Assessing The Ecological Implications Of Prescribed Burning: Where Do You Start?

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Abstract

Differences between repeatedly burnt and long unburnt experimental areas are often reported as impacts of burning. The implicit assumptions are that long term fire exclusion is 'natural' or a 'control' rather than an alternative 'treatment', and that environmental changes do not occur with fire exclusion. Another frequent assumption in ecological assessments is that larger populations of various species represent increased biodiversity. Ecological assessments of prescribed burning often fail to consider the consequences of not burning.

Examples of ecological assessments are discussed and alternative perspectives are proposed that can reduce the apparent conflict between property protection and environmental conservation goals.

Introduction

The perception of conflict between management aimed at protecting biodiversity, and prescribed burning to protect human life and property is largely false. Frequent, extensive and intense wildfires pose a substantial threat to biodiversity, as well as human life and property, whereas low intensity prescribed burning reinforces edaphic controls and protects sensitive species and environments (Jurskis *et al.* 2003, Jurskis 2001). The false perception results from assessments that are based on false premises because they do not start at an appropriate place in time, space, and in terms of dynamic ecosystem processes. That is, the reference point used to compare fire regimes is not a healthy dry forest with a natural fire regime. In order to assess the ecological implications of burning or of not burning, it is necessary to specify an optimum ecological position for a landscape, usually a 'natural' state; to compare it with the current position; and to consider how fire management may change that position. Under Australia's National Forest Policy Statement (Commonwealth of Australia 1992), the benchmark for conservation of biodiversity is set at 1750, and the policy requires that ecosystem health and vitality be maintained by reducing threats from diseases, weeds and unnatural fire regimes.

Fire regimes

There is a view in Australian fire ecology that fire was naturally rare before European settlement, with infrequent high intensity fires, and that fires became more frequent after settlement. This view holds that fires lit by people are unnatural and ecologically damaging, and that exclusion of human and lightning fires from native forests is natural. This view is sometimes deliberately stated, but is more often an implicit assumption. For example, Whelan (1995) stated that one problem with hazard reduction burning was "predicting the effect of increased fire frequency in an area". However there was no discussion of past fire regimes to support this proposition. Some ecologists have argued in a circle (*e.g.* Benson and Redpath 1997, Horton 2003) that fire is ecologically destructive, but ecosystems haven't been destroyed, so fire was naturally rare, and prescribed burning must be ecologically destructive.

These and other ecologists (*e.g.* Keith and Henderson 2002) have also argued that pre-European fire regimes are not known.

It is known that the frequency of intense fires increased following European settlement of Australia, however it is not generally appreciated (*e.g.* Keith and Bedward 1999, Benson and Redpath 1997) that this was associated with a reduction in low intensity fires. Frequent and extensive low intensity fire was a feature of pre-European fire regimes in Australia, whereas high intensity fires dominate current fire regimes (Jurskis *et al.* 2003). Dendrochronology and sediment coring have traditionally been used to investigate past fire regimes, but these methods cannot detect low intensity fires (Jurskis *et al.* 2003). Furthermore dendrochronological sampling is inherently biased towards recent fires because older trees are scarcer, so most studies around the world show increasing fire frequency in recent times (Whitlock *et al.* 2003). Sediment coring has the additional problems that it cannot distinguish individual fires, or even individual years, and it cannot determine the location of fires (Whitlock *et al.* 2003).

On the other hand, fire dating using grasstrees in south western Australia has clearly shown a reduction in fire frequency since European settlement (Ward *et al.* 2001) corresponding with an increase in frequency of fire scarring as determined by dendrochronology (Burrows *et al.* 1995). The grasstree evidence corresponds very well with evidence from historical documents written before and during European settlement (Abbott 2003). Despite ongoing debate about the extent and nature of Aboriginal burning in eastern Australia, a clear association of human activity, including burning, with grasslands, and grassy woodlands and forests is not disputed (*e.g.* Benson and Redpath 1997, Jurskis 2000). These frequently burnt formations covered most of the continent (AUSLIG 1990).

Whelan (1995) suggested that hazard reduction burning "has become the most extensive use of fire in land management", however this ignores the contribution of both fire suppression and wildfires to current fire regimes. Wildfires are by far the major component of modern fire regimes in temperate Australia (Jurskis *et al.* 2003). Also, the nature and extent of fires started by lightning has changed dramatically since European settlement. This component of modern fire regimes is dominated by fewer, larger and more intense fires, mostly burning in extreme conditions (Jurskis *et al.* 2003). Much of the ecological literature (*e.g.* Keith and Henderson 2002, Benson and Redpath 1997) overlooks these obvious changes since European settlement.

Following European settlement, there was a decrease in the proportion of low intensity fire in the Australian landscape and an increase in high intensity fire (Jurskis *et al.* 2003). In response to many disastrous fires, broadscale hazard reduction burning was introduced into public forests around the mid 20th Century (Shea *et al.* 1981). At about the same time, deliberate burning of many grassy forests declined substantially as a government superphosphate 'bounty' encouraged graziers to develop improved pastures (*e.g.* Wylie *et al.* 1993). More recently, the development of the 'environmental movement' and extensive conservation reserves has brought a renewed emphasis on fire suppression and exclusion in public forests (Hurditch and Hurditch 1994). Furthermore, logistic and aesthetic impediments to burning are ever increasing with urban, rural and 'alternative lifestyle' developments and associated infrastructure (Jurskis and Turner 2002).

Vegetation

Ecologists have often argued or implied that some Australian pre-European open forests were naturally very shrubby and that deliberate burning has simplified their structure by removing shrubs. For example, Henderson and Keith (2002) ignored fire exclusion and suppression as a disturbance. This allowed them to construct the argument that an association of dense shrubbery with 'lack of disturbance' indicates that dense shrubbery was the natural pre-European condition in forests that were subsequently selected for grazing (Keith and Henderson 2002). The argument was illogical in that grassy forests were selected for grazing whereas shrubby forests were not suitable and remained largely undeveloped (*e.g.* AUSLIG 1990, Keith and Bedward 1999, Jurskis 2000). Keith (2002) also suggested that the understorey of some northern New South Wales grassy forests had been simplified by grazing and burning. However, dieback, and shrub and weed invasion are evident in many ungrazed, unburnt public forests, whereas some adjoining private forests that are frequently burnt and grazed are healthy and grassy (pers. obs). The declining health of the dominant components in the shrubby forests suggests that natural processes have been disrupted by fire exclusion.

Keith and Bedward (1999, page 46) classified two "wet" forest types (Brogo wet vine forest and Bega wet shrub forest) within a group of "dry grassy eucalypt forests" that dominate the "large rainshadow valleys of the Bega and Towamba Rivers". These were distinguished from the other types in the same group, by an "abundance of mesophyll shrubs and vines" in one case, and in the other by "prominent small tree and shrub strata". Nearly a half to two thirds, respectively, of their pre-European distribution had been cleared and three quarters of the remaining area was privately owned. Unaccountably, Keith and Bedward (1999) did not discuss whether it was likely that the characteristic structure of these two forest types had been affected by changes in management following European settlement, but they proposed that frequent burning for hazard reduction is a potential threat, especially to their woody components. The high proportion of these two types that was cleared suggests that they were generally open and grassy at the time of European settlement, otherwise they would not have been selected for agriculture. Keith and Bedward (1999) noted that the dry grassy forests of all the coastal rainshadow valleys from the Hunter River to the Gippsland Lakes had been "exploited for their pastoral resources".

According to Keith and Bedward (1999), Brogo wet vine forest and Bega wet shrub forest, are representative of the pre-European vegetation. However it appears more likely that they are artefacts of post-European management regimes that are changing grassy forests into shrubby forests. These two forest types are the focus of eucalypt dieback in the region (Jurskis and Turner 2002). They are mostly located near improved pastures, small 'alternative lifestyle' holdings, or conservation reserves, and as a consequence, fire has been deliberately excluded for several decades (pers obs). Although they are amongst the most species-rich ecosystems in the region, the shrubbery that distinguishes them from other grassy forests (Keith and Bedward 1999) contributes little to this richness. Less than 20% of the "diagnostic species" associated with these types (Keith and Bedward 1999) are trees and shrubs. The "woody rainforest elements" that are 'potentially threatened' by prescribed burning are not 'diagnostic' species, rather they are associated with true rainforests (Keith and Bedward 1999) and appear to be invading the dry grassy forests (pers obs). Fire exclusion has not only changed the forest structure, but has also detrimentally affected ecosystem processes leading to declining forest health (Jurskis and Turner 2002).

Structural changes, weed invasion, pest and disease outbreaks, and tree decline with changed fire regimes have been reported in Australia (Anon. 2002, Jurskis and Turner 2002, Lunt 1998, Rose 1997, Smith and Smith 1990, Gleadow and Ashton 1981), and in North America (Dwire and Kauffman 2003). Another Australian study associated weed invasion of bushland with suburban development and eutrophication (Clements 1983), but failed to recognise fire exclusion as an important part of the process (Rose 1997). These studies showed that both exotic plants (*e.g.* lantana, privet, camphor laurel) and native plants (*e.g.* pittosporum and sheoak) can achieve weed status with fire exclusion. In either case there are dramatic changes in vegetation structure. Both pittosporum and sheoak have behaved as weeds across a large range from northern New South Wales to southern Victoria, whilst pittosporum has been noted more widely as a weed at Norfolk Island, King Island, South Australia and Albany (Jurskis 2002, Lunt 1998, Rose 1997, Smith and Smith 1990, Gleadow and Ashton 1981).

Populations and resources.

Ecological assessments often fail to consider that native plants and animals can behave as weeds or pests when there is an ecological imbalance. For example, large populations of native fungi, mistletoes, cherries, stick insects, beetles, lerps, bellbirds and koalas have variously been associated with eucalypt decline in Australia (Jurskis and Turner 2002). However ecological studies usually assume that more is better, whether of moisture, nutrients, invertebrates, shrubs, birds, possums or koalas (*e.g.* York 1999, Abbott *et al.* 1984). This ignores the adaptation of most Australian ecosytems to aridity and infertility (AUSLIG 1990, Florence 1996).

On the other hand, ecologists have sometimes taken little comfort in numbers when assessing the potential threat of prescribed burning to plant species. For example, it was suggested (Anon. 2003) that two shrubs, *Banksia ericifolia* and *Petrophile pulchella* were at risk from frequent burning (Bradstock and O'Connell 1988), even though they are present in large numbers across a wide range (Harden 1991). Another study cited to support this proposition ironically found that the least common plant occurred only in the frequently burnt areas (Morrison *et al.* 1996). Keith and Bedward (1999) considered that various woody plants in south east New South Wales were potentially threatened by prescribed burning, but these were common and widespread plants (Harden 1991).

None of the rare and threatened plants in south east New South Wales appear to be vulnerable to frequent, low intensity fires (pers obs). Of 77 rare and threatened plants in the region (Keith *et al.* 1999), 86% are rare because they have very specialised habitats that have a very restricted distribution (Harden 1991). These habitats such as rock outcrops and swamps have edaphic protection from fire, but would be better protected with more low intensity burning in the landscape (Jurskis *et al.* 2003). The remaining rare and threatened plants in the region are mostly found in inaccessible and undeveloped habitats, mainly occurring in National Parks (Harden 1991) that are not subject to frequent prescribed burning. Frequent wildfire may be a potential threat to these plants, but the threat could be reduced by prescribed burning (*e.g.* Jurskis *et al.* 2003). Another threatened plant that occurs in the region was not considered by Keith *et al.* (1999). *Euphrasia scabra* is known from only two sites in the State. Both are open grassy and swampy areas that were previously grazed and burnt but are now 'protected' in conservation reserves. Some interstate populations of this plant may have declined following 'protection' from prescribed burning (Chris Slade pers. comm.).

Assessing prescribed burning impacts.

There are few published reports of long term fire experiments in Australia. Guinto *et al.* (2001) reported that frequent prescribed burning of blackbutt and mixed dry hardwood sites in south east Queensland reduced the weight, organic matter content and nutrient content of forest floor litter. They reported that burning reduced soil nitrogen at one site and increased soil phosphorus at another. Raison *et al.* (1993) reported that frequent burning of snow gum forest in the Australian Capital Territory reduced soil nitrogen mineralisation, N released from decomposing litter, N held in tree foliage, rates of leaf fall, and N content of leaf fall. They suggested that reduced fertility, as a result of frequent burning, may alter the structure and composition of vegetation, exacerbate flammability and increase susceptibility to pests and diseases. Abbott *et al.* (1984) found that soil moisture and extractable N were higher in a long unburnt than a frequently burnt stand, but they reported that frequent burning didn't deplete soil nutrients and had little impact on invertebrate fauna.

York (2000) reported that frequent burning of blackbutt forest at Bulls Ground in New South Wales "resulted in the loss of a substantial number of species" of ants, but that the richness of burnt areas was "maintained by the addition of" other ant species. Unburnt areas had higher litter weight, higher cover values of tall shrubs, higher topsoil moisture, more large logs and lower ground level insolation, whereas burnt areas had higher cover values of herbs and small shrubs. York (2000) also suggested that "frequent burning may be impacting upon nutrient cycling", having "serious implications with regard to the maintenance of ecological sustainability". York (1999) reported that frequent burning reduced forest floor litter and moisture levels, litter dwelling invertebrate populations and taxon richness.

A number of retrospective comparisons of vegetation according to fire regimes around Sydney have been reported. These mostly refer to wildfires and also have methodological difficulties that severely limit their relevance to prescribed burning (Jurskis *et al.* 2003). Henderson and Keith (2002) surveyed vegetation in relation to "disturbance indicators" in two northern New South Wales escarpment forests. They reported that grazing and burning reduced woody understorey species richness and density. Keith (2002) described native vegetation map units and formations across New South Wales. He proposed that grazing and burning had simplified the understorey in some northern NSW grassy forests. Keith and Bedward (1999) surveyed vegetation in south east New South Wales, and suggested that frequent prescribed fires may cause declines and local extinctions of some woody plant species.

These experiments and assessments of prescribed burning were conducted in dry sclerophyll forests. Wet sclerophyll forests are not usually flammable and fires will only penetrate them under severe conditions (Florence 1996). Their distribution is determined by moisture availability (*e.g.* Keith 2002). It is not possible to conduct frequent low intensity prescribed burning in wet sclerophyll forests. However the understorey of the long unburnt treatments at Bulls Ground (State Forests unpublished data) is now characteristic of wet sclerophyll forest as described by Keith (2002). It is not logical to argue that the understorey was simplified in the burnt areas (*e.g.* Keith 2002), or that burning reduced nutrient cycling (*e.g.* York 2000), because it was a dry ridgetop site which was easily burnt, under mild conditions, ten times in 30 years. Had it been a wet sclerophyll forest, the experiment would not have been physically practical. It is apparent that fire exclusion has changed the understorey in the unburnt areas, so that they would now be difficult to burn under mild conditions. Long term fire exclusion has promoted soil moisture, nutrient cycling, unnaturally mesic and shrubby understorey development, shade, and an unnatural invertebrate fauna. These environmental changes diminish the regenerative capacity of dry eucalypt ecosystems (Jacobs 1955).

Hessburg and Agee (2003) described similar changes with post – European fire exclusion in the Inland North West of North America. They reported that the demise of frequent burning inhibited the regeneration of the previously dominant, dry forest trees and promoted uniform stands of dense multilayered forests, pest insects, pathogens, and more extensive high intensity fire regimes.

The Australian burning studies and flora surveys were reported as if the differences between long unburnt and frequently burnt areas were impacts of burning. Some studies (*e.g.* Guinto *et al.* 2001) explicitly referred to long unburnt areas as controls, implying that they were in a natural steady state condition. York (1999, 2000) acknowledged that 30 years absence of fire was quite unusual in dry blackbutt forests, but he nevertheless reported differences between burnt treatments and fire exclusion treatments as impacts of burning. However, low intensity fires were more prevalent in dry sclerophyll forests prior to European settlement than in recent times. The differences between frequently burnt and long unburnt dry sclerophyll forests should properly be described as impacts of long term fire exclusion (*e.g.* Abbott *et al.* 1984, Hessburg and Agee 2003), since frequent, low intensity fire rather than fire exclusion was characteristic of the pre-European conditions. From this perspective, the assessments would appropriately guide management in accordance with Australia's National Forest Policy Statement.

Where do you start?

It should not be assumed that fire exclusion is natural, and that accumulation of nutrients and increasing populations of some species are ecologically desirable. Ecological decline with long term fire exclusion has been documented in Australia (*e.g.* Anon 2002, Jurskis and Turner 2002, Lunt 1998, Rose 1997, Ellis and Pennington1992) and overseas (*e.g.* Dwire and Kauffman 2003). Eutrophication has long been recognised as a threat to aquatic ecosystems (*e.g.* Dasmann 1972, Kormondy 1969). More recently it has been recognised that eutrophication or nitrification may be associated with decline and weed invasion in terrestrial ecosystems (*e.g.* Prober *et al.* 2002, Granger *et al.* 1994, Clements 1983), but there has been little recognition that it may be promoted by imposing unnatural fire regimes on ecosystems that evolved with frequent fire (Dwire and Kauffman 2003, Hessburg and Agee 2003, Jurskis and Turner 2002).

Concerns about depletion of nutrients (*e.g.* Guinto *et al.* 2001, York 2000, Raison *et al.* 1993) or populations of some species (*e.g.* Keith and Henderson 2002, York 1999) by frequent, low intensity burning, appear to be misplaced. High nutrient levels and high populations of some native plants and animals such as woody shrubs (*e.g.* Keith and Henderson 2002), litter dwelling invertebrates (*e.g.* York 1999), bellbirds (*e.g.* Clark and Schedevin 1999) or koalas (*e.g.* Martin 1985) can be symptomatic of a breakdown of natural processes of nutrient cycling, competition, mortality and recruitment (*e.g,* Jurskis and Turner 2002, Lunt 1998, Granger *et al.* 1994, White 1993). The situation is analagous to eutrophication in the Great Lakes of North America during the mid 20th Century, where commercial and sportfish declined dramatically, whilst bacteria, algae and carp proliferated (Kormondy 1969). Henderson and Keith (2002) suggested that frequent burning, prolific grass, and abundant macropods were a potential threat to woody shrubs in dry grassy forests, but their assessment started from a false premise. No one argued against reducing pollution and treating waste water entering the Great Lakes, on the grounds that it would lower nutrient levels and deplete bacterial, algal and carp populations. However this would be no different to arguing that frequent low intensity burning is an ecological threat to grassy eucalypt ecosystems.

The status quo is not necessarily the optimum position that management should aim to maintain (Jurskis 2001). Rather management should seek to maintain healthy ecosystem processes, and should focus on the ecosystems and species that have been most depleted since European settlement (Jurskis and Turner 2002). Assessments of prescribed burning should consider the ecosystems that evolved with frequent low intensity fire. These are the ones that are flammable under mild conditions conducive to low intensity fire. However their flammability in mild conditions is reduced after low intensity fire has been excluded. The inevitable result is that these ecosystems burn more intensely and uniformly in more severe conditions and these intense fires carry into naturally less fire prone ecosystems containing more sensitive species. Thus natural edaphic controls on fire are weakened by fire exclusion and consequential high intensity fire regimes (Jurskis *et al.* 2003).

Ecological assessments of prescribed burning should start from a pre-European landscape as the optimum position. That is, a landscape with much open and grassy forest maintained by frequent, low intensity fire. They should recognise that grassy eucalypt forests have been substantially depleted by clearing, and that many remnants are unnaturally shrubby and weed infested, with declining canopies. They should recognise that high intensity fires are more frequent and extensive, and low intensity fires are less prevalent than in the pre-European landscape. Thus many ecosystems and species are threatened by both fire exclusion and frequent high intensity fire. Ecological assessments should recognise that fire exclusion has profound impacts in ecosystems that evolved with frequent fire. Fire management should aim to restore some balance by increasing the proportion of low intensity fire in the landscape to protect both grassy, fire dependent ecosystems and also fire sensitive ecosytems such as rock outcrops and rainforests. Strengthened edaphic control of fire and reduced high intensity fire in the landscape will also protect human life and property.

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