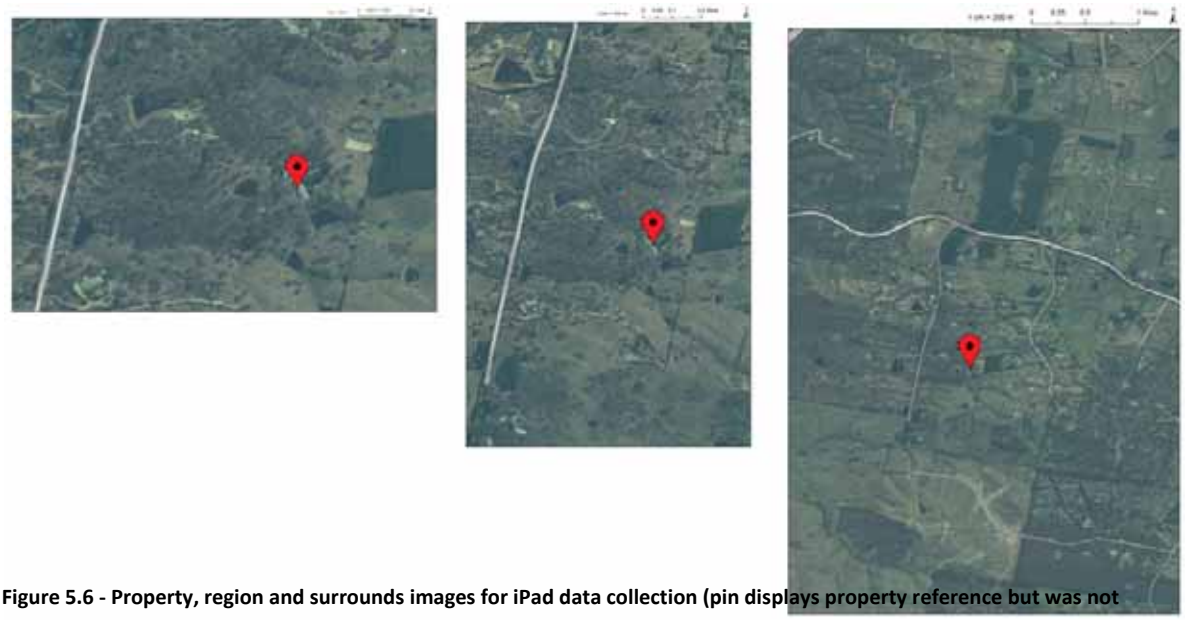

Figure 5.6 - Property, region and surrounds images for iPad data collection (pin displays property reference but was not used in interviews)

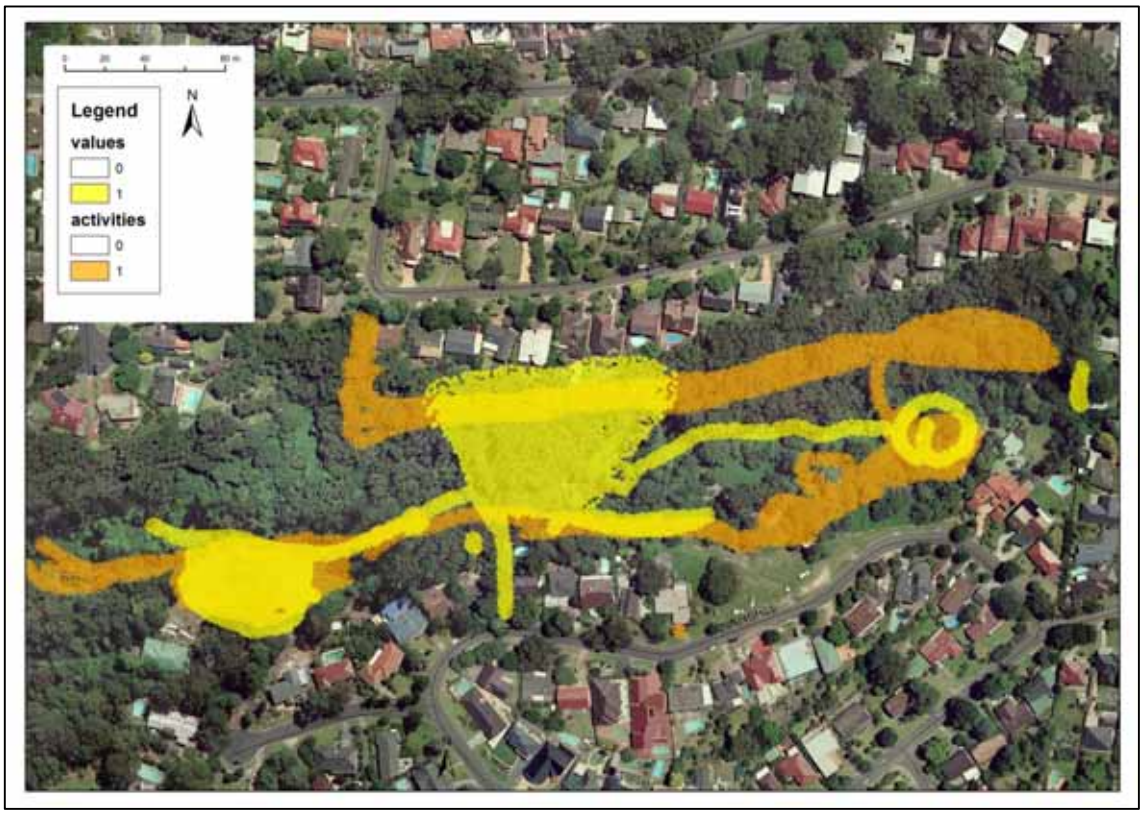

Figure 5.7 – Amenity values output map from trial of spatial methods (yellow = areas of value, orange = areas of activities)

Deployment of Methods: Resident Interviews

As mentioned above, engagement with rural residents was composed of four parts. The purpose of the pre-interview questionnaire was to gather some brief descriptive data about the resident, their property, their history and pattern of living in the area, and experience of bushfires. This was mailed or e-mailed to the participant and completed in advance of the face-to-face interview thus providing the researchers with some context to the resident's background while also reducing the time required for the face-to-face interview. Upon commencement of the face-to-face interview resident responses to the pre-interview questionnaire were discussed serving to act as an ice-breaker and, more importantly, as a chance for residents to talk freely about when they moved to their property and what attracted them to living there, thereby capturing historical aspects of the resident's relationship with the landscape and experience of bushfire. The interview then rapidly moved on to the mapping exercise which drove much of the face-to-face interview.

The specific purpose of the mapping exercise was to capture how residents visualise, utilise and value their property and surrounding area in a spatial sense. Residents were presented with an aerial image of their property on an IPad and shown how to use the Sketchbook Pro drawing software. They were asked to practice using the software by marking out their property boundary using a stylus. Next residents were asked to mark out, firstly, activities they did on their property; secondly, features or particular parts of their property that were of value; and, finally, any parts of their property that were of concern (Figure 5.8). This framing acted as a natural starting point and useful prompt to let the participants talk about their property in detail. They were able to highlight their activities, what was of value and concern to them. Throughout the interview, however, it was important for us to be mindful that we were particularly interested in the residents' views on vegetation. Therefore, it was important to pick up on points made by residents about vegetation or vegetation-related issues and prompt them to elaborate on these views as they arose during the interview or exercises.

Figure 5.8 - Mapping output example (clockwise from top left): property outline, activity, concern, value

Following the mapping exercise, residents were asked to complete a photo elicitation exercise. The purpose of the photo elicitation exercise was to gather a slightly different perspective on the resident's thoughts about vegetation and amenity by presenting them with some external prompts of different images of vegetation. Details of how this exercise was executed and relevant results have been detailed in the paper 'Landscape preferences, amenity and bushfire risk in New South Wales, Australia'.

Finally research participants were asked to take the interviewers on a walk around their property. Some residents simply led the interviewers around their property pointing out features of interest, while others asked the interviewers what they preferred to see. When asked what they preferred to see, the interviewers would explain they would like to see features the residents had marked out on the map during the mapping exercise and anything else the residents felt was of interest. The purpose of the property walk was a chance for the researchers to visually solidify their understanding of the resident's property and talk to the resident in a less structured, informal manner. In particular, this was a chance to get a feel for the topography of the landscape and assess if/how the topography played any role in shaping the resident's value of their property, the landscape and overall sense of amenity.

The advantage of carrying out the photo elicitation exercise and walking tour on the resident's property following the mapping exercise was that interviewers already had a comprehensive first-hand understanding of how vegetation was being 'managed' on the resident's property and a clearer idea of what it was that residents valued. This was useful in contextualising their potential responses to images presented during the photo elicitation exercise. In addition, the photo elicitation exercise, as a latter focus during the face-to-face interview, started to shift the focus of the interview away from data gathering about the individual resident's property and onto broader ideas about landscape management. It also meant that if time ran out during an interview, interviewers could be sure to have already gathered the 'harder to obtain' unique data about the resident's property through the previous mapping exercise.

Overall, the face-to-face interview allowed researchers to gain a more thorough understanding of the appeal and attractiveness of the area where the residents live (from the resident's perspective), any concerns they had about living where they do (particularly in relation to bushfire) and to more specifically gather their views on vegetation preference (species choice, management and patterns of growth). It is also was a chance for free flow discussion and for any other issues of importance to the resident to emerge.

Data Analysis Process

The pre-interview questionnaire and face-to-face interview were conducted at 65 different properties across the four study sites. At least six types of data were produced for each individual interview:

- Pre-interview questionnaire results
- three mapping layer files (activity layer, value layer, and concern layer)
- Video footage of mapping exercise activity
- Photo evaluation ranking results
- Photographs taken during the property walk
- Audio recording of the interview

Qualitative analysis software NVivo 10.0 allowed video files, audio files, audio transcripts, map images, property walk photographs, pre-interview questionnaire data, and photo ranking data from each individual interview to be neatly linked together for data coding and interrogation. Mapping data processing and analysis was also conducted separately in ArcGIS, enabling more spatially oriented tasks to be carried out, including distance measurements and overlays with other spatial data sources. This section details the steps taken to prepare the data for analysis within both NVivo and ArcGIS.

Selecting clusters of properties

Interview contacts were first established through the local RFS brigades and then neighbouring properties were referred on an individual basis. Every effort was made to make contact with neighbouring properties however the realities of participant availability and interest in the research meant that not all neighbouring property owners were available for interviewing. This has left the project with a dataset of 65 interviews spread across the study areas, interspersed with four instances of clustered properties; two in Mount Wilson, one in Bungendore, and one in Bywong (refer to Figure 9). Clustered properties were defined as either sharing a property boundary with a neighbouring interviewee, or were within one property of a neighbouring interviewee. These clustered properties amounted to 17 interviews and 19 properties having been identified for detailed analysis. Below are the steps deployed in analysing these 17 interviews in detail.

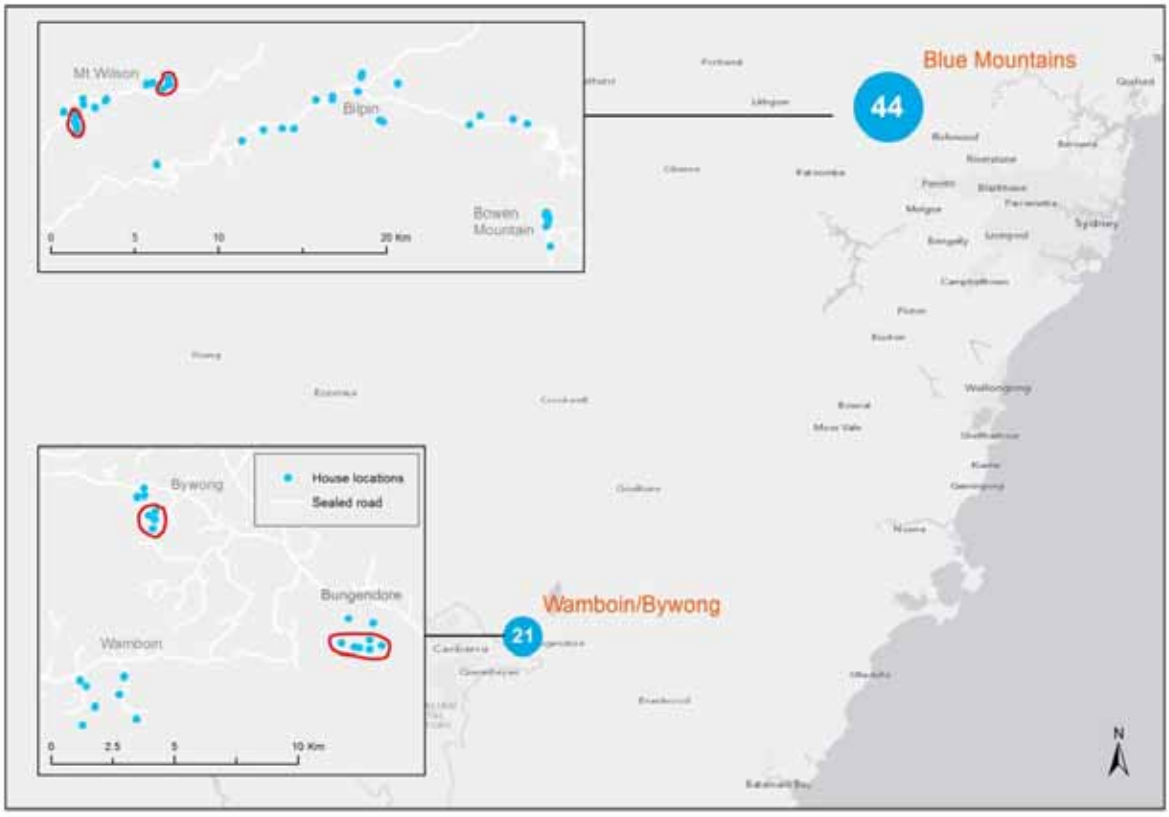

Figure5.9 - Interview locations, clustered properties outlined in red

Preparing data for analysis in NVivo 10.0 software

In preparation for data analysis, an NVivo project file was created and a case node created for each individual interviewee. Of the seven different types of interview data mentioned above, some could be imported directly into the NVivo 10.0 project while others required preparation to be imported. Video files8, audio files, and property walk photographs were able to be directly imported into the project and coded to the relevant interviewee case node. Pre-interview questionnaire results and photo ranking data results were firstly entered into an Excel spreadsheet and then imported to the NVivo project as a Node Classification Sheet. This resulted in each interviewee case node being assigned attributes, the attributes being the individual interviewee's responses to the pre-interview questionnaire and their photo ranking preference data. During the data analysis phase, further attributes were added to the classification sheet as will be described below. Finally, the mapping data required importing into the NVivo project. Before this could be done, images had to be prepared. The detailed steps for preparing mapping data layers for importation into the NVivo project are provided in Box 1. Once all relevant data was imported into the NVivo project, a process of cross-referencing the different items of data was carried out with the audio recording transcript being the key means through which this occurred (see Box 2).

Once the data preparation was complete, analysis was undertaken using the interview transcripts, mapping video, and maps to identify and code for activities close to the house, within twenty metres, and for activities beyond this, at up to one hundred metres. In addition, we coded for the reasons that people gave for undertaking different activities. These reasons were coded under various 'amenity' codes such as aesthetics, habitat/environmental, and views. We also coded for other aspects of management, including whether interviewees managed vegetation in the direction of greatest likelihood of fire and whether they perceived limits to what they could achieve through vegetation management on their property.

Box 1 - Preparing Mapping Data for Import Into Nvivo

Creating images from sketched layers:

1. Export drawn layers capturing research participant activities, values and concerns on their property and surrounding areas from Sketchbook Pro as a .PSD file
2. Exported .PSD files are imported into the software GIMP (version 2.0).
3. Once in GIMP, the file is saved as a .xcf file and becomes a working file where new layers can be created to extract certain markings made by research participants.
4. Layers from the .xcf file can be exported as .jpg images and the following three .jpg files are exported for each of the interview participants:

[8] Importing video files into NVivo 10.0 can be difficult because of file format limitations and large file size limitations of NVivo. If the file is in .mov format, it needs to be imported into a version of NVivo 10 running in 32-bit version because .mov files cannot be imported into a 64-bit version of NVivo 10 because Quicktime player does not have a 64 version. Once .mov files are imported into NVivo10 via 32-bit version, then they seem to be able to be viewed in an NVivo10.0 64-bit version. Note that if large file sizes are embedded in the NVivo project it can impact on the performance, therefore it is preferable to store the video files outside the project (for example on a network share drive) and instead link the NVivo project to the location of the media file. Further information available here: http://help-nv10.qsrinternational.com/desktop/procedures/store_audio_and_video_files.htm

i. a .jpg image showing the activities that each resident carries out on their property relating in some way to vegetation;
ii. a .jpg image showing the specific values that each residents has mapped out on their property; and
iii. a .jpg image showing the specific concerns that each residents has mapped out on their property.

5. The .jpg mages created at step 4 above are imported into the NVivo 10 amenity research project and become part of the material linked to each interview 'case node'.

Box 2 - Cross-Referencing Data Types in Nvivo 10 By Time Stamping

The time-stamped audio transcript file of each interview is a .doc file and opened in Word. Initially, the audio transcript file is a table with:

- a column containing the time from the start of audio recording (referred to in NVivo terminology as 'Timespan') entered in an NVivo-compatible time stamping format,
- a column containing what was being said (referred to in NVivo terminology as 'Content'), and
- a column indicating the person speaking.
- each row of the reflecting each time a different person in the interview speaks.

Stage 1 - Preparing the Audio Transcript file for further entries:

1. A new column is inserted into the beginning of each audio transcript file table for the purpose of becoming an 'identifier column'. An 'identifier column' is specific NVivo terminology and simply means that each row of the audio transcript file can be identified, in this case, by sequential numbers i.e. 1,2,3,4,5,..etc.
2. To insert numbers into the 'identifier column', select the first column to highlight all its rows and then click on the 'numbering' button on the Home tab ribbon in Word.
3. A fifth column is inserted to the audio transcript file for the purpose and is labelled 'mapping information'. This fifth column is for recording any relevant mapping information, for example sketching or gesturing, that was carried out during the interview against the relevant conversation and time during the interview that the map sketching or gesturing was carried out.
4. A sixth column is added to the audio transcript file and is labelled 'IPad video timestamp'. This sixth column is for the purposes of recording the timing of the IPad video footage of interviewee's mapping activities in order to precisely link it to the equivalent timing of the interview's audio transcript.

Stage 2 - Entering the IPad video footage data and mapping information into the audio transcript file:

5. The IPad video footage file of the layers being sketched during the interview is opened in appropriate video footage viewing software (e.g. VLC media player or QuickTime).
6. The IPad video is viewed and:
    a) the IPad video is started and the start point of the video is noted in the fifth column 'mapping information' of the interview audio transcript
    b) the timespan of IPad footage playing for each row of conversation is recorded in the sixth column 'IPad video timestamp' according to appropriate NVivo-compatible time stamping formatting (note: this latter step is very important for later importing the video transcript into NVivo). Once it is known how far into the audio recording (i.e. at what time point) the IPad video commenced, an Excel spreadsheet can be used to do some automatic calculations to convert the audio timing into equivalent timing for the video footage – this is a helpful time saver
    c) relevant notes relating to map sketching are entered into the 'mapping information' column of the interview transcript e.g. noting when the interview participant began talking or pointing out areas of the aerial image of their property and then when those specific areas were physically marked out in the relevant layer in the Sketchbook Pro software. Consistent

wording and phrasing should be used to allow for more accurate and easier searching and filtering when the transcript is later imported into NVivo. Appendix 2 indicates the terms used to record mapping information carried out during the interview.

d) Each time a new type of activity, value or concern started to be physically marked out on the property level layer on the IPad, the words "[.jpg image]" was added to the 'content' column of the audio transcript. This will be later used as a reference point for a 'see also link' to be created when linking up relevant areas of the static .jpg images to the non-static audio and video files in NVivo. The purpose of this step is to enable the linking of the interview conversation to the sketched .jpg images in NVIvo (as well as IPad video footage) according to the interview transcript time stamping.

7. Every single column in the audio transcript file should contain an entry (even if it is 'no mapping' or 'no IPad video') so that it is clear what was happening during the conversation. Once all entries in the audio transcript file are complete, then the transcript file is ready to be imported into NVivo.

Stage 3: Coding of image layers and cross-referencing with transcripts (happens in parallel to stage 2):

8. Within the NVivo 10.0 project, open the relevant .jpg images for the interview audio transcript being worked on.
9. As 'mapping information' notes are being added to the fifth column of the audio transcript, the corresponding relevant sketched out area in the .jpg image is highlighted/selected using the 'select region [of image] feature' for pictures imported into NVivo10 and notes for the selected region are logged in the corresponding NVivo image 'contents' field for each selected region. Specifically, the time that the relevant feature was sketched onto the aerial image during the interview is noted in the 'contents' field according to both the audio and IPad video time stamp in the corresponding interview transcript as well as any mapping amendments needed for later spatial analysis work. In this way, the .jpg images, audio files and IPad video files for each interview are linked by the time stamping in the original audio transcript files.

Stage 4 - Importing audio and video transcripts into NVivo 10 project:

10. Open the audio file transcript with all six columns and all rows of data entry completed.
11. Save a second copy of the file and this will become the IPad video transcript file. In this second copy, delete all rows where there is no IPad video footage i.e. IPad video timestamp data.
12. Close both the audio transcript file and the IPad video transcript file.
13. Follow the NVivo 10.0 instructions for importing audio and video transcripts to link them up with their relevant audio and video files in the NVivo project: http://help-nv10.qsrinternational.com/desktop/procedures/import_audio_or_video_transcripts.htm

Stage 5 – Linking coded image layers to imported audio and video transcripts in NVivo 10 project:

14. The highlighted areas of each .jpg image is linked to the relevant action of the sketching in the IPad video using the 'see also link' feature. This is done twice: firstly creating a link from the selected area of the .jpg image to the relevant part of the audio and video transcripts; and, secondly, by creating a link from the relevant audio and video transcripts to the selected area of the .jpg image.
15. To create a link from the .jpg image to the audio and video transcripts:
    a) open the .jpg image being worked on
    b) select a row in the picture log to identify corresponding selected region of .jpg image
    c) move to the selected region of .jpg image, trace over the selected region shape, right-mouse click , and 'copy' the traced over area of the selected region
    d) open the corresponding interview audio transcript and find the timing point at which the selected region image of the .jpg image was drawn
    e) once the relevant timing row is found in the audio transcript highlight the relevant "[.jpg image]" entry in the contents column (see stage 2, step 6 (d) above) and right-mouse click to 'paste as see also link'

f) do this for each selected region of each of the three .jpg images for each interview
g) repeat steps 15 (d) and (f) for of the IPad video transcript

16. To create a link from the audio and video transcripts to the .jpg image:
    a) open the audio transcript being worked on
    b) locate rows containing "[.jpg image]" in the content column using the column filter feature for NVivo transcripts
    c) highlight the text [.jpg image] and right-mouse click to copy noting the audio timestamp for the particular row
    d) open the corresponding interview .jpg image and identify the picture log row corresponding to the selected region of the .jpg image
    e) within the picture log row, highlight the corresponding audio timestamp and and right-mouse click to 'paste as see also link'
    f) do this for each "[.jpg image]" entry in the audio transcript
    g) repeat steps 16 (a) and (f) for the corresponding IPad video transcript

Once stages 1-5 are completed, the interview content of each audio transcript is ready for qualitative coding.

Processing map data for analysis in ArcGIS

Figure 5.10 details the steps required to convert interview mapping data gathered on the iPad into a format suitable for GIS analysis. GIMP 2.0, a freeware raster editing software with similar functionality to Adobe Photoshop was used to manipulate the Sketchbook Pro mapping files. Every map consisted of three layers (concern, activity and value), each requiring conversion to .png format for importing into ArcGIS.

Rather than simply importing all instances of 'activity' as one spatial data layer, the mapping exercise video recording was reviewed, to discern the different instances of 'activity' that occurred during the interview. For example, a row of native plantings could be discerned from an area that was mowed and so on. This process was repeated across the 'concern' and 'value' layers.

Once all instances were in .png format they were individually imported into ArcGIS and georeferenced (assigned a common co-ordinate system). Two further steps were conducted to simplify the raster data: reclassifying to reassign the drawn areas to a value of 1, and converting each raster to a vector representation (.shp). Vector conversion established compatibility between the GIS data and NVivo by assigning a number in the vector attribute table that corresponded with its relevant quote in the NVivo transcript. Once this linking number was established, a particular drawing upon the map, such as a native planting 'activity', could be understood in the context of exactly what was said at the time it was drawn upon the iPad and vice versa.

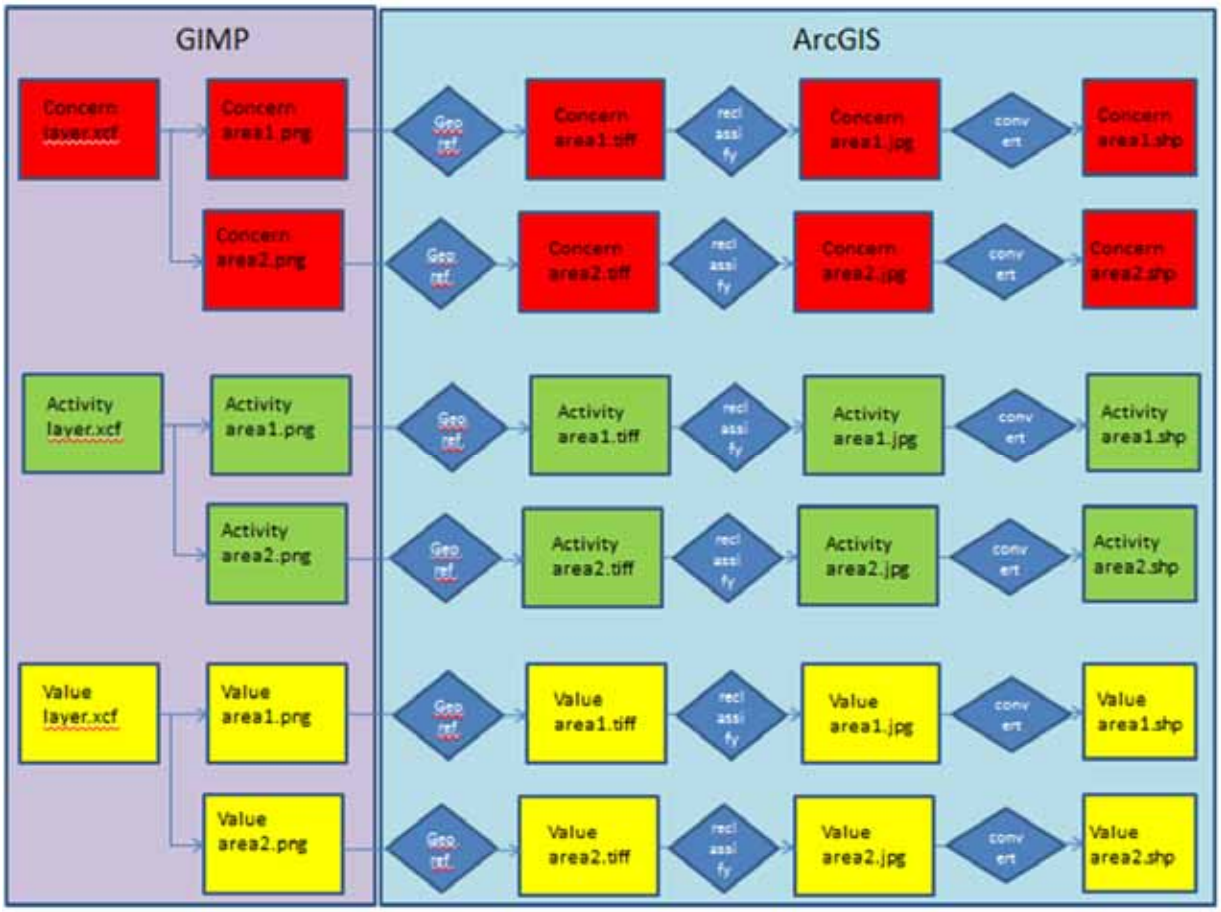

Figure 5.10 -Spatial data processing schematic

Results

Cluster Analysis

As detailed previously, our interview strategy attempted to gather contiguous property groupings to examine if neighbouring residents perceived the landscape around them in similar ways. The examples discussed in this section are taken from one particular Blue Mountains property cluster, consisting of five proximate properties hemmed in by steep and heavily wooded National Park and public land. The lot sizes are relatively large and of an irregular shape. The first image, Figure 5.11 displays zones of resident activity (coloured in green) in relation to vegetation management for each property. Captured here are instances of removing unwanted plants close to residences, of maintaining cleared zones, vegetable and ornamental gardening and examples of managed succession planting. Almost all activities were taking place 'on property' with a lone example of a property owner maintaining an existing fire trail to keep it clear of fallen logs and regrowth. In this instance, the land upon which the trail sits was donated to National Parks as it had become unwieldy to manage.

The layout of activity zones reflects the interplay between any number of diverse factors, including the underlying terrain, existing vegetation growing on or adjacent to properties, by government and

council regulations dictating vegetation clearing, by the (in)actions of neighbours, physical and economic capacity and historic legacies. These are also tempered by property owners' vegetation management preferences and perception of bushfire hazard in the area. Rather than go into detail about the various motivations behind each activity swathe, Figure 5.11 simply illustrates the myriad of spatial differences and idiosyncrasies of vegetation management – each property owner conducts activities in a variety of different places and ways, reacting to the specific challenges and affordances of their property.

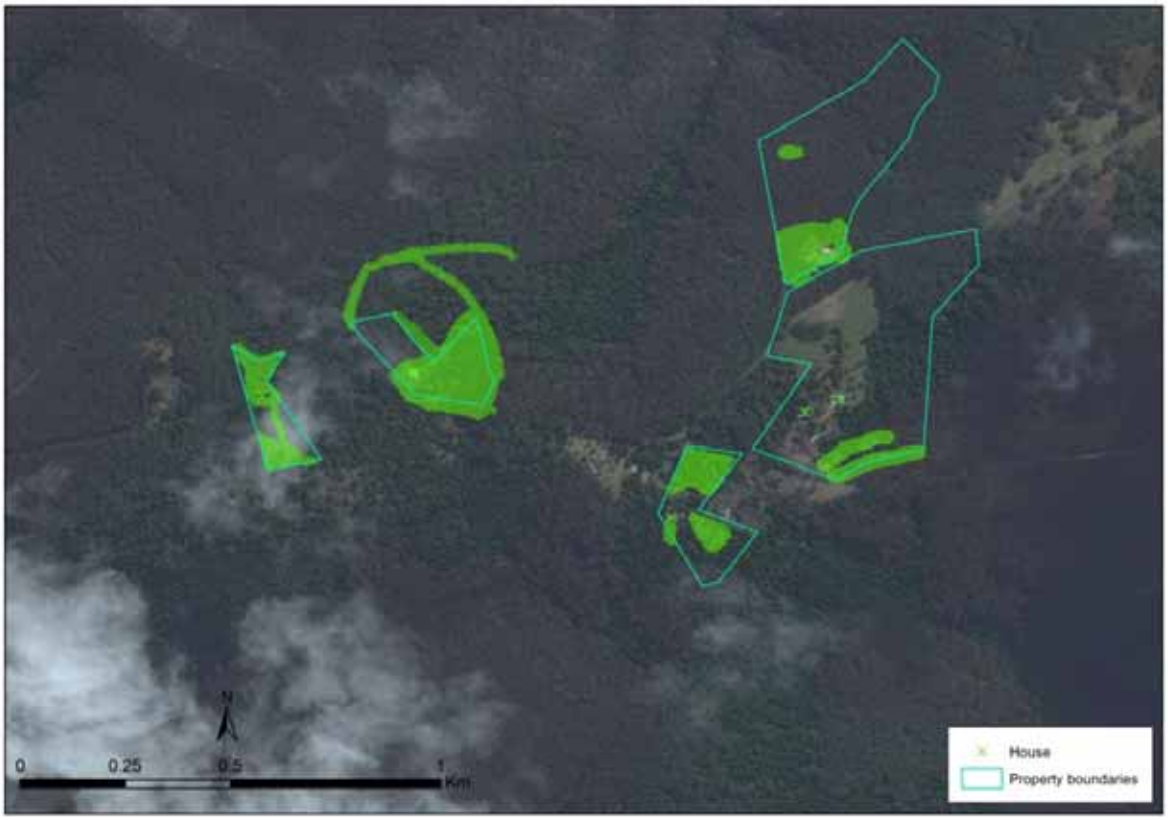

Figure 5.11 - Vegetation management activities (displayed in green) for five proximate Blue Mountains properties

Figure5.12 displays in red the zones of concern for those same five residences. Examples here include individual trees close to built structures, concern about neighbouring property management techniques (or lack thereof), and knowledge about flammable vegetation types (visible in the south east quadrant is a blob covering a stand of highly flammable mountain ash). Most prominently in Figure5.12 are the large swathes of red stretching out from each property toward the North West[9].

[9]A shortcoming of conducting a mapping exercise with defined edges is evident in Figure5.12. Often residents would draw a zone that continued to the edge of the map (as limited by the static aerial image base-layer and physical size of the iPad screen) . This squared edging is carried across from the iPad to the GIS analysis. It is likely that in these instances, zone of concern may stretch further however due to the confines of the mapping method a more accurate representation cannot be provided. Future development of mapping tools should look to technologies used in GIS and web-based maps such as google earth with greater control on extent/zoom capacity.

In the minds of these particular residents, this cardinal direction represented the greatest hazard for their properties, a perception that was tested in the recent State Mines fire of October 2013 where the fire front posed a direct threat to these properties from the NW, as discussed in the post-fire analysis in this report. Given the peculiarities of layout and proximity of these properties, there were not many instances where neighbouring zones of concern overlap, however in the few instances that they do, they tend to be beyond property boundaries on public land.

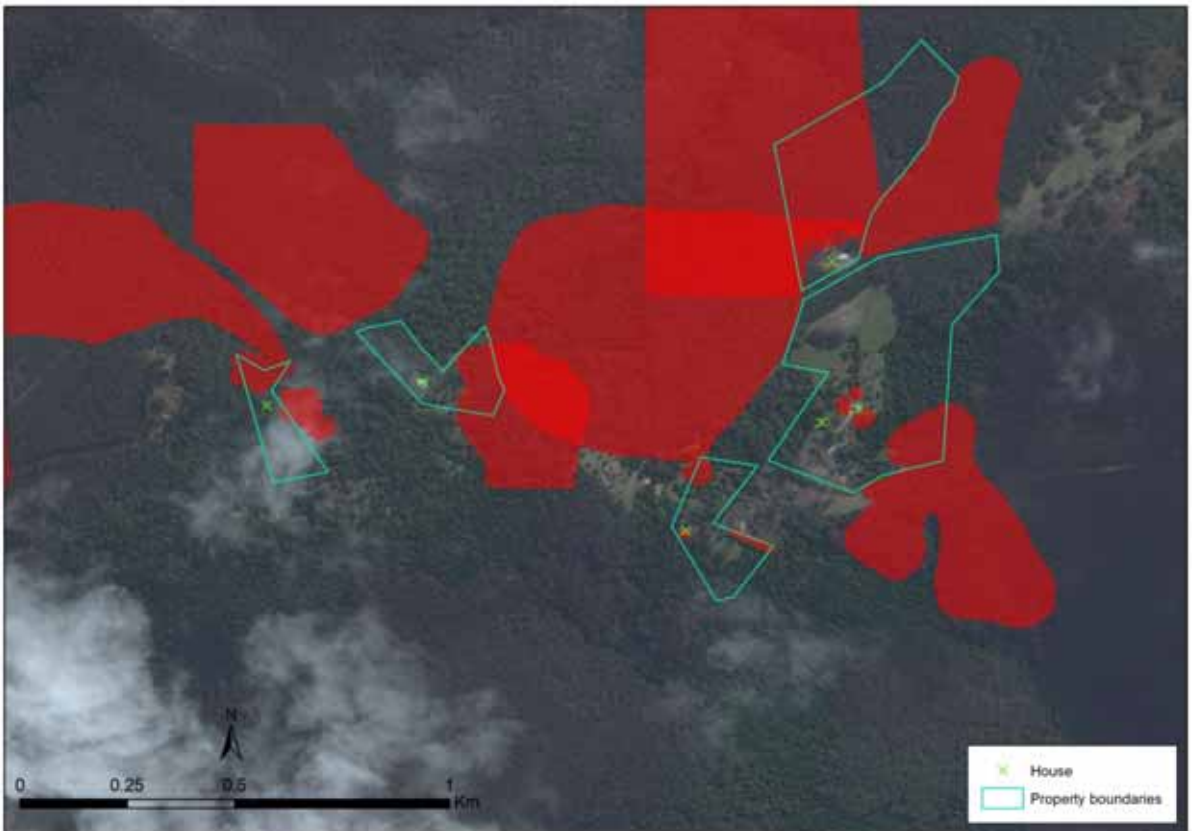

Figure5.12 - Zones of concern (shown in red) for five proximate Blue Mountains properties

When zones of concern are overlaid against areas of vegetation management activity (Figure 5.13) two things are evident. First, concern tends to occupy the wooded areas and cleared areas are usually notated as an activity zone where hazard mitigation activities have taken place. Second, there is not a large amount of overlap between the concern and activity layers. For these property owners, risk is being managed close to their properties through a range of vegetation management strategies, and concern is perceived as occurring beyond where they are capable of or are legally allowed to take action. These zones of activity (within 20m and 100m of houses) and the specific approaches to vegetation management taking place within them will be discussed in greater detail in the following section.

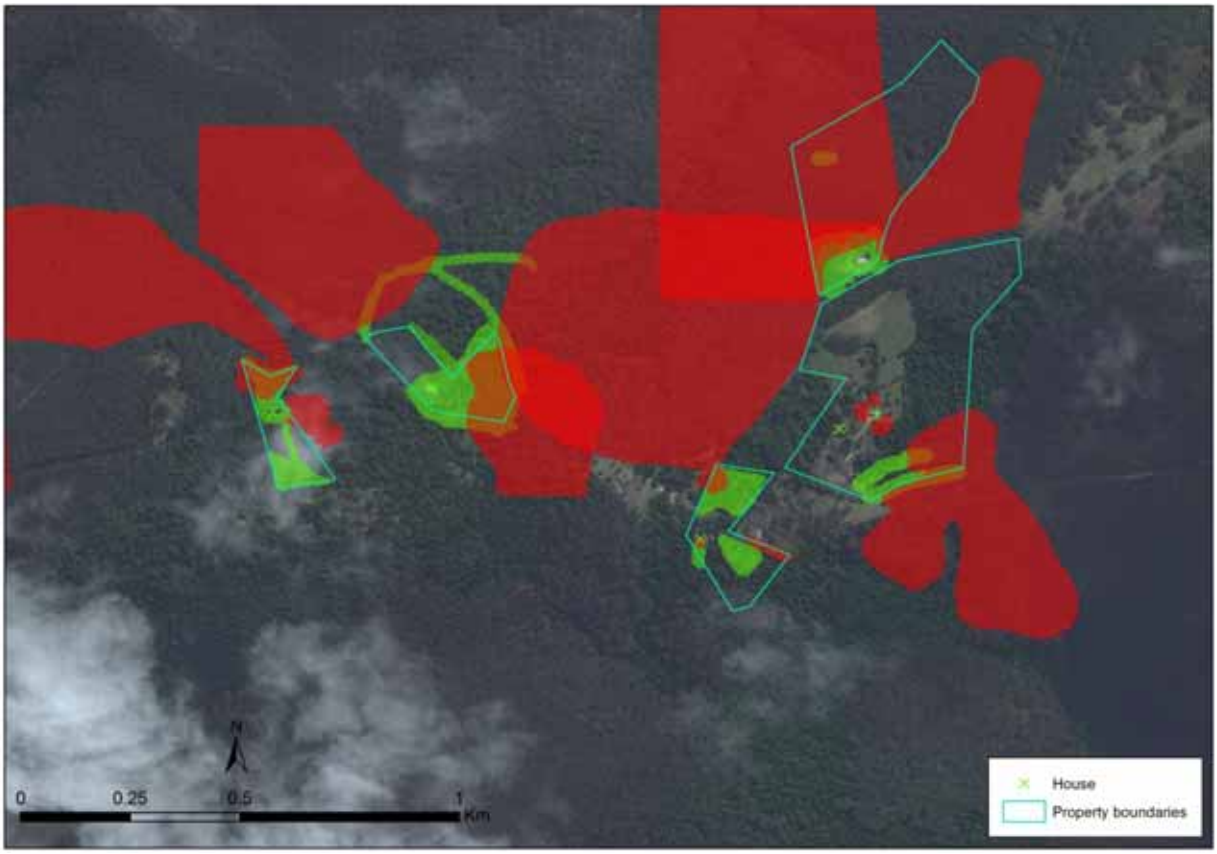

Figure 5.13 - Zones of concern (shown in red) versus activity (green)

Activities on Property

In this section we present results regarding management and decision-making from our cluster properties as well as three property case studies. Our aim is not only to present some general results but also to illustrate the outcomes of our mapping and interview approach. First drawing on three case studies, we will explore residents' vegetation management activities as revealed by the spatial mapping exercise. Second, we will discuss what people are doing within twenty and one hundred metre intervals (radii) from their houses drawing on interviews from our four clusters. The twenty metre zone corresponds to the area immediately around the house, usually those elements of the garden directly abutting the house and surrounding it. The one hundred metre zone is more varied. For many of the properties we visited this included native bushland or forest beyond the garden zone. For others with more extended gardens, it still included garden areas, and for others the topography and aspect also varied around the house. For smaller properties it also often encompassed neighbouring public or private land and roads. Depending on land parcel layout in each case, the extent to which any one of these circumstances was present at different points around a house also varied.

Mapping Management Activities

As discussed above our mapping exercise in the course of the interviews provides a spatial context to residents' mitigation activities, helping to understand their decision-making and vegetation management choices. We have chosen three properties from residents who are actively managing for bushfire hazard mitigation. The three are of different sizes and layout and the owners face different constraints and exposure to bushfire hazard.

The first property, Figure 5.14, is that shown in photo A in both Figure **5.20** and Figure 5.21 in the following two sub-sections. These residents were leaving trees very close to their house and variously undertaking both fuel reduction and planting elsewhere on their property. This property is on a south-facing slope, is downslope of the most likely fire direction, is relatively moist, and much of the vegetation is rainforest. As a result the owners feel relatively safe, although they know they are at risk from bushfire. Both the aesthetic and habitat values of the trees and vegetation on their land are key attributes of the property and they actively manage to enhance these values.

Figure 5.14 - Property management mapping A

The map shows the distribution of their key vegetation management activities around the house. To the south of house in an area visible from the balcony and living areas they are planting and encouraging trees ferns. This activity necessitates an annual clean-up of dead material to remove fuel. To the south-east, they are fostering rainforest and keeping an area mown and clear to both maintain a view to Sydney and also to manage fuel loads near their neighbour's house to the east. Their focus of vegetation management to mitigate bushfire hazard is to the north, the most likely

source of a bushfire. Here they are both managing understorey and ground level fuel. They are planting rainforest species they see as of relatively low flammability and as important for habitat, particularly habitat connectivity in this location. To the west and south they feel relatively safe due to the rainforest vegetation, noting that in a sustained drought, this would be less safe. They are also less concerned about fire coming from the south as it doesn't constrain their potential escape routes as a fire from the north could. They thus think that they are more likely to have to stay and more likely to be defending their property from a fire coming from the north and thus concentrate their management effort in that direction.

The second property, Figure5.15, is the property in photo B in Figure **5.20** below. This is a property where the gardens are the main focus of effort and value for both personal interest and for open garden programs. The gardens around the house are mown but also mean that there are shrubs and trees close to the house, as can be seen in the twenty metre zone around the house. Across the property, however, and on neighbouring land, the owner undertakes considerable management to mitigate bushfire hazard and has a large amount of water storage for firefighting. The main likelihood of a fire is in an arc from the west around to the east. Local knowledge and past experience is that fires from the west and south-west tend to wrap around the cliffs to the south of the property and come up from the south and south-east. To the west, there has also been hazard reduction burning on public land, reducing some of the owner's concern about fire from that direction.

Figure5.15 - Property management mapping B

The owner has also undertaken significant understorey and ground layer management on the land he owns to the south of the land parcel with the house (Figure 5.16). There has also been similar

work on adjacent public land to the south-west and a recent hazard reduction burn on this land. The area to the east of the house is steep and rocky. Management is difficult and the owner has addressed his risk concerns here through an access track for fire management, by maintaining lawn between this area and the zone around the house, and by establishing areas of moister garden and vegetation to the east of the house. To the north the owner is constrained by a property boundary but is fortunate in having been able to purchase and manage the land to south.

Figure 5.16 - Mowing and understorey management

Our third example (Figure5.17), is a smaller property where the owners' management options are more constrained that in the previous two cases. One of the owners is an active RFS brigade member. Most of the area within a hundred metre radius of the house is not in the control of the owners. On this property, the land slopes steeply to the west, the road is close to the house to the east and neighbours to each side are undertaking none or minimal vegetation management. A bushfire is most likely to come from the west.

Figure5.17 Property management mapping C

The garden to the front of the house is relatively formal; the focus of effort for bushfire hazard mitigation is to the west. In this direction, the owners do have eucalypts within twenty metres of the house. When they renovated the house after purchase they did remove some trees and wanted to remove more but they told us that the council did not approve it. While they like their view and the way it is framed through the canopy due to the steep slope, they would still like to remove trees that are close to the house for hazard mitigation. Outside to the west, they have not yet established gardens to a significant extent post -renovation and some shrubs such as rhododendrons, planted by the previous owner, remain. They have however, largely established or maintained open lawn under the trees close to the house and removed understorey and fallen timber downslope of the house for bushfire hazard mitigation and intend to extend this further. They have also established access north-south across the property to make it easier to manage downslope and to facilitate access during a fire (Figure5.18).

Figure5.18 Understorey and fallen timber management and access establishment

These three cases, the mapping process, and associated interview data illustrate several key points. First, as Brenkert-Smith et al (2006) found, landholders are adopting hazard mitigation measures to various extents. In addition, as the mapping highlights, in varying ways across their properties consistent with their assessment of their exposure to bushfire hazard, the layout of their property, the spatial context of their property and its relationship to landscape elements that enhance or mitigate bushfire hazard, and what they judge as practical and achievable. Second, amenity and aesthetics can cause residents to compromise on some mitigation activities – most commonly by leaving vegetation close to the house – but they seek to offset this by managing vegetation for hazard mitigation elsewhere on their property or it is judged an acceptable risk in the broader context of the property and its constituent elements and landscape setting. In this sense, the mapping exercise was useful for facilitating discussion around such vegetation management dynamics within different distances and orientation from houses; it permitted residents to comprehensively discuss their range of activities across their entire property and even beyond. In the next section we will see the particular details of vegetation management at a distance up to 20 metres from the residents' house as well as the distance 20 – 100 metres from the residents' house.

Management Close to the House – Twenty Metres

The mapping data produced by residents aided in exploring and triangulating interview transcript data and photos taken during the property walk to understand what vegetation management activities residents were undertaking at different distances from their houses. At twenty metres our interviewees were divided almost equally into those who were unambiguously keeping a clear, or at least a consciously safe, zone around the house and those who were not keeping such a clear zone (Table 5.2).

Landholder Type (n=17)	Action/Outcome	Management Driver
Those who keep a clear zone around the house (9)	Lawn, fire-wise garden, driveway/parking areas, water feature, remove trees	Fire hazard reduction, garden design or layout, lawns, views
Those who don't keep an unambiguous clear zone (8)	Leave/plant exotic or rainforest plants, flammable trees remain, bushland close to house	Aesthetics, cost/practicality, believe they are reducing or managing risk, 'habitat' or proximity to nature, too late/history of ownership, part of a broader property strategy, garden design, vegetation regulations

Table 5.2 - Resident Management Actions at 20 metres

As we will elaborate further on below, some of these interviewees were doing other vegetative hazard mitigation work, in some cases, a considerable amount. As noted earlier, it is difficult to separate residents into distinct groups of 'adopters' and 'non-adopters' of bushfire hazard mitigation activities, most are doing, or not doing, a mix of mitigation activities but not always with bushfire hazard in mind. The section below, where we discuss the case studies based on property mapping, will illustrate this further. However, for those we have classified here as keeping the twenty metre zone clear, the zone immediately around the house was made up of various elements including lawn, cleared areas, garden plants chosen or left in place due to their relatively low flammability, gravel paths or stonework, driveways, and water features (see examples in Figure 5.19).

The three photos in Figure 5.19 illustrate three approaches to keeping a clear zone around the house. Photo A is where an open space is characterised by lawn and no garden beds. In this case the owner, someone committed to restoring and managing the forest around their property, is maintaining the existing lawn and keeping it open around the house through constant maintenance – '*The only natives I've removed are the blackthorn around the house, because the blackthorn is a coloniser. As soon as you open the ground up the blackthorn will seed… if you don't have canopy you've got maintenance to keep an area open. Once you've made an open area you've got maintenance to keep it open'… I don't want bush right up to the windows. I want an open space around the house.'* As the photo shows, the interviewee has, however, left tree ferns on the lawn and actively encourages and plants them elsewhere on the property. The reason for this lies in the appearance of these plants and associations with their age as a species – '*they're just magical. They look beautiful with snow on them… they're primordial, they're just, you know… you can't help just loving them, they're just such amazingly beautiful things. They're just staggering'.*

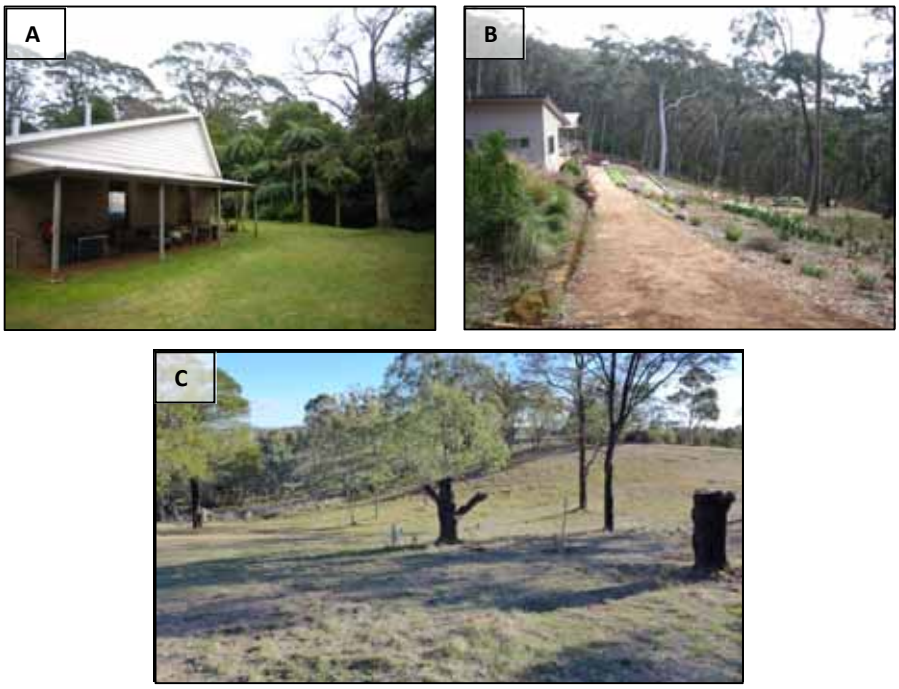

Figure 5.19 - Clear zones around houses

Photo B shows a space cleared of forest around a new house for fire protection purposes and the establishment of a garden designed to meet aesthetic considerations and also be of low flammability – *'Initially we only cleared 62 trees… but when I stood there that tree line was very, very close to that deck in the old days and it was frightening …So when I first did it I had like a garden planner and so he worked with me…So he worked with me on making sure we had plantings that would not be really flammable. Like this burgundy hedge, both of those are natives'.* Moving away from the house, the garden design incorporated a shift from the formality of the house garden back into bush – '*So I've put in grevilleas at the end of that path. Everything on that side is going to be native to kind of get that softening and this is the more formal*'

Photo C is a view from the house in an area where the owner is in the process of establishing a garden and improving the clear zone near the house. She has recently removed several large trees near the house - *'Like we've got out here where we've taken it, where the trees are stand alone. There's no vegetation or bush around them and the plants that I'm planting are fire retardant. Nothing with sticky undergrowth or old growth inside it and this sort of stuff, and mowable grass, which can be that high, and kept green'.* This is primarily driven by fire concerns but is also compatible with a desire to retain views from front of the house where the owner has a home office and had made a recent decision to remain on the property. With this commitment to stay came a decision to not live '*in a paddock anymore*' and to create a garden with colour and variety that presents relatively little danger in the immediate vicinity of the house –*'I want something that starts cheerful and colourful around the house, but goes back into the landscape itself, and then these huge roses that I can grow because the one thing I've got is space'.*

Images from those we have classified as not keeping a clear zone around the house are shown in Figure **5.20**. We have chosen these four to represent a range of management regimes. Photo A shows a property where having native plants close to the house is important to the

owners. They value this kind of proximity to nature and it is a key driver for much of their management –*'because it's very close to the house, but it's got all that moss and the little orchids. It's got heaps of little orchids on it…it's really nice, and also the birds sit in it. You can be sitting in the dining room here and you're sort of eye-balling the birds, it's so nice'.*

Figure 5.20 - Lack of clear zone around houses

These owners (RFS brigade members) have made a very conscious decision about retaining such vegetation close to the house and have done so by weighing up various risk factors and the role of such proximate trees in the amenity they derive from their property:

> 'And I think, I personally think this is an individual decision that how much risk are you going to run with bush close to your house. Bear in mind we have a house, we have a fair amount of faith in is pretty fire resistant, so we're probably lived with bush coming closer. Secondly it's rainforest, so less likely to burn and, I mean, we could clear everything, you know, 200 metres back if council would allow us but you could theoretically clear everything 200 metres back…But then why would we live here?'

In addition they rely on their house design and construction which was undertaken with bushfire in mind. Moreover, they also take into consideration their management for hazard reduction elsewhere on their property.

Photo B is managed largely for its gardens, including for open garden events. There are a series of carefully designed and differentiated garden zones and the owner spends much of his time working on the garden. The owner is cognizant of fire hazard and, again, manages other parts of his property for hazard reduction, but his main focus of effort is the garden – *'Well there's lawn, there's lawn below and above. There's sort of three lawn areas. We've created a series of garden projects, which has, sort of, in their own element. One's called a secret garden, which you will see, which is interesting. To a small degree, fire retardant planting was used, but not as a high priority'.* His main concern regarding fire in close proximity to the house is not the garden plants but the larger

eucalypts in the garden, of which he would remove more if he was building again, partly for fire and partly because they fall over and have damaged the house in the past – *'It's the crown fire that would come basically over the hill, because we have not taken as many trees down as we should have'.*

Photo C shows one of the few properties among our interviewees where the owner was indeed doing little to mitigate bushfire hazard and appeared comfortable with the bushfire hazard this engendered – *'even though I'm saying I'm clearing a break around, it is for access but I wouldn't regard, you know, if a fire comes through here, I'd say they'd be more busy saving my neighbour's house than mine'.* She had removed some larger trees and improved access close to the house but considerable and relatively dense native vegetation, most of which she planted in the 1980s and which she continues to take a close interest in, remains close to the house.

We have included a fourth example (photo D) here because it highlights further the range and the mix of activities people may undertake on their property with various consequences for the degree of hazard mitigation. As the photo shows, this interviewee, an RFS member, has done a large amount work clearing downslope (and in the direction of the main fire threat) of the buildings. She has undertaken additional work further from the house, clearing undergrowth from eucalyptus forest downslope of the house as far as possible (about 40-50 metres) before a cliff line inhibits access. However, for aesthetic and garden design reasons she has planted several silver birch quite close to one the main buildings on her property – '*I've put in some standard silver birches over there because they're, that's a very tall building when you look at it from below, and I wanted to soften that face. Plus it's a very light, I like them. I like the bark and everything, but it's a very light tree, so if a bushfire comes through it's not a very dense material*'. The hazard represented by these trees may not be high and the interviewee argues that they won't provide a significant fuel load but they are located within several metres of the house and the Tasmanian Fire Services lists Silver Birches as highly flammable and not suitable for planting close to or in the vicinity of houses (Tasmania Fire Service, 2010). Apart from the birches, however, this interviewee wanted an open, easy to maintain garden near the house which also afforded views into the, now, open forest further downslope – *'what I want to do is, so a little bit of formal garden at the top to the buildings, and past the buildings, apart from vegetation to soften things up, I really just want lawn'.*

Several key themes emerge from this empirical material. First, even among those who we have classified as not unambiguously creating a clear zone within twenty metres of the house, almost all are taking various actions to mitigate bushfire hazard. For some interviewees, this was action was considerable as in the case of photo D in Figure **5.20**, but this interviewee was not alone. Second, as we will discuss further below, decisions regarding what to do close to the house are made in the context of other mitigation actions taken elsewhere on the property. Most interviewees are making conscious assessments of the efficacy of their total efforts in concert with considerations of the amenity they wish to create or maintain or against the effort, cost, time or practicality of what it would require to mitigate hazard further. For example, it was not uncommon for residents to have some trees close to the house that they planted early in their ownership or which were already present at the time of purchase and which they would like to remove. The costs of removing these trees was a barrier for residents, one of whom had received quotes of seven thousand dollars *per tree* for removal, far beyond what they were willing to, or could, pay. Third, aesthetic considerations and amenity, more generally, can influence action in various directions,

including within the one property but are not necessarily inconsistent with bushfire hazard mitigation. We will come back to this issue further below.

Management Further from the House – One Hundred Metres

At one hundred metres, our interviewees were much more differentiated in the vegetative hazard mitigation work they were undertaking (Table 5.3). Of our cluster interviewees, thirteen were undertaking active management of their property further from the house. As we discuss below and illustrate in the discussion of the maps, this was not always uniform around the house for a variety of reasons, including a concentration of effort in the direction from which fires are most likely to come. Again, however, the exact nature and location of the work was the result of conscious and active decisions about hazard and risk in the context of the whole property relative to landownership aspirations. In some respects, those who are not actively managing further from the house, are similar but the mitigation activity is quite different.

Landholder Type (n=17)	Action/Outcome	Management Driver
Active Managers (13)	Removing/managing understorey/mowing (n=10), managing succession, removing as much as possible	Fire hazard reduction, views, keeping it 'tidy', garden design or layout, grazing
Non-managers (4)	Past tree planting, relatively dense vegetation at 100m	Aesthetics, soil conservation, cost/practicality, believe they are reducing or managing risk, environmental protection, history of ownership, part of a broader property strategy, rely on house design, veg not oriented to likely fire direction, perceive relatively low hazard

Table 5.3 - Resident Management Actions at 100m

Of the thirteen active managers, most are engaging in some combination of clearing understorey, mowing already cleared areas, and keeping such areas free of fallen timber. One is removing as much as is practically possible in combination with understorey removal and two are actively engaged in encouraging rainforest succession to engender relatively less flammable vegetation near their house.

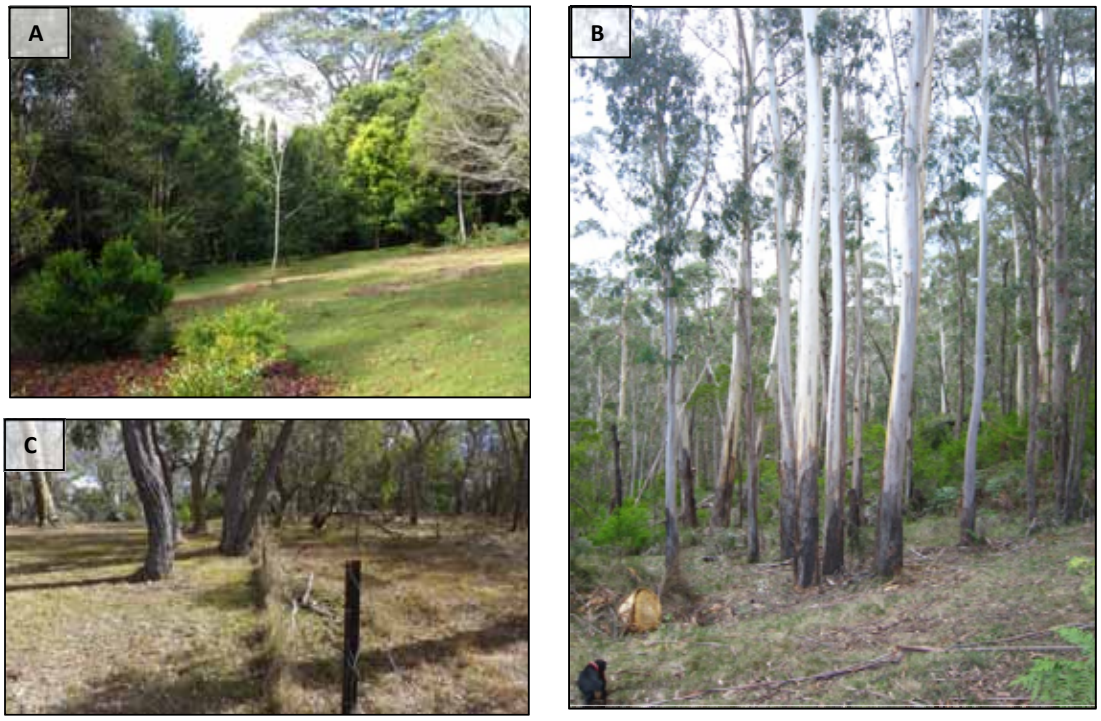

Figure 5.21 - Active vegetation management up to 100m

Figure 5.21 illustrates three active management regimes within the 20-100metre zone in our study areas. Photo A is from the same property as photo A in Figure **5.20** above with trees very close to the house. These owners have a relatively heavily vegetated property in a moist location with a southerly aspect in the Blue Mountains. The management across the property reflects their assessment that they are in a relatively safe position and other factors such as discussed above such as their house design. On parts of the property, both where they perceive the most likely direction of fire, where they wish to maintain views, and where they wish to protect a neighbouring property they mow and keep the understorey controlled - *'there's several reasons for that but one of them is fire, just keeping it clear. I don't want to knock over trees. We knock over trees only if they're dying or they're going to cause a problem or something'.* They are also planting native rainforest species in some areas. This is again part of a strategy to minimise relatively flammable vegetation but it is also to create a low maintenance property so they can stay on the place longer as they age and also to enhance habitat and forest connectivity in the area – *'Just to get, we're planting back, we're actually planting back a track for native animals across our block so that, 'cause there used to be a great tranche of rainforest trees here and it's a natural path for animals from this valley across through into that valley across our block. We just want to plant that back so that they've only got relatively narrow patches that they have to go across in the open sort of thing*'.

Photo B in Figure 5.21 is the same property as photo D in Figure **5.20** where the birches had been planted close to one of the buildings. It shows part of the understorey management downslope of the house – *'I would like it to be completely clear, well, hang on; I have removed all the understorey down to the cliffs. There was that, can you see that light green shrub? I don't know if it's tea tree, but it was thick with that so you couldn't see through it, and I've removed all of that because that was a very hazardous…'* This management also involves removal of fallen

trees and creating access to the downslope areas so that timber and other vegetation can be removed from the site more easily. Aesthetics were also important for this interviewee on this part of the property and this was also a motivation to remove understorey and fallen timber – *'I do love looking into the bush and seeing tree ferns; I think that's quite exciting. But just, there is a natural short grass down there which is really nice, and it's nice just to see…the profile of the land just with the short grass on it and the rocks and a few sprouting things… So it's, yeah, aesthetically pleasing and also hazard reduction in terms of bushfires'.*

Photo C in Figure 5.21 illustrates a similar approach to management further from the house in our Wamboin study area. This owner was mowing and removing understory and removing dead from a large area around the house where access was straightforward. This was also on those sides of the house where a fire was mostly like to come from. This was initially for aesthetic reasons only – *'I did it mainly for aesthetic. It just made it look neater'* – but more recent engagement by the local RFS brigade has caused this interviewee to reassess their exposure to bushfire and they now also undertake this work for hazard mitigation. There are limits, however, to how far this management will go on environmental grounds – *'…a lot of rock, there's a lot of fallen trees, there's a whole lot of, I mean I would love from an aesthetic point of view to clear it out, but I start to also worry about the environmental point of view, because if I remove all the habitat, dead tree logs and low grasses and all that sort of stuff, I'm also removing a whole chain of the wildlife, which we don't want to do'.* Further, on the other side of the house where there is a steep slope and sweeping views, this owner is not undertaking much vegetation management on environmental and practical grounds – *'Oh yeah, if I could, if I could do it safely I would actually clear it out. Yeah, I would. But there comes a point where I would want to stop because the natural land has to, the natural environment has to exist. So I would probably stop probably where the next layer of dead wood, is, way down the hill about 30 metres away, 40 metres away. But you can see, if I had to remove 30 metres, or 50 metres of trees, how many trees would you remove? There'd be hundreds'.*

Figure 5.22 shows two scenes from properties where the owners are doing no vegetative mitigation management at 100m from the house. In the case of photo A where the house it visible through the trees, the owner does have a clear zone and a dam around the house and both these features are oriented to the likely direction of a fire.

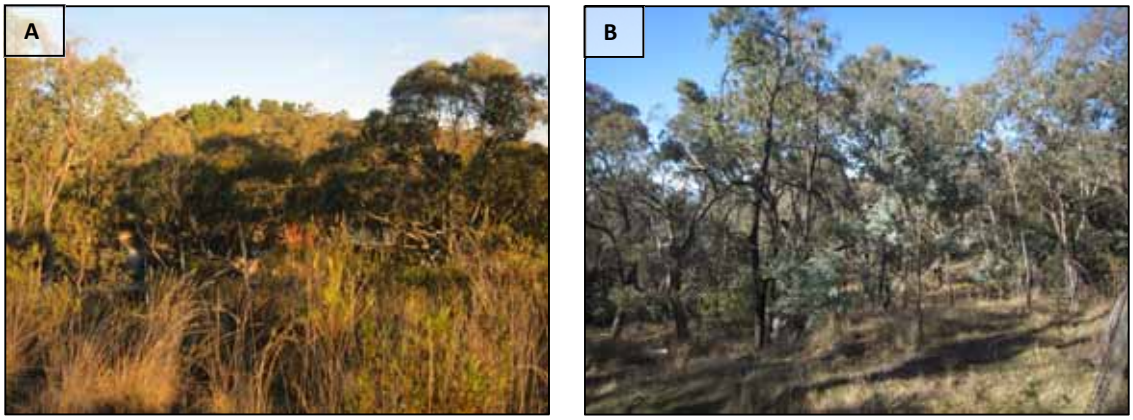

Figure 5.22 - No active vegetation management, 100m

This interviewee perceives that by these features of their property they have mitigated bushfire hazard to a significant extent – *'With the materials, with the facing of the house, with the thinking*

about how we were going to landscape to try and keep the area around the house fairly free and open, to not have trees right next to it'. The owner also perceives that the vegetation on their property does not represent as much of a hazard as forests elsewhere – *'I tend to think of us as not as at risk of those really bad fires that have happened in South Australia and Victoria because our vegetation is not that bad. It's not as dense. And, if you have a fire go through, it goes through but it doesn't stay burning. I think that, maybe naïve, but I think, you know, in Kinglake and the fires in Victoria that were so bad, that burned for days and days, I don't see our vegetation supporting that kind of a fire'.*

This is also a property where the owners planted a lot of the trees since moving to the land in 1990, especially on the early years of their ownership. These trees, and bush areas that were extant in 1990 have been and are highly valued by the interviewee and her family – *'I think the diversity of both plant and animal life is something that we have appreciated and continue to appreciate. Now, I think when we first moved in it was really fun to make a list of what things were growing and what things were flowering…So finding the diversity when you're walking around is always a plus'.* They encouraged their children to value the bush and memories of particular trees or animals that used to live around the land remain important. Today, they remain birdwatchers, enjoy taking guests through the bush, and enjoy daily observations of plants, animals, and change on their land. This does not however, represent a careless sentimentality about nature – the house area is clear and for hazard mitigation purposes. It is more about how their habitation of the land has evolved over time at different stages of their lives and how the vegetation further from the house has been an integral part of that. One further point of interest here is that observing change in flora and fauna on their land is an important part of their proximity to nature –*'So seeing how the land changes over time is something that we both really value, so being able to have a big enough piece of land that has variety in it gives us scope for seeing change'.* This is a characteristic of some other interviewees from both study areas. It potentially suggests an opportunity with such residents for dialogue on how fire might be integrated with such values.

The second property here in photo B is different again. Apart from a very limited area of lawn near the house, there is virtually no vegetative mitigation on this land at all. This is primarily due to strong conservation values and desire to repair damage from past sheep grazing – *'But little things like okay, the tree falls over, we don't cut it up, alright. We leave it for habitat, and as a result of that, we've had really, really good habitat…This is, conservation-wise, extremely rich in wildlife. We have…eastern greys, swamp wallabies, red necked wallabies, we have three possum species here, brushtail possums, ring tail possums, sugar gliders. We have the native marsupial carnivore'. The owner is aware of the bushfire hazard, he sees fire as the 'single biggest risk we're having'* and getting burnt out one day as inevitable. However he is not prepared to remove vegetation – *'There's no place in Australia safe from fire. So it's a risk we need to manage. And at the same time, I don't believe that we should get out there and flatten all those trees to reduce the fire risk. That's just wrong, dead wrong'*. To manage the risk and protect assets on the property, he has installed significant water storage capacity, pumps, and a sprinkler system around the house and other structures.

Several key themes emerge from this empirical material. First, most residents are undertaking vegetative hazard mitigation further from the house. Where this was occurring the focus of effort was to the direction from which fire was most likely. This was partly a function of focussing available

resources on the highest hazard areas but also often a function of the house orientation or location relative to roads or neighbours. For example, interviewees may have a formal or more structured front garden oriented away from the most likely direction of fire in which they might leave or plant trees (usually deciduous but including existing conifers) for privacy or garden layout purposes. Second, as for management close to the house, decisions regarding what to do further away from the house are made in the context of mitigation actions taken elsewhere on the property and the extent to which residents perceive that have thereby reduced hazard to an acceptable extent and can tolerate leaving vegetation in place. Third, again as for close to the house aesthetic considerations and amenity, more generally, can influence action in various directions, including within the one property but are not necessarily inconsistent with bushfire hazard mitigation. In fact, despite the potential for environmental concerns to work against mitigation, it was more common for the appearance of open forest or woodland to be liked by residents, especially if they felt their property was large enough to still encompass areas in which the environmental values of more unmanaged vegetation were retained.

Conclusions

Interviews, heavily guided by a mapping exercise, proved to be a useful aspect in addressing our overarching research question about values and vegetation management of residents living at the WUI. Presenting residents with an aerial image of their property acted as a prompt that rapidly allowed research participants to identify and discuss features of the natural landscape that shaped their actual and potential vegetation management activities whether out of a sense of amenity, bushfire risk, or both. For example, residents could point out where they cleared a particular patch of trees to open up a view or because they lay in the prevailing direction of the main fire threat. Further, residents could point out particular trees or patches of vegetation that were of concern from a bushfire perspective whether such features existed on their own or neighbouring properties. Using interactive mapping software allowed us to quickly capture ideas, values and concerns that were being articulated by residents' values as geographic data that could later be overlaid against pre-existing landscape such as topography, vegetation cover and land use. Not only were values, ideas and concerns captured but also a sense of what activities residents were doing on different parts of their property and why. For example, where mowing was used to manage vegetation versus manual thinning of understorey layers of bush, or, even where replanting of vegetation was occurring along with the reasons why. Overall what was revealed is that residents manage the vegetation on their properties in all manner of different ways taking into account the topography of the landscape and residents' awareness of fire and the particular fire threat to their property, as well as multiple amenity drivers such as attracting birds around the house, creating wildlife corridors, providing privacy from neighbours, gardening activities, creating recreational spaces, or encouraging particular plant species while removing others.

The mapping exercise, however, was not without some limitations. Firstly, using static aerial images (a limitation of the particular software choice which was not specifically designed for capturing spatial data) proved to limit the extent residents were able to mark out features on the map based on the boundaries of the images presented to them. If undertaking a similar exercise in future, a more systemic approach would be beneficial in terms of photographing and identifying vegetation

species in situ. For example, using a camera with Geographic Positioning System (GPS) or ensuring GPS points are taken when photos are snapped to more accurately record vegetation species and their distance from the house. Further, taking photos along each side of house would be helpful in capturing the complexity of different ways residents manage vegetation in the twenty metre zone around their house. More systematic analysis of vegetation on the ground during property walk would have been helpful however this required constant presence of an ecologist in the field which budget-wise is not always feasible and introduces a third researcher at a resident's property which prove somewhat overwhelming for some residents.

Overall, carrying out the mapping exercise, allowed for both residents and interviewers to simultaneously view the property as a whole and for comprehensively locating management decisions spatially and in relation to each other. For example the property where vegetation was kept close to the house but then managed further out could be seen in the mapping - it allows for residents to talk through their logic in deciding where and why they manage vegetation in particular locations.

Our findings regarding vegetative hazard mitigation activities are broadly consistent with the US studies discussed above. As in the US, most residents are undertaking some kind of hazard reduction management and amenity considerations are not necessarily inconsistent with vegetative hazard mitigation and that they are can in fact be achieved together. The most obvious example of this is via management for open woodland or forest where this might be undertaken primarily for aesthetic reasons. Our results to do, however, suggest that amenity and hazard reduction activities are more likely to be in tension close to the house where many residents like to retain favourite trees for aesthetic reasons, to bring birds close to the house, or wish to retain gardens close to house. Further away from the house, within the 100m radius, most residents were undertaking some form of vegetative hazard reduction work, including those who kept vegetation close to the house.

Further, what our spatial approach provides is a clear picture and interpretation of how management actions at different scales on the properties and the reasons they are undertaken interrelate. Residents make decisions and tradeoffs about which vegetative hazard mitigation activities they will undertake and where they will do it based upon what other hazard mitigation activities they have done elsewhere on their property, how this reduces their perception of risk, their amenity interests and preferences, the landscape setting of their property and its potential exposure to fire, and the time and resources they have or are prepared to put into hazard mitigation. They may perceive that mitigation further from the house has reduced hazard to the extent that they can reduce such effort closer to the house – or vice versa. Thus hazard mitigation is likely to vary spatially within properties, responds to social and landscape context, is likely to vary in intensity within a property, and is likely to be oriented to directions of highest risk. Nelson et al. (2005) noted in their study of bushfire preparedness and landscape preferences that they could not account for why some residents managed vegetation for hazard reduction on some sides of their house but not on others. Our results, and our spatial perspective, suggest that it is the result of these kinds of tradeoffs within their properties and often a result of decisions to focus on the direction from which a fire is most likely to come.

Finally, our results have constructive implications for managers. Our interviewees generally had a good sense of the bushfire risks they faced and how their house was located relative to bushfire risk and hazards. While this was usually something acquired over a period of residence, there were sources from which they could learn, usually local RFS brigades and knowledgeable locals. The process of creating and/or maintaining their gardens and other property environments is a creative and dynamic process of weighing up the risks they perceive and face with their aspirations for their home and property and the resources they have to enact these. As also suggested by Nelson et al. (2005, p.424), managers need to interpret what residents need and want in bushfire engagement assistance, and this is not necessarily going to be 'broad alerts there is a problem' with a concomitant need to act. Rather engagement needs to understand what residents are already doing, where they are doing it as well what they value and desire for their property, what their understandings of 'natural' are, and what aesthetic or other amenity values (e.g. habitat) they wish to realise in conjunction with managing hazard. Our, and the US, research shows that landscapes in which bushfire hazard has been mitigated can co-exist with landscape elements valued by residents. The engagement exercise thus become one of mutual problem identification and solving rather than simply, or always, education and informing. In this respect that range of skills that are needed by those undertaking this engagement may need to encompass garden design and environmental skills and knowledge as well as bushfire experience, skills and knowledge.

Appendix 1 – Pre-Interview Questionnaire

"Co-Existing with Fire: Managing Risk and Amenity" Project: PRE-INTERVIEW QUESTIONNAIRE

This questionnaire is to be completed by a member of the household who is in charge of household decisions at the residence to which this questionnaire was sent (even if it is your secondary residence).

1. Name

2. Gender

◯ Female ◯ Male

3. Age

Years

4. Occupation

5. Do you commute to work or other activities three or more days a week

◯ Yes ◯ No

6. Do you own or rent your residence?

◯ Own ◯ Rent

7. Is this your main or secondary residence?

◯ Main ◯ Secondary

8. What year did you move to this property?

Year

If a multigenerational property, please indicate how long it has been in your family

9. What were your main reasons for purchasing and/or moving to this property? (i. being the most important reason)

i.

ii.

iii.

10. To what extent do you value the following features on your property?

	Very high	High	Moderate	Low	Very low
Peace and quiet	◯	◯	◯	◯	◯
Space and privacy	◯	◯	◯	◯	◯
Being close to nature	◯	◯	◯	◯	◯
View / Scenery	◯	◯	◯	◯	◯
Sense of community	◯	◯	◯	◯	◯
Bushland and/or forest	◯	◯	◯	◯	◯
Lifestyle	◯	◯	◯	◯	◯

Other (please specify)

11. Did you consider bushfire safety issues when buying / building / renting this property?

◯ Yes ◯ No

12. Size of landholding/property

Acres

Hectares

13. How close is your house to vegetated areas, such as bushland or forest?

◯ Less than 30 metres ◯ 81 - 100 m ◯ 1 - 2 km

◯ 31 - 60 m ◯ 101 - 500 m ◯ More than 2 kilometres

◯ 61 - 80 m ◯ 501 m - 1 km

14. Is your house located on a slope, such as a ridge or hill?

◯ Yes, on lower slope ◯ Yes, on ridge top

◯ Yes, on upper slope ◯ No, on the flat

15. Do you have insurance on your property, which includes loss from bushfire?

◯ Yes ◯ No

16. Have you talked to your neighbours about working together to make your properties safer from bushfire?

◯ Yes ◯ No

17. Have you received professional advice on bushfire risk and preparedness on your property?

◯ Yes ◯ No

18. What direct personal experience with bushfires have you had? (tick all applicable answers)

☐ I am/have been a professional fire fighter

☐ I am/have been a volunteer fire fighter

☐ I have defended my own property from bushfire

☐ I have defended neighbouring property

☐ I have left early or evacuated due to bushfire

☐ My property (other than house) has been burnt

☐ My home has been damaged by bushfire

☐ My home has been destroyed by bushfire

☐ I have seen bushfire burning vegetated land

☐ I have seen bushfire burning houses

☐ I have seen a burnt area post-bushfire

☐ I have smelled or seen bushfire smoke

If you have defended, lost or evacuated your property from bushfire, when did you last experience this? (e.g. 2009)

19. Are you a member of/volunteer for any voluntary or community organisation(s)?

◯ No

◯ Yes (please specify)

Appendix 2 - Items Noted in Mapping Information Column of Audio Transcript

The following are items noted in the additional 'mapping information' column created in the relevant audio transcript for each interview.

Mapping information noted	Other information noted
'No mapping'	'No IPad video'
'No mapping, but points out features on map'	'IPad video starts'
'No mapping, but discusses future plans for ….'	'IPad video ends'
'No mapping, but cross reference…'	
No mapping, but discusses location of regional …'	'Photo evaluation exercise starts'
	'Photo evaluation exercise'
'Lead up to boundary mapping '	'Photo evaluation exercise ends'
'Start boundary mapped'	
'Boundary mapped'	'Property walk starts'
'End boundary mapped'	'Property walk'
'Follow on from boundary mapped '	'Property walk ends'
'Lead up to activity mapping'	'Chris Note'
'Start activity mapped'	'Chris Note:….'
'Activity mapped'	
'End activity mapped'	
'Follow on from activity mapped '	
'Lead up to regional activity mapping'	
'Start regional activity mapped'	
'Regional activity mapped'	
'End regional activity mapped'	
'Lead up to value mapping'	
'Start value mapped'	
'Value mapped'	
'End value mapped'	
'Follow on from value mapped '	
'Lead up to regional value mapping'	
'Start regional value mapped'	
'Regional value mapped'	
'End regional value mapped'	
'Lead up to concern mapping'	
'Start concern mapped'	
'Concern mapped'	
'End concern mapped'	

'Follow on from concern mapped '

'Lead up to regional concern mapping'
'Start regional concern mapped'
'Regional concern mapped'
'End regional concern mapped'

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