Vegetation Changes in Southeast Australian Temperate Grasslands

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VEGETATION CHANGES IN SOUTHEAST AUSTRALIAN TEMPERATE GRASSLANDS

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Abstract

In temperate areas of southeast Australia, the combined effects of tree clearing, grazing, application of fertilizer and the introduction of exotic species have modified the original grasslands. This paper describes these changes and attempts to explain them in terms of ecological principles derived from North American grasslands. Stability of the original grasslands appears to have been due to the lack of disturbance and the slow rates of nitrogen (N) cycling within them. Increased N cycling after disturbance has allowed invasion of species better adapted to higher N status, particularly exotic annual grasses and weeds. The present composition of grasslands, in terms of native perennial grasses and exotic species appears to be explainable by the ecological principles outlined.

Keywords: Botanical change, Australia, native grasslands, grazing, fertilizer, nitrogen

Introduction

Botanical change in Australian grasslands is closely linked to agricultural development since settlement in 1788 (Moore 1993). Because of isolation, a unique vegetation originally developed in Australia which was very sensitive to changes in grazing, soil fertility and the introduction of exotic species. This vegetation was characterized in grassland areas by a dominance of perennial grasses. There were few legumes present and, consequently, soil N levels were likely to have been low.

After settlement, livestock and agricultural practices were imported from Europe. The effects of grazing by domestic and feral animals, accidental introduction of cool-season annual grasses, legumes and forbs, and of a changed pattern of burning were marked. In addition, exotic plants were deliberately introduced into agricultural areas, either legumes oversown with superphosphate, or introduced grasses and legumes sown after removal of the existing vegetation by cultivation. This paper seeks to describe the botanical changes which have occurred and to explain them in terms of recently proposed ecological processes.

Patterns of change

Botanical change in the temperate grasslands of south-east Australia has been described by Moore (1993). Figures 1 and 2 show the separate (but interrelated) pathways of change which occur for pastures on the southern tablelands of NSW which have been either originally unsown (Figure 1) or cultivated and sown (Figure 2). The first major change in composition (to Stage II - Figure 1) was from taller warm-season perennial grasses (e.g. *Themeda triandra*) to shorter cool-season perennials such as *Austrodanthonia* spp. and *Austrostipa* spp.

The next change in composition (to Stage III – Figure 1) was caused by further grazing and the application of fertilizer. Legumes and annual grasses increased as a result of increased soil fertility. While *Austrostipa* spp. remained, the balance of native perennial grasses shifted more towards *Austrodanthonia* spp. and, where rainfall was adequate, *Microlaena stipoides*. Further degeneration of pastures to the final stage of annual dominance described by Moore (1993) is indicated by the path from III to IV. Although Figure 1 allows for the possibility of reversion from Stage IV to III, the mechanisms are unclear, and it is unlikely to be easily achieved.

Where cultivation occurs and introduced species are sown with fertilizer, grasslands from Stages I, II, III and IV (Figure 1) can be converted to Stage V (Figure 2). Depending on soil conditions (e.g. soil acidity) and the success of establishment, resultant pastures can range from highly successful sown pastures to those with only low proportions of exotic species present. There is some evidence that pasture composition can move from Stage V to VI (Figure 2) under the influence of increased soil acidity, reduced fertilizer, drought and overgrazing (Hutchinson and King 1999).

Stage VI pastures represent a situation that is common on the tablelands of NSW (Kemp *et al.* 1996). While there are some remaining introduced perennial grasses, the proportion is low. The bulk of the perennial species may be made up of native year-long green grasses (e.g. *Austrodanthonia* spp.). Depending on season and fertilizer, inter-tussock spaces are filled with introduced cool-season annual grasses, legumes and weeds. Such pastures are stable and productive under a wide range of conditions, providing the perennial:annual ratio is high (Garden *et al.* 2000).

Progress to Stage IV (Figure 1) from VI (Figure 2) results when a pasture is destabilized, perennial grasses are reduced, and bare areas are created which allow recruitment sites for annual grasses. This situation can be created by overgrazing caused by drought and high stocking rates. Stage IV is an inherently unstable system, as changes in botanical composition are unpredictable and reliant on timing of rainfall events.

Ecological processes underlying botanical change

Recently, the roles of two complementary ecological processes, competition and recruitment limitation, have been recognized as important determinants of plant community structure (Tilman 1997; Hubbell *et al.* 1999). Recruitment limitation (the inability of species to disperse, germinate or establish successfully) is a major factor determining species composition between sites, while competition has strong effects within a site.

We propose that competition and recruitment limitation may have been important in determining change in Australian temperate grasslands (Figure 1), through interactions with grazing and other management and environmental factors. Nitrogen is often the most limiting resource in many grasslands (Wedin 1995). The original dominants of Australian temperate grasslands were warm-season perennial grasses which are generally good competitors for N and tend to maintain soil mineral N at low levels (Moore 1993; Wedin and Tilman 1993). The competitive dominants in North American tallgrass prairie are the species that can reduce the concentration of the limiting resource to the lowest level (Wedin and Tilman 1993). These species thus create the low N conditions in which they are superior competitors. This positive feedback between plant competition and N cycling may be an important process in maintaining stability of many grassland plant communities, including the Stage I Australian grasslands referred to in Figures 1 and 2.

Grazing precipitated the change from Stage I to Stage II pastures (Figure 1). The native, warm-season perennials were poorly adapted to grazing and, thus, grazing reduced the cover and production of these dominants, caused soil disturbance which created open sites for invasion of other species, and increased the rate of nutrient cycling via the animal pathway. Under this new regime, the previously subordinate cool-season perennial grasses, which were more tolerant of grazing and better recruiters, were able to become dominant. Also, Stage II pastures had higher levels of soil mineral N, allowing naturalized annual species to invade.

Further grazing and the application of fertilizer caused the change from Stage II to Stage III pastures. Greater fluctuations in soil mineral N under Stage III pastures, in combination with climatic variation, can result in large fluctuations in the proportions of perennials and annuals within and across years. These transient and reversible fluctuations in species composition generally do not cross thresholds and, thus, these Stage III pastures are considered to be stable under a wide range of conditions (Garden *et al.* 2000). However, continued grazing and inputs of fertilizer, perhaps in combination with an extreme climatic event such as drought, can destabilize these Stage III pastures and shift them to a state dominated by less stable and less productive annual species (Stage IV).

These ecological processes are hypothesized to operate in a similar manner in determining species composition in cultivated situations, as outlined in Figure 2. The main difference is that the introduced perennial grasses are poor recruiters, so changes in pasture states (Stage V to Stage VI, and Stage VI to Stage III or Stage IV) due to loss of these species are considered essentially irreversible, due to recruitment limitation.

Although we have provided some support for the role of these ecological processes in determining patterns of change in Australian (native) temperate grasslands, much of this discussion remains hypothetical, awaiting experimental testing. Nevertheless, the importance of the complementary roles of competition and recruitment limitation in structuring such diverse plant communities as tallgrass prairie (Tilman 1997) and tropical forests (Hubbell *et al.* 1999) suggests that these processes are generic and likely to be important in Australian temperate grasslands as well.

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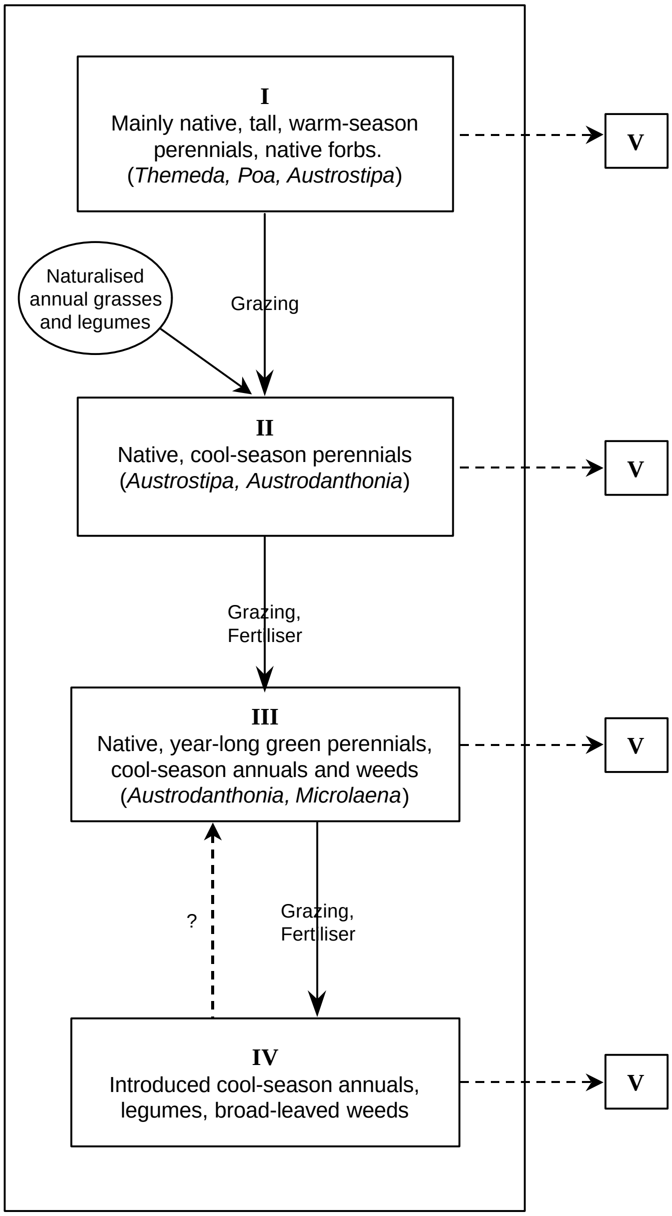

Figure 1 - Sequence of botanical changes in native grasslands on the southern tablelands of New South Wales without cultivation. Species listed are dominants only. Links to Stage V refer to Figure 2.

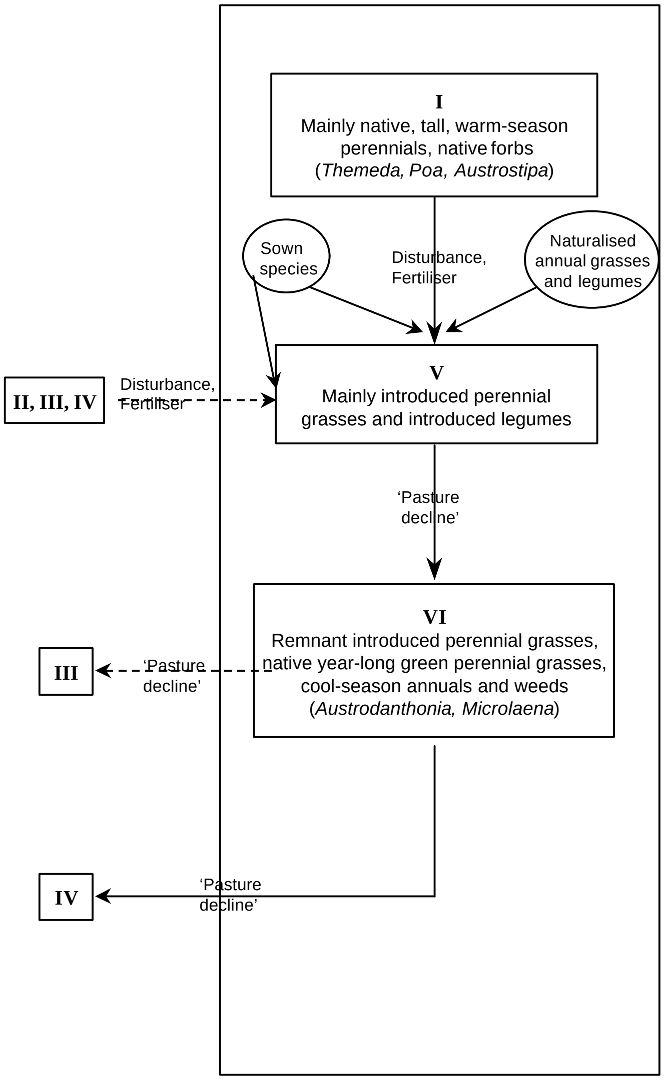

Figure - 2 Sequence of botanical changes in native grasslands on the southern tablelands of New South Wales following cultivation and sowing of exotic species. Species listed are dominants only. Links to Stages II, III and IV refer to Figure 1.