FIRE REGIMES, BIODIVERSITY CONSERVATION AND PRESCRIBED-BURNING PROGRAMS

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In the trend towards the domestication, or taming, of fire regimes in Victoria, Australia, the level of prescribed burning has been stepped up due to a recommendation from the 2009 Victorian Bushfires Royal Commission. While prescribed burning programs may be instituted for a number of reasons, especially the protection of life and property, they have consequences for the conservation of biodiversity. Not all vegetation types can be prescribed burned because the weather does not always allow it to occur under safe working conditions; where prescribed burning programs are carried out, unplanned fires may still occur. Thus, the general issue is the effect on biodiversity of both prescribed and unplanned fires, neither alone. Here, the importance to biodiversity conservation of all the components of the fire regime– interval, season, intensity and type (peat fire or otherwise) – and their domain of variability is emphasized. If conservation of biodiversity is to be guaranteed in a changing fire world, then much more knowledge about the systems being managed, gained in large part through effective monitoring, is needed. Issues such as targets and some assumptions of management are addressed here.

Key words: biodiversity, conservation, fire-regime, prescribed burning, targets

THE TOPIC OF THIS PAPER IS THE CONSERVATION OF BIODIVERSITY in fire prone landscapes of Victoria, Australia, especially in relation to the practice of prescribed burning. Prescribed burning was an issue tackled by the Royal Commission into the socially disastrous 1939 Victorian fires – as 'strip' and 'patch' burning (Stretton 1939) – as well as in the more recent 2009 Victorian Bushfires Royal Commission following 'unprecedented' unplanned fires (or 'bushfires') (Teague et al. 2010). Thus, prescribed burning has been a longstanding topic of considerable debate. Why is this so?

'Prescribed burning' is manifest as 'slash burning', 'broad-area burning' or 'ecological burning'. Prescribed fires may be confined to a burning-block or may be labelled as 'unbounded' in some cases (Sandell et al. 2006), 'unbounded' referring to the absence of a road or track marking the downwind edge where burning is planned to finish.

A major issue has been how much prescribed burning should take place each year. The recent Royal Commission recommended that the level of prescribed burning in Victoria be increased to 5% of public land per year (Teague et al. 2010), a major increase. Is 5% the best, or even appropriate, target?

'Ecological burning' implies the use of fire by managers to achieve a favourable ecological outcome, usually in the form of a better protected indigenous flora and fauna – 'biodiversity' in its most obvious but narrowest sense. It can be expressed as burning to avoid extinction of biodiversity and promote extinction of non-indigenous species. Despite 'ecological burning' being a relatively new term, the practice was used in Victoria for insect control as early as the first part of the 20th century (Barrett 1914). In the widest sense of 'biodiversity', have we the knowledge to avoid extinction of the numberless, nameless species of invertebrates, non-vascular plants and micro-organisms that form our ecosystems, let alone the genetic diversity manifest in populations of species?

While the focus in this paper is on ecological burning for biodiversity outcomes, ecological burning just represents the management motivation for prescribed fire, rather than the reality of the effects of all forms of prescribed and unplanned fire. Thus, while the emphasis is on prescribed fire, this paper is concerned with biodiversity outcomes resulting from any series of fires.

A series of fires at a point is called a fire regime. While single events comprising the regime all have effects, it may be just a pair of fires, or a longer sequence of fires, that has major ecological impact such as local extinction. The intervals between events can be important to the species as recovery from the previous event takes place, but the properties of the fire – such as fire intensity, or predominantly smouldering or predominantly flaming ('type of fire'– Gill 1975, 1981) – and the season of occurrence

can be important also (see also Gill 2008). Prescribed fires in Victorian conservation reserves are likely to be predominantly flaming, of low intensity and occur in autumn in forests but can occur in mallee in spring (Sandell et al. 2006).

PURPOSE OF PRESCRIBED-BURNING PROGRAMS

Purpose

Prescribed fires are fires instigated by management authorities in order to achieve a specific purpose under safe working conditions. Prescribed burning on public land may be used for the:

- disposal of post-logging materials so as to allow ready site access and the successful growth of young trees, an economic and ecological asset;
- reduction of fuel levels to an extent which impedes the spread of an unplanned fire to protect vulnerable social and economic asset (see also below); and,
- attainment of ecological objectives such as avoiding extinction of native flora and fauna and combatting non-indigenous species in reserves.

Prescribed burning as a program for asset management

'Prescribed burning' is a management operation, a process, but is better considered as taking place as a program of fire events, each event having its own particular properties, for the achievement of particular outcomes on particular assets whether these be social, economic or environmental. 'Assets' here are considered to be the things we value. It is the program of prescribed fires interacting with the occurrences of unplanned fires that is important to fire's effects on ecological and other assets. In simple terms, the ecological effects of fires can be said to be the on-going result of the fire regime-ecosystem interaction, among other things.

Chains of objectives

There is a chain of objectives from the immediate operational objectives to the ultimate objective of attaining a benign or enhanced condition of assets. Because there is a chain – a multiple-step list – the ultimate objective may be overlooked. This is understandable given that ultimate objectives may be long term, like an ecological response, and will involve more than one fire whereas operational objectives are short term. The use of terms like "hazard-reduction burning", without qualification as to what or to whom the hazard may be, leaves the question of ultimate objective unstated.

Explaining objectives can involve a number of steps: e.g. a low-intensity fire may be prescribed to reduce the surface fuels to a relatively low level over a given area; while fuel levels are low, fire intensities of a subsequent unplanned fire are reduced; with a reduction in potential fire intensity, the chance of successful fire suppression is increased; when suppression is successful, the chance of undesirable fire reaching assets at risk is reduced. A complication is that there may be multiple short-term objectives for a prescribed-burning operation such as: protection of human life and property for people on, and off, site; advising neighbours and visitors of the impending fire; prescribing the fire accurately, monitoring the fire effectively and revising fire-behaviour prescriptions; and, achieving specified fuel treatment coverage within fire-intensity limits (State of Victoria 2006).

To achieve the above objectives, an infrastructure of roads, tracks and water storages may be constructed – which can have an effect on biodiversity (Gill 2008): keeping physical infrastructure to a minimum – as for any intervention in 'natural systems' for conservation – is desirable. Zoning systems may be instituted (State of Victoria 2006, Gill and Stephens 2009) to identify assets broadly and to provide a prescription focus. Making ultimate objectives explicit avoids the problem of having an entrenched system in which the ultimate objectives can be forgotten in time.

EFFECTS OF PRESCRIBED-FIRE PROGRAMS ON BIODIVERSITY

That the effects of fires on biodiversity, including those of prescribed fires, ultimately depend on fire regimes, was mentioned above. Not mentioned was that the variation around average levels of fire-regime components may be important, e.g. variation in lengths of intervals between fires. This may be intuitive in that variation is natural or it may be indicated from experiments where certain fixed intervals and seasons, for example, can have adverse effects on populations (Noble 1997, on mallee eucalypts). Models may show the same thing where data are poor – as for populations of Leadbeater's Possum (*Gymnobelideus*

leadbeateri McCoy) in forests of Mountain Ash (*Eucalyptus regnans* F.Muell.) under unplanned fires with various mean intervals (M.A. McCarthy, A.M. Gill and D.B. Lindenmayer, unpublished). Landscape-scale models also support the importance of interval variation for keeping a range of species in the landscape (Clark et al. 2002). The effects of on-site variation in fire-regime components in general, are poorly understood. Scheduling prescribed fires based on on-site variation in fire interval (Gill and McCarthy 1998) is important, especially given our lack of knowledge. Scheduling can be done within the tolerable limits of species persistence using a relatively simple method (Gill 2008) based on one of a number of mathematical functions for the probability of burning at a point in the landscape (McCarthy et al. 2001).

CONTEXTS

Multiple assets and the question of targets for annual area of prescribed burning

Managing for multiple assets means that optimal fire regimes for managing them are likely to be different. Even for the biodiversity asset alone, suitable fire regimes will differ from place to place and unplanned fires may constitute a large part of the fire regime. As a result, different extents of prescribed burning will apply in different places at different times. The ideal extent of the landscape burnt per year will depend on the assets concerned, the present landscape condition, and the number of suitable days for prescribed burning. The extent of burning per year ideally will not be an imposed percentage but an emergent property of the management system (Professor Mike Clarke, personal communication) and recent unplanned-fire extent for example. Thus the real issue with targets is not the total area per year burned by prescription: it is the effect of fire regimes, including prescribed fires, on assets. There is a possibility that in meeting targets, the real issue of meeting ultimate objectives is overlooked.

Landscapes

Prescribed burning occurs in a landscape context. The area of burning in any one operation can be up to 400 ha as a result of ground ignition or up to about 5000 ha using aerial ignition (State of Victoria 2008, FM10.1/FG10.1.2, p.1). Not all of the area is anticipated to burn, nor even considered desirable in all cases. The amount of coverage aimed for in any one operation may be 90% or more for areas near houses and less so generally (Esplin et al. 2003). What the pattern of burning is varies with lighting pattern, terrain, vegetation, roads and waterways for example, but there are only a few studies of the pattern of burning from a single operation (e.g. Sandell et al. 2006, Heemstra 2007), let alone a series of operations (but see Penman et al. 2007). The latter is important because some parts of a 'burning block' will burn more frequently than others (Penman et al. 2007). This is an important topic when considering the 'mosaic burning' idea which, in one form at least, suggests that all a manager has to do to maintain biodiversity is to burn the landscape in a mosaic pattern (see Gill 2008). Potentially, the regime concept could be overlooked in doing this.

While some areas can be prescribed burnt, others cannot. Not all areas in a region can be prescribed burnt because of fuel structure or usually-wet habitat. Wet-forest types are not suitable while in low rainfall forests and sclerophyll woodlands like box ironbark communities it may be arguable: the benchmark 8 t ha^{-1} litter load (Gill et al. 1987) may not be reached in box-ironbark forest in north-eastern Victoria but other parts of the fuel array may be used to justify inclusion in the burning program (Chatto 1996; Tolhurst 2003). In forest areas with intermediate rainfall, prescribed burning as a practice is more suited to the conditions there. Tolhurst (2003, table 1) considered that 79% of public land in Victoria was suited to prescribed burning if mallee vegetation was included, or 75% if mallee vegetation was not considered suitable. Alpine vegetation may be excluded because of its slow rate of recovery and its burning-grazing history (Forestry Tasmania 2005, p.6).

Because prescribed fire programs are not possible everywhere – and even where they do occur, they occur in a context of unplanned fires – the effects of unplanned-fire suppression and suppression infrastructure on biodiversity need to be considered as part of the context (Gill 2008).

Ex situ effects

There are effects of fire regimes beyond reserve boundaries and these can affect policy within the reserves. Effects can be from prescribed-fire smoke or from a fire escape. Traffic flow may be impeded

because of poor visibility during operations and human health and crops may be adversely affected. Public reaction may be such as to modify the practice of prescribed burning – as at Laverton North Native Grassland Reserve where traffic accidents from smoke have been an issue (Dr John Morgan, personal communication).

ASSESSMENT OF PRESCRIBED-FIRE PROGRAMS

Prescribed-fire programs will be assessed by different people according to the value they place upon various assets. From a biodiversity point of view, it is perhaps obvious that the biodiversity itself needs to be monitored but less obvious may be the need to monitor non-indigenous species (pests, plantings, feral animals and weeds) and drivers of change such as fire regimes. Doing these things is not easy, either conceptually or operationally. There are difficulties in measuring areas burnt and not burnt within a fire area; there are difficulties in measuring biodiversity comprehensively, even using indicators; and there are difficulties in recording, analysing and disseminating data.

As well as monitoring biodiversity, the various stages of the prescribed-burning operation may be monitored. There may be a shortage of skilled staff, money and time so monitoring a minimal number of items for minimal periods of time at a minimal number of sites is reasonable (Gill & Nicholls 1989).

One of the aims of monitoring is to learn. This requires diligence as well as recording, analysing and disseminating results, and also needs auditing. Some of the difficult things to test and learn from, although vital, are the assumptions behind our practices. Theory may be considered to be one branch of assumption space. Can we test the assumptions behind the common theory used in management for biodiversity? A major theory may be stated to be that indicator plant species, chosen to be the most vulnerable of the community to fire interval (after Noble & Slatyer 1980), are reliable indicators for the persistence of all species to all fire regimes within the interval range. Indicator species are chosen based on the responses of mature plants of the species to a single fire together with fixed life history time-markers. Although these can provide a useful guide to the scheduling of prescribed fires, the indicators are chosen on the basis of their presumed response to fire intervals only, not to other components of the fire regime, and on life history markers such as first seed set which may be uncertain and variable. Furthermore, the theory applies to vascular plants only. Theoretical models are less well developed for other groups of organisms, and barely at all for most invertebrates. Scheduling fires on the basis of plants alone may not cater to the persistence of fauna (Clarke 2008, Gill 2008).

THE FUTURE

The prescribed-burning debate has been long running and intense and likely to continue. The seeds of the debate seem to be:

- disagreement as to what is considered to be an asset, especially biodiversity – despite a legislated aim (State of Victoria 2010)
- multiple objectives of public land management, not just in reserves, such as recreation, biodiversity conservation, protection of human life and property, protection of cultural artefacts, recreation and water supply; and, with growing awareness of the problems of green-house gas emissions and their global effects, new ‘assets’ may be perceived in the form of large carbon stocks such as old growth forests
- ex situ effects of fires such as escapes from prescribed burning and smoke effects on human health, tourism and horticulture, for example (Esplin et al. 2003)
- interference in Nature
- uncertainty as to what are the effects of particular fire regimes on biodiversity etc.

Prescribed burning is now taking place within a context of atmospheric (CSIRO 2011) and fire-weather change (Lucas et al. 2007) that is likely to alter unplanned ignitions, fuels, fire behaviour (Cary et al. 2011) and management. Effects of atmospheric and climate change on biodiversity may be direct – and be evident as ‘novel ecosystems’ (Hobbs et al. 2006) – or indirect through the effects of changed fire regimes and fuel management systems generally (Williams et al. 2009). Also, human populations are growing rapidly and are likely to exert more influence on fire regimes through fire starts and unintentional invasions of non-indigenous species into biodiversity reserves. Public expectations may hasten the trend towards the creation of synthetic fire regimes, a process seemingly impelled by the Forests Act 1958, Section 62(2) which requires the ‘immediate prevention and suppression of fire’and ‘planned prevention of fire’ (State of Victoria 2011) and the recent increases in prescribed-burning

activity as a result of the 2009 Victorian Bushfires Royal Commission (Teague et al. 2010). A trend to 'novel ecosystems', including exotic species (Hobbs et al. 2006), acted upon by largely synthetic, or domesticated, fire regimes seems likely to continue.

To avoid extinctions of indigenous species, and promote the extinction of non-indigenous species in conservation reserves, we will require a great deal more knowledge of biodiversity and the processes affecting it than we have at present. This is highlighted by the recognition that all four variables comprising the fire regime (Gill 1975, 1981) may need to be considered in understanding the effects of fire regimes, not just interval (Gill and Stephens 2009; Cheal 2010). Off-reserve management through 'corridors' and perhaps natural refuges, and their associations with on-reserve management, may be future conservation and management issues in which fire regimes will need to be considered (Dunlop and Brown 2008).

The effects of changed fire regimes, through changed fuels, ignitions and climates, may take a very long time before they are evident. The effects of continual death of tree seedlings may not be noticed in a forest until the trees begin to die out, for example. Therefore long programs of asset-based monitoring are essential if any prescribed-fire program is to be deemed successful; designing and implementing such a monitoring system in a climate of change is a formidable challenge. Doran et al. (2003) have implemented such a system for aspects of the biodiversity asset in Tasmania, a useful reference point.

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