# ANALYSIS OF PASTURE MANAGEMENT PRACTICES WITHIN A PASTURE COMPOSITION MATRIX MODEL

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## ABSTRACT

In extensive livestock industries better pasture management is seen as the main strategy to improve poor quality pastures, or to maintain newly sown ones. Pasture management practices need to be evaluated within a framework that considers the desirability of changes in species composition rather than simply considering the statistical significance of the results. This can be done through the *state and transition* model used in rangelands management, but difficulties were found when applying that model to temperate perennial pastures as the interactions between species often showed continuous distributions. An alternative *pasture composition matrix* model based on the ratios of functional species groups i.e. legumes : other broadleaved species plotted against perennial : annual grasses, enabled most pastures to be defined with four common *states* in a continuous *matrix* and the impact of management treatments to be assessed. Data can be plotted directly on this *matrix* as shown with results from an experiment on a degraded cocksfoot pasture. The patterns of change can then be shown simply, for extension messages.

## KEYWORDS

Pasture management, states, species, composition, matrix, evaluating results

## INTRODUCTION

In southern Australia composition of the dominant naturalised temperate perennial pasture ecosystems is frequently suboptimal for production and sustainability (Kemp and Dowling, 1991) and this has been attributed to management and environmental factors and plant competition (e.g. Moore, 1970). Resowing pastures to restore composition and productivity is an expensive option and alternative management strategies are being considered. The impact of practices needs to be defined in ways that enable research results to be evaluated and readily translated into advisory messages. Similar needs exist in rangelands where management has progressed from being based on the single climax theory, to acceptance that ecosystems can exist in a number of more, or less stable *states*. This has led to the development of the *state and transition* model (Westoby et al., 1989) as a framework for interpreting research results and as a tool for technology transfer. This model has been applied to higher rainfall native grass ecosystems (Lodge and Whalley, 1989), but difficulties have been found when applying it to a range of different pastures ecosystems (Kemp et al., unpublished). Typically within temperate perennial pastures, continuous distributions are seen with some cyclical behaviour, rather than step changes between components.

This paper outlines an alternative *pasture composition matrix* model and then illustrates its use for defining the impact of management treatments on a degraded cocksfoot (*Dactylis glomerata*) pasture and for providing advice to farmers.

## METHODS

**Model concepts.** The model is structured on four functional species groups that are common in most naturalised temperate perennial pastures i.e. perennial and annual grasses, legumes and other broadleaved species. Most of the grasses compete for similar resources, and the ratio of perennial to annual grasses can provide a separation into different pasture *states*. This is particularly relevant where the aim is to improve, or maintain, the proportion of perennial grasses in a pasture i.e. the ratio of desirable to less-desirable grasses. The ratio of legumes to other broadleaved species separates pastures into weedy (less-desirable e.g. thistles) to legume (desirable) dominant mixtures, to aid pasture management for the non-grass components.

These ratios, when expressed as proportions of the biomass, can be readily used by producers and their advisors and are easily obtained using dry weight ranks (Tothill et al., 1992). Four *states*, in terms of the dominant species groups can be defined by using ratios of 1:1 to define boundaries and plotting the legume: broadleaf weeds ratio against that for perennial: annual grasses (Fig. 1) i.e.:

- annual grasses and broadleaf weeds
- annual grasses and legumes
- perennial grasses and broadleaf weeds
- perennial grasses and legumes

**Data.** To investigate the use of the *pasture composition matrix*, data was used from an experiment on a degraded cocksfoot pasture (Dowling et al. 1996). The pasture had been sown at Newbridge in central New South Wales in the 1980's, but over time perennial grasses had declined while annual grasses (especially *Vulpia* spp.) and thistles had invaded. The main legume was subterranean clover (*Trifolium subterraneum*). The pasture was continuously grazed with sheep and management treatments were imposed on plots within the pasture. Half the experiment was not fertilised and the other half fertilised at recommended rates, based on soil tests (250 kg superphosphate / ha / year plus 2 t lime (surface applied) / ha in each of the first two years). Measurements of composition were taken every six weeks from June, 1990 until June, 1996. The management treatments presented are: i) continuously grazed control, ii) three month summer rest from grazing, and iii) herbicide treatment (carbetamide at 2 kg a.i. / ha for annual grass control in the first three years then oversown with cocksfoot seed and summer rests imposed in later years).

## RESULTS

Under continuous grazing and without fertiliser the composition of the pasture at Newbridge was dominated by annual grasses and variable legume / broadleaved species (Fig. 1a). With the addition of fertiliser, the perennial grass content increased in 1995 (Fig. 1b), but in general annual grasses dominated the continuously grazed treatments. In contrast, both summer rest treatments caused a larger shift towards more perennial grasses and more broadleaved species, fertiliser increased the size, but not the direction of change (Fig. 1c, d). Herbicide applications reduced annual grasses causing an initial shift towards more (apparent) perennial grass (Fig. 1e, f), but the real increase only occurred after 1994 when cocksfoot seed was broadcast and a summer rest applied on this treatment. The herbicide treatment had a larger impact on the legume: broadleaves than summer rest as there was not the same strong movement to the perennial grass / broadleaved *state* (lower right quarter of *matrix*) and more points started to appear in the upper right of the *matrix* after the treatment was modified. The cyclical nature of some of these changes during each year is evident.

## DISCUSSION

The evaluation of research results within this *matrix* enables the agricultural relevance of these management tactics to be considered. Statistical analyses showed significant differences between these treatments, but gave no clues as to the mechanisms involved or whether the resultant pasture was satisfactory. These plots show when changes were occurring, which species groups were changing the most and how useful the overall direction of change was. For this pasture, both the summer rest and herbicide treatments had useful effects, increasing over time, but a combination was needed to shift the pasture into the more desirable state i.e. the top right of the matrix. Fertiliser influenced the scale of change, but not the direction. Summer rest had a larger effect in years with enough summer rain to enable seed set of the perennial species and for some seedling recruitment to occur. The *matrix* allows the direct evaluation of research results and then a simplification of those results for advisory messages. Extension information can be easily shown on these diagrams by using arrows to describe the general direction of treatment effects and removing the data points.

The *pasture composition matrix* provides a broad overview of the state of a pasture in terms of the major functional groups commonly found within pastures. Since the *matrix* is designed to explore the interactions between components, it may not be useful in pastures dominated by only one, or two desirable components. The present model for the *matrix* only considers four *states*, but could be extended to more *states* to identify more specific boundaries for pasture management and linked to pasture productivity (Kemp et al., 1996). The number of defined states would depend upon needs and the sophistication of the user.

Within each ratio, the relative proportions of species are considered, but between grasses and the other species they are not. This could be a difficulty where for example, the non-grass components were not really a significant part of the pasture. This could result in some erroneous conclusions about management treatment effects and users would need to consider that when using this model. As with many generalised approaches some critical judgement is needed in interpretation. This same problem applies in the conventional *state and transition* models which often do not quantify the relative proportions of species.


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**Figure 1**

Trends in composition against the pasture species *matrix*, over six years for a degraded cocksfoot pasture under three management treatments with nil or recommended fertiliser. Numbers indicate the last digit of the year from 1990 to 1996. Dashed lines mark the 1:1 ratio for perennial and annual grasses, or for legumes and other broadleaved species. Measurements taken every six weeks. Axes are in log scales.