A systems approach to managing greenhouse gases on New Zealand sheep and beef farms

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Introduction Agriculture contributes more than 50% of New Zealand's greenhouse gas (GHG) emissions, mainly through release of methane (CH_4) and nitrous oxide (N_2O) from pastoral farms. Decisions on implementation of mitigation strategies will be made by individual farmers, who seek also to maintain financial performance in the face of declining terms of trade for commodities, hence leading to pressure to further intensify production. New Zealand (NZ) sheep & beef farms are typically hill country properties with a mixture of steep and easier topography, and year-round grazing of mainly permanent pastures. Specific GHG mitigation technologies will be difficult to incorporate into these systems and most of them are a considerable distance from commercial application. Farming system change is currently the only effective mitigation approach likely to be readily available to those farmers in the short term.

Materials and methods Methane and N_2O emissions were calculated for a theoretical 500 ha hill country sheep & beef farm operating under 3 different farming scenarios involving increasing levels of fertiliser (phosphorus, sulphur and nitrogen) inputs, lambing percentage, forage crop use, a change in enterprise design from all breeding and sale of offspring to finishing of lambs for slaughter and the purchase of young cattle for finishing in preference to maintenance of a breeding cow herd to generate young cattle. Low, Medium and High intensity scenarios were simulated using the whole-farm decision-support model Stockpol to predict production and economic outcomes, and the nutrient budgeting decision-support model Overseer to predict GHG outcomes. Effects of replacement of areas of pasture with plantation forestry on the steepest, least productive areas of the farm, to mitigate increases in GHG emissions as a result of intensification through carbon (C) sequestration, were also estimated.

Results Production (feed intake, meat & wool production) and financial returns increased as level of inputs increased across the Low to High scenarios (Table 1). Similarly, system efficiencies (meat & wool produced per unit feed and per unit GHG emission, and meat & wool and $ earned per unit GHG emission) increased. However, CH_4 and N_2O emissions also increased. The markedly increased N_2O emission for the High scenario was a consequence of increased fertiliser N use.

Table 1 Results of farming scenario simulations for Low, Medium and High intensification scenarios

	Low	Medium	High
Feed intake (t DM/ha per yr)	6210	7719	10501
Net meat & wool production (kg/ha per yr)	163	258	366
Financial returns ($ gross margin/ha per yr)	411	601	934
Feed to product conversion efficiency (kg product/t feed intake)	26.3	33.4	34.8
Production per unit GHG emission (kg product/t CO_2 equivalent)	47.3	59.8	60.9
Financial return per unit GHG emission ($/t CO_2 equivalent)	119	139	156
Methane emissions (t CO_2 equivalent/ha)	2.76	3.45	3.78
Nitrous oxide emissions (t CO_2 equivalent/ha)	0.70	0.86	2.22
Total GHG emissions (t CO_2 equivalent/ha)	3.46	4.31	6.00

Conversion of 30 ha and 81 ha of pasture on Medium and High intensity scenarios respectively to plantation forestry, maintained total CH_4 and N_2O emissions at the same level as for Low intensity but resulted in a reduction in livestock returns of $13,000 and $61,000 for Medium and High respectively; however balanced against this were average (over the production cycle) annual returns from sale of timber of $30,000 and $81,000 respectively. Cash flow for costs and returns of forestry enterprises differ for annual livestock and 30-year forestry production cycles, and this would be an issue in transition to the combination of livestock and forestry.

Conclusions There are existing feasible system solutions involving changed land use that would enable New Zealand's Kyoto commitments to be met whilst meeting farmer requirements for ongoing financial viability. Design and implementation of such systems would require that whole-farm GHG budgets pay regard not just to CH_4 and N_2O emissions but also to C sequestration. Although CH_4 is currently the most important agricultural GHG in New Zealand, increased N fertiliser use will markedly increase the relative importance of N_2O.