Greenhouse gas production by ruminants in New Zealand: a serious problem, or just hot air?*

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ABSTRACT

Methane and nitrous oxide produced by farmed ruminants may cause over one third of the potential greenhouse warming which can be attributed to New Zealand. This is a result of high populations of domestic ruminants (mainly sheep and cattle), and the large warming potential of methane and nitrous oxide. New Zealand's total greenhouse gas production is an insignificant component of the global total, but this fact cannot be used as a reason to ignore New Zealand's contribution. International negotiations have commenced with the aim of producing a treaty to limit global greenhouse gas production, and New Zealand may be forced to act on agricultural emissions. This paper discusses current estimates of greenhouse gas production by ruminants in New Zealand, and identifies areas needing further research. It concludes that; (1) the accuracy of estimate of greenhouse gas emissions from agriculture needs to be improved; (2) technology to reduce greenhouse gas emissions from ruminants should be developed for, and applied to, New Zealand farming systems; and (3) that equitable methods of implementing limitation policies need to be investigated.

Keywords Ruminants, methane, nitrous oxide, greenhouse effect, global warming, New Zealand.

INTRODUCTION

The greenhouse effect is the process by which trace gases in the atmosphere absorb infrared radiation (heat) being emitted from terrestrial sources, resulting in warming of the atmosphere. It is important to realise that the greenhouse effect is not a new process on planet earth, but one that has existed for many millions of years, and was critical in the development of life on earth. Energy balance calculations suggest that without the greenhouse effect, the average temperature of the earth would be around 33°C cooler than at present (Henderson-Sellers and McGuffie, 1987). The main gases of importance for greenhouse warming are water vapour, carbon dioxide, methane, nitrous oxide, chloroflurocarbon's (CFC's) and tropospheric ozone[1]. In recent years concern has been expressed by many scientists about the likely effects of the observed increases in the concentrations of these greenhouse gases (Pearman, 1987) resulting from human activity. There is general agreement that enhanced climate warming is likely to result from greenhouse gas emissions associated with human activities (Houghton *et al.*, 1990). Other effects such as increasing sea levels and changes in rainfall patterns are likely to occur, but are more difficult to predict at present.

Human induced climatic change will have a range of effects including the loss of low lying land as sea levels rise, changes in agricultural productivity resulting from atmospheric warming and enhanced carbon dioxide concentrations, and shifts in climatic risk factors. On a global scale the effects are likely to present serious problems, with millions of people displaced from their traditional homelands, and major reductions in food production of some regions. In addition it should also be noted that the underlying cause of climate change is the pressure on the environment resulting from the increase in human population, and associated industrial and agricultural development. Global population is expected to double and reach ten thousand million by the middle of the next century, and this will accentuate problems associated with climatic change. On a regional scale, in some areas there may be positive benefits resulting from climatic

* Opinions expressed in this paper are those of the author and do not necessarily represent those of the Ministry of Agriculture and Fisheries.

[1] The Troposphere is the lowest level of atmosphere.

TABLE 1 Comparison of annual human induced greenhouse gas emissions for New Zealand and the global total for the year 1989. There is a high degree of uncertainty associated with some of these data. Notes:

- 1 Tg equals 10^{12} grams or 10^6 tonnes
- The per capita, and land area ratios are obtained by dividing the New Zealand percentage contribution for each gas by New Zealand's percentage of the global population (0.07 %) and land area (0.13 %) respectively. New Zealand has around 0.07 % of the total global population and 0.13 % of global land area.

Trace Gas	Global Emissions (Tg)	New Zealand Emissions (Tg)	New Zealand Share of Global Total (%)	New Zealand per capita ratio	New Zealand Land Area ratio
CO_2	26000	26.2	0.10	1.4	0.8
CH_4	300	1.6	0.53	7.6	4.1
N_2O	6	0.045	0.75	10.7	5.8
CFC-11	0.3	0.001	0.33	4.7	2.5
CFC-12	0.4	0.001	0.25	3.6	1.9

Source: Ministry for the Environment (1990)

change. For example in New Zealand the combined effects of temperature and enhanced atmospheric carbon dioxide concentrations may lead to increased pasture growth and animal production (Martin *et al.*, 1991).

International pressure is growing for action to reduce global greenhouse gas emissions, as one way to minimise the impacts of human induced climatic change. The first step in this process has been to obtain estimates of global greenhouse gas emissions, as well as a breakdown on the basis of region and country. Reasonable estimates exist for global emissions, and in some countries, including New Zealand, there are estimates of the national contribution to the global total (Ministry for the Environment, 1990). These estimates show that New Zealand's greenhouse gas emissions are an insignificant component of the global total, to the extent that if all New Zealand emissions were stopped, there would be no affect on likely global climatic change.

The question can then be asked, why should New Zealand act to reduce greenhouse gas emissions when it is obviously "someone else's problem"? There are two answers to this question. Firstly New Zealand is pressing for rapid international action to reduce global greenhouse gas emissions, and will need to be seen to act in line with any resulting agreements. Secondly, if New Zealand does not act to reduce emissions economic sanctions or non-tariff trade barriers by trading partners may affect terms of trade. On a global scale most effort will be needed to reduce carbon dioxide emissions, since this is the dominant greenhouse gas. In New Zealand however, methane and nitrous oxide emissions from agricultural activities may contribute to around one third of the total contribution, and will need to be examined in any attempt in reduce total emissions. The remainder of this paper examines the contribution of ruminants to New Zealand's greenhouse gas emissions, discusses how policy could be implemented to reduce emissions, and identifies areas needing further research.

NEW ZEALAND'S AGRICULTURAL GREENHOUSE GAS EMISSIONS

The New Zealand climate change programme (Ministry for the Environment, 1990) has produced estimates of global and New Zealand human induced greenhouse gas emissions for 1989 (Table 1). New Zealand's emissions of each of the major greenhouse gases do not exceed one percent of the global total, but when expressed on a per capita or land area basis, the emissions of methane and nitrous oxide are very high. The estimates for New Zealand emissions presented in table 1 represent the best currently available, with those for carbon

TABLE 2 Warming potential of New Zealand's and global human induced greenhouse gas emissions. Global warming potential describes the effect of 1 kg of a trace gas relative to 1 kg of carbon dioxide. The CO_2 equivalent emission is obtained by multiplying the actual emission (Tg, Table 1) by the global warming potential. The values used in this table are the same as used by the Ministry for the Environment (1990) and describe the relative effect of a trace gas emission in 1989 over the next five hundred years.

Trace Gas	Estimated Lifetime (years)	Global Warming Potential (over 500 years)	CO_2 Equivalent Emission (T_g)	Percentage of Total Global Warming	CO_2 Equivalent Emission	Percentage of N.Z. Contribution
CO_2	120	1	26000	73	26.2	43
CH_4	10	9	2700	8	14.4	23
N_2O	150	190	1140	3	8.5	15
CFC-11	60	1500	450	1	1.5	3
CFC-12	130	4500	1800	5	4.5	6
Others			-	Balance		Balance

dioxide and the CFC's considered reasonably accurate with an uncertainty of around ten percent. In contrast the estimates for methane and nitrous oxide are considered highly uncertain, and are the result of relatively crude assumptions and calculations based on data obtained in other countries under different production systems.

The estimates of New Zealand's methane emissions used by the Ministry for the Environment (1990) were derived from a report by Lassey, Lowe and Manning (1990). They calculated that livestock produced 75 percent of New Zealand's total human induced methane emissions, with the majority of this coming from ruminants. Their calculations were based upon estimates of methane production from German livestock (Crutzen, Aselman, and Seiler, 1986). Similar calculations by Hollinger and Hunt (1990) are in broad agreement with those of Lassey *et al.* (1990), as are calculations by other New Zealand workers using different assumptions (P. Fennessy and K. Lassey *pers. comm.*) All studies suggest that the main agricultural sources of methane are sheep and cattle, each contributing around half of the total. Whilst there is broad agreement in the approximate magnitude of methane emissions from domestic ruminants in New Zealand, the uncertainty associated with the estimates is at least 25 percent.

Nitrous oxide emissions from urine patches in pasture is the most important source of this greenhouse gas in New Zealand. Agricultural sources of nitrous oxide may make up to 98 percent of New Zealand's total emission of that gas. The calculation of agricultural emissions used by the Ministry for the Environment (1990), is based upon the simple assumption that one percent of the total nitrogen flux in improved pastures will be released as nitrous oxide (R. Sherlock, *pers. comm.*). This estimate is considered extremely crude and the actual value could be within the range of one third to three times the current best guess of 0.045 Tg.

Agricultural sources such as effluent disposal systems and several major non-agricultural sources, for example municipal sewage systems were not included in the national total. Much work is required to refine these estimates.

GREENHOUSE WARMING

The relative impact of a greenhouse gas is a function of the amount of gas released into the atmosphere, the amount of infrared radiation that each gas molecule absorbs, the average lifetime of the gas in the atmosphere, and the integration time used for comparison (Lashof and Ahuja, 1990) There are several ways of expressing this concept, with the most popular currently being the greenhouse or global warming potential (GWP) expressed relative to that of carbon dioxide. Greenhouse

warming potentials are used to calculate the relative impact of each greenhouse gas (as in Table 2), and can be used to assist policy decisions. Greenhouse gas production by ruminants in New Zealand contributes to around one third of the national warming potential. When carbon dioxide emissions from fossil fuel use (mainly petrol and diesel) are included, the agricultural sector may produce over forty percent of the national total. There are several reasons why methane and nitrous oxides constitute such a large proportion of New Zealand's total warming potential. The most obvious is that New Zealand has a high population of ruminants on both an area and per capita basis. Secondly, New Zealand's carbon dioxide emissions are relatively low for a developed nation, since most electricity is produced from hydro-electric resources. Lastly the global warming potential (Table 2) of methane and nitrous oxide are much higher than carbon dioxide. Methane in particular, is a very active greenhouse gas, and it's impact on global warming is only reduced by it's relatively short atmospheric lifetime.

GREENHOUSE POLICY

Many reasons have be produced why New Zealand should not act to reduce greenhouse gas emissions from agriculture. These include; the extreme uncertainty associated with the estimates; that agriculture is managing renewable resources as opposed to exploiting non-renewable resources such as fossil fuels; New Zealand exports most of it's produce and the problem therefore belongs to other countries; and that food is needed to feed the worlds growing population. There is no escaping the fact that if international agreement can be reached to produce a treaty to reduce global greenhouse gas emissions, New Zealand will be expected to act on agricultural emissions. Good policy cannot be developed in the absence of adequate information. One challenge for New Zealand science in the next few years is to address some of the important issues associated with agricultural greenhouse gas emissions.

Greenhouse gas emissions are closely linked to the total number of stock in any year. The combined effects of drought and the downturn in the rural sector have resulted in major reductions in stock numbers. Agricultural statistics for 1989 show a reduction of sixteen percent in cattle numbers compared with the peak of 9.3 million in 1974, and a reduction of fourteen percent in sheep numbers compared with the peak of 70.3 million in 1982 (Department of Statistics, 1990). These reductions are however partially offset by increases in deer and goat numbers. If trends in New Zealand's domestic animal numbers are examined, a simple calculation suggests that levels of methane emission from ruminants have been static for at least ten years, and may have declined in recent years. In contrast, methane emissions from municipal landfill sites have been rapidly increasing over the last decade (Currently 20 % of national total, Lassey *et al.*, 1990), and the increase are likely to continue until steps are taken to limit the rate of refuse production by New Zealand society. These observations must be considered when developing policy for New Zealand.

Negotiations towards an international treaty limiting greenhouse gas emissions have commenced (Lindley, 1991; Victor, 1991), and it is useful to consider how this may affect New Zealand. Agreement has not been reached on the likely form of any treaty, but the method of implementation is likely to be left up to individual nations. One option would be the use of tradeable emissions limits, which in New Zealand would be administered under the new resource management bill. Taxation is another option, with a "carbon tax" of five cent per litre of petrol equating to an annual "methane tax" of around $2 per head of sheep, and $20 per head of cattle. The problem of the uncertainty associated with agricultural emissions of greenhouse gases will need to be addressed in any national limitation policy to ensure that the policy is fair and equitable.

RESEARCH NEEDS

Two areas of research need to be developed in New Zealand to improve knowledge of greenhouse gas emissions by ruminants; (1) estimates of fluxes and emissions; and (2) methods for reducing emissions.

Work is needed to identify sources and sinks for methane and nitrous oxide, using *in situ* flux measurements. Greenhouse gas emissions by ruminants need to be measured and compared between different agricultural systems. This should include comparisons between animal species and breeds, as well as different feed sources such as grain and grass. The estimates of greenhouse gas emissions obtained in these studies

should be compared on the basis of total warming potential per kilogram or dollar value of product. On this basis New Zealand's production may be more efficient than many other agricultural producers.

Techniques to reduce methane emissions from ruminants should be investigated. Methane production represents a loss of energy from the animal, and methods to reduce methane production, will increase animal productivity. A range of possible techniques have been identified, including feed supplements, improved reproductive efficiency, improved feed quality, use of synthetic hormones to increase production, microbiological techniques including the use of genetically modified organisms (GMO's), and improved waste management systems (IPCC, 1990). Some options such as synthetic hormones and GMO's are likely to face resistance from consumer or environmental groups.

It will be much more difficult to reduce nitrous oxide emissions from soils. The estimate of nitrous oxide emissions from improved pasture used by the Ministry for the Environment (1990) needs to be improved by further research, but in addition estimates must be obtained for alternative land uses so that possible limitation policies can be evaluated.

CONCLUSIONS

Greenhouse gases from ruminants are a major contributor to the total effective global warming potential of New Zealand's human induced emissions. New Zealand's emissions are insignificant on a global scale, but pressure to reduce emissions is likely as part of an international treaty to limit global warming. It is in New Zealand's interest to be seen to act on national gas emissions, and the agricultural sector of the economy should not expect to be excluded from a national limitation policy.

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