Impacts and implications of climate change for the pastoral industries

AL Cowie and RJ Martin

Primary Industries Innovation Centre, University of New England, Armidale NSW 2351

Abstract: *Agriculture is the second largest greenhouse gas emitter behind stationary energy in NSW. Primary industry sectors have a role to play in reducing emissions. This paper outlines the impacts and implications of climate change with respect to the pastoral industries of NSW and draws heavily from the climate change research priorities for NSW DPI (Fairweather & Cowie 2007). The paper provides details of research required to enhance available options and to quantify the expected biophysical and socio-economic changes, and develop climate change response strategies for the pastoral industries. The paper also provides an outline of research in progress in the National Centre for Greenhouse Research (NCRGGR) a partnership between the NSW Department of Primary Industries and the University of New England.*

Introduction

Agriculture is responsible for 16% of Australia's greenhouse gas emissions. As such, it is the second largest greenhouse gas emitter, behind stationary energy (50%). Increases in greenhouse gases in the atmosphere are causing climate changes, which in turn impact on agriculture and other primary industries. Reducing emissions, as part of an international approach, is expected to reduce the severity of climate change impacts in Australia. All NSW primary industry sectors have a role to play in reducing emissions. Research is required to enhance available options. However successful we are in reducing emissions, some climate change is inevitable because of the lagged effects of greenhouse gases already in the atmosphere. Primary industries must therefore adapt to those inevitable changes. Research is needed to quantify the expected biophysical and socio-economic changes, and develop response strategies.

Impacts on pastoral farming systems

Much of the beef, dairy and sheep industries in NSW comprises pasture-based production systems. While research has shown that a rise in carbon dioxide tends to promote pasture growth, this could be counteracted by reduced rainfall: a 10% reduction in average rainfall is predicted to counter the effect of a doubling of CO_2 concentration in the atmosphere (Pittock 2003). If rainfall declines by more than 10%, the likely impact will be reduced pasture growth, which is not only important for animal production, but could also lead to potential environmental degradation of some grazing lands. In conjunction with the likelihood of reduced pasture growth, there is potential for increased variability of pasture production.

The nutritional quality of pastures is likely to decline, through a reduction in foliar nitrogen concentration due to elevated CO_2, reflected in the impact on crude protein and water-soluble carbohydrates. However, the interaction between CO_2 and the main drivers of plant growth (i.e. temperature, water and fertiliser) makes it difficult to determine the exact impact of climate change on nutritional quality.

Plants may differ in their ability to acclimatise to gradual increases in temperature, and the incidence of extreme temperatures outside the coping range may result in changes to the botanical composition of pastures. In the subtropics, C3 grasses (e.g. rye grass, used as winter forage for subtropical dairies) are vulnerable to both an increase in average and extreme temperatures in spring–early summer. Modelling has already indicated yield losses in spring (K Sinclair, pers. comm.).

A shift in botanical composition towards C4 species (many of which have lower digestibility than C3 species) is likely, due to higher temperatures and the possible shift towards greater summer rainfall dominance. It is not, however, inevitable; a shift towards C3 species with increased CO_2 may be equally likely, and has been suggested as an underlying mechanism of the worldwide encroachment of C3 'woody weeds' in semi-arid rangelands.

In addition to these impacts on pasture yield and quality, increased temperature and humidity will impact directly on the productive capacity of grazing animals, particularly cattle. The temperature-humidity index (THI) is a measure of the heat stress on cattle, and hence a measure of their productive performance.

The impacts of increased heat stress in cattle include reduced grazing time (partly as a result of animals seeking shade), reduced feed intake, increased body temperature, increased respiration rate, and weight loss. In dairy cows, heat stress reduces milk yield, reduces milk fat and protein content, and decreases reproduction rates (Jones & Hennessy 2000). High-producing dairy cows are the most susceptible to increases in the THI. Heat stress days with THI > 80 lead to a substantial effect on reproduction of dairy cows, particularly for Holstein-Friesian. When assessing the impact of climate change on THI, it is important to assess, not just the change in the mean, but also the change in the number of extreme days (Howden et al. 1999).

The response of beef cattle to THI is similar to the response of dairy cattle, although *Bos indicus* cattle seem to be about 10% more tolerant than *Bos taurus*. All cattle require significantly more water when under stress. Significant stress is experienced at a THI of 80, and a recovery period is important in minimising production losses (Davison et al. 1996).

A cooling strategy, such as the provision of shade and sprinklers, is a key factor in minimising the impacts of increased THI for both dairy and beef cattle. The THI threshold at which a cow will generally start to be impacted by heat when no shade is provided is ~72. This can be increased to 76 by providing shade in feeding areas, and to 78 through the provision of shade and sprinklers (Jones & Hennessy 2000).

Implementing strategies to reduce heat stress is more practical for intensive livestock systems; however, shade infrastructure can be expensive for very large operations. Using sprinkler systems to reduce heat stress in dairy cows can also increase the risk of mastitis, because udders can become wet and dirty, creating ideal conditions for the growth of bacteria (Dairy Australia 2007).

For intensively fed (feedlot) beef cattle, heat stress is already a monitored health risk in mid to late summer. The risk is a function of the duration and intensity of heat load, together with the capacity for heat dissipation. A risk analysis program available to feedlot operators links with internet-supplied regional heat load index forecasts (www.katestone.com.au/mla). Climatic change leading to prolonged periods of sustained hot weather and greater peak temperatures can be expected to extend this risk period and increase feedlot operators' reliance on such a service, which will allow them to invoke heat protection procedures (MLA 2007).

An additional risk from climate change to livestock industries, both intensive and extensive, is the potential for changing patterns of parasite risk to animals; for example, the potential for the 'tick line' (the cattle tick boundary) to move further south. Managing the impact of this increased parasitic risk to animals will require changes to operational practices, such as dipping and drenching.

Adaptation to climate change is likely to require more flexibility and improved management of seasonal risk. An example of a risk management strategy for the extensive livestock industries is the maintenance of a higher proportion of 'disposable' animals in the flock. Adaptation to increased heat stress could involve cross-breeding.

Climate change research in NSW

The Primary Industries Innovation Centre (PIIC) was established in 2007 to facilitate co-operation between the University of New England and the New South Wales Department of Primary Industries. In July 2008, the NSW Minister for Primary Industries, Ian Macdonald, announced that a National Centre for Rural Greenhouse Gas Research (NCRGGR) would be established under the PIIC banner to foster synergies in climate change research. Professor Annette Cowie was appointed as the first Director of NCRGGR and commenced in May 2009.

The federal Department of Agriculture, Forestry and Fisheries Climate Change Research Program (CCRP) is funding research projects and on-farm demonstrations to help prepare Australia's primary industries for climate change and build the resilience of the agricultural sector into the future. The program involves projects that provide practical management solutions to farmers and industries.

The first round of projects funded in the CCRP are focussing on climate change mitigation: reducing greenhouse gas emissions such as methane, nitrous oxide and carbon dioxide; and improving soil management and determining the potential of sequestration of carbon in agricultural soils.

It is expected that further funding rounds will focus on providing primary producers with capacity to adapt to climate change with priorities in the following areas: (i) production systems and nutrient management; (ii) biosecurity - pest, disease and weed management; (iii) changed or alternative management practices (e.g. grazing, cropping, intensive farming, soil fertility); and (iv) plant breeding and adaptation of existing varieties.

The following UNE-DPI projects have received funding in the CCRP:

- Land – the carbon bank – Professor Annette Cowie.
- Genetic improvement of beef cattle for greenhouse gas outcomes – Dr Roger Hegarty.
- Novel strategies for enteric methane abatement – Dr Roger Hegarty.
- Mitigating nitrous oxide emissions from soils – Dr Graeme Schwenke.

Land – the carbon bank

This project will measure monitor and determine the viability of sequestering carbon in agricultural systems in NSW and will assess the impacts of changes in agricultural management on soil carbon. It is part of a national integration project that has been established under the CCRP. National coordination will provide consistent methodology for providing data on changes within the separate pools of soil carbon under various management regimes and under a range of defined environments.

The focus is on attaining new data and particularly to 'fill the gaps' in knowledge on how adoption of best management practice or new practices may change soil carbon fractions under NSW agricultural systems (for example: natural vs improved pasture; pasture-cropping; mixed farming systems; conventional vs reduced or no tillage cropping systems, irrigated cropping systems and high intensity cropping systems).

The project will provide an assessment of the impacts of changes in agricultural management, and cover a range in soil type and rainfall combinations in NSW. Soil profile samples will measure the amounts of carbon as well as soil properties such as total nitrogen, soil texture, and pH. The allocation of total soil organic carbon to its constituent fractions will be quantified for a range landuse-soil combinations. The organic carbon fractions are: humus; particulate organic carbon (POC); and charcoal. Attempts will be made to relate soil carbon status to site history, management, plant productivity and plant residues. The data will enable a range of modelling activities to inform government policy.

Mitigating ruminant methane emissions

In Australia there are more than 31 million beef and dairy cattle, 85 million sheep and three million farmed goats which are emitting methane into the atmosphere as food is digested in the rumen. It is estimated that each cow could produce greenhouse gas emissions equivalent to around 1.5 tonnes of carbon dioxide per year. The goal of these projects is to reduce the output of methane emissions while maintaining quality and productivity in Australian livestock production.

A study of genetic variation in beef cattle herds that differ in methane production has received funding to evaluate the potential for breeding cattle with reduced methane emissions, without compromising animal performance. An additional project will investigate techniques to reduce methane production in ruminants by eliminating protozoa from the rumen and through the use of dietary supplements.

Mitigating nitrous oxide emissions from soils

Use of fertiliser nitrogen in the agricultural sector accounts for 32% of N_2O emissions or 5.2 Mt CO_2-e per year. Of the 1 million tonnes of fertiliser nitrogen used annually in this sector, approximately 70% is applied to cereals. Dr Graeme Schwenke is leading a project to investigate options for mitigating nitrous oxide emissions from cropping soils in north-western NSW.

It is postulated that emissions in cereal production systems could be mitigated through (i) partial substitution of fertiliser nitrogen inputs with biologically-fixed legume nitrogen, (ii) increasing nitrogen use efficiency (NUE) through strategic location of crop rows in relation to nitrogen fertiliser and prior crop residues using precision guidance technology, and (iii) modelling and development of effective extension packages for farmers. The researchers will also attempt to develop regionally-relevant multiplier factors to replace Intergovernmental Panel on Climate Change (IPCC) default values used in calculating greenhouse gas emissions from fertiliser and legume use.

The research will provide robust strategies to reduce inputs of fertiliser nitrogen, with direct consequences for both on-farm and off-farm emissions, as well as economic benefits for farmers through reduced input costs and more efficient production systems. The project will also develop effective management tools that farmers can use at the paddock level to mitigate their emissions whilst maintaining farm productivity.

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