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Primary Industries Climate Challenges Centre

ADAPTATION IN THE SOUTHERN LIVESTOCK INDUSTRIES

Whole farm systems analysis of climate change impacts on the southern grazing industries

Background

Climate change projections for southern Australia indicate a general increase in average and extreme temperatures, as well as changes in rainfall patterns and reductions in annual rainfall. The effects of these changes on pasture growth in grazing systems are uncertain and likely to vary regionally, depending on the combination of changes to temperature and rainfall, as well as plant responses to elevated atmospheric carbon dioxide concentrations.

While the physical impacts of a changing climate pose a range of challenges for grazing systems, changing policy settings offer a number of opportunities. For example, the federal government's Carbon Farming Initiative (CFI) provides financial incentives for farmers to reduce greenhouse gas emissions from agriculture and land use.

However before farmers can begin changing their practices, improved knowledge of the regional impacts of climate change on grazing systems is needed, along with a better understanding of how adaptation and mitigation strategies will affect farm productivity.

This project is using biophysical models to examine what dairy, beef and sheep grazing systems might look like at a regional level under future climate scenarios, and to simulate options to reduce greenhouse gas emissions.

It is part of a larger national research program looking at climate impacts, adaptation and mitigation in the southern Australian livestock industries. A network of extension officers in all southern Australian states are working with farmers to communicate and ground-truth the model simulations, and provide direct feedback to the modelling teams.


Photo Roger Charlton

Research location

The research is based on a series of models and tools simulating climate change impacts, mitigation and adaptation at sites across all southern states of Australia.

Project objectives

The research will:

- develop simulations of likely pasture growth in 2030 and 2050 for a range of geographic areas in southern Australia, at appropriate regional scales
- analyse the likely impact of climate change on current grazing systems across southern Australia
- develop regionally specific simulations of likely adaptation and mitigation options and the likely impact of adopting these options on productivity, greenhouse gas emissions and farm business.

Project outline

PICCC researchers initially used future climate prediction models and historical climate data to model climate change impacts on pastures. More recently the team have modelled pasture production for a range of species to evaluate resilience to changes in rainfall (-30%, -20%, -10%, 0, +10%) and temperature (0 °C, +1 °C, +2 °C, +3 °C, +4 °C, with corresponding carbon dioxide concentrations of 380, 435, 535, 640 and 750 parts per million).

The studies covered pastures based on either C_3 or C_4 grasses and systems from the subhumid and subtropical climates of southern Queensland to the cool temperate climate of Tasmania. The models also simulated nitrous oxide and methane emissions from pasture systems under future climates.

Research progress

To date the research team have completed and published 15 modelling studies exploring the impacts of future climate scenarios on pasture production, livestock emissions and adaptation of grazing systems.

White clover (*Trifolium repens*)


Photo Ksd5

PASTURE PRODUCTION

The effects of changes in temperature and rainfall on pasture systems were shown to be dependent on the existing pasture type and climate of the site. Warming and higher carbon dioxide concentrations, coupled with changes in rainfall, are expected to:

- increase production of perennial ryegrass/white clover pasture in the cool temperate climate at Elliott, Tasmania (Figure 1a)
- reduce production of perennial ryegrass/white clover pasture in the temperate climate at Ellinbank, south eastern Victoria (Figure 1b)
- increase production of C_4 grass-based pasture systems in the Mediterranean climate at Wagga Wagga, southern New South Wales (Figure 1c), particularly if there is little rainfall decline.

Changes in the seasonal patterns of pasture production are also expected across all sites as the climate becomes warmer and possibly drier:

- pasture growth rates in winter are expected to increase, with warmer temperatures more conducive to growth and soil moisture adequate
- the length of the spring growing season is expected to contract, with an earlier onset of the dry summer period.

Figure 1a. Elliott, Tasmania

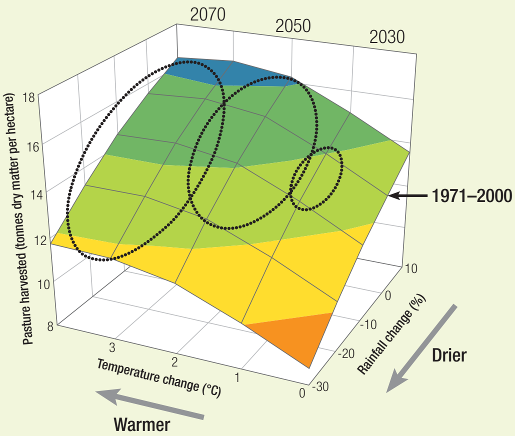

Figure 1b. Ellinbank, Victoria

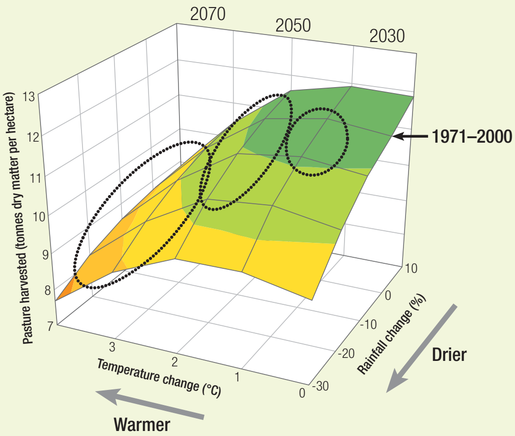

Figure 1c. Wagga Wagga, New South Wales

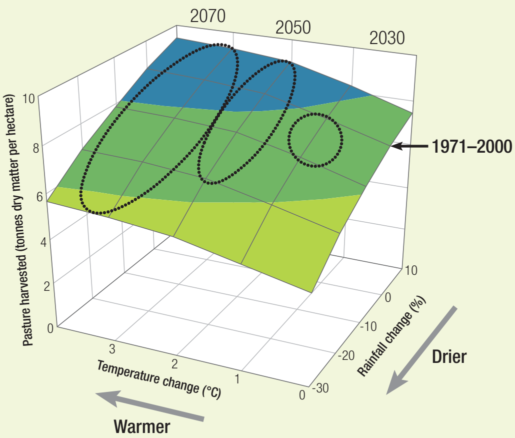

Figure 1. The impacts of temperature and rainfall changes on pasture harvested from (a) perennial ryegrass/white clover at Elliott, (b) perennial ryegrass/white clover at Ellinbank and (c) phalaris/subclover/C_4 native grass at Wagga Wagga. The projected climate change ranges under a high rate of warming for an IPCC A1FI emission scenario in 2030, 2050 and 2070 are indicated by the dotted lines, with the average 1971 to 2000 production indicated.

Photo Roger Charlton

Photo Oxfordian Kissuth

LIVESTOCK EMISSIONS

Under the future climate scenarios modelled:

- total annual nitrous oxide emissions increased, except on well drained soils, largely due to higher emissions in the cooler months when increased soil temperatures coupled with wet but less saturated soils resulted in improved conditions for nitrous oxide production
- potential for nitrous oxide production during the warmer months remained low
- nitrous oxide emission factors (i.e. the proportion of nitrogen lost as nitrous oxide) differed between sites and scenarios, emphasising the need for a more dynamic and mechanistic modelling approach for nitrous oxide emissions in national greenhouse gas inventories
- enteric methane remained a significant contributor to grazing systems emissions regardless of the pasture type, indicating the need for mitigation strategies targeted at methane production in ruminants.

ADAPTATION

Modelling showed that adapting current pasture systems and management practices could counter some of the effects of warmer, drier conditions:

- incorporation of deep rooted and heat tolerant plant traits were found to be effective means of preventing pasture production decline in higher rainfall regions of southern Victoria
- supplemental autumn and spring irrigation of annual ryegrass based pastures was shown to be a more efficient use of irrigation water than summer irrigation of perennial ryegrass pastures in northern Victoria
- forage cropping systems using heat tolerant and water use efficient maize were effective at increasing dry matter production per megalitre of irrigation applied.

Left: Phalaris
(*Phalaris aquatica*)
Below: Perennial ryegrass
(*Lolium perenne*)

Photo Rasbak

Kikuyu (*Pennisetum clandestinum*)

Photo Forest and Kim Starr

With warming and higher atmospheric carbon dioxide concentrations, heat tolerant and deep rooted C_4 pasture species such as kikuyu may become more prevalent in temperate regions of southern Australia. Modelling at Hamilton in south west Victoria showed that perennial ryegrass based pastures are more productive than kikuyu pastures under current temperature regimes. However with warming of more than 2–3 °C, kikuyu pastures are expected to become more productive than ryegrass (Figure 2). This suggests an increasing role for C_4 species in the grazing systems of southern Australia under future climate scenarios.

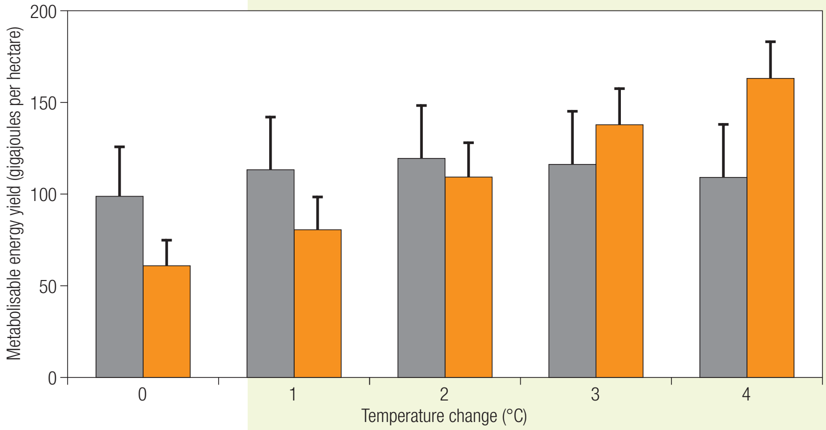

Figure 2. The impact of rising temperature on the metabolisable energy yield of a perennial ryegrass/ subclover pasture (■) and a kikuyu/subclover pasture (■) at Hamilton.

MODEL SUPPORT AND TRAINING

The project team conducts bi-annual workshops with researchers to develop and improve the modelling skills of those using the models. The team also provides one-on-one model user support, with the aim of maximising the use of models, as part of a comprehensive research program.

MODEL DEVELOPMENT

Improvements made to the suite of models used by the team, particularly the DairyMod and Sustainable Grazing Systems models, have improved simulations of the nitrogen and carbon cycles, and the distribution of dung and urine. The animal model has also been enhanced and coverage of more pasture species provided. These developments have resulted in a better understanding of soil carbon, enteric methane and nitrous oxide fluxes under current and future climates, and more regionally-specific knowledge of the impacts of future climates on grazing systems.

Next steps

In order to participate in the CFI, farmers need information on the cost-benefits of a range of mitigation options, with each evaluated in a whole farm systems context. This project will deliver the data needed to inform the development of CFI offset methods, plus identify and communicate to industries the potential opportunities for additional farm income.

While the modelling demonstrated the impact that gradual changes in average climate may have on southern grazing systems, it provides little information on the impact of extreme events. Further modelling is required to investigate the impact of heat waves, extended frost and flooding on pasture persistence and production.

Research team

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Tasmanian Institute of Agricultural Research

CSIRO

Department of Primary Industries New South Wales

South Australian Research and Development Institute

Department of Agriculture and Food Western Australia

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July 2009 to June 2012

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Further information

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