Agriculture, Ecosystems and Environment 129 (2009) 17–27

Contents lists available at ScienceDirect

Agriculture, Ecosystems and Environment

journal homepage: www.elsevier.com/locate/agee

Overstorey tree density and understorey regrowth effects on plant composition, stand structure and floristic richness in grazed temperate woodlands in eastern Australia

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ARTICLE INFO

Article history:
Received 5 December 2007
Received in revised form 17 June 2008
Accepted 17 June 2008
Available online 29 July 2008

Keywords:
Tree density
Woody regrowth
Production landscapes
Paddock trees
Biodiversity benefits
Eucalypt woodlands

ABSTRACT

As natural woodlands decline in both extent and quality worldwide, there is an increasing recognition of the biodiversity conservation value of production landscapes. In low-input, low-productivity grazing systems in Australia, the modification of natural woodlands through overstorey tree and woody regrowth removal are vegetation management options used by landholders to increase native grass production for livestock grazing; however, there is little empirical evidence to indicate at what tree densities biodiversity attributes are compromised. We examined the effects of overstorey tree density and understorey regowth on the floristic composition, stand structure and species richness of eucalypt woodlands in a grazing landscape in the Traprock region of southern Queensland, Australia. We sampled 47 sites stratified according to vegetation type (*Eucalyptus crebra/Eucalyptus dealbata* woodland; *Eucalyptus melliodora/Eucalyptus microcarpa* grassy woodland), density of mature trees (<6 trees/ha; 6–20 trees/ha; >20 trees/ha), and presence/absence of regrowth. Distinct patterns in composition were detected using indicator species analysis and non-metric multidimensional scaling, with low density areas compositionally indistinguishable, although distinct from other land management units. Within vegetation type, medium tree density woodlands were compositionally similar to high density and reference woodlands. Species richness ranged from 18 to 67 species per 500 m^2 across all sites. No differences in total or native species richness were detected across management units; however, some differences in exotic species richness were detected. Differences in grass cover existed between low and high density management units, yet no difference in grass cover was evident between low and medium density management units. Our results suggest that medium tree densities may provide biodiversity benefits concordant with more natural areas, yet not adversely impact on pasture production. Retaining trees in grazing landscapes provides significant landscape heterogeneity and important refuges for species that may be largely excluded from open grassland habitats. Maintaining a medium density of overstorey trees in grazed paddocks can provide both production and biodiversity benefits.

1. Introduction

Biodiversity research has over recent decades recognised the importance of landscape and regional scale conservation, especially in highly modified production landscapes (e.g. McIntyre and Lavorel, 1994; Fensham, 1998; Firbank, 2005; Kirkpatrick et al., 2005; Tscharntke et al., 2005; Manning et al., 2006). In some agro-ecosystems where there has been a long history of grazing, landscape biodiversity may be enhanced by low levels of grazing disturbance (McIntyre et al., 2003; Tallowin et al., 2005; Guretzkya et al., 2007). However, ecological studies assessing whether different grazing management strategies sustain biodiversity value while retaining long-term productivity are few (Dorrough et al., 2004). In contrast, the negative effects of grazing have been well documented. Grazing may alter the composition of understorey species (Prober and Thiele, 1995; Clarke, 2003), prevent seedling recruitment (McIntyre and Lavorel, 1994), contribute to soil erosion and compaction (Yates and Hobbs, 1997) and enhance

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0167-8809/$ – see front matter
doi:10.1016/j.agee.2008.06.011

the invasion of exotic species (Prober and Thiele, 1995; Clarke, 2003).

In grazing landscapes, trees have been historically viewed as having negative impacts on grass production (Scholes and Archer, 1997). Trees may compete with grasses for water, soil nutrients, light or a combination of these factors (Scholes and Archer, 1997). Numerous studies (e.g. Walker et al., 1986; McIvor and Gardener, 1995; McIvor, 2001) have shown that tree density is inversely related to pasture yield in many woodland communities, with often a significant increase in pasture yield when all trees are killed (McIvor and Gardener, 1995; McIvor, 2001). However, the initial benefits of increased grass production for livestock grazing may be reduced by the invasion of woody shrubs and other undesirable species and, in some cases, the excessive regrowth of overstorey tree species following clearing (McIvor, 2001). Kaur et al. (2006) recently found that short-term gains from increased pasture production following tree clearing in semi-arid Queensland woodlands did not persist over time and suggested that tree clearing adversely impacted upon soil properties such as availability of nutrients and pasture growth.

Furthermore, some recent studies suggest that the presence of trees in the grazing landscape may not be completely incompatible with production (Tscharntke et al., 2005). Retaining mature trees on grazing lands can provide shelter and shade for stock (Walpole, 1999), reduce salinity and land deterioration (McIvor and McIntyre, 2002), enhance soil nutrients and potentially improve the quality of grasses for livestock (Jackson and Ash, 2001). It is now recognised that even scattered paddock trees provide important ecological functions at disproportionate levels relative to their size (Manning et al., 2006). In spite of these benefits, the clearing of remnant vegetation and re-clearing of woody regrowth in grazing landscapes has resulted in the loss and severe modification of large areas of woodlands in eastern Australia (McIvor and McIntyre, 2002). In particular, grassy temperate woodlands that once covered millions of hectares in eastern and southern Australia have largely been cleared for cropping or modified for sheep and cattle grazing (Prober and Thiele, 1995; Prober et al., 2002). In addition, pastoral land management in many grazing systems often involves removing or reducing the tree layer in remaining wooded areas to increase native grass production for livestock grazing (McIvor and McIntyre, 2002). As a consequence, eucalypt woodland remnants with near natural understorey are now rare and often restricted to patches that vary considerably in size, quality and isolation (Prober and Thiele, 1995; Yates and Hobbs, 1997; Prober et al., 2002). It is now clear that in temperate grazing landscapes in Australia, where woodlands have inadequate representation in nature reserves, regional biodiversity conservation may best be achieved if combined with current production systems (Chilcott et al., 1997; Kirkpatrick et al., 2005; Dorrough et al., 2007).

Early evidence suggests there can be both biodiversity and production benefits if some tree cover is retained in grazing landscapes (e.g. Jackson and Ash, 2001). However, there is little empirical information to suggest what overstorey tree density may be appropriate so that both production and conservation goals may be achieved in these agricultural systems. Dorrough et al. (2004) suggested that compatibility between grazing management strategies and biodiversity conservation may be best achieved in low-input grazing systems in low-productivity landscapes. In this study, we use combinations of mature (overstorey) tree density and the presence or absence of woody regrowth in the understorey as broad surrogates of past vegetation management practices in the Traprock wool-producing region of southern Queensland, Australia. The region is recognised for the production of fine wool fibres by predominantly unimproved native perennial pasture grazing and so represents a suitable landscape in which to explore the compatibility between grazing management and biodiversity conservation. The 'land management units' in the study landscape ('management cells', *sensu* Dorrough et al., 2004) from the perspective of landholders result from a number of practices which influence the overall structure and composition of vegetation: the broad-scale clearing of vegetation and continual grazing, clearing and burning regimes maintaining open structures (essentially open grassy paddocks with no or very few trees); broad-scale clearing of vegetation and continual re-clearing of trees through ring-barking and/or poisoning, grazing and burning regimes maintaining low shrub (regrowth) structures (no or few trees, high shrub regrowth); broad-scale clearing allowing woody tree regrowth to re-establish and developing into pole stage regrowth (high overstorey tree density, low understorey (shrub) regrowth); maintaining (semi-natural) remnants by minimal selective logging (occasionally for fence posts) and low intensity grazing and low frequency fire regimes (intermediate to high overstorey tree densities, presence of woody shrub regrowth dependent on grazing and fire regimes).

The objective of this study was to determine the effects of vegetation management for livestock grazing (altered overstorey tree density and understorey woody regrowth) on floristic composition, cover and plant species richness of two eucalypt woodland communities that previously dominated the landscape. Specifically, we examined the following questions: is there a difference in floristic composition, stand structure and species richness among mature tree density classes? Do woody regrowth areas have a different floristic composition, stand structure and species richness compared to areas without woody regrowth? Are there differences in vegetation responses across eucalypt woodland vegetation types?

2. Methods

2.1. Study area

The study was undertaken in the Traprock wool-growing region of southern Queensland, in the northernmost part of the temperate zone in eastern Australia. The region lies between the major towns of Warwick and Stanthorpe to the east and Inglewood and Texas to the west (Fig. 1). The climate is influenced by both tropical and temperate weather patterns with mean annual minimum and maximum temperatures ranging between 2.6 and 30.2 °C for Warwick (28°22′S, 152°03′E) and 0.9 and 27.4 °C for Stanthorpe (28°66′S, 151°93′E) (Queensland Murray Darling Committee, 2004; Bureau of Meteorology, 2007). Rainfall is generally higher in summer months, although the winter proportion can be significant, with mean annual rainfall ranging from 701 to 770 mm (Bureau of Meteorology, 2007). The original vegetation of the region has been subjected to clearing by ring-barking more than 80 years ago and many sites were re-cleared (regularly until about 30 years ago) to control woody regrowth (Traprock Wool Association 2005, pers. comm.). While less intense than the broad scale clearing of mature trees, the clearing of woody regrowth vegetation remains a component of many management practices employed by landowners (Traprock Wool Association 2005, pers. comm.). The Traprock region supports approximately 300,000 ha of sheep grazing country at a stocking rate of about 1–2 DSE (dry sheep equivalent) per hectare (Queensland Murray Darling Committee, 2004). Native pastures are the main source of forage within the study area, with past land management practices also including regular burning to control woody regrowth and to remove unpalatable dry herbage (Wills, 1976), although preliminary landholder surveys suggested that the use of fire to