When is a fire an ecological emergency?

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Introduction

Bushfires are spectacular events which have the power to catch the common imagination. Most people, whether they live in the city or country, have knowledge and opinions about bushfires. A smaller proportion of the population has direct experience of fires, including those who have defended lives and property (their own or those of others). Our perceptions of bushfires are strongly shaped by direct experiences or for the vast majority, indirect experiences portrayed through media. Extreme conflagrations (e.g. 1939, 1983 in Victoria; 1968, 1994 in NSW; 1961 in WA; 1967 in Tasmania) have had a strong influence on popular thinking and the development of formal fire management policies and practices. A common perception is that all or some fires are disasters in ecological terms. The media routinely reports that the bush is 'destroyed' by fire, especially at the time of large, intense conflagrations. One well intentioned but mistaken outcome of this is the belief that the bush must be actively rehabilitated or replanted following fires.

Some fires may precipitate an ecological crisis but it follows that not all fires cause such crises. How do we distinguish those fires that could be ecologically deleterious from those that aren't? This paper explores some of the basic concepts that may be used to answer this fundamental question. We then outline measures that may be taken to integrate such concepts into contemporary management of bushfires, from both the planning and suppression angles.

Possible deleterious effects of fires

A range of deleterious ecological effects are listed in *Table 1*. The list is indicative but may not be exhaustive and involves the perceptions of observers including the general public. Any of these effects may result from the passage of an individual fire through a landscape but we emphasize that the state and context of the landscape at the time of fire is the key to understanding whether problems will ensue.

How would a single fire precipitate any of these problems? In the case of extinction or loss of a species from a landscape, such a problem would occur if that fire created an adverse fire *interval* perhaps with an adverse fire *type* or *intensity* in an inappropriate *season*. The fire *regime* consists of four components: fire type, frequency, intensity and season (Gill 1975). For most ecosystems a broad range of fire regimes are possible. Individual species are able to cope with some fire regimes but not others. Inability to cope may mean extinction for a species in a landscape depending on the scale of any adverse regime.

The notion of the fire regime immediately indicates that fire effects are not merely the result of one-off events, but rather, due to recurrent disturbances with additive or other modifying effects on biological populations. Recurring fires interact with fundamental processes such as survival and reproduction in populations. The ability to survive and regain regeneration capacity after a particular fire determines the likely response to the next. Timing of subsequent fires, in biological terms is therefore crucial.

The most notable example of this are plants termed 'seeders'. Seeder species have populations that are strongly shaped by fires. Established plants are typically killed by fires, so that recovery is dependent on germination from stores of seeds. Post-fire germinants eventually grow and become mature, thus replenishing seed stores and the regenerative capacity of the population. In extreme circumstances a fire may re-occur before maturation (i.e. during the 'juvenile period'), resulting in extinction (Gill and Bradstock 1995). The juvenile period in seeder-type plant species has been the focus of considerable research, especially as such species form a prominent component of the Australian vegetation (Gill and Bradstock 1995).

In a similar but not identical vein are animal species whose occurrence may be restricted to a particular time stage after any particular fire. A prominent example is the arboreal marsupial, Leadbeaters Possum (*Gymnobelideus leadbeateri*), a hollow-dependent dweller in tall moist eucalypt forests of southern Australia. These animals require hollows in trees for nesting, but suitable hollows are usually not available until trees reach about 190 years of age (Lindenmayer 1996). Part of the reason for this is that the dominant trees in such forests (e.g. *Eucalyptus regnans*) are seeder species. Such trees may have a juvenile period and life-span of about 20 and 400 years respectively. Trees have to reach a suitable size for hollows to form. A fire interval for tree-killing fires of 20-50 years would

Possible deleterious effects of fires
Biodiversity
extinction of species (scale an issue)
visible injury and death of 'charismatic' animals
peat fires
Other environmental effects
changed water yield and quality
increased erosion/sedimentation
loss of visual amenity
loss of recreational use
introduction of weeds/ferals etc. to local areas

Table 1: *Possible outcomes of fires that may be perceived as constituting an ecological emergency.*

allow the tree species to persist at a site but not the hollow dependent mammals. Note that a fire frequency of <20 years would result in elimination of both trees and mammals.

The example can be further used to highlight the gap between common perceptions of fire as a disaster and contemporary scientific knowledge. Fires in tall moist forests often include sectors of high intensity during periods of drought (e.g. in 1939). The resultant scene is one of apparent disaster, with expanses of dead trees seemingly devoid of animal life. The temptation to portray the transformation from living to dead as a disaster is understandable. Trees and animals can die but the reality is that if such a fire occurs in mature forest of an appropriate age then it is likely that the species will persist. In fact, a true disaster would occur if a fire happened not when plants were mature, but immature (i.e. lacking regeneration capacity). Similarly a high intensity fire in a mature forest containing possums will not be a disaster provided that some part of the forest containing animals is unburnt and those animals can later reach the burned area when suitable habitat is available. A disaster would occur (loss of possums from the landscape) if all sites containing possums had their habitat destroyed. This could happen if all the possums were confined to hollows in dead trees and a fire consumed all the dead trees. We have used the example of these forests to illustrate the importance of understanding the fire regime. Similar, but not identical examples, can be found in many other Australian ecosystems. Commonality of processes exists though rates and mechanisms of such processes may differ.

Peat fires perhaps offer a special case of this extinction scenario. Consumption of peat eliminates a substrate and potential habitat that may have taken thousands of years to develop. Thus organisms solely dependent on peat as habitat, or those with all their propagules in peat, will be rendered locally extinct by a single fire. The fires of 1960–61 on the Central Plateau of Tasmania are a case in point. We are told that the peat-fire edge can still be seen there today. Three species of woody plant are believed to have been made extinct locally by these fires. Gill (1996) reviewed the case which he referred to as 'arguably the most ecologically significant fire in Australian history'. Thus extensive losses of species from landscapes that may be irreversible, or only reversible over a long time-frame.

While extinction is an immediate concern of managers charged with responsibility to conserve biodiversity, we have noted other important ecological processes and properties in *Table 1* that may be of concern to many land managers. Rates of erosion, sedimentation and water yield may, for example, be important in natural and semi-natural landscapes that are managed for water supply. Again, the nature of the fire regime and thus the 'system-state' will be a paramount concern in assessment of the impact of any real or potential fire. For example, the tall moist eucalypt forests described in the prior example serve as water-supply catchments in the hinterlands of Melbourne. Water yield from such forests declines as trees regrow and re-establish their dominance (Langford 1975). Yield gradually returns to near maximal levels as forests gain development and stature. The recovery period may be 35 years or more (Langford 1975). Repeated fires at short intervals (e.g. < 20 years) at a catchment scale would be disastrous for biodiversity (see above) and water yield. Note that the yield reduction is a function of time after fire and so is linked with the intervals between fires as well.

In summary, the state of the system, namely the set of fire regimes that prevail in a landscape, pre-conditions the responses of biodiversity and ecosystem processes to any particular fire. Awareness of this fundamental principle and the concept of fire regimes is a mandatory pre-requisite for decision-making and evaluation of ecological effects of any fire.

A Framework for Decision Making

It is evident from these examples that the relevant concepts are subtle an d that practical application requires insight and knowledge that may be difficult to obtain. Furthermore such concepts and background knowledge do not necessarily mesh well with conventional emergency management of bushfires. How do we incorporate such considerations into emergency management and bushfire planning in general?

Major bushfires are essentially managed as destructive events. When human lives and property are at risk this is justifiable and understandable. We have briefly illustrated above that ecological consequences of such fires cannot be viewed simplistically in this manner, despite the popular slant portrayed in the media. In ecological terms the event has to be managed within the perspective of the fire regime. How do we meld important considerations of disaster management for human protection (which focus purely on the immediate consequences of the 'event') with more complex ecological considerations (the fire regime), particularly during suppression of major fires? Here we argue that it is possible to achieve this by the implementation of simple systems for planning and decision support. Such systems may be relevantly applied during phases of disaster management (e.g. Preparedness, Response and Recovery, Paul 1999 or 'before', ' during' and 'after').

Key elements of the preparedness phase are: use of appropriate ecological decision-support methods; compilation of knowledge of the distribution of biodiversity and fire regimes; and the annual formulation of strategies which spell out what fire regimes are currently desirable based on the state of the system.

Ecological decision support can take a number of forms. One approach is to prepare guidelines that summarise ecological knowledge about appropriate or inappropriate fire regimes in some usable form. Another approach is to implement monitoring systems, on the ground, that are targeted at critical events such as time of first flowering in plants or the development of habitat structure. Gill and Nicholls (1989) describe an ongoing approach for plants which may be used to discriminate parts of a landscape in which vegetation may be able to cope with a fire from those parts which are not in such a condition. Note that these methods can be complementary, not mutually exclusive.

To apply the above methods effectively, knowledge is required as to where species of plants and animals occur in a landscape perhaps related to an effective vegetation map. Similarly, compilation of an overview of fire regimes in a landscape is dependent on the availability of mapped records of past fires over some reasonable time frame. This highlights the importance of good records. A logical platform for assembly of fire maps and fire details is in an effective fire management plan. Plans of this kind are currently being written and implemented in conservation reserves in NSW (Conroy *et al*. 1997, Bradstock 1999). A strong ecological fire management plan should bring the key elements (i.e. knowledge of fire regimes, ecological guidelines etc.) together in a coherent way and should compel the manager to annually evaluate the ecological status quo within the landscape under his/her jurisdiction. A good plan should also highlight potential problems that may result from suppression activities, such as trail construction, earthworks and the use of fire-fighting chemicals. Areas of particular sensitivity to these activities may be identified in advance. Thus any major fire event is anticipated and critical areas in need of protection from a major fire or suppression activities can be identified. It follows from such a process that the location of critical areas may change from year to year as circumstances change.

During a major fire (the response phase) it is crucial that planning is implemented effectively. Contemporary management of major fires is now accomplished in many parts of Australia using the Incident Control System (ICS). ICS provides an ideal framework for incorporation of ecological management considerations into fire suppression. Development of the planning strand of ICS to incorporate roles for ecological specialists is required. Such specialists would provide the inputs from the preparedness phase and help to shape strategies and tactics for suppression that result in appropriate fire regimes and avoid adverse ecological impacts of suppression activities (i.e. use of MIST—Minimal Impact Suppression Techniques, Caling 1998).

There is an urgent need to integrate mapping of fires into the response phase of emergency management. We have noted that good maps of fires (areas burnt) are integral to planning for ecological management. Often, procrastination defeats good intentions in this regard. The longer the task is left, the greater the loss in accuracy. There are obvious practical and financial reasons for incorporation of mapping into the routine operational component of ICS. Mapping should be part of the mop-up. Detailed mapping provides baseline data for fire regimes, and can now be carried out using differential global positioning systems. Aerial photographs or other imagery in association with tree-height maps can assist with the mapping of fire intensities.

The 'recovery' phase following major fires is broad-ranging. Basic questions include: What fire regimes resulted? What are the possible effects and how can these be verified through monitoring on the ground? Execution of monitoring and feedback of information into planning should result from attempts to get to grips with these questions. Issues of rehabilitation and even, in extreme circumstances, reintroduction may arise if circumstances warrant (i.e. adverse fire regimes or effects of suppression). Analysis, interpretation and monitoring are required to adequately address these problems. Again, part of the recovery phase may be capable of being dealt with under the ICS framework. Equally, a platform for many of these activities can be laid in a competent ecological fire management plan.

A postscript to the discussion of the 'recovery phase' is the desire that members of the public have for feeding native animals in the field with introduced fruits, hay, lawn clippings etc., capturing and tending wounded animals in 'refuges'. Some authorities desire to carry out expensive 'restorative' or 'preventive' actions after, or in anticipation of, erosion using readily-available introduced grasses. All of these actions may be inappropriate, unnecessary or unsatisfactory in conservation reserves but they are actions that need to be considered in the appropriate social, geographical and land-use context.

Conclusions

Enlightened management of major fire emergencies is dependent on awareness of the importance of fire regimes as a powerful influence on ecosystems. Not all major fires or parts of fires will cause ecological disasters. Disasters will arise when components of fire regimes are adverse to the ecological values of the area. A precise knowledge of fire regimes and clearly stated objectives are required to distinguish when potentially disastrous circumstances may emerge in landscapes. Comprehensive summaries of relevant ecological knowledge, monitoring systems, and knowledge of where plants and animals live are prerequisites for assessment of fire regimes and decision-making.

An ecological fire management system should bring together these elements. Modern emergency management systems such as ICS have potential for development to incorporate ecological planning to assist with the management of major fires.

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