Burning for biodiversity or burning the biodiversity?

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Abstract

Prescribed burning is a common and valuable management tool for forest practitioners, but both frequent burning and the exclusion of fire may result in significant changes in vegetation communities. As a result, there has been considerable debate regarding the costs and benefits of prescribed burning for biodiversity with little resolution. In 1986, Forests NSW (formerly the Forestry Commission of NSW) established a long term study in the Eden region in south-eastern Australia in an attempt to record medium to long term ecological changes in response to three prescribed burning regimes (fire exclusion, routine burning and frequent burning) in logged and unlogged forests. Here we present some of the results from this study and use these to highlight issues for biodiversity conservation in fire management planning. Anthropogenic burning regimes resulted in changes to plant species diversity within the study area but these changes were minor and less than the magnitude predicted from other studies. The major change occurring within the study appeared to be a natural response of the vegetation to the time since the last wildfire and this occurred independently of the imposed management regime. These results suggest that, while some prescribed burning regimes have minimal direct adverse impacts, they also fail to stimulate the recruitment of many plant species and thus may have longer term indirect impacts. In developing fire management plans, consideration should also be given to the intensity, seasonality and frequency of the burns because these factors will affect the conservation of biodiversity.

Introduction

Prescribed burning is a commonly applied management tool in forest ecosystems worldwide (e.g. Turner *et al.* 1994). Managers aim to reduce the risk and intensity of future wildfires by reducing or removing forest fuels through burning under mild conditions (Morrison *et al.* 1996; Bradstock *et al.* 1998; Fernandes *et al.* 2003). Prescribed burning can also encompass ecological burns, post-logging burns and strategic burns. Frequent prescribed burning is associated with significantly lower costs than the occasional but more destructive wildfire, particularly for commercial forests. As a consequence forest managers may attempt to maintain low fuel loads by regular burning to protect the timber resource. Altered fire regimes are considered to result in significant ecological change (Whelan 2002). Land managers, therefore, have a requirement to develop fire management strategies that help control wildfires while maintaining biological diversity and ecosystem processes (Gill 2001).

Frequent fire has generally been considered to have negative effects on biodiversity throughout Australia (e.g Trainor and Woinarski 1994; Bradstock *et al.* 1997). As a consequence, frequent fire is listed under threatened species legislation in a number of states. For example, in NSW the Ecological Consequences of High Frequency Fire has been listed as a key threatening process under the NSW *Threatened Species Conservation Act* 1996. (DECC 2007). There is strong theoretical and empirical evidence regarding the impacts of frequent fire at the site or local population level (Keith 1996). However, at the landscape level where prescribed burning operations are planned and implemented, the evidence is not as clear with much of the supporting data being derived from chrono-sequence studies of repeated unplanned, high intensity fire.

In contrast, the effects of fire exclusion on forest communities have received little attention. The general understanding of the response of a vegetation community to a single fire event is that the greatest richness of species is observed immediately after a fire and thereafter the community changes through competitive interactions between individual species (Gill 1981; Noble and Slayter 1981). However, the results are variable among the few studies that have recorded vegetation responses in the absence of fire (Lunt 1997; Lunt 1998b; Lunt 1998a; Woinarski *et al.* 2004; Gent and Morgan 2007), and this is probably due to the range of communities studied. Regardless of the reason, the absence of fire results in significant ecological change and it is unclear whether the return of fire will be sufficient to restore the species diversity at a site.

In this paper, we summarise some of the results from a long-term study examining the impacts of prescribed burning in logged and unlogged dry sclerophyll forests. We use this information to highlight some of the issues for fire management and the conservation of biological diversity.
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Study area

The Eden Burning Study Area was established in 1986 to examine the impacts of prescribed burning and timber harvesting at an operational scale. It is located in Yambulla State Forest, situated 29km south west of the township of Eden, New South Wales (37°14′S, 149°38′E) and covers an area of 1080 ha of Timbillica Dry Shrub Forest (Keith and Bedward 1999) with smaller patches of other similar forest types. The overstorey is dominated by *Eucalyptus sieberi, E. consideniana, E. agglomerata* and *E. muelleriana* on the ridges, with *E. cypellocarpa* and *E. obliqua* locally dominant in lower lying areas. The site supports a diverse shrub understorey with the most common understorey species being *Allocasuarina littoralis*, shrubs *Daviesia buxifolia, Epacris impressa, Acacia terminalis, A.longifolia* and *Platysace lanceolata*, and herbs *Gonocarpus teucrioides, Lomandra multiflora* and *Pteridium esculentum* (Binns and Bridges, 2003).

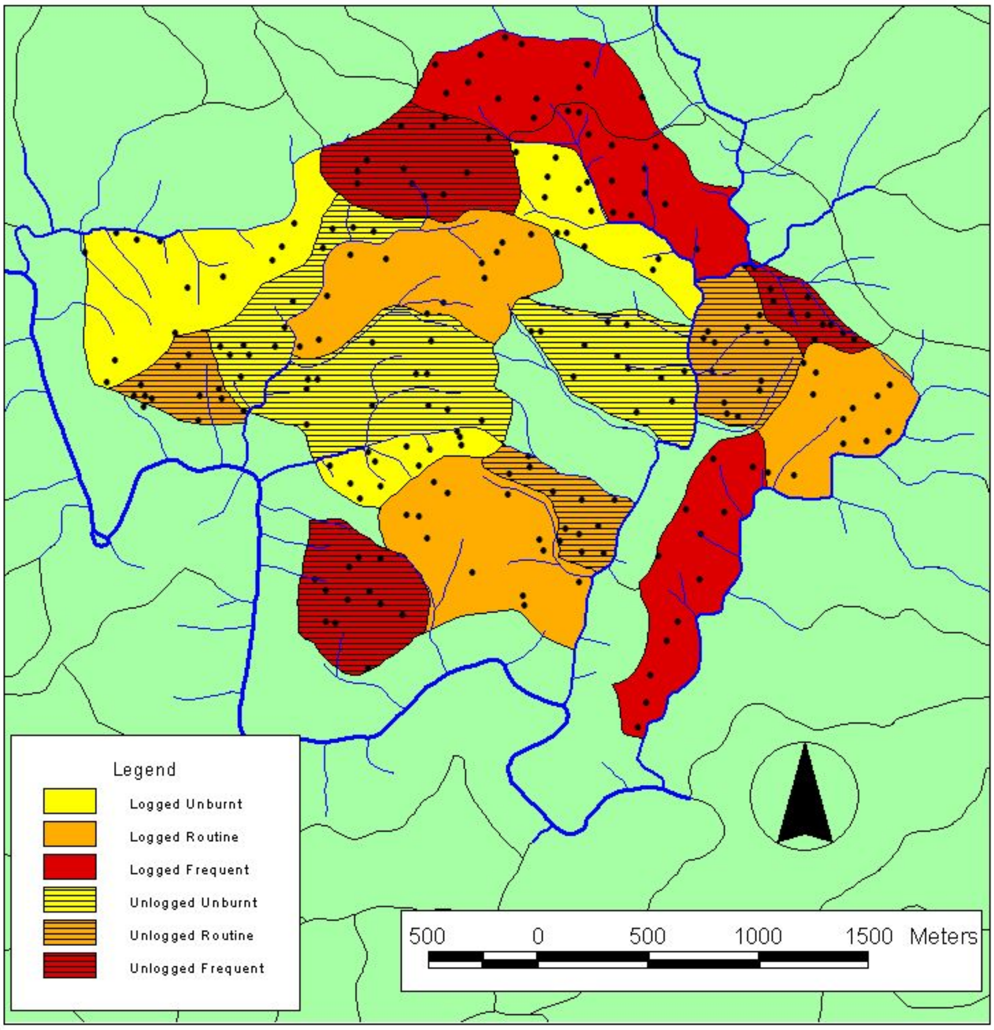

Figure 1: Layout of the EBSA.

The EBSA is comprised of 18 coupes ranging in size from 8 to 56 ha, with a mean of 32 ha (Figure 1). These sizes are consistent with operational practices in the region. Using a randomised block design, each coupe was allocated to one of the six experimental treatments – unlogged not burnt, unlogged routinely burnt (every four years), unlogged frequently burnt (every two years), logged not burnt, logged routinely burnt (post-log burn, 10 year regeneration, then every four years) and logged frequently burnt (post-log burn, every two years). The logging was an integrated operation which exacted saw logs and pulp wood, while retaining a proportion of mature trees for seed trees, existing and future fauna habitat, future saw logs and visual amenity. Approximately 30 %o f the original overstorey was retained in the net logging area (Binns and Bridges 2003). Burning treatments were based on those prescribed by the Fire Management Policy for the Eden Region (SFNSW 1982). Ground crews ignited spot fires or line fires using drip torches in various patterns according to fuel and weather conditions at the time of the fire (see Penman *et al.* *in press-b* for more details).

Within each coupe, 12 vegetation plots were randomly located in order to record the changes in understorey vegetation over time. Ground vegetation (defined as less than 1 m in height) and shrub vegetation (>1 m in height and less than 10cm dbh) was measured in a 5.64 m radius of the plot centre. Measurements were taken in 1986 prior to any anthropogenic disturbance and then at approximately 5 year intervals thereafter. Measures were taken of the identity and abundance of the individual species (see Binns and Bridges (2003) and Penman *et al.* (*in press-a* for more details).

Changes in understorey vegetation

One commonly applied measure of diversity is species richness, i.e. the number of species within an area. We examined species richness in the EBSA vegetation plots for the ground vegetation, shrub vegetation and combined the two for total vegetation richness. Frequent fire resulted in a relative increase of species richness of species less than one meter in height and total species richness, but caused a decline of the shrub species. At the coupe scale, these effects were no longer apparent, possibly due to the patchiness of fire-frequency at this scale in our study. There was a general decline in plant species richness throughout the study for the ground and shrub layers and the total species richness at both coupe and plot scales and these effects occurred independently of imposed management regimes. Figure 2 presents the results for the total species richness for the unlogged plots as an example. The full results of this work are presented in Penman *et al.* (*in press-a*)

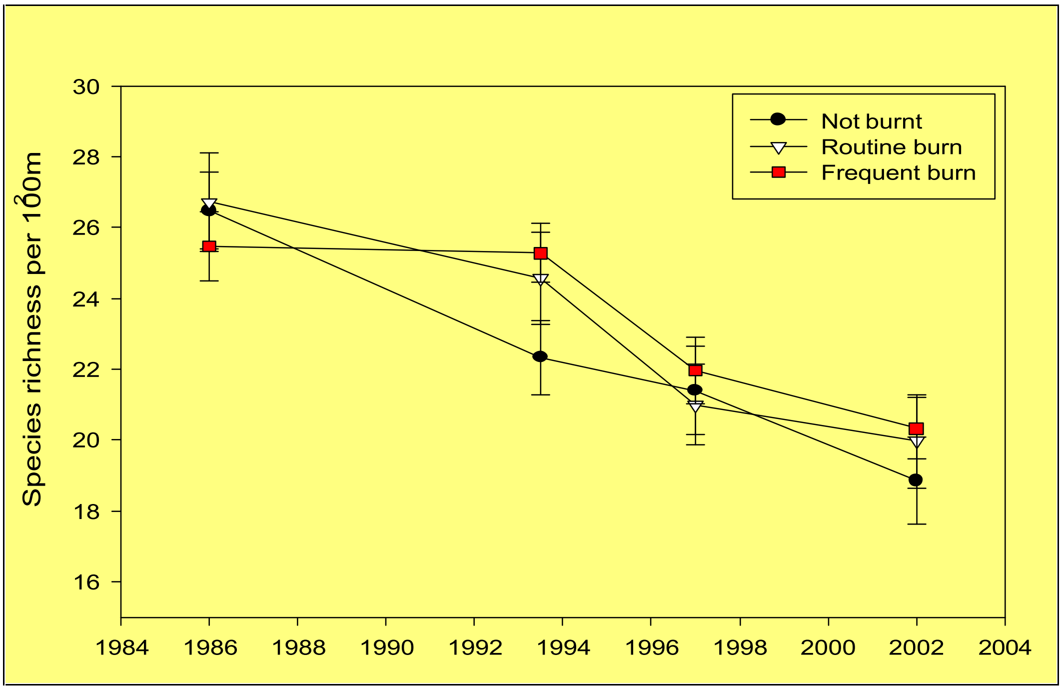

Figure 2: Total species richness for the understorey vegetation in the unlogged plots over the study period.

Community composition is another indicator of biodiversity which considers the identity and the relative abundance of the species present at a plot. We examined changes in the communities at each of the plots over time using dissimilarity measures. Results of the work indicated that the number of prescribed fires experienced at a plot resulted in greater change in the shrub assemblages, but less change in the ground species vegetation assemblages and the total understorey assemblage. However, the most notable effect was that all sites underwent significant changes over time independently of the imposed management regimes (Penman *et al. in review*). Figure 3 presents the results for the ground vegetation by way of example.

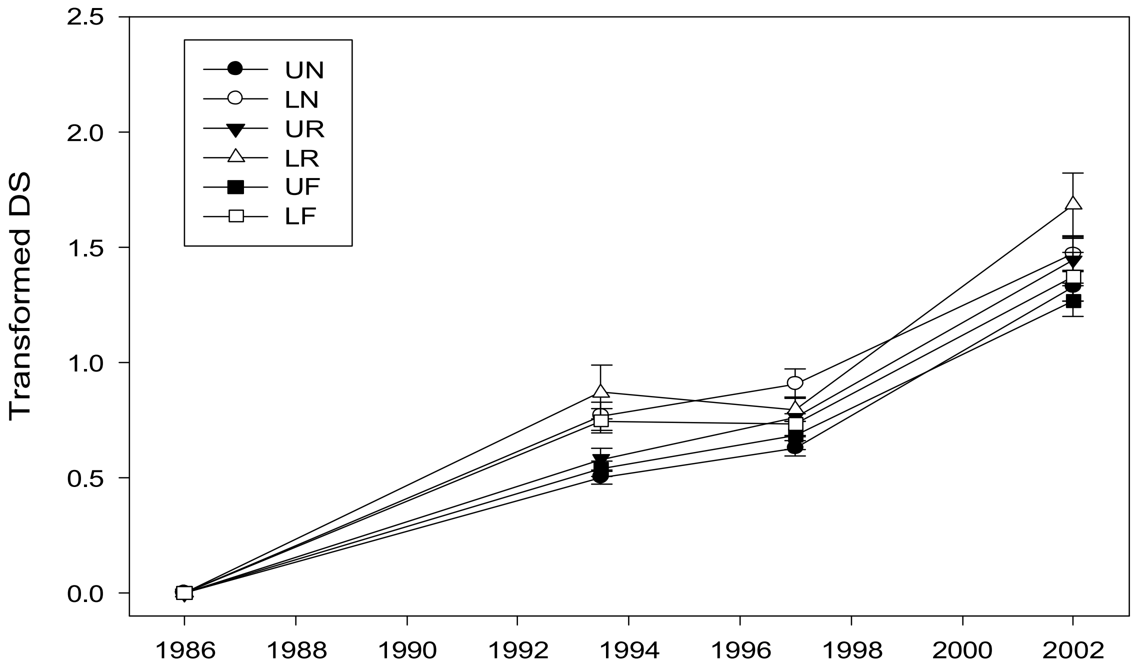

Figure 3: Plot scale community changes for the ground vegetation in the EBSA. Y-axis is a transformed dissimilarity score that relates to differences between the composition of a plant community at various time periods compared to its original state at the beginnning of the study. Treatment codes - LF: Logged Frequently Burnt, LN: Logged Not Burnt, LR: Logged Routinely Burnt, UF: Unlogged Frequently Burnt, UN: Unlogged Not Burnt, UR: Unlogged Routinely Burnt.

Responses of individual species are also important for understanding the impacts of management actions. Frequent fire increased the distribution of four species that have a short generation time and one large seeding shrub. A further 7 species declined in coupes with frequent fire. The distribution of 26 species changed over the study period independent of management treatment. Only five species increased their distributions, while 21 species decreased their distributions. Generally the species that declined were considered poor competitors and commonly require disturbance to regenerate. They include both resprouters (e.g. *Amperea xiphoclada*, *Aotus ericoides*, *Daviesia buxifolia*) and obligate seeders (e.g. *Acacia longifolia, A. terminalis, A. myrtifolia)*

A wildfire response?

Theoretical predictions and observations over a range of Australian plant communities suggest that flora species richness increases in the first few years following a wildfire and then slowly declines.. Over time the relative abundances of species changes through competition or as some species cease to exist in the above ground community and become restricted to the soil stored seed bank (Gill 1981; Noble and Slayter 1981). Changes recorded in the understorey vegetation plots at the community and species levels suggest a natural response of these communities to increasing time since wildfire. The last wildfire passed through the EBSA in 1973 and therefore the study represents a period from 13 to 28 years post-wildfire. Similar changes have been recorded for understorey communities in dry sclerophyll forests at sites which have not been subject to forest management practices (Penman *unpublished data*).

The few differences observed in plant species composition between those plots burnt by prescribed fire and the unburnt sites suggest that the prescribed fires at the EBSA do not stimulate regeneration to the extent expected from a wildfire. One of the most likely reasons is the low soil temperatures achieved during prescribed burns. Many plant species require soil temperatures to reach in excess of 80^{o} C to trigger germination (Auld and O'Connell 1991; Enright *et al.* 1997; Clarke *et al.* 2000). Soil temperatures during prescribed burns rarely reach these temperatures (Bradstock and Auld 1995; Penman *et al.* 2006). In such instances, there will be little or no recruitment for these species and as a result, little or no replenishment of the soil-stored seed bank. Even though frequent low intensity fires do not directly decrease the seed bank, in the long term (at least several decades or longer for most species) seed bank reserves will be depleted as dormant seeds die without replacement. This may result in long-term population decline if there is significant depletion of seed reserves before a fire of sufficiently high intensity occurs to promote recruitment.

Implications for forest fire management

The direct impact of prescribed burning on plant species richness in these dry shrubby forests was minimal compared to the changes observed over time, and these differences were probably a function of time since the last wildfire. These results suggest that the exclusion of fire from dry sclerophyll forests, as for prescribed burning, should be thought of as an active management decision that is likely to result in significant ecological changes. On land managed for conservation, land managers need to develop strategies that allow for fires which maintain or enhance biodiversity values of a site. This may include fires of higher intensity than usually desired for prescribed burning. We acknowledge that this approach will have significant challenges for fire management, particularly in ensuring that the fire does not impact upon neighbouring properties or endanger lives

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