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Official publication of The Australian Rangeland Society

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Impact of future climate scenarios on pasture production and livestock enterprises in western NSW

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key words: climate change, pasture production and modelling.

Abstract
This paper explores the impact of future climate scenarios on pasture and livestock production at five locations in western NSW. Outputs of climate and pasture models, simulating future pasture production are presented. The approach uses daily weather values, generated by downscaling historical data that statistically represent future climate as projected by four global circulation models (GCMs). These weather values are used in GRASP, with and without adjustments for increased atmospheric CO_2, to model pasture growth scenarios. The work explores the direction and feasible range of change and what it will mean for livestock production.

Introduction
Climate change is expected to alter pasture production and quality due to the interaction of increasing temperatures, changes in rainfall and a higher concentration of atmospheric CO_2. This will influence livestock production and natural resource management and the impacts are expected to vary regionally (Stokes *et al*. 2012).

Pasture quantity and quality directly impact livestock enterprises, determining carrying capacity (Johnston *et al.* 1996) and the quality and quantity of animal product produced (NSW DPI and MLA 2011). Generally, livestock carrying capacities are anticipated to decrease across the Australian rangelands under climate change (McKeon *et al.* 2009).

The marked variation in monthly and annual rainfall and forage availability in western NSW (Hacker *et al*. 2006) may make it difficult to detect that the climate has changed. Livestock producers need to know how temperature, rainfall and pasture production may vary from ranges experienced in the past. This will allow them to avoid negative impacts and capitalise on opportunities. It will also be important to avoid resource damage, as climate change may leave rangeland areas more vulnerable to degradation (Hacker, 2010).

Method
The GRASP model was used to explore the impact of future climate scenarios on pasture production (expressed as total standing dry matter TSDM) for five locations in western NSW. The model simulates pasture production based on pasture growth parameters, soil characteristics and meteorological data. Existing NSW models were used that have been reliably used in other projects (e.g. Hacker *et al.* 2006).

Future pasture production was modelled using projected weather data (30 years of potential 2030 data) and adjusting parameters for increased atmospheric CO_2. The projected weather data were produced by downscaling historical weather data (baseline data 1961-2009) using the WeatherMaker application (developed by A Moore from CSIRO in 2008). The data represent future climate as projected by four global circulation models (GCMs). These GCMs were developed by organisations in the USA (2), Germany and UK. The four GCMs were chosen due to their skill in modelling Australian weather for the period 1970 to 2000 and they represent the range of projected temperature increases and changes in rainfall.

Pasture growth parameters described by Howden *et al.* (1999) were adjusted to represent the effect of doubling atmospheric CO_2 (to 700ppm). This is well above projected 2030 levels of 444 ppm (IPCC 2000), however this represents current capacity to adjust parameters to model CO_2 effects in GRASP.

Grazing management scenarios where incorporated at one location. Scenario A had a set stocking rate (0.5 DSE /ha), determined by allowing 20% utilisation of mean annual TSDM. Scenario B adjusted stocking rate four times per year, determined by allowing 20% utilisation of TSDM, at the time of adjustment. Mean annual TSDM and the percentage of days under 300 kgDM/ha where used to compare scenarios.

Results

An increase in mean maximum and minimum temperatures (range 1^{o}C -1.6^{o}C) was projected by all GCMs, relative to the baseline period (Fig. 1). The projected changes in mean annual rainfall, compared with baseline, had a large range (-20% to + 20%) (Fig. 2).

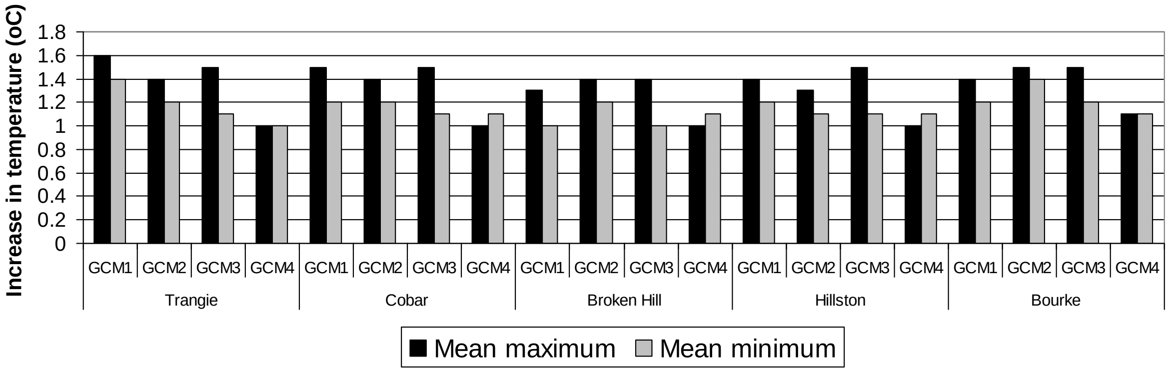

Fig.1. Increase in temperature projected by the four GCMs at five locations

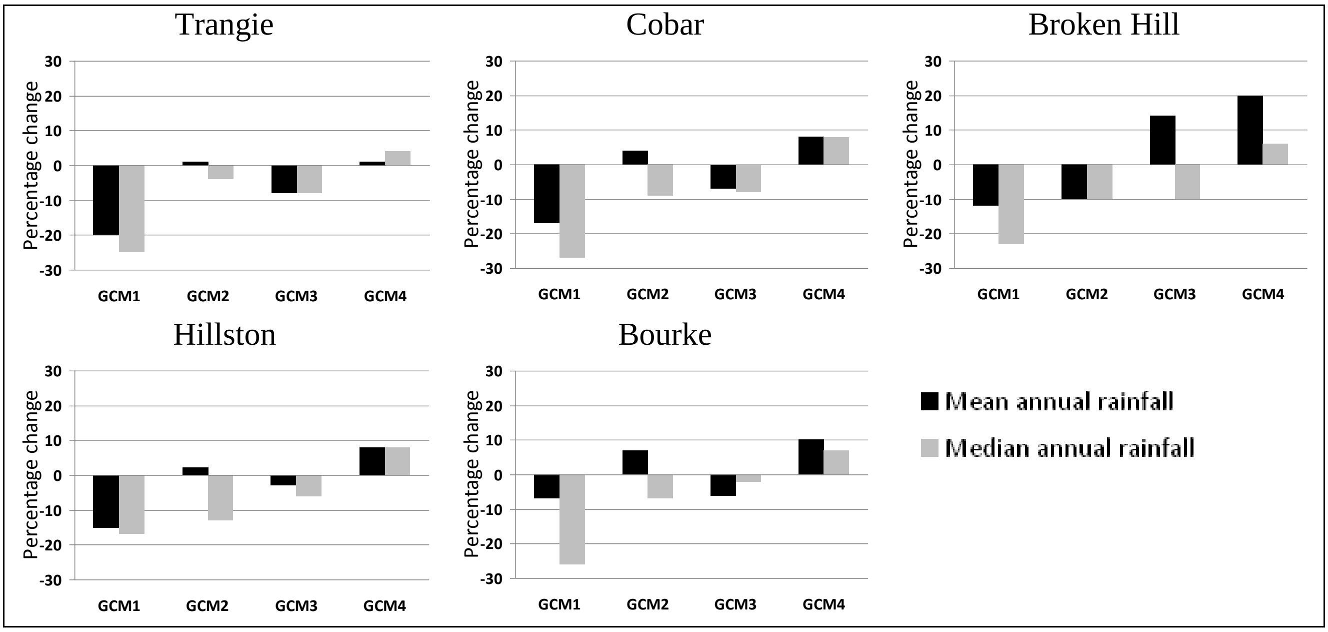

Fig.2. The percentage changes in mean and median annual rainfall (30 years x 2030), relative to the baseline period (1961-2009) at five locations.

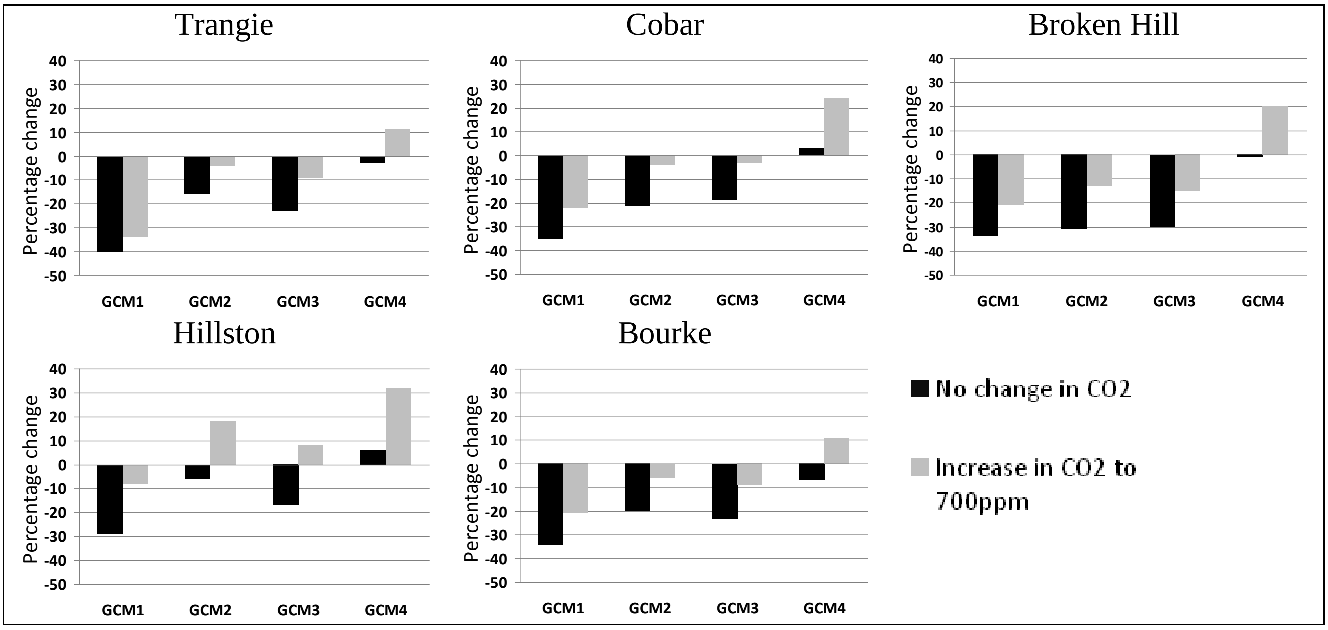

Fig.3. Percentage change (relative to the baseline period) in mean annual TSDM, based on projected GCM data, with and without parameter changes for an increase in $C0_2$.

Estimated future pasture production changes (with and without an increase in CO_2) ranged between a 40% decline to a 32% increase in mean annual TSDM, relative to the baseline (Fig.3). A decrease in mean annual rainfall tended to result in a greater percentage decrease in TSDM, when no changes to CO_2 where made. When CO_2 was increased this trend is not evident. An increase in CO_2 resulted in the TSDM change being less severe or further increased compared with no change to CO_2 (Fig.3).

The implications of different grazing management scenarios are shown in Table 2. Maintaining traditional stocking rates (scenario A), if future climate scenarios reduce TSDM, increases the number of days under 300kgDM/ha compared with the baseline. For example, GCM1 had 18% of days under 300kgDM/ha compared with the baseline that had 5%. This was reduced in scenario B to 8% by altering management and reducing stocking rate.

Table 1. Influence of grazing management at Cobar, under difference climate scenarios (with increased CO_2), on TSDM and percentage of days under 300kg/Ha.

Grazing Management		Baseline	GCM1	GCM2	GCM3	GCM4
Scenario A (SR set at 0.5 DSE/ha)	Mean annual TSDM (kgDM/ha)	884	662	862	846	1139
	Day < 300kgDM/ha	5	18	11	5	1
Scenario B (SR adjusted 4 x per year)	Mean annual TSDM (kgDM/ha)	946	749	918	921	1183
	Day < 300kg (kgDM/ha)	1	8	5	0.2	0.7
	Mean stocking rate	0.4	0.3	0.4	0.4	0.5

Discussion

Temperature increases (1- 1.6°C) projected by the GCMs are similar to current estimates of a 1-1.2 °C increase in temperature over inland Australia by 2030. The large range in projected rainfall change used in this modelling reflects current uncertainty in the direction and degree of rainfall change (CSIRO-BoM 2007).

A feasible range of pasture production change at the five locations has been determined. The broad range is expected given uncertain changes in rainfall and the limitations in modelling CO_2 effects. Large ranges in expected pasture production change have been reported in other studies; simulations averaged for 90 locations across the rangelands of Australia ranged between -55% to +62% (McKeon *et al.* 2009).

A decrease in rainfall resulting in a greater percentage decrease in TSDM (with no change in CO2) is consistent with other reports that have suggested pasture production will amplify changes in rainfall (eg. Crimp *et al.* 2002). The positive effect of increasing CO_2 on TSDM is expected, given that similar studies have reported beneficial effects of increased CO_2 on pasture growth (Howden *et al.* 1999; McKeon *et al.* 2009).

The projected pasture production changes indicate that carrying capacities in western NSW may change. The grazing management scenarios highlight the potential implications for livestock production and resource damage, if future climate scenarios decrease TSDM and indicate that grazing management may present adaptation options.

Future work should aim to narrow the range of pasture production projections. This will involve improving capacity to model effect of increased atmospheric CO_2, refining NSW pasture models, using updated GCMs data and analysis of seasonal changes.

Acknowledgments
This analysis has been undertaken as part of the NSW component of the Southern Livestock Adaptation Project -funding by the Australian Government Department of Agriculture, Fisheries and Forestry, Dairy Australia and Meat and Livestock Australia. Grant Fraser (DERM) and Greg McKeon are acknowledged for providing $C0_2$ parameters for the NSW models and assistance with GRASP.

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