THE PASTURE SPECIES COMPOSITION MATRIX: AN AID TO INTERPRETATION?? OF RESEARCH RESULTS

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Abstract

Pastures are typically complex mixtures of many species, some being more desirable than others. An important aim of management is to optimise the composition of those mixtures to improve productivity and sustainability of the pasture. In the past the results of management experiments have been analysed using univariate techniques. The analysis of individual components may show significant differences between components but that may not mean a lot in a wider agricultural context, nor does it tell how components reacted to each other. A series of analyses need to be done and then interpreted through discussion to understand the inter-relationships among species. This paper outlines a tool, the *pasture species composition matrix model*, which has been developed to consider the status, trends and functional group interactions in pasture composition. Research results can be displayed on one diagram and then simplified to deliver messages to producers on the impact of treatments. This approach has similarities with the *state and transition* model developed for rangelands, but overcomes some of the limitations of that technique. Use of this model will be illustrated with data from a series of experiments designed to investigate management techniques for the control of vulpia in a phalaris pasture.

Key words: Pasture composition, matrix, analysis, management, goals, phalaris, vulpia, functional groups.

Pastures are complex mixtures of desirable and less-desirable species. Pasture research, development and management have the common goals of optimising and maintaining the composition of these mixtures. Traditionally emphasis has been placed on individual components and a univariate approach (*eg.* selected cultivars) for the analysis, interpretation and manage-ment of single pasture components but this is not always compatible with the need to optimise pasture mixtures. Research results of the behaviour of mixtures can be analysed using multivariate statistical procedures, but different techniques are then needed to package advice for producers. This paper outlines a technique that can put research results into a wider practical context by identifying the goal for management practices in a way that is readily translated into extension messages.

The *state and transition model* (6) was developed for rangelands as an advisory tool. It characterises communities as having reasonably stable states with more rapidly changing transitional phases between those states. Paths between two states can vary depending upon external factors and direction. To use this tool it is necessary to define the states and transitions and then determine what causes shifts in the communities. In it's present form the state and transition model does not allow research results to be directly superimposed on it and hence quickly analysed. It is a valuable extension tool, but difficulties are experienced when bridging the gap to research.

In temperate perennial pastures across southern Aust-ralia species composition is continually changing and while there is evidence that some stable states can exist (2), in other cases the changes among species are more continuous (4). The assessment of *states* may reflect the time intervals chosen between measurements and, or the scale of those measurements.

The *pasture species composition matrix model* (3) has been developed to characterise the status and changes in composition of typical temperate perennial pastures though it can be adapted to other ecosystems. It overcomes some of the limitations with the state and transition model. Instead of discrete states, the more likely conditions are considered to be part of a wider continuous distribution in composition. An important aspect of this matrix model is that external criteria can readily be set to decide if treatments and practices are achieving desirable pastures. Normally in experiments treatments are tested for statistically significant differences. However, while significance may be found, the actual scale of effects may still not be of much practical relevance.

The use of the pasture species composition matrix will be illustrated with results from experiments designed to manipulate the composition of pastures. These results are from a series of five complementary experiments run over four years in Central NSW which investigated a total of 120 treatments designed to de-velop better practices for the management of vulpia in a phalaris pasture (1).

The pasture species composition matrix

The pasture species composition matrix is based upon allocating species to functional groups, in its simplest application. Species and cultivars within a group are assumed to have more similarities than exist between groups. Grouping species and cultivars also reduces the number of components that need to be considered and avoids having many missing values. If no data are avail- able for a group it can be set at a low value (*eg*. 0.1%) to enable calculation of useful statistics. The criteria used to group species depend upon one's aim. In an agri- cultural context species can often be usefully allocated into four groups – desirable (*eg.* perennial) and less desirable (*eg.* annual) grasses, legumes and other broadleaf species (often weeds). This provides two desirable and two less-desirable groups. The ratio between the desirable : less-desirable grasses is then plotted against the ratio of legumes : broadleaves. On each axis mid-range boundaries are set to separate desirable from less- desirable states. This delineates four potential states. These states vary from less desirable grasses and weeds in one quarter to desirable grasses and legumes in another. The position of boundaries depends upon the range in the data and an appropriate ratio to identify desirable pastures. In practice the data can be constrained to a range of 0.1 to 10 as this provides limits of 10:1 at either end, illustrating dominance by one species. There is little merit in going beyond that range unless the aim is to reduce the less desirable components to trace amounts, an unlikely case on farms. In the absence of other criteria to separate states a boundary ratio of 1:1 can provide an initial estimate of when the desirable group is exceeding the less desirable. In such cases log- arithmic scales are best used to portray the data. Where boundary ratios of greater than 2:1 apply, linear scales are more suitable.

Data for these analyses can be obtained using a variety of techniques. Among the more useful are dry weight ranking (5), or direct measurement of yields within each functional group. Such data already form part of many research programs and are understood by producers, who can use related techniques (*eg.* as promoted in PROGRAZE? courses). The ratios between functional groups can be subjected to statistical analyses if required. For this paper that was not done as information came from five separate experiments and the aim was more to identify potentially important management tactics.

Results and discussion

The results presented here are a minor part of a large program and complement those being presented in another paper (1). The 120 treatments explored factorial combinations of a range of grazing, herbicide, fertiliser and other tactics designed to limit vulpia species within a phalaris pasture. The matrix has been used here to provide an initial indication of which treatments resulted in a desirable pasture. The data used were those obtained in early spring each year as that is considered to provide a better comparison across years.

The matrix used with these data constrained the ratios on each axis to a range of 0.1 to 10. Grasses were the major components over the four years of experiments. The perennial grass component was almost exclusively phalaris and the annual grasses were dominated by vulpia species. Other results (1) indicated that at least 80% phalaris was needed to stop vulpia growth over winter. If vulpia accounted for the remaining 20% of a pasture then this set a ratio of 4:1 as the appropriate boundary. That ratio was considered suitable as the data further indicated at least 50% phalaris was required before vulpia growth was restricted. At that level a 4:1 ratio would result in 12.5% vulpia. In general it is considered that the effective practical limit for control of vulpia in a pasture is 10-15%. At this site the interactions between legumes and broadleaves were limited and the boundary value for a desirable state was left at 1:1. In general legumes were dominant over broad-leaves. Data from 1995 to 1997 are presented. The 1994 data were obtained before many treatments had been fully implemented. Initial measurements found that the pasture had a reasonable legume content, but was dominated by vulpia.

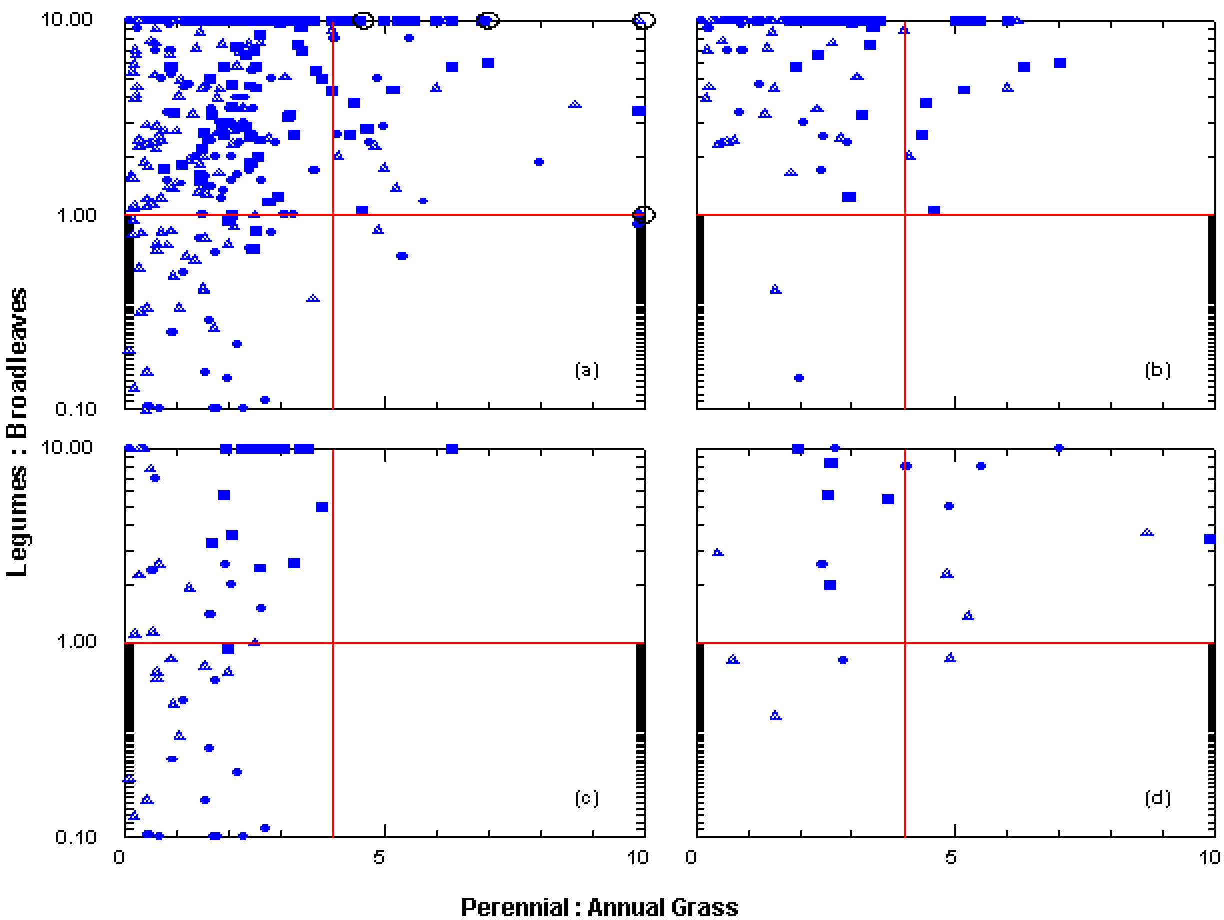

Figure 1

The majority of treatments did not result in a desirable pasture (Fig. 1a) as described by the 4:1 and 1:1 boundaries *ie*. the top right of the graph. Most treatments resulted in pastures where the perennial : annual grass ratio was less than 4, though the legume content was greater than broadleaves. The majority of continuously grazed treatments were in this group. The better treatments *i.e.* perennial : annual grass greater than 4, included all the ungrazed treatments and others where strategic rests during autumn and, or winter were used, extra grazing pressure and, or herbicides.

Many pasture plants are sensitive to grazing during flowering and a range of treatments was explored where extra grazing pressure was applied during tiller elongation. These were more effective in 1995 and 1996 (Fig. 1b). Where desirable changes in composition occurred, the outcome was better the earlier extra graz-ing was applied. The acceptability of vulpia to sheep declines as flowering advances. Reasons for the differ-ences between years are uncertain. Treatments that incorporated extra grazing pressure also had a lower content of broad-leaves.

Herbicides are an important management tool. However treatments that incorporated glyphosate (applied in early spring) were only effective in one case (Fig. 1c) and generally resulted in a decline in legume content and continuing dominance by vulpia. Simazine (Fig. 1d) and paraquat (data not shown) were more useful, though their effects depended upon the year. For example the simazine treatments in 1995 were ineffect-ive. Simazine had no effect on the legume content. The spread in results from the herbicide treatments was similar to that achieved with extra grazing pressure.

Conclusions

The use of the matrix enables an efficient appraisal of the treatments that resulted in a desirable pasture composition. The only individual treatments that always limited vulpia were those where grazing was excluded for a long period, but that is not always a practical option. The alternative is to use combinations of tactics to achieve effective control. Given the many options available it was not possible to test all combinations, but the indications are that a combination of some rest in autumn and winter followed by extra grazing pressure as soon as tillers start to elongate will help control vulpia populations. In the early phase of a vulpia management program herbicides are useful to initially reduce weed populations but need to be combined with other tactics to maintain vulpia at low levels. More studies are needed to refine all tactics as results were often quite variable for this difficult to control weed. The impact of climatic variability needs to be better defined.

The *matrix* is best used to investigate management techniques that bring a pasture into a desirable *state*. Once pastures are in a desirable *state* then other pro-cedures are needed to refine management and optimise production. The figures presented here can also be simplified to illustrate to producers what is a desirable pasture in relation to treatments and the status of their own pastures can be superimposed on the matrix diagrams. Trends in individual pastures and treatments can be shown over time. In some cases it would be important to identify the treatments that achieved for example, a legume content above some limit or desirable levels of herbage mass. These points could be identified by different symbols or the average values could be portrayed as contours over the whole data set.

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