

Copyright is owned by the Author of the thesis. Permission is given for a copy to be downloaded by an individual for the purpose of research and private study only. The thesis may not be reproduced elsewhere without the permission of the Author.

# Agricultural Greenhouse Gas Emissions:

---

## Costs Associated with Farm Level Mitigation

A thesis presented in partial fulfilment of the requirements for the degree of

Master of Applied Economics  
in  
Economics

at Massey University, Palmerston North,  
New Zealand.

Antony Raymond Wolken  
2009

## **Abstract**

Agricultural greenhouse gas emissions within New Zealand account for 48 percent of all national greenhouse gas emissions. With the introduction of the emissions trading scheme farmers will soon be liable for their emissions, introducing additional physical constraints and financial costs. Farmers that still operate within the sector will have two options to meet emissions targets; to purchase carbon credits from the open market, or mitigate farm level emissions at added costs to the farmer. This study examines the latter case of assessing farm level options for mitigating greenhouse gas emissions, and quantifying the physical and financial costs associated with mitigation strategies. Results show that, based on the assumptions in the study, there are available options for dairy farmers to profitably meet Kyoto protocol emissions targets. Sheep and beef farmers can increase profit, but cannot meet Kyoto protocol emissions targets, through examined scenarios.

## **Acknowledgements**

First of all, I'd like to thank my two supervisors, Alan Rae and Anton Meister, I am grateful for your timely advice and guidance when required. Without your help this research would not have been possible. Also, to Phil Journeaux who was kind enough to provide the vital farm level data used in the analysis. David Gray helped tremendously with the farming side of this research. To Phillip Old, who helped bounce hundreds of ideas around and gave motivation when it was needed most, a huge thanks. Other people who contributed along the way include; Tianxiang Mao, Phillip Mellor, Harry Clark, Jessica McIvor, and Lynne Egan.

# Table of Contents

<b>Abstract .....</b>	<b>ii</b>
<b>Acknowledgements .....</b>	<b>iii</b>
<b>List of Tables .....</b>	<b>v</b>
<b>List of Figures .....</b>	<b>vii</b>
<b>1 Introduction .....</b>	<b>1</b>
<b>2 Literature Review .....</b>	<b>7</b>
2.1 Mitigation of Methane Emissions from Ruminants .....	7
2.2 Mitigation of Nitrous Oxide Emissions from Ruminants .....	17
2.3 Agricultural Greenhouse gas Modelling .....	29
2.4 OVERSEER Nutrient Budgets Model .....	32
<b>3 Methodology and data.....</b>	<b>39</b>
3.1 Physical Methodology .....	39
3.2 Financial Methodology.....	43
3.3 Data .....	46
3.4 Mitigation Strategies Simulated with OVERSEER.....	51
<b>4 Results .....</b>	<b>63</b>
4.1 Effects on Physical Characteristics .....	63
4.2 Effects on Financial Position.....	75
4.3 Regional and National Results .....	84
<b>5 Summary and Conclusions .....</b>	<b>94</b>
5.1 Summary .....	95
5.2 Conclusions .....	101
<b>References .....</b>	<b>104</b>
<b>Appendices .....</b>	<b>119</b>
A.1 Dairy Sector .....	119
A.2 Sheep and Beef Sector .....	128

## List of Tables

Table 2.1: A calculation of the proportion of the methane emission attributable to maintenance or milk production in 450 kg grazing dairy cows .....	10
Table 2.2: Global animal production in 1994, in terms of nitrogen (measured in Tg) .....	19
Table 2.3: Default emission factors for estimating nitrous oxide emissions for a given source of nitrogen, and the distribution factors for estimated indirect nitrogen losses (FRAC) in the two different modes of the model .....	36
Table 3.1: Selected summary production and physical characteristics for each dairy representative farm (2007/08) .....	46
Table 3.2: Selected summary production and physical characteristics for each sheep and beef representative farm (2006/07) .....	47
Table 4.1: Dairy farming mitigation scenario effects, on methane and nitrous oxide emissions .....	64
Table 4.2: Farm level impacts from methane scenarios, for the Waikato/BOP dairy representative farm (2007/08) .....	65
Table 4.3: Farm level impacts from nitrous oxide scenarios, for the Waikato/BOP dairy representative farm (2007/08) .....	65
Table 4.4: Sheep and beef farming mitigation scenario effects, on methane and nitrous oxide emissions .....	68
Table 4.5: Methane and nitrous oxide scenario farm level impacts for the Waikato/BOP sheep and beef representative farm (2006/07) .....	69
Table 4.6: Emissions per unit of production, for dairy methane scenarios (Kg CO <sub>2</sub> -e per Kg milk solids) .....	73
Table 4.7: Additional costs / forgone revenue, for the Waikato/BOP dairy representative farm (2007/08) .....	75
Table 4.8: Additional revenue / forgone costs, for the Waikato/BOP dairy representative farm (2007/08) .....	76
Table 4.9: Profit changes from each mitigation strategy, for all dairy representative farms, per financial year (2007/08) .....	77
Table 4.10: Dollars per ton of CO <sub>2</sub> -e mitigated, for each representative dairy farm ...	78
Table 4.11: Alternate scenario, dollars per ton of CO <sub>2</sub> -e mitigated for each dairy representative farm, when milk solids are \$4 per kg (2007/08) .....	79

Table 4.12: Alternate scenario, dollars per ton of CO <sub>2</sub> -e mitigated for each dairy representative farm, when maize silage is 20 cents/kg DM (milk solids price is the same as the base case) (2007/08) .....	79
Table 4.13: Additional costs / forgone revenue, for the Waikato/BOP sheep and beef representative farm (2006/07) .....	80
Table 4.14: Additional revenue / forgone costs, for the Waikato/BOP sheep and beef representative farm (2006/07) .....	81
Table 4.15: Profit changes from each mitigation strategy, for all sheep and beef representative farms (per financial year) (2006/07) .....	82
Table 4.16: Dollars per ton of CO <sub>2</sub> -e mitigated, for each sheep and beef representative farm (2006/07) .....	83
Table 4.17: Selected regional dairy farm summary statistics (2007/08) .....	84
Table 4.18: Total mitigation for each dairy region 2007/08 (CO <sub>2</sub> -e, 000's of tons) ...	85
Table 4.19: Dairy total regional change in profit from implementing each strategy (2007/08, \$m) .....	86
Table 4.20: Selected regional sheep and beef farm summary statistics (2006/07) .....	87
Table 4.21: Regional mitigation for sheep and beef farms (000's tons CO <sub>2</sub> -e) (2006/07) .....	88
Table 4.22: Sheep and beef total regional profit change from implementing each mitigation strategy (2006/07, \$m) .....	89
Table 4.23: Dairy strategies implemented to meet the Kyoto target (000's of CO <sub>2</sub> -e tons) .....	91
Table 4.24: Dairy profit change of adoption, and counterfactual carbon credit cost for the status quo (\$m) .....	91
Table 4.25: Sheep and beef strategies implemented to meet the Kyoto target (thousands of CO <sub>2</sub> -e tons) .....	92
Table 4.26: Sheep and beef profit change of adoption, and additional carbon credit cost to meet Kyoto (\$m) .....	93

## List of Figures

Figure 2.1: Process of nitrification and denitrification .....	18
Figure 2.2: Nitrogen fertiliser use in New Zealand since 1960 (units in Gigagrams) .	23
Figure 3.1: Effect of Eco-n on Pasture Production .....	54
Figure 3.2: Cross section of a typical stand-off pad.....	56
Figure 3.3: Cross section of a feed pad.....	59
Figure 4.1: Mitigation of greenhouse gas emissions for each dairy representative farm (tons of CO <sub>2</sub> -e, 2007/08) .....	66
Figure 4.2: Mitigation of greenhouse gas emissions for each dairy representative farm, expressed as a percentage of base case emissions (2007/08).....	67
Figure 4.3: Mitigation of greenhouse gas emissions for each North Island sheep and beef representative farm (tons of CO <sub>2</sub> -e, 2006/07) .....	70
Figure 4.4: Mitigation of greenhouse gas emissions for each South Island sheep and beef representative farm (tons of CO <sub>2</sub> -e, 2006/07) .....	70
Figure 4.5: Mitigation of greenhouse gas emissions for each North Island sheep and beef representative farm, expressed as a percentage of base case emissions (2006/07) .....	71
Figure 4.6: Mitigation of greenhouse gas emissions for each South Island sheep and beef representative farm, expressed as a percentage of base case emissions (2006/07) .....	72