Assessing Resilience of Pasture Production to Climatic Changes

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Introduction

Increasing temperatures and atmospheric carbon dioxide (CO_2) concentrations, together with changes to rainfall patterns, will influence seasonal pasture production; however climate change projections for south eastern Australia are uncertain (CSIRO and BoM 2007). Despite this, climate change impact assessments generally rely on specific climate projections, but in this study an alternative approach was developed to test the resilience of production to incremental changes in climate.

Methods

Sites and pasture systems modelled

Representative pasture types were simulated for Wagga Wagga (phalaris, subterranean clover, annual ryegrass and a native C_4 grass), Hamilton (perennial ryegrass and subterranean clover) and Elliott (perennial ryegrass and white clover) in south eastern Australia (Table 1). Annual pasture production was simulated as a cutting trial, with pasture mass cut to 1 t DM/ha on the last day of each month, using the Sustainable Grazing Systems pasture model (Johnson *et al.* 2003). In all simulations soil nutrients were non-limiting.

Climate scenarios

Twenty-five future climate scenarios were developed by scaling the historical climate (1971-2000) by increments of 0, 1, 2, 3 and 4ºC (with corresponding changes to atmospheric CO_2 concentrations and relative humidity) and rainfall by +10, 0, –10, –20 and –30%, following the procedure of Cullen *et al.* (2012). These scenarios represent the range of climate change projections for southern Australia to 2070.

Data analysis

Surface charts showing annual average pasture production for the 25 climate scenarios were produced, and on them the range of climatic changes for 2030, 2050 and 2070 (CSIRO and BoM 2007) were indicated.

Results and Discussion

With warming alone, annual production increased for the pasture sward at Wagga Wagga that consisted of a mixture of plant species with C_3 and C_4 photosynthetic pathways (Fig. 1). At the cool temperate site of Elliott warming of up to 3ºC increased production, while warming up to 2ºC increased production at Hamilton. At each site, production declined with lower rainfall. Generally annual pasture production was not lower than that simulated in the historical climate with the climate change projections for 2030, but it may be reduced under the 2050 and 2070 climate projections particularly if rainfall declines are >10%.

These results indicate that pasture production is more resilient to warming in cooler regions, and where there is a mix of C_3 and C_4 species. In cooler regions, warming overcomes low temperature limitations to growth, while it increases production of the C_4 species within mixed C_3/C_4 swards (Cullen *et al.* 2012). For C_3 pastures in temperate regions warming of more than 2ºC will decrease annual production as increased growth rates in winter and early spring are counteracted by a shorter spring growing season.

Conclusion

Testing the sensitivity of production to incremental changes in climate can provide insights into the characteristics of regions and pasture systems that make them more or less resilient to climate change.

Acknowledgments

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Table 1 Location, soil types and average annual rainfall at Wagga Wagga, Hamilton and Elliott.

Site	Lat./Long.	Soil type	Climatic zone	Rainfall (mm)
Wagga Wagga	-35.10, 147.30	Red chromosol/leptic tenosol	Mediterranean	565
Hamilton	-37.83, 142.06	Brown chromosol	Temperate	689
Elliott	-41.08, 145.77	Red mesotrophic haplic ferrosol	Cool temperate	1220

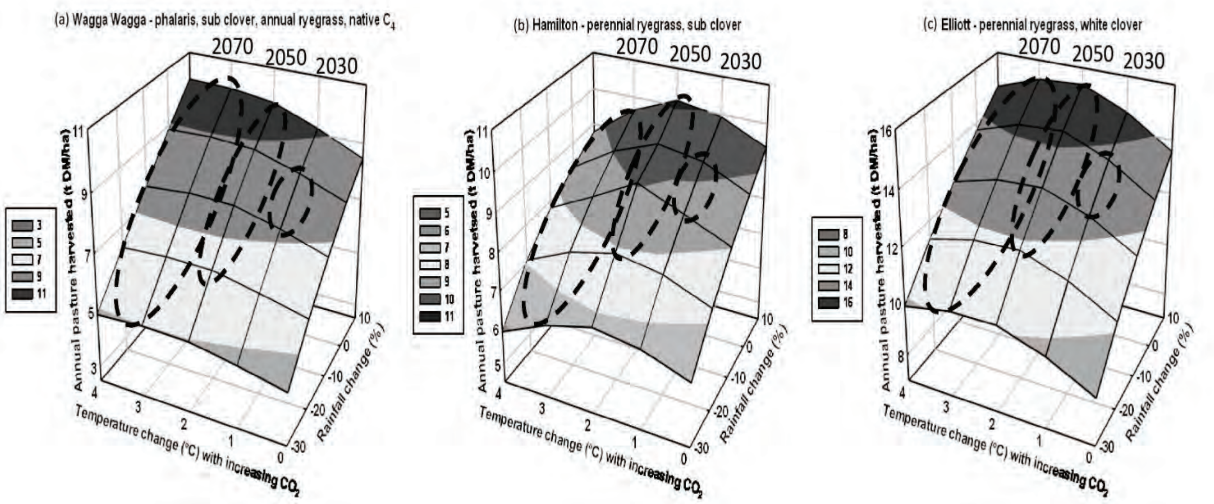

Figure 1. Surfaces of average annual pasture harvested (t DM/ha) under increasing temperature (°C) and change in rainfall (%) scenarios at (a) Wagga Wagga, (b) Hamilton, and (c) Elliott. Contours show equal values across the response surfaces. Dashed ovals show the range of climate projections for 2030, 2050 and 2070

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