**Impact of climate change on Tasmanian dryland pasture production**

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## Abstract

Dealing with climate variability is a fact of life for the farming community and a key element of most farm management and investment decisions, particularly in the context of expected anthropogenic climate change. The aim of this study was to investigate the likely impacts of changing seasonal conditions associated with expected climate change scenarios on pasture production. We simulated pasture growth based on current practice and historical and future climate datasets for Cressy, a representative dryland pasture growing region of Tasmania. For projections of future climate we used outputs from the Climate Futures Tasmania project, with six global circulation models downscaled to 14 km cells. The SGS model was used to simulate pasture growth for historical and future climates. Results indicated that there will be fewer incidences of low temperatures limiting production; however with current species growth may be limited in summer due to high temperatures. Rainfall is projected to be similar to current levels, resulting in a potentially positive net outcome.

## Key Words

Growth limiting factor, ryegrass, subterranean clover

## Introduction

Agriculture in Tasmania is highly dependent on weather conditions, depending on the enterprise and the location, and is thus potentially vulnerable to changes in climate. Changes in regional climate in Tasmania have been estimated by Nunez (2004), McInnes et al. (2004) and McIntosh et al. (2005). Recently the Climate Futures Tasmania (CFT) project has produced climate projections on a 14 km grid across the state from 1961 to 2100 (Corney et al. 2010). Mean annual temperatures were projected to increase by 2.8?C by 2100 for the A2 emissions scenario. Annual rainfall changes varied regionally but were generally less than 10% in the major agricultural areas. A current project aims to explore the impacts of climate change on production and economics of the mixed crop-livestock systems of Tasmania and to develop adaptation strategies to address those impacts. This paper reports on climate change impacts on pasture for one of the five Tasmanian regions in the study.

## Methods

The Sustainable Grazing Systems (SGS) pasture model (Johnson et al. 2003) was used to simulate the impact of climate change on dryland pasture growth at Cressy, Tasmania. Farms in the area typically have intensive cropping and grazing systems, on brown chromosols and vertosols. Annual rainfall is around 630 mm and many farms have access to irrigation. The pasture model was parameterized with a duplex soil (chromosol), growing a mixture of dryland ryegrass (Lolium perenne L.) and subclover (Trifolium subterraneum L.), which were cut at the end of each month to a residual biomass of 750 kg/ha. The simulations were set to be unlimited by nutrient constraints. Climate data projections were A2 scenario outputs for the six general circulation models used in the Climate Futures for Tasmania project (Corney et al. 2010). To enable the SGS model to reach a more stable state of nutrients and organic matter levels, an initial 'spin-up' period of 50 years was used. Following this, the pasture model was run from 1961 to 2010, separately for each general circulation model. Atmospheric $CO_2$ concentrations were increased annually, taken from the ISAM model conversion of the A2 scenario emissions, reaching 856 ppm by 2100 (IPCC 2000).

**Results and Discussion**

*Growth limiting factors*

The growth limiting factor results for ryegrass (Figure 1a) show the average effects of temperature and water on growth, where 0 is no growth, and 1 is no restriction to growth. For temperature, the 1995 scenario was most limiting in winter months and least limiting in March, November, and December. For the 2085 scenario, temperature was less limiting throughout late autumn, winter, and spring due to increased maximum and minimum temperatures; however temperature became increasingly limiting through summer, due to more days above 28$^{o}$C (Figure 2), the point in the SGS ryegrass model at which the rate of photosynthesis is approximately half of maximum, and temperature stress begins. For the 1995 scenario, water was not limiting throughout the winter, but became increasingly limiting during spring, and during summer, and became less limiting during autumn. The 2085 scenario for water was very similar, with the exception that water was less limiting during summer. These results suggest potential positive results for ryegrass growth, with the possible exception of summer.

For subclover (Figure 1b), temperature was the most important growth limiting factor. Throughout the growing period, temperature was less restrictive on growth for the 2085 than the 1995 scenario, due to the increase in both maximum and minimum daily temperatures. In comparison, there was no change in water as a growth limiting factor. These results suggest potentially positive effects of climate change for subclover throughout the growing period because its life cycle enables it to avoid the dry summer.

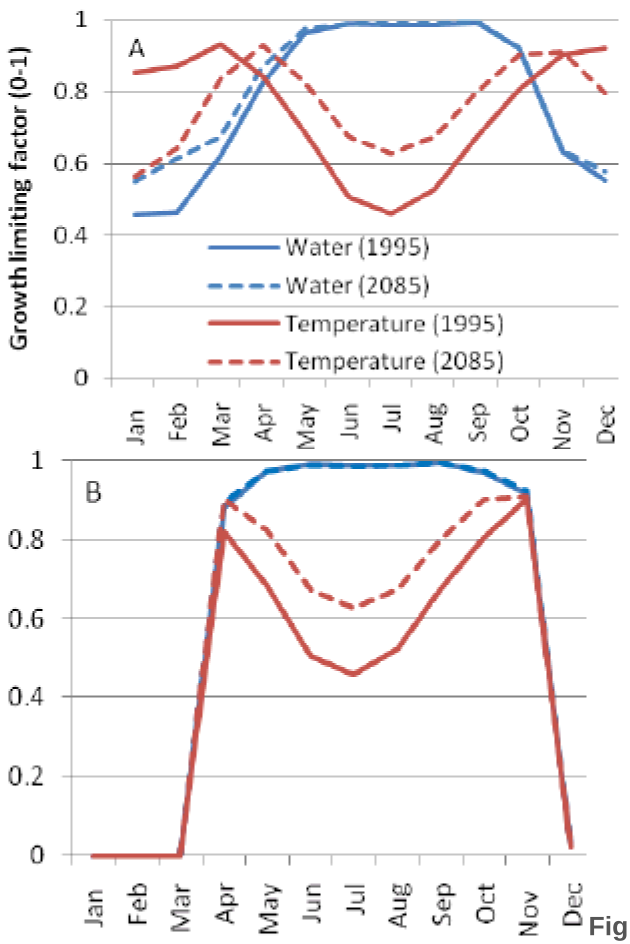


**Figure 1. Monthly simulated growth limiting factors for (a) ryegrass and (b) subclover, grown at Cressy, Tasmania. Each point is an average of six general circulation models and 30 years (15 years either side of the specified year).**

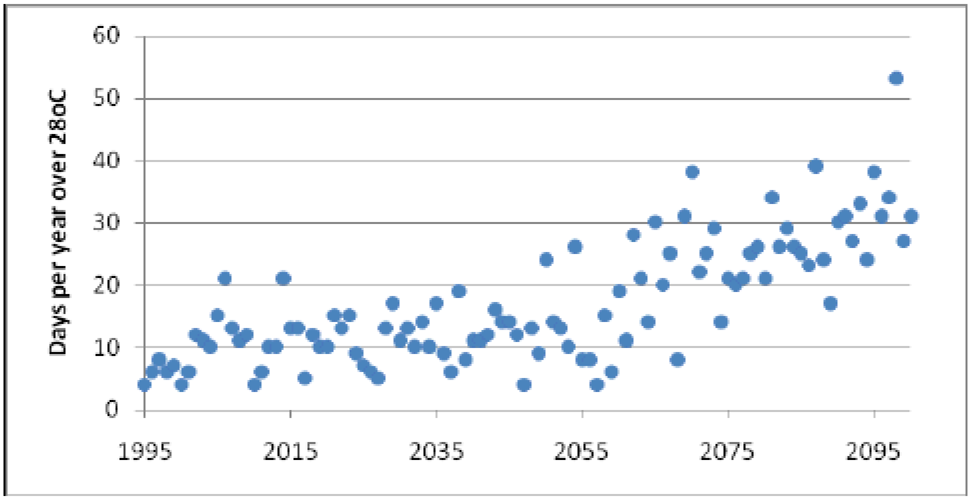


**Figure 2. The number of days per year where the projected maximum temperature exceeded 28$^{o}$C at Cressy, Tasmania, based on the projections of the GFDLCM2.1 general circulation model.**

*Daily growth rates*

For ryegrass (Figure 3a), the effect of future climate scenarios on growth rate was a small increase in autumn, essentially no change in winter or summer, and a greater growth rate in spring. These results reflect the growth limiting factors of temperature and water. For subclover (Figure 3b) there was a small increase in growth rate throughout the growing season. Small increases in autumn and winter growth, when feed resources are often limiting, could be comparatively more useful than more spring growth.

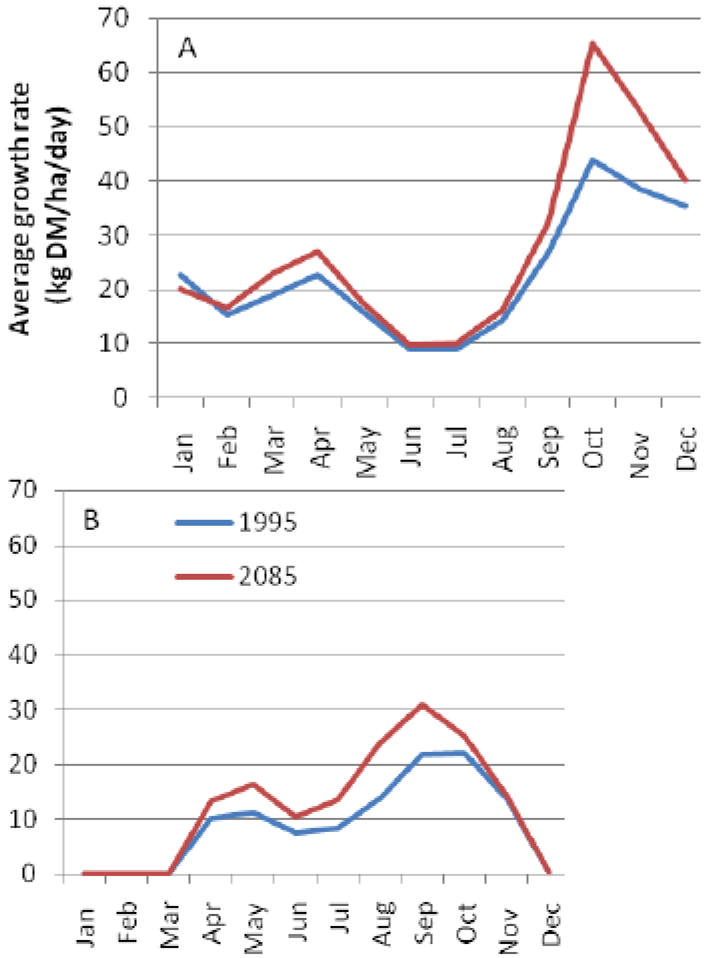


**Figure 3. Average daily growth rate for (a) ryegrass and (b) subclover, grown at Cressy, Tasmania. Each point is an average of six general circulation models and 30 years (15 years either side of the specified year).**

*Annual cut pasture yield*

The growth rates of ryegrass and subclover result in the accumulation of pasture biomass that is cut at the end of each month (Figure 4). The pattern of cut yield generally reflected the pattern of ryegrass growth, but with a difference between 1995 and 2085 during winter, due to the subclover component. This resulted in slightly more cut pasture throughout the year, the exception being during February where there was no difference in biomass production. There was limited difference between the models for either climate period from May to November which may be due to the growth times being predominantly limited by temperature, and temperature trends being consistent across models. Rainfall trends were less consistent across the models, and this was reflected in greater variation during the summer months when rainfall was the dominant determinant of pasture growth. During summer, there was also better agreement among models for the 1995 scenario than the 2085 scenario. This is likely because the general circulation model outputs were bias adjusted to match observed data for the period of 1961-2007, and these same bias adjustments were then applied across the entire dataset 1961-2100. The results do not necessarily suggest that there will be an increase in the variability of cut yield with time.

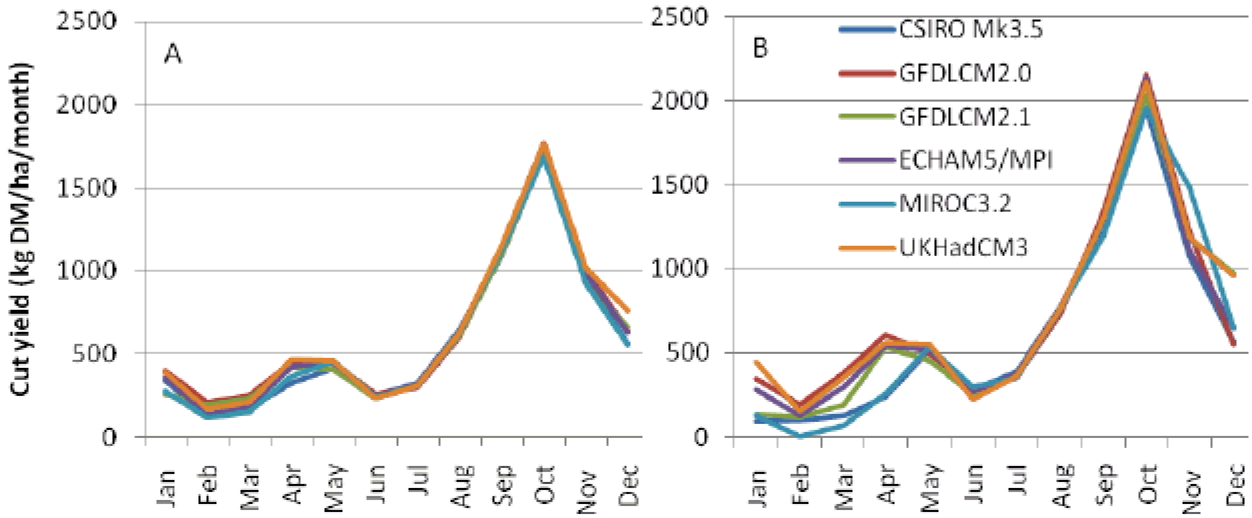


**Figure 4. Monthly cut pasture yield for ryegrass and subclover grown at Cressy, Tasmania. Data are averaged outputs of six general circulation models for a 30 year climate period either side of (a) 1995 and (b) 2085.**

For a thirty-year running average of the annual cut yield, all models project an increase in cut yield until approximately 2050-60, followed by a plateau in yield (Fig 5). The plateau in production may be due to the increasing temperature exceeding the point where there is a known response to production.

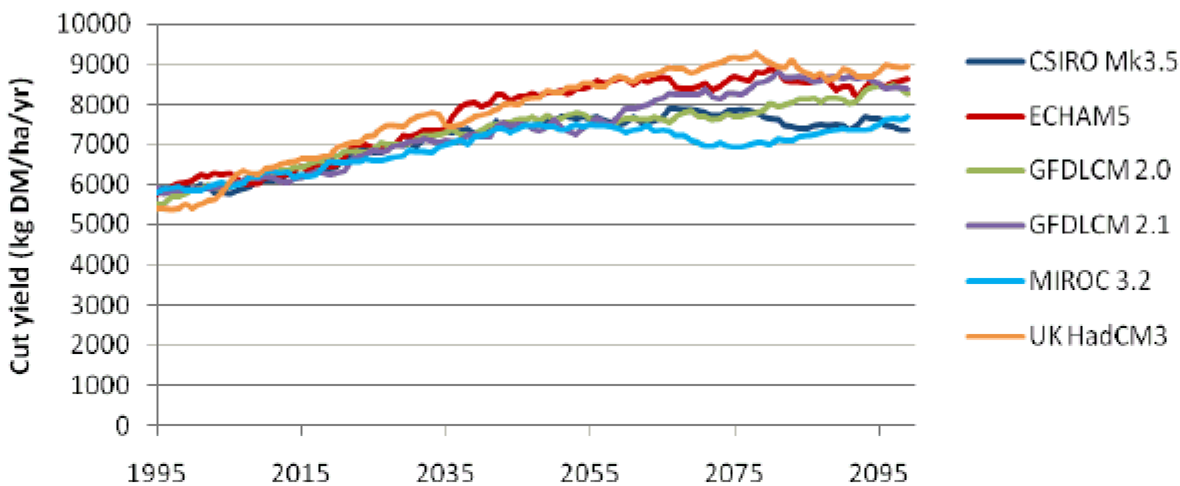


**Figure 5. Annual cut pasture yield for ryegrass and subclover grown at Cressy, Tasmania. Data are running averages of the previous 30 years of outputs for six general circulation models.**

**Conclusion**

Results indicated that there will be fewer incidences of low temperatures limiting production, which will results in increased growth and production, particularly during spring for ryegrass, and throughout the growing season for subclover under future climate scenarios. For ryegrass, growth may be increasingly limited in summer due to high temperatures. Rainfall is projected to be similar to current levels, and thus will have limited impact on pasture growth. The net result is a potentially positive outcome for pasture production in this region of Tasmania.

**Acknowledgements**

We thank the Climate Futures Tasmania project for making their climate change projections available.

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