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Review

A conceptual model of land use effects on the structure and function of herbaceous vegetation

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Abstract

We apply an ecological perspective to the understanding of land use change and its implications for vegetation dynamics in the agro-pastoral zone of eastern temperate Australia. We have presented a state-and-transition model to describe in broadest terms the range of land uses that affect grassy vegetation. We predict the biological attributes of plant traits that are likely to be associated with different land uses and identify some gaps in our knowledge that are seen as necessary for future management of this land. These gaps reflect, to some extent, differences between ecological and agricultural disciplines in types and land uses for which data have been collected. In particular, the floristics and transitions involved in change of land use from fertilized pastures to native grassland is poorly understood. The plant traits associated with the more intensive land uses have not been described, and thus form a test for the predictions of plant trait changes that can be derived from other continents.

We suggest that plant traits provide a vital link between vegetation change and ecosystem function, and are therefore a potentially important integration tool for understanding the consequences of land use change for ecosystem services.

Keywords: Plant functional traits; State-and-transition model; Pastures; Eucalypt grassy woodlands

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1. Introduction

Worldwide, land use changes are shaping the dynamics of native and semi-natural vegetation. Agricultural abandonment has been widespread in Europe (Rounsevell et al., 2005; Klein Goldewijk, 2001) and North America (Flinn and Vellend, 2005), and is expected to dramatically increase particularly in lands that are economically marginal for production (Rounsevell et al., 2005). In contrast, productive areas have tended to be managed more intensively, with associated problems of pollution, waste disposal and biodiversity loss (Lemaire et al., 2005). This segregation of land use replaces small-scale mosaics of animal and crop production and may reduce the sustainability of agricultural landscapes (Lemaire et al., 2005). Similarly in temperate Australia, there are trends towards both pasture ex- and intensification in different regions and landscape elements. Experiences with the application of fertilizers and naturalized species to native grassy vegetation from the mid-20th century, has led to recognition that pasture intensification practiced over entire landscapes is ineffective in terms of stability of sown pastures and damaging in terms of losses of perennial species (Simpson and Langford, 1996). Agricultural lands can offer alternative values to that of maximizing production when managed more extensively, including enhancement of ecological functioning in relation to soil and water processes (Jansen and Robertson, 2001a; Johnston et al., 2003; Eldridge and Freudenberger, 2005) and the conservation of biodiversity (Jansen and Robertson, 2001b; Dorrough et al., 2004), and major programs have been established to regain some of these ecological functions. However, in some areas, increasing intensification of productive land is still being promoted.

We suggest that in understanding these processes, it is important to be able to predict management effects on vegetation. Results emerging from Europe and elsewhere indicate that for the ground layer, management associated with different land uses can be linked not only to plant species composition, but to biological attributes of the vegetation (Al Haj Khaled et al., 2005; Louault et al., 2005). These attributes, in turn, influence the functioning of the landscape and the ecosystem goods and services that will ultimately be available for human well-being. The physiological basis of some traits has been noted as having global generality (Wright et al., 2005). However, the response of vegetation to management variables in terms of trait composition is far more complex, and can be affected by climate (Díaz et al., 2001; de Bello et al., 2005) and potentially by other factors such as evolutionary history. Trait data relating to management responses in Australian landscapes are currently limited to a small subset of potential land uses and environments, primarily because of disciplinary specializations in terms of the types of data collected and the land uses of interest (Robertson, 2000; Table 1).

This paper aims to provide a unifying framework for the understanding of vegetation change and trait responses to land use over the wider rural landscape. We used grassy eucalypt woodlands that are typical of temperate agricultural areas in eastern Australia as our example. A state-and-transition (S&T) model was developed to provide the framework, and in the process, we have aimed to summarize our current state of knowledge regarding floristic change and trait response, and to identify knowledge gaps. Our approach is an advance on previous models which deal with vegetation states and transitions, in that has consciously attempted to synthesize floristic information from both agricultural and ecological disciplines. In addition, we have systematically considered functional attributes associated with the vegetation states and, where trait information is absent for the region, we have used studies from Europe and elsewhere to predict attributes that would be expected to occur. Our aim is to provide a set of hypotheses relating land use to plant traits that has the potential to be generalized across different

Table 1
Some general characteristics of research and associated literature concerned with the management of the grassy layer of eucalypt woodlands in agro-pastoral areas of south-eastern Australia

	Agricultural research	Plant ecology
Land uses studied	Sown pasture, fertilized pasture	Ungrazed (reference) areas, native pastures
Ecosystem features of interest	Soil health and fertility, biomass quality and production	Plant diversity, vegetation structure, plant functional responses, carbon and nitrogen cycles
Floristic data	A priori determined functional groups (perennial, annual, grass, legume)	All plant species
Management variables of interest	Managing grazing, fertility, cultivation and weeds	Managing grazing, fire other disturbances and weeds