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USING A STAGE-STRUCTURED PROJECTION MODEL TO PREDICT THE SUSTAINABILITY OF POPULATIONS OF SHRUBS AND TREES IN THE CHENOPOD RANGELANDS OF EASTERN SOUTH AUSTRALIA

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ABSTRACT

The South Australian rangelands are characterised by dominant chenopod shrubs with over-story of long-lived tree species. Because of longevity of many plants, population models are widely recognised as basic tools for analysing demographic data (Caswell 2001). They can be used to identify important processes like population growth rate, longevity and extinction. We used the matrix model developed by Tiver *el. al.* (this volume) to evaluate the demography of an arid zone plant species *Acacia aneura* (mulga) F.Muell. ex Benth. at various herbivory intensities.

INTRODUCTION

Mulga is a small tree or large shrub ranging in height from 2-8 m, often multi-stemmed with a spreading crown. Mulga is a very common and significant plant species of Australian arid zone vegetation and mulga lands occupy a wide geographical range in Australia (Nix & Austin 1973). Flowering occurs after rains and wet winters are required for viable seed production (Preece 1971).

METHODS

Populations of mulga were surveyed during 2003 in the North-East pastoral district of South Australia, re-monitoring sites surveyed earlier by Tiver & Andrew (1997).

Mulga individuals of each species at each site were recorded into one of seven possible stage classes based on the nine stage-classes of (Tiver & Andrew 1997) with the exception that dead standing and dead fall (lying dead) individuals were excluded because they cannot be assigned vital rates. We used a modified "random walk" method to measure the populations following the technique previously used by Tiver and Andrew (1997). At each site, the recorder left a fixed point and followed a roughly circular path covering several hundred m and returning to the starting point. All mulga individuals which could be observed about 20 m either side of the transect line were recorded including seedlings of 5 cm height.

The matrix model developed by McArthur *et al.* 2006 (in press) and Tiver et al. (this volume) was used to determine projected demographic structures of populations of *Acacia aneura,* using as input the data collected in 2003. We used different grazing combinations to project the possible demography of plant populations over 500 years. The rainfall data used were 116 years of real rainfall records from Koonamore Station (SA), the file copied and repeated to provide data for the required 500 years. It is well known that watering points in sheep paddocks, by concentrating grazing have resulted in drastic effects on the plant populations. Taking this into account, our grazing combinations modeled heavy sheep grazing and moderate rabbit and kangaroo grazing near the watering points, and moderate sheep grazing and low grazing levels of kangaroos and rabbits far from the watering points. In addition pulse grazing (10 years sheep in and 10 years sheep out) was modeled to predict the usefulness of spelling in restoration of plant species within paddocks. These three scenarios were compared with a scenario of roadside vegetation reserves, where the domestic stock impact is nil but there is still access by rabbits and kangaroos. All these scenarios were compared against a projection showing intrinsic growth rate of populations (Lambda , λ, > 1) Begon *et.al.* (2006) by setting the model to $\lambda = 1.046$ and including no grazing variables.

RESULTS

A projected population showing intrinsic growth rate (λ =1.046) was appeared in the no grazing variables (Fig 1). An intrinsic growth rate (λ =1.043) to achieve a stable population against a background of grazing by rabbits and kangaroos was set for the road reserve populations (Fig 2). Stability was confirmed by a non significant regression slope ($p > 0.05$). This stability was maintained in spite of fluctuations in population number caused by rainfall variation. In the two set-stocked sheep-grazing scenarios (Figs 3 & 4), $\lambda < 1.0$, indicating extinction of *A. aneura* populations over 500 years. The downward slope was confirmed by regression analysis, giving a significant negative slope ($p < 0.001$). In the site nearest to the watering point (Fig 3) there is a drastic fall in the plant numbers and they reach half-extinction in 66 years. Extinction was slower in the sites far from the watering points, but was still inevitable, with half-extinction reached in 86 years (Fig 4). Pulse-grazing did not prevent extinction, with the population reaching half-extinction at 70 years (Fig 5).

DISCUSSION

Projected population growth rates from the matrix model indicated that the sheep-grazed *A. aneura* populations all declined over 500 years, with the most rapid decline in the first 100 years. Plant populations in the road side reserves, in the absence of domestic animals, were stable over 500 years. Assuming that the input parameters, based on literature and experimental data, are correct, the projections show that the sheep grazing is the most critical factor affecting population dynamics of *A.aneura* populations, with populations able to survive drought and grazing by rabbits and kangaroos at low numbers. There is spatial variation of plant populations: those nearer to the watering point decline at a grater rate than those far from the watering point where the grazing pressure is less, resulting in the elimination of palatable perennial plant populations around the watering points. These results are consistent with those of Hunt (2002), who found greater extinction of *Atriplex vesicaria* populations nearer to the watering point than the far from it.

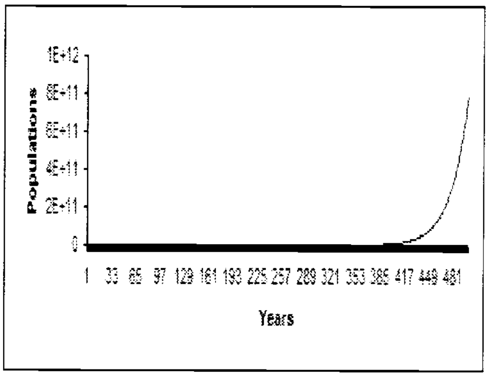

Figure 1: Model output showing an ungrazed population of *A. aneura* with an intrinsic growth rate (λ =1.046)

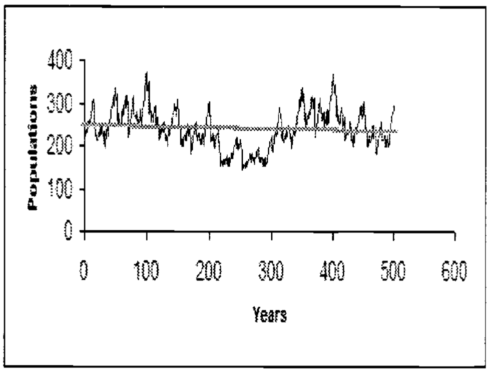

Figure 2: Model out put showing a stable population of *A. aneura* in road side reserves (Sheep=0, Rabbits=1 Kangaroos=1), (λ =1.043)

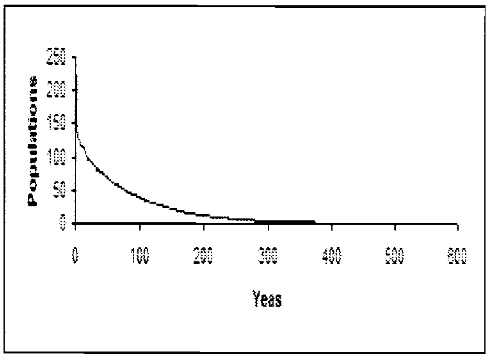

Figure 3: Model output showing extinction of a population of *A. aneura* at sites nearest the watering point (Sheep=4, Rabbits=1 Kangaroos=1), (λ = 0.998).

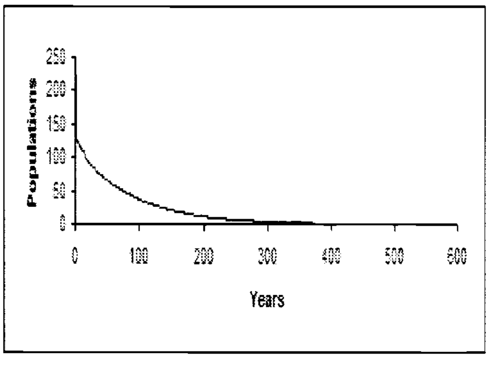

Figure 4: Model output showing extinction of a population of *A. aneura* at site furthest from the watering point (Sheep=2, Rabbits=1 Kangaroos=1), (λ =0.998)

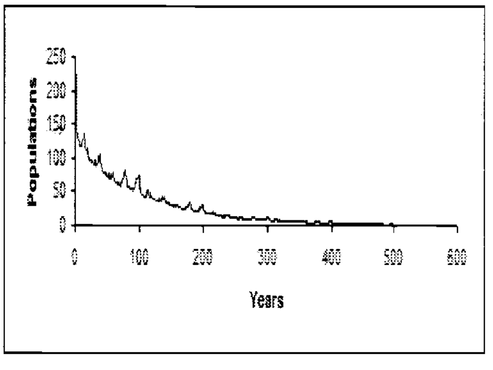

Figure 5: Model output showing extinction of a population of A. aneura under a pulse-grazing regime (10 years of sheep grazing alternating with 10 years of no sheep grazing), (λ =0.998).

However, our results indicate that palatable species can also be eliminated at points further from the watering points confirming Lange & Willcocks (1978).

CONCLUSION

In this study sheep are shown to have potential to cause extinction of *A. aneura* plant populations in all parts of paddocks. A large proportion of the Australian arid lands is not preserved as parks or reserves, but is subject to extensive grazing by herbivores. It is therefore essential that the effect of domestic herbivores is taken into account when planning for conservation and management of biodiversity in the arid lands.

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