State and transition models for rangelands. 13. A state and transition model for the mulga zone of south-west Queensland

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Abstract

We present a state and transition model for the mulga zone of south-west Queensland describing different states involving shrub, tree, grass, forb, soil loss and seed reserves so that landusers can use the model to make responsible decisions about land management. Factors assisting transition between states, the time-frame for a high probability of the event to occur, and the relative degradation of each state are described. Areas where information is lacking include the effect of kangaroos and feral goats, and frequency and severity of grazing pressure and fire on trees, shrubs and pasture. Information transfer of the model to landusers is another problem and we suggest using a poster model with colour prints depicting each state.

Pasture zone description

The mulga zone of south-west Queensland comprises 150 000 km^2 and all falls within the semi-arid/arid region. Sheep and cattle raising are the main agricultural pursuits. The gross value of livestock production (wool and beef) has averaged $135M per annum for the period 1980-81 to 1989-90, highlighting the region's economic importance (Newman and Carson 1992). Annual rainfall averages 500 mm in the north-east to 250 mm in the south-west, with 67% falling in the summer months. Cold winters and hot summers characterise the area. The landforms are ranges, gently undulating plains, flat plains and run-on areas. Soils are mainly loamy red earths and sandy red earths. Infertile soils, low and variable rainfall and extremes of temperature ensure difficult conditions for plant growth. The vegetation is characterised by mulga and other trees, woody weeds, perennial and annual grasses and forbs. Mulga is a drought-resisting tree and is important as a food source for stock in drought and a supplement in dry times.

Woody weeds are a major problem through their association with land degradation and include shrubs and trees and, in some cases, mulga itself. The perennial grasses are medium-height tussock grasses which have drought dormancy. They are usually moderately palatable and are nutritious for several months after rain. The annual grasses survive dry periods as seeds and germinate and rapidly set seed following summer rain. During good conditions, they can become dense, and stands persist for several years. The forbs consist of drought-evading ephemerals which rapidly germinate, grow and set seed on mainly winter rain. They are palatable and nutritious (McMeniman *et al.* 1986).

Survey work has shown that two-thirds of the mulga zone is degrading through a lack of ground cover, increases in sheet erosion and woody shrub cover (Miles 1988). The degradation has been attributed to changes imposed since settlement. This involved increases in domestic and native animal grazing pressure resulting from increased watering points, and prevention of fires. The use of mulga phyllodes as drought fodder has also allowed heavy grazing pressure entering and exiting droughts, leaving the ground bare and prolonging recovery. Overgrazing and lack of fires have led to increases in shrub density, which further suppress perennial grasses.

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Table 1. Definition of vegetation and soil states occurring in the mulga *(Acacia aneura)* zone of south-west Queensland.

State 1. Mulga woodlands
— >200 mulga trees/ha
— <0.3% basal area of perennial grasses
— high-density seed source of annuals (forbs and grasses)
— 5–10 woody shrubs/ha (e.g. *Cassia, Dodonaea, Eremophila*)
— high-density seed source of woody shrubs and mulga
— good soil surface conditions
— <10 poplar box *(Eucalyptus populnea)*/ha

State 2. Mulga and shrubs
— <100 mulga trees/ha
— <0.3% basal area of perennial grasses
— 500–50 000 shrubs/ha (species dependent)
— 5–20% shrub canopy cover
— high-density seed source of woody shrubs and mulga
— <10 poplar box/ha
— season-dependent seed source of annuals (forbs and grasses)
— 2–4 cm soil loss

State 3. Mulga, shrubs and grass
— <100 mulga trees/ha
— 500–50 000 shrubs/ha
— 0.5–1.0% basal area of perennial grasses
— <10% shrub canopy cover
— moderate-density seed source of woody shrubs and mulga
— high-density seed source of annuals (forbs and grasses)
— <2 cm soil loss
— <10 poplar box/ha

State 4. Grassland
— <50 mulga trees/ha
— 2.5% basal area of perennial grasses
— <30 shrubs/ha
— <1% shrub canopy cover
— moderately limiting seed source of woody shrubs and mulga
— high-density seed source of annuals (forbs and grasses)
— <2 cm soil loss

State 5. Shrubs and grass
— no mulga trees
— severely limiting seed source of mulga
— 2000–50 000 shrubs/ha (species dependent)
— 15–25% shrub canopy cover
— 0.5–1.0% basal area of perennial grasses
— high-density seed source of woody shrubs
— high-density seed source of annuals (forbs and grasses)
— <2 cm soil loss

State 6. Bare ground
— no mulga trees
— severely limiting seed source of mulga
— <30 shrubs/ha
— <1% shrub canopy cover
— 0–0.1% basal area of perennial grasses
— very limited seed source of annuals (forbs and grasses)
— >5 cm soil loss

State 7. Mulga and grass
— <100 mulga trees/ha
— <1.5% basal area of perennial grasses
— <30 shrubs/ha
— <1% shrub canopy cover
— moderately limiting seed source of mulga and shrubs
— high-density seed source of annuals (forbs and grasses)
— <2 cm soil loss

State 8. Shrubs
— no mulga trees
— severely limiting seed source of mulga
— <0.3% basal area of perennial grasses
— season-dependent annuals (forbs and grasses)
— 500–50 000 shrubs/ha (species-dependent)
— 30–40% shrub canopy cover
— high-density seed source of shrubs
— 2–4 cm soil loss

State 9. Mulga seedlings, shrubs and grass
— 5000 mulga seedlings/ha
— <1.0% basal area of perennial grasses
— 500–50 000 shrubs/ha (species-dependent)
— 10–20% shrub canopy cover
— high-density seed source of mulga and shrubs
— high-density seed source of annuals (forbs and grasses)
— <2 cm soil loss

Table 2. Transitions between the vegetation and soil states defined in Table 1 and the time frame associated with a high probability of the transition occurring. T_{12} is the transition from State 1 to State 2 etc.

T_{21}	**Cause:** mortality of shrubs caused by drought and/or insect attack, low grazing pressure. **Time:** 10–50 yr.
T_{31}	**Cause:** mortality of shrubs caused by drought and/or insect attack, low grazing pressure. **Time:** >30 yr.
T_{13}	**Cause:** mechanical removal of mulga e.g. chaining, low grazing pressure. **Time:** <2 yr.
T_{91}	**Cause:** mortality of shrubs caused by drought and/or insect attack, low grazing pressure. **Time:** 10–20 yr.
T_{93}	**Cause:** low grazing pressure. **Time:** 10–20 yr.
T_{39}	**Cause:** mechanical removal of mulga, summer rain, low grazing pressure. **Time:** <5 yr.
T_{32}	**Cause:** high grazing pressure. **Time:** <3 yr.
T_{23}	**Cause:** low grazing pressure, fire. **Time:** <3 yr.
T_{37}	**Cause:** fire, mechanical or chemical shrub control, low grazing pressure. **Time:** <3 yr.
T_{73}	**Cause:** no shrub control, moderate grazing pressure. **Time:** <10 yr.
T_{34}	**Cause:** single hot fire or several moderate fires or chaining and single moderate fire, low grazing pressure. **Time:** <10 yr.
T_{35}	**Cause:** chaining, moderate grazing pressure. **Time:** <1 yr.
T_{76}	**Cause:** fire, followed by drought feeding of mulga, high grazing pressure. **Time:** <5 yr.
T_{67}	**Cause:** no grazing. **Time:** <10 yr.
T_{46}	**Cause:** drought, high grazing pressure. **Time:** 5–10 yr.
T_{64}	**Cause:** mechanical intervention to prevent runoff, reseeding perennial grasses, summer rain. **Time:** 10–20 yr.
T_{54}	**Cause:** fire, low grazing pressure. **Time:** <2 yr.
T_{45}	**Cause:** moderate grazing pressure, no shrub control. **Time:** <10 yr.
T_{74}	**Cause:** drought feeding, winter grazing only. **Time:** <2 yr.
T_{47}	**Cause:** no mulga seedling control, low grazing pressure. **Time:** <10 yr.
T_{84}	**Cause:** mechanical and/or chemical shrub and mulga control, low grazing pressure, summer rain. **Time:** 10–20 yr.
T_{85}	**Cause:** mechanical and/or chemical shrub and mulga control, low grazing pressure, summer rain. **Time:** <5 yr.
T_{58}	**Cause:** high grazing pressure. **Time:** 5–10 yr.
T_{86}	**Cause:** mechanical and/or chemical shrub control, high grazing pressure. **Time:** 1 yr.

A state and transition model

In some areas, drought feeding has led to over-utilisation of mulga, while in other areas, absence of sheep grazing and/or lack of fire has led to mulga forests. Episodic native insect attack can contribute to shrub and mulga mortality over large areas especially in drought. Excessive summer rains can lead to uncontrolled wildfires. Winter rains often lead to shrub germination and establishment. These processes together with unreliable seasons have led to the vegetation and soil states described in Table 1. The state data presented for the herbaceous layer are for average seasonal conditions (cf. Orr *et al.* 1993). Transitional processes between the states are given in Figure 1 and Table 2. Degradation is undesirable from an environmental and production viewpoint. The relative degradation status of each state is described in Figure 2.

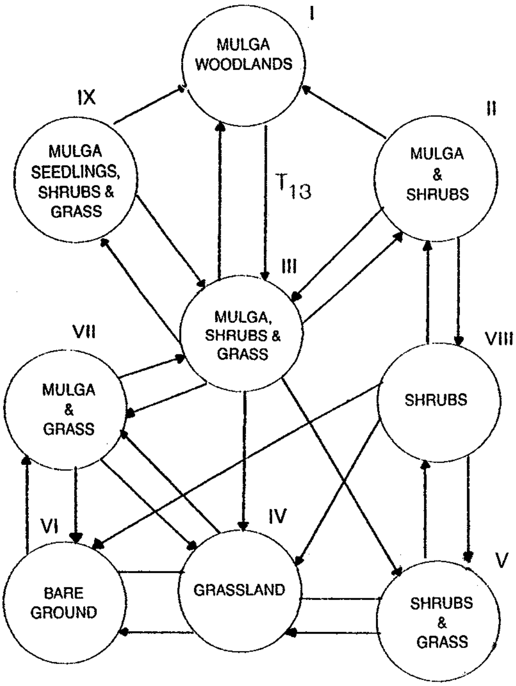

Figure 1. State and transition model for vegetation and soil states in the mulga zone of south-west Queensland. See Table 2 for explanation of transitions (e.g. T_{13} is the transition from State I to State III — the arrow indicates the transition direction).

The state and transition model presented is a guide to aid graziers in making responsible land-management decisions to combat the described undesirable states. Pasture and shrub species composition have been ignored to simplify the model and no distinction has been made between preferred and undesirable perennial grasses. Grazing pressure and fire severity are stated as low, moderate and high.

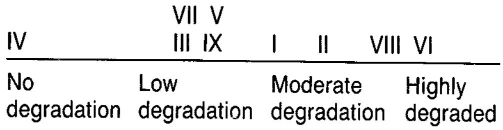

Figure 2. Relative degradation status of each state in Figure 1.

Knowledge gaps

Areas where information is lacking include:

- the effect of kangaroos and feral goats on total grazing pressure;
- the effect of varying frequency and severity of grazing pressure; and
- the effect of varying frequency and severity of fire on trees, shrubs and pasture.

During the workshop in which this model was presented, it was noted that the model was complex and could be difficult to understand. We concluded that a poster with a colour print representing each state and summarised captions describing transitions would be easier to grasp. This poster is currently under development. The model presented here was derived from an earlier interpretation given in Silcock *et al.* (1988). Burrows (1986) provides a detailed analysis of the reasons for woody plant dominance in these systems.

Acknowledgement

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