Climate change adaptation-mitigation tradeoffs in the southern Australian livestock industry: GHG emissions

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Abstract: The trade-offs between farm system production and profitability, adaptation to climate change and mitigation of greenhouse gas (GHG) emissions are associated with complex interactions. The GHG mitigation consequences of effective adaptations should be taken into account when including them in mitigation policies. In this paper, we present the results of 2 modelling studies of climate change adaptation x mitigation interactions in southern Australian broadacre livestock production: (a) case studies of adapting to climate change by increasing soil fertility at 2 locations that examine the effects on farm-level GHG balances, and (b) an examination how systematic combinations of adaptations (grassland management and animal genetic improvement) might affect future methane (CH_4) emissions across the whole of southern Australia (33.25 Mha). We used the AusFarm model to simulate the effects of climate change under the SRES A2 scenario in 2030.

Merino ewe grazing systems were modelled at 2 locations (Lake Grace, WA and Wellington, NSW) under historical climate and climates projected for 2030. The effects of adapting to climate change by increasing soil fertility by adding phosphorus (P) on system productivity, profitability, N_2O emissions, enteric CH_4 emissions, and changes in soil carbon stocks were estimated. The negative impacts of climate change on productivity were reduced by achieving higher soil fertility, so increasing profitability at 2030. CH_4 emissions declined under 2030 climate owing to lower sustainable stocking rates, but the reduction was smaller when soil fertility was increased. Soil C stocks were predicted to decrease under 2030 climate due to a decrease in net primary productivity of the pasture. Increasing soil fertility was predicted to cause little change in soil carbon stocks, because its main effect was to increase NPP consumed by livestock instead of NPP left to be incorporated into the soil. An increase in N_2O emissions under 2030 climate can be related to changes in rainfall regime. Increased soil fertility by P could slightly reduce this increase. Higher soil P fertility decreased N_2O emissions compared with no adaptation by 7% at Lake Grace and 25% at Wellington.

CH_4 is the second most important anthropogenic GHG. Ruminants (2.4 Gt CO2-eq yr^{-1}) are the largest source of CH_4 emissions. By modelling 5 livestock enterprises at 25 representative locations, we estimated an area-average ruminant CH_4 emission rate of 70 kg ha^{-1} yr^{-1} during the historical period, which is consistent with previous estimates. By decreasing optimal sustainable stocking rates (OSSR), climate change impacts were projected to decrease ruminant CH_4 emissions to 55, 51, and 42 kg ha^{-1} yr^{-1} in 2030, 2050, and 2070, respectively. Ruminant CH_4 emissions under the most profitable systemic adaptation were estimated to vary among sites, depending mainly on OSSR. If the most profitable adaptations were fully adopted, average ruminant CH_4 emissions were estimated to increase to 84 kg ha^{-1} yr^{-1} in 2030, 83 kg ha^{-1} yr^{-1} in 2050, and 75 kg ha^{-1} yr^{-1} in 2070.

Across regions and averaging among enterprises, a linear relationship was found between CH_4 emissions (kg ha^{-1}) and profit (A\$ ha^{-1}). A linear relationship was predicted between CH_4 emission and meat production. In 2050, the most profitable combination of adaptations will result in CH_4 emission changes that range between factors of -0.82 and +1.08 relative to the reference period. In addition, CH_4 emissions will reach an intensity of 0.26 kg ha^{-1} yr^{-1} (6.5 CO_2-eq kg ha^{-1} yr^{-1}) for each A\$1 of profit and 0.99 kg ha^{-1} yr^{-1} (24.9 CO_2-eq kg ha^{-1} yr^{-1}) for 1 kg of meat production. Across regions and averaging among enterprises, changes in the CH_4 emissions for the most profitable combinations had a logarithmic relationship with changes in profitability (e.g. for 2050: $\Delta CH_4 = 0.207\ln(\Delta profit) - 0.326$, $R^2=0.63$).

Ruminant CH_4 emissions will depend on animal numbers (i.e. stocking rates) that, in turn, will be controlled by adaptation intensity. Greater intensification and ruminant CH_4 emission are likely to occur, because increasing demand of meat has been projected for the future and there is capacity for higher and profitable production to respond this demand. Future food market projections have shown such a great demand even under price effects.

Keywords: *Grazing systems, climate change, nitrous oxide, methane, soil carbon*