State and transition models for rangelands. 9. Development of state and transition models for pastoral management of the golden beard grass and limestone grass pasture lands of NW Australia

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Abstract

This paper describes the development of state and transition models for pastoral management of the golden beard grass (*Chrysopogon fallax*) and limestone grass (*Enneapogon* spp.) pasture lands in the north-west of Australia. The models were developed with the specific aims of: describing the effects of management and seasonal conditions on botanical composition; providing a practical and effective tool to enhance management of the pasture types for grazing; and providing a tool to enhance communication of range management practices and principles between producers, extension officers and research workers.

Vegetation change in both pasture systems was found to be driven by seasonal conditions, degree of utilisation and frequency of fire. The golden beard grass model was well received by an industry group in terms of its ability to describe the pasture system as presented by the authors. However, prolonged discussion ensued on the accuracy of the model, particularly in terms of the role of fire. The model provided a useful tool for collating and representing accumulated knowledge and opinion. As a process, it imposed a logical structure which tested the validity of opinion and anecdotal evidence. It also provided a useful method for identifying where changes in states could not be easily or reliably identified.

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Introduction

The golden beard grass (*Chrysopogon fallax*) and limestone grass (*Enneapogon* spp.) pasture lands are significant for pastoral production in the north-west of Australia. They generally occur in the transitional zones between high rainfall areas supporting tall tropical annual and perennial grasses, and the more arid areas supporting short tussock grasses including the mitchell grasses (*Astrebla* spp.) on the heavy clay soil types (Stewart *et al.* 1970).

Golden beard grass communities are found on heavier clay soils, whereas the limestone grass communities are generally associated with lighter calcareous red earths, but may also occur on basalt-derived red earths. The two pasture types, however, are generally closely associated in a landscape noted for its mosaic of pastures and soils. Most importantly, they are productive pasture types for grazing. The golden beard grass, being a perennial community, is relatively stable. Dry matter yields may vary between 500-3 500 kg/ha depending on season (Stockwell 1989). The limestone grass is perceived as an annual pasture community although perennials often dominate. It is a lower yielding pasture community, and due to position in the landscape and an earlier response to seasonal rainfall, it can be preferentially grazed.

Pasture management research on these pasture types has been much less than on the tropical tallgrass pastures to the north, or the mitchell grass systems and the arid pasture types to the south. However, some information is available from the work of Foran *et al.* (1985), Stockwell (1989), R.T. Andison (unpublished data) and M.H. Andrew (personal communication).

This paper describes the development of state and transition models (S&Ts) (Westoby *et al.* 1989) for pastoral management of these pasture types, the aims being to produce models which would:

- describe the effects of management and seasonal conditions on botanical composition;
- provide a practical and effective tool to enhance management of the pasture types for grazing; and
- provide a tool to enhance communication of range management practices and principles between producers, extension officers and research workers.

Materials and methods

The use of scientific jargon or manner in language, writing style and the general description of the S&Ts were avoided to aid acceptance by practical land managers.

The authors represent a group who had some experience with, and had previously built, S&Ts for these or similar pasture types. The work of Foran *et al.* (1985), Stockwell (1989), Bastin and Andison (1990), R.T. Andison (unpublished data), Ash *et al.* (1993; 1994), Bellamy *et al.* (1993) and Bellamy and Brown (1994) contributed to the knowledge base used to build the models.

A workshop session was devoted to building, critiquing and testing the model based on the group's experience and input by others such as J.J. Mott, University of Queensland.

Detailed models built previously (T.G.H. Stockwell and R.T. Andison, unpublished data) were used as a starting point, with transitions and states tested against others developed on similar pasture types in other areas (Ash *et al.* 1993; Bellamy *et al.* 1993).

Repetitive questioning of the criteria for defining states and the various transitions driving change was used to simplify the models. The aim was to identify easily recognisable and distinct states and transitions, which could be reasonably justified on the basis of existing data or collective knowledge and experience.

After the workshop, the model for the golden beard grass pastures was presented to a group of producers, who manage these pasture types on their properties, to gauge the degree of success in achieving the aims of the workshop. Colour coding was used in the presentation to producers to provide another dimension of description. Green was used for desirable states and desirable transitions. Amber was used to signify less desirable states but those which could be managed within an existing system. Similarly amber transitions were undesirable but generally achievable within a management system. Red states and transitions were those which were totally undesirable and reversible only with high cost intervention by management. Transitions requiring high cost management inputs were described by broken lines.

Results

Vegetation change in both pasture systems was found to be driven by seasonal conditions, degree of utilisation and frequency of fire.

The proposed S&Ts for grazing management of the golden beard and limestone grass communities are described in Figures 1 and 2, respectively, and the associated transitions are detailed in Tables 1 and 2. The probability referred to in the tables is the likelihood of a transition from one state to another occurring, given that the pasture is in the initial state and the stated cause occurs for the time-frame indicated.

Table 1. Transition between vegetation states described in Figure 1 with an indication of likely cause, probability of the transition occurring and time-frame for the transition to occur.

Transition	Cause	Probability	Time-frame
T_{12}	Heavy continuous utilisation	High	2–3 yr
	Moderate grazing	High	3–5 yr
T_{21}	Light utilisation	Moderate	3 + yr
T_{23}	Heavy utilisation Aristida present	High	2 yr
T_{32}	Nil or light utilisation	Moderate	2 + yr
T_{34}	Heavy utilisation	High	2 yr
T_{43}	Moderate utilisation	Moderate	1 yr
T_{42}	Nil or light utilisation	Low	3 + yr
$T_{15,25,35,45}$	Lack of fire	High	5–15 yr
$T_{51,52}$	Seasonal spelling, good rainfall conditions to give high fuel load, fire, herbicides	Low	5–15 yr

Table 2. Transition between vegetation states described in Figure 2 with an indication of likely cause, probability of the transition occurring and time-frame for the transition to occur.

Transition	Cause	Probability	Time-frame
T_{12}	Light to moderate early wet season grazing, perennial grasses seed	High	2–3 yr
T_{21}	Heavy utilisation of perennial grasses	Low	2–3 yr
T_{16}	Heavy utilisation	High	2 yr
T_{61}	Seasonal spelling, seed present, good rainfall	Low	1–2 yr
$T_{25,35,15}$	Lack of fire	Medium	8–15 yr
T_{52}	Good seasons, high fuel load, fire	Medium	5–15 yr
T_{23} T_{36}	Heavy utilisation	High	2–3 yr
T_{64}	Nil — low utilisation, seed available	Medium	2–5 yr
T_{42b}	Nil — low utilisation, seed available	Medium–high	2–3 yr

The workshop group expressed a high degree of confidence in the validity of the S&T constructed for the golden beard grass community, but was less confident regarding the model for the limestone grass community.

Little progress was made in combining the models for the two pasture types.

Although the golden beard grass model was well received by the industry group in terms of its ability to describe the states in the pasture system as presented by the workshop group, prolonged discussion ensued on the accuracy of the model, particularly in terms of the role of fire in causing transitions.

Discussion

The model provided a useful tool for collating and representing accumulated knowledge and opinion. As a process, it imposed a logical structure which tested the validity of opinion and anecdotal evidence. It also provided a useful method for identifying areas where changes in states could not be easily or reliably described.

The reaction of the industry group was informative. The model was extremely successful in presenting the system as perceived by the workshop group. However, opinions varied on the accuracy of the model in terms of the effects of grazing and fire. The group argued against many of the proposed transitions but, interestingly, used the structure of the model to describe their opinions. The discussion revealed the circumstantial nature of much of the evidence used to develop the model, which was highlighted by the widely varying experiences of individuals with respect to seasonal influences, land type, burning and grazing management regimes. This was not unexpected as the models were originally developed to describe gaps in the knowledge base to develop research programs. It does, however, suggest that, while the models may be useful at pasture management level for enhancing communication between producers, extension officers and research workers, the rationale for defining each state or, more importantly, each transition will need to be well described and widely accepted before these pasture types will be managed using the S&T framework. The ability to promote discussion on pasture systems should be seen as a positive role for the model. The disagreement expressed by producers with some aspects of the models, particularly transitions, supports the need to gain better knowledge of the forces driving the various transitions, as well as the specific use of the model in promoting communication between managers, their advisers and research workers.

The use of colour to add an extra dimension for description proved beneficial. Providing photographic evidence to improve the understanding of the various states would also strengthen the power of the model for communication.

The workshop group made little progress with developing a method for integrating models for different pasture types in a simple diagrammatic way. The use of several S&Ts within a spatial decision support system framework as proposed by Bellamy *et al.* (1993) appears the most promising solution at present.

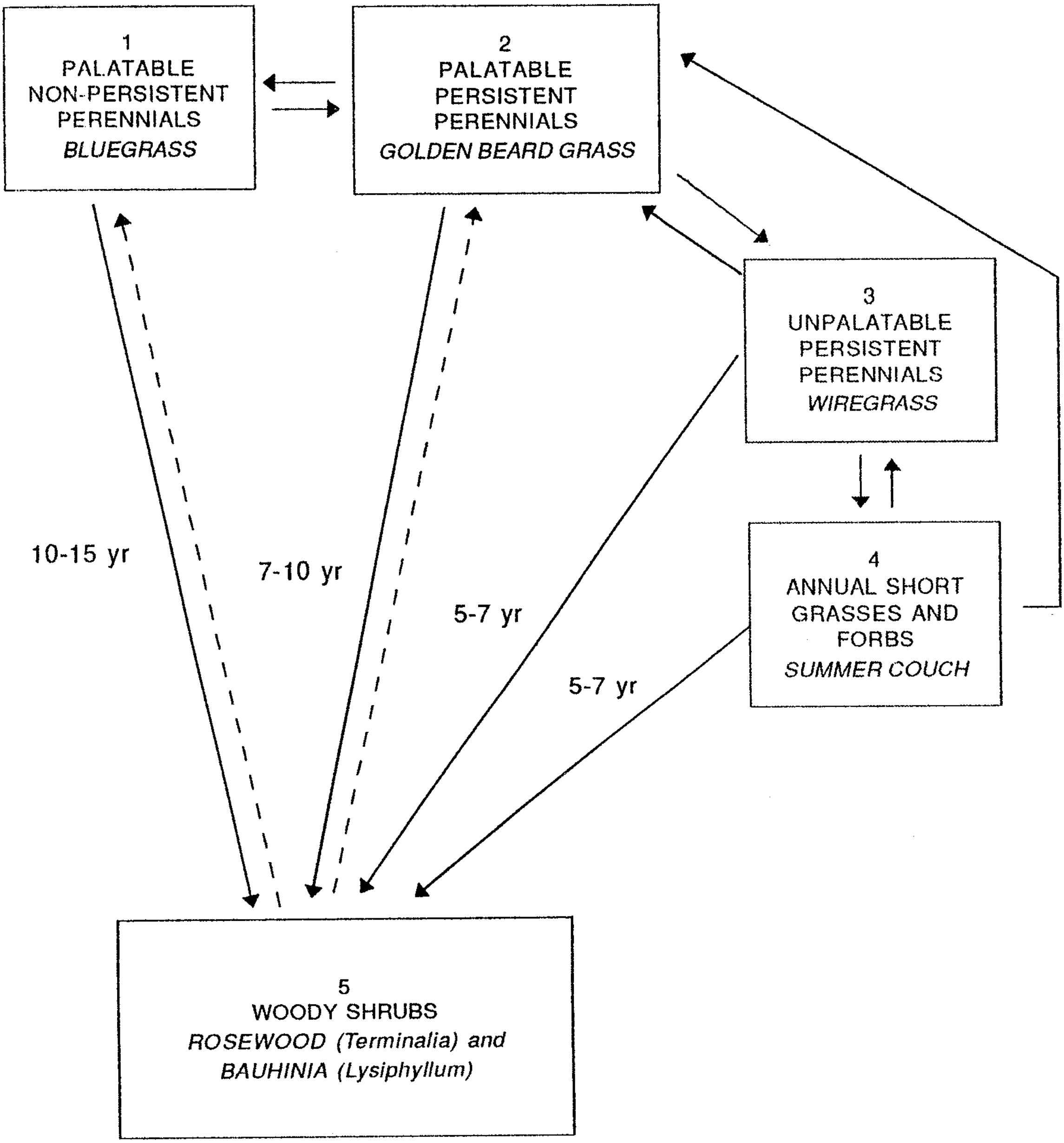

Figure 1. A state and transition model for pasture and shrub management on golden beard-bluegrass country in north-west Australia.

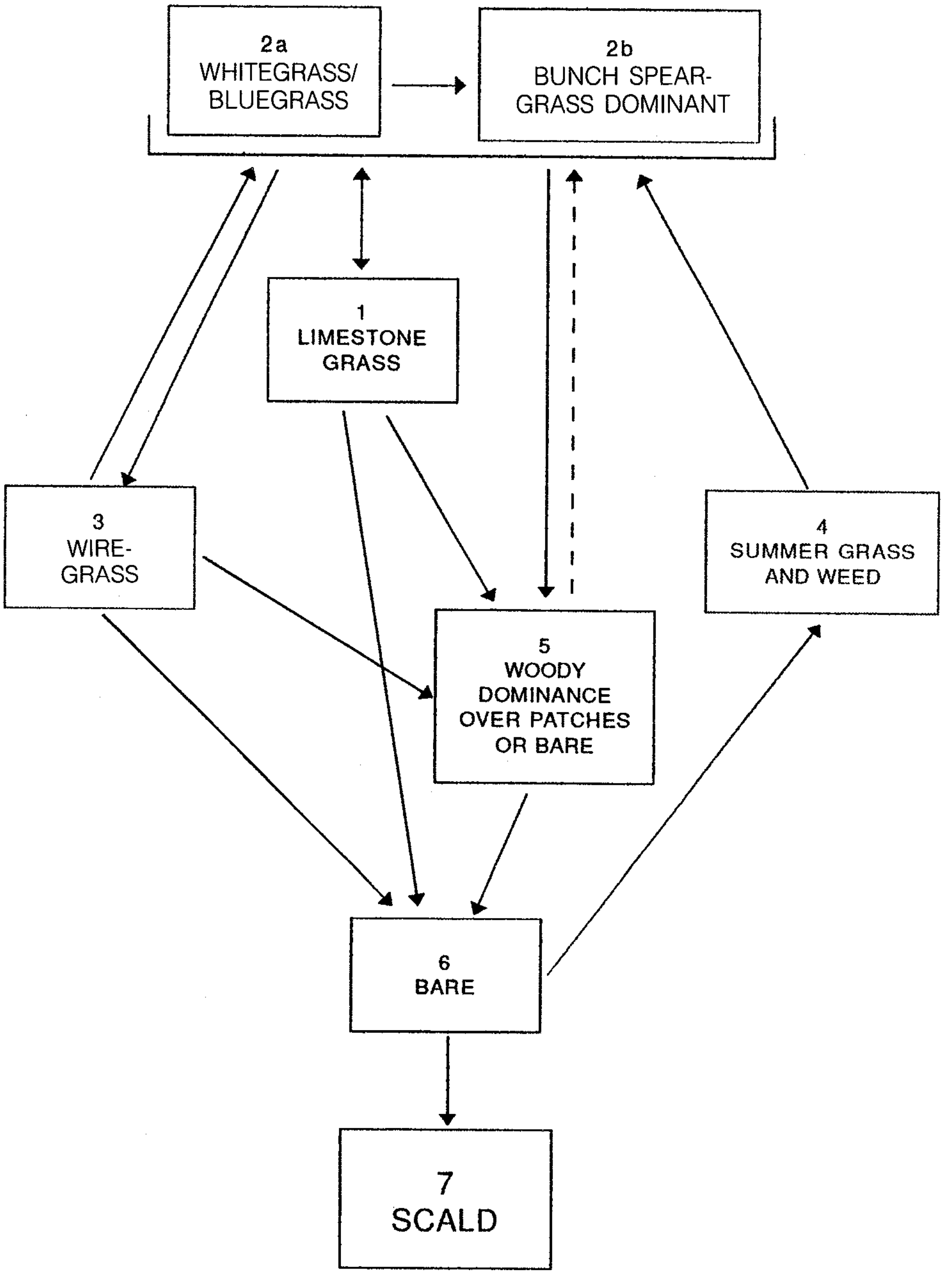

Figure 2. A state and transition model for pasture and shrub management on Victoria River District red country.

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