Fire Management Tradeoffs at the Bushland-Urban Interface?

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Abstract
A series of common perceptions arise in discussing management of fire-prone land. Following socially disastrous fires there is often a call for more prescribed burning to reduce fuels and so protect houses and other buildings while, on the other hand, there are some who see the situation as disastrous for the environment. From these perceptions it could be argued that the public sees a trade-off between building protection and species' persistence mediated by prescribed burning. On the one hand are obvious dollar assets like buildings while on the other are assets like rare species, biodiversity and aesthetics which are harder to pin down. In practice, a regime of fire occurs which involves both prescribed and unplanned fires. While it is possible that there could be trade-offs between some species and some fire regimes, to what species under which combination of prescribed fires and unplanned fires is often uncertain. From a policy point of view the situation is complex as the relationships between unplanned fires, building protection and prescribed burning are probabilistic rather than certain, and with graded interactions, not alternatives. We use the Blue Mountains of New South Wales as a means of helping to illustrate the issues.

Introduction

When major bushfires impact suburban areas of cities or towns there can be large numbers of houses and other buildings lost. Deaths may occur. The media may declare that "Bushfires have destroyed thousands of hectares". The shocked citizens and affected communities often respond vigorously, demanding answers, but the 'answers' may involve a number of tradeoffs at various scales. It would appear that one of these is a trade-off between protection of properties at the urban edge and the loss of species from the bush. What evidence is there to support or refute this?

The general rationale for prescribed burning is one of pre-emption. If we remove the fuel under mild weather conditions then it won't be available for unplanned ('wild') fires later. Fuel can be seen as being traded off between prescribed fires and unplanned fires. Given that the fuel is reduced the chances of fire control are improved and the chances of loss of life and property are minimised. The public discussion would imply a perception among many that stopping unplanned fires means that Nature cannot follow its usual path so species will be lost; introducing prescribed burning is apparently seen as 'unnatural' and so threatens our native biodiversity. These are extreme views. Where in the middle-ground public policy should lie is imperfectly known. What is known is that fire regimes near interfaces will usually consist of a mix of prescribed and unplanned fires because it is unlikely that prescribed fires will eliminate unplanned fires. Thus there will be interactions between the effects of unplanned and prescribed fires which we need to understand.

This paper concerns the effects of fire and fuel management (subsumed under 'fire management' for convenience) on species persistence while attempting to avoid the destruction of houses (and other buildings, and human life) as a result of bushfires. We pay particular attention to rare buildings and rare plant species. To give substance to the analysis we have chosen the Blue Mountains area to the west of Sydney, New South Wales (NSW) as the main source of examples.

What is a trade-off?

A trade-off (exchange, substitution) usually occurs when there is competition for one item over another. As one desirable element goes up in value another comes down; or, there is one negative item that goes down in value while another goes up. Thus there can be a middle position where you gain neither one thing or the other but you gain some of one and some of the other. Or, you reduce the disadvantages of one or the other but eliminate neither.

Complete removal of the risk of unplanned fire in rural areas, including that from native forests, would entail either the removal of all the fuel or having an extremely large and densely distributed suppression force available at all times - but one having little to do most of the time. A compromise position is chosen by society, usually through governments but also by individuals, in which fuels are modified to some degree and suppression forces created at a cost-effective level but one not sufficient enough to eliminate the problem. The consequences of these implicit choices are rarely discussed, perhaps because we naturally avoid paying attention to the implications of difficult decisions (Fiske and Tetlock 1997).

An analogy to this bushfire problem, that most people would understand immediately, is the road-toll problem. We know that the presence of a road network means that people will be killed there and that there will be serious economic repercussions for some individuals and, potentially, some insurance companies by having such a transport system. While we can eliminate road deaths by banning vehicles from our roads we would also lose the multiple benefits of road usage – such as the facilitation of trade and the transport of holidaymakers to their destinations. While removal of road-users is an absurd proposition in a modern economy, this example highlights one aspect of the trade-offs that we support as a society. What we do in response is to try to eliminate the road toll by instituting a wide variety of measures such as improvements to road design, the use of seat belts, the setting of speed limits, and the restriction of alcohol consumption by drivers. These measures have been highly successful but there remains a residual trade-off between the benefits of road use and the negative impact on human life and property. Some would argue that the benefits of a road transport network are also offset by the use of fossil fuels, the generation of air and noise pollutants and the exacerbation of climatic change.

The fire story is just as complicated as the road story and the responses to it are similar. As we do not want to eliminate the 'fuel' - due to our dependence on the products it represents, such as timber and pastures - we choose which are the parts of the landscape fuel array to be reduced by burning under mild weather conditions, or to be modified by grazing, mowing, changed species composition, or irrigating, or to be eliminated entirely through the creation of fuel breaks. We might do these things in order to help protect assets like human lives, houses, fences and plantations. In doing so, concerns might be raised over the extent of emissions affecting human health, the affect on climate change and the possible loss of biodiversity through creation of adverse fire regimes. By introducing fire into the landscape, we risk having prescribed fire becoming unplanned fire and the potentially negative effects that may flow from it. There is a trade-off between the potential impact of unplanned fire – bushfire – and that of the prescribed fire or series of prescribed fires. A little realised trade-off dependent on this is the production of smoke from a series of prescribed fires or that from a series of less frequent, possible more intense, unplanned fires.

There is another view, a biological one that needs to be considered in this context. What if the prescribed burning program or even the occurrence of unplanned fires benefits biodiversity? There may be advantages to a burning program or unplanned fire occurrences that need to be considered.

Fuel: traded between prescribed fires and unplanned fires?

Fuel can either be burnt by a prescribed fire or burnt by an unplanned fire. In the usually mild prescribed fire there are areas either deliberately left unburnt or unintentionally unburnt so there is remnant fuel. In the unplanned fire (not all 'wild') there are times and places where intensities are low to the extent that the effects on fuels may be similar to those in prescribed fires. In a low intensity fire in forests and woodlands there will be tree and shrub crowns, and bark on trees, that escape the flames whereas under extreme weather these fuels will also be depleted.

The trade-off of fuel between prescribed fires and unplanned fires is qualified according to time and place. Thus, not all fuel is consumed by low intensity fire, either prescribed or unplanned. Remnant fuel may not be exposed to fire until surrounding fuels can carry a fire. As fuel is replenished after fire it is potentially available first to unplanned fires burning under extreme weather conditions. Only later will it be possible to burn the fuel under mild weather conditions.

Species extinctions and fires

The effects of an individual fire on vegetation may be reflected in survival or death of populations, changed habitats, and the birth of new generations of plants and animals. What happens after any fire depends not only on seasonal conditions as the years pass but also on the timing of the next fire and its seasonality and intensity. Populations and individuals have reached certain stages in their life cycles and may be resistant or sensitive to a fire at that stage. The usual low intensity of a prescribed fire may be of little consequence or may be significant. An unplanned fire with a wider range of intensities may affect populations and habitats differently according to the weather, fuel condition and topography at the time the fire arrives at any one point.

In brief, extinctions of plants or animals as a result of fires will be a function of a particular set of fire regimes, a regime being a sequence of fires having particular properties and occurring at various intervals. One fire may finish off a species in a particular area – local extinction - but earlier fires set the scene for the final blow. If the fire regime is appropriate then habitats will be satisfactory for the variety of local animal species and populations of all plant species there can flourish or at least persist.

The survival or loss of a particular species usually cannot be predicted with certainty. Rather we have to deal in terms of chance, probabilities. While we focus on rare plant species to illustrate our points we start with the hypothesis that rare species have the same range of characteristics in relation to fires as any other group of species (Gill and Bradstock, in press). Fires could conceivably eliminate a common species from an area let alone a rare species. However, if the species is rare to the extent that it is only found locally then the chances of eliminating it could be higher than those of eliminating a common species with the same characteristics. We classify species as 'common', 'rare with local populations only' and 'rare with widespread populations'. For current purposes, we assume that endangered and vulnerable species are also 'rare'.

We can predict which plant species, at least, are most likely to go extinct. These are species with populations that are largely sensitive to any fire of any intensity due to characteristics such as thin bark, short stature and absence of dormant buds. These plants have short-lived seed storage (less than 1 year, usually held in woody fruits in the shrub or tree canopy until the fire). If the population has no seed for re-establishment at the time of the fire then that portion of the population is effectively doomed. Under these circumstances the recurrence of fire, i.e. the length of the between-fire interval, is of primary interest. If the plants are trees, individuals within the population may have greater survival chances because fires are never of uniformly high intensity. In such cases, consideration of intervals and intensities will be important.

In any one area there are plant species with a variety of responses. Thus, plant species can have populations that resprout after fire or have a pool of hard seeds in the soil that may progressively germinate after stimulation by the passage of successive fires. A few species depend on the ingress of seeds into the fire area after the fire for their presence there.

There are time limits between fires for the persistence of plant species. If we take the group we believe to be the most vulnerable – those with juveniles and adults vulnerable to all or most fires and with seed storage only on the canopy of the plants - we need to know the timing of fires in relation to the times of seed presence on the plants. Thus, if fires occur at an interval shorter than that required for seed production then local decline or elimination is likely. If there is only effective regeneration in such species after fire then longevity of the species may also be a factor because fire would then be required prior to the loss of seed presence on ageing plants. Such outcomes may vary spatially due to overlapping areas and intensities of successive fires. There may be a critical level of spatial variation in interval and intensity that exceeds the ability of particular species to cope *via* dispersal and recolonization (e.g. Bradstock and Kenny 1993). Spatial variation in fire intensity and between-fire interval (sometimes referred to as 'mosaics' or 'patchiness') is therefore not an automatic solution to the problem of unfavourable regimes for particular species of plants. The spatial extents of regimes that are deemed to be unfavourable for particular species therefore need to be measured and evaluated.

A simple example of the way in which animal species can be affected by inappropriate fire regimes is indicated by fire's affect on habitat. For many species, the removal of cover creates intolerable conditions for habitat such that local extinctions are possible. Therefore, if fires are very common and lead to a substantial loss of shrub cover, then the local effects may be adverse to a certain suite of animals (Catling 1991).

Bushfires and building loss

Bushfires ignite buildings by one or more of three accepted forms of ignition as the fire front sweeps towards the edge of the suburb. These are radiation, flame contact and embers (Ramsay et al. 1987). These forms of ignition vary widely in their expression. When the fire enters the suburb the fire becomes fragmented, the fuels become more heterogeneous (including houses) and secondary ignition sources – not due directly by the primary bushfire source - may become significant. The spatial scale of concern also diminishes. An example in the fire-affected suburb is that of a wooden fence set alight at one end then burning toward a house after the fire front has passed. Furthermore, we may define as a tertiary source of structural ignition any rekindling event that results from undetected smouldering. Extraneous sources of ignition provided by clashing high voltage power lines or fallen live power lines may ignite structures also and could be considered as 'tertiary'.

There are numerous structural and design factors predisposing houses and other buildings to loss. There are urban-interface conditions exemplified by patterns of land use, fuel management, roading, slope and aspect. Within house blocks, there are garden factors such as plant species, bedding plans, mulching depth and built garden structures. Then there are building designs, building exposures, decks, structure heights, wall and roof materials. Furthermore there are human behavioural factors. Perhaps 100 variables could be enumerated.

Bushfires and rare buildings do not mix just as ordinary houses and bushfires do not mix. There are elements of historic buildings that may make them particularly vulnerable (e.g. wooden, two storey) but we will hypothesise that their vulnerability is no different than others in the same location. We lack a suitable sample to test the idea.

Buildings vs Species?

Individual structures matter to us if we own them or live in them but, as a society, concern may be expressed in terms of numbers of destroyed buildings irrespective of ownership. The home-owner is concerned about the loss of his or her house, the individual structure, not the proportion of houses lost from a neighbourhood. By way of contrast, the death of individual plants in a wild population rarely concerns most of society. However, the extinction of plant or animal species is of major concern locally, nationally and internationally as shown by land use designations, management policies and international agreements. To compare house or other building loss with plant species we need to declare 'house' as a 'species' having populations responsive to fire regimes. Alternatively we have to consider 'species' as populations of individuals, each of which is important to us; we do this to a certain extent with rare species. As a society, rather than as individual members of it, we mourn the loss of individual human lives or structures in bushfires but necessarily base our policies on 'house' as a 'species' albeit one subject to 'genetic engineering' – ideally as modification to improve its adaptation to fire regimes.

The Blue Mountains of New South Wales

Having sketched some aspects of the theory of building loss and species loss in the face of fires, we turn to our study area, the Blue Mountains Local Government Area (LGA).

The Blue Mountains are a handsome feature of the landscape to the west of Sydney. They reach over 1000m in height. They consist of deep valleys hewn from more-or-less horizontally bedded strata of sedimentary rocks thereby creating cliffs, canyons, ledges and attractive rock formations. There is a wide variety of vegetation due not only to this topographic diversity but also to the presence of other rock types in the area – basalt and granite for example. Average annual rainfall varies from about 750 to 1400 mm per year with average peak monthly rainfall being reached in January (Cunningham 1984).

The Blue Mountains LGA is dominated by the Blue Mountains National Park (74% of the LGA but only 43% of the 247,000 ha Park) and the Blue Mountains City Council (BMCC) non-park area of 37,000 ha. The former is administered by the NSW National Parks and Wildlife Service (NPWS) while the latter includes of a string of 27 small towns and villages, with a population totalling about 76,000 people. The settlements are spread along two major roads, both east-west trending, which cross the mountains and the National Park between Sydney to the western plains. From the mountain-spanning roads are secondary roads also supporting ribbon developments that are often found along the tops of short steep-sided spurs and ridges. These developments penetrate the shrubby eucalypt forests that are the most common vegetation type of the region. Orchards are a feature of the eastern part of the northern road (Bell's Line of Road). The area is a popular tourist destination and the repository of a number of rare species (see below).

The area has a long established history of bushfires. Most fires destroying buildings in the period leading up to 1984 have occurred in November or December with major building losses – more than 30 houses per event - occurring in 1944, 1951, 1957, 1968 and 1977, the towns of Leura and

Warrimoo having the largest number destroyed (Cunningham 1984). Since 1984 there have been houses lost in 1994, 2001 and 2002.

There have been a number of historical buildings lost to bushfires. Hungerford and Donald (1982) mention quite a cross section of buildings, and contents, from the Blue Mountains area: the rectory and early church records of St Pauls Anglican church at Emu Plains (church licensed in 1848, consecrated in 1872) destroyed in a bushfire in 1929; Warrimoo Railway station built in 1918 but burnt in the bushfires of 1951; Pilgrim Inn, Blaxland, built in 1825, later a private residence for 99 years, destroyed in the 1968 bushfires; No. 1 Gatekeepers Cottage (for the railway) apparently constructed in 1867, lost in the 1968 bushfires; and, "Weemala" or "Eurama", an historic house erected in 1881, burnt in the 1968 bushfire.

We can apply the concept of fire regimes to houses. Mostly, of course, the fire regime at a house block situated well away from bushland is a function of the rate of loss due to fires started within suburbia. While house loss can occur from internal causes near the interface with the bushland also, added to this are the losses from repeated bushfires. For example, in the Blue Mountains at Warrimoo there are streets where bush fires have repeatedly destroyed buildings (Cunningham 1984, personal communication 1/2/2003).

A problem of great practical significance in relation to protection and to the persistence of species is that the rate of fuel accumulation after fire is rapid so the maintenance of relatively low fine-fuel loads – say less than 8 t/ha - would require very frequent prescribed burning. Near Lawson in the mid Blue Mountains "total fine fuel", mainly in the form of litter, reached 8 t/ha in 3 years, and 10 t/ha in 4 yrs (Van Loon 1977). Conroy's (1993) data for open forest (*syn.* dry sclerophyll forest) around Sydney, probably applicable to the lower Blue Mountains, showed a fine fuel litter load of 8 t/ha had accumulated in about 3 years.

In the Blue Mountains LGA there are 67 species listed as 'endangered' or 'vulnerable': 35 vascular plant species, 2 insect species, 6 frogs, 1 fish, 3 reptiles, 8 birds, 4 bats and 8 other mammals (Les Moore, BMCC, personal communication). These species occur either in the Park, the BMCC off-Park areas, or both. The species may be confined to the Blue Mountains or be much more widespread. Confined to the Blue Mountains is *Eucalyptus copulans* with only one plant left of in the wild (Les Moore, personal communication). A decade ago there were only 455 plants of *Microstrobus fitzgeraldii*, the Dwarf Mountain Pine, which is largely found on ledges and upper cliffs adjacent to waterfalls (Jones 1999). This species, and others like *Epacris hamiltonii* (NSW NPWS 2001*a*) and *Leionema lachnaeoides* (NSW NPWS 2001*b*), are found in both the National Park and in off-Park areas in the Mountains. Further work is needed to see which fire regimes are related to the distributions of such species.

If fires recur repeatedly at intervals less than that for plant species to flower and fruit then the population appears to be slated for decline unless it is vegetatively spread. Some species flower sooner than others so the situation is not uniform. Through systematic analysis of all available information relevant to the major vegetation types in the region, NPWS has defined conservative threshold fire intervals for the persistence of all plant species in local vegetation types. Such thresholds can be used to predict the possible consequences of current fire regimes. Within the National Park area and in the non-Park areas of the LGA, the figures for "overburnt" (10% in

Park areas and 8% outside), “currently within bounds” (60% in Park areas and 71% outside) or “recently burnt” (30% in Park and 21% outside) are similar. “Overburnt” sends a message to managers to pay attention to plant species in such areas; it could precipitate the implementation of a monitoring system designed to refine appropriate fire-regime thresholds. Plant species in “recently burnt” areas will require some time to flower and fruit before the area will qualify as being “within bounds”. The conclusion is that the current combined effects of prescribed and unplanned fires are not generally adverse to those elements of biodiversity regarded as sensitive either inside or outside the Park.

The effects of fires on species can be indirect. For example, *Microstrobus* may be affected indirectly through the influence of fire regimes on shading by competing plants and on changed water quality (Jones 1993).

At this stage we are unable to predict the effects of fire regimes on animal species mentioned above for the BMCC area but note that for ground-dwelling mammals “frequent, low-intensity burns in autumn currently used in fire management, will reduce and eventually eliminate the dense understorey” at the expense of many native mammal species populations and to the advantage of many exotic species (Catling 1991). We might expect that the canopy-dwelling Koala, which is on the BMCC list, will be disadvantaged by repeated high intensity fires.

Some species of plants and animals will do better (in terms of populations or, for plants, ground cover also) when intervals are short; others, when intervals are longer. In nature it would appear that variety in the fire component of habitat is achieved by a degree of randomness in when fires occur at a site and this is expected to allow survival of a range of species. Notionally, at least, current variation in intervals is high. A challenge is to further clarify what is the optimal level of variation in fire regime components.

Discussion

In this paper we have touched on the perceived trade-offs between unplanned and prescribed fires and between species and buildings in fire-prone areas. In reality there are many trade-offs at various different scales from garden scale (between organic mulch to reduce water loss and mulch as fuel for fire) to landscape scale. There are also relatively remote areas where the trade-off may not exist. The most likely place for any trade-off between species’ and buildings is in any ‘asset protection zone’ near houses (see below) but whether or not this is important to the conservation of species generally will depend on the fire responses and the rarity of the species involved. For the perpetuation of both species and buildings, rare or otherwise, it is important that we add to the growing knowledge of species’ responses to fire regimes and the quantitative influence of prescribed burning on asset protection in the Blue Mountains. Presently, our knowledge of the responses of plants is incomplete for many species (Bradstock and Kenny 2003).

For the protection of houses and other structures, and to lessen the chances of fire escape, the NPWS declares zones for asset protection and creates appropriate burning prescriptions to help achieve this. Their policy includes zones for broadscale strategic burning and for maintaining biological assets. The local government body (BMCC) appears to be moving toward a policy emphasizing burning at interfaces: “the greatest hazard reduction is to reduce the hazard at the asset … [while] broad-scale hazard reduction as may be carried out in National Parks or State Forests [is] part of the land management role of the managing agency and may not be the most appropriate way to undertake hazard reduction around private property or assets.” (BMCC 2003).

Conclusion

The answers to the bushfire problem – the protection of environmental, social and monetary assets - are many rather than single; they occur at multiple scales and concern a variety of ‘assets’ that differ in value between individuals and within governments. One way we deal with this variety is to geographically separate asset classes through land-use designations, and to deal with them separately. This is a way of dealing with some of the trade-offs that arise. Boundaries between land-use zones such as the bushland-urban interface, where the changes in the nature of assets are greatest, are likely to be the zones where the trade-offs are also the greatest in terms of fire management. Defining these trade-offs in terms of species affected, costs incurred, benefits accrued, and reduction in risks to homes is difficult and location specific; it remains a challenge.

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