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Greenhouse gas emissions from Rotorua dairy farms: Summary report

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MAF Sustainable Farming Fund

July 2010

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Background and Objectives

A previous project examined nitrogen (N) leaching from all 26 dairy farms in the Lake Rotorua catchment and evaluated effects of some management practices on N leaching. The objectives of this project were to build on the previous project to:

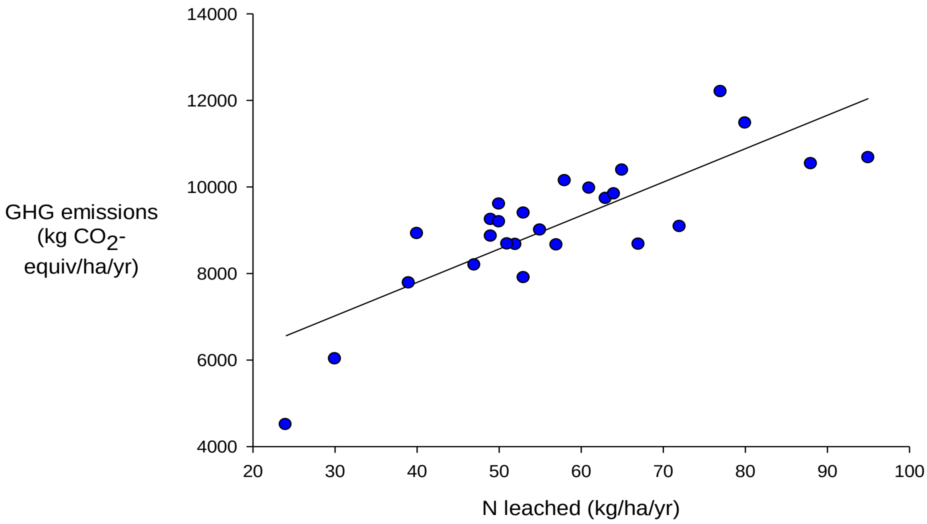
- determine variation in greenhouse gas (GHG) emissions and N leaching between the individual farms using the OVERSEER nutrient budget model,
- examine general effects of some management options on reducing GHG emissions and decreasing N leaching (using OVERSEER),
- compare GHG emissions with estimates using a carbon footprint (CF) model
- choose six farms with contrasting systems and evaluate effects of a range of management and mitigation practices on production, profitability, N leaching and GHG emissions.

Variation in GHG emissions between individual farms

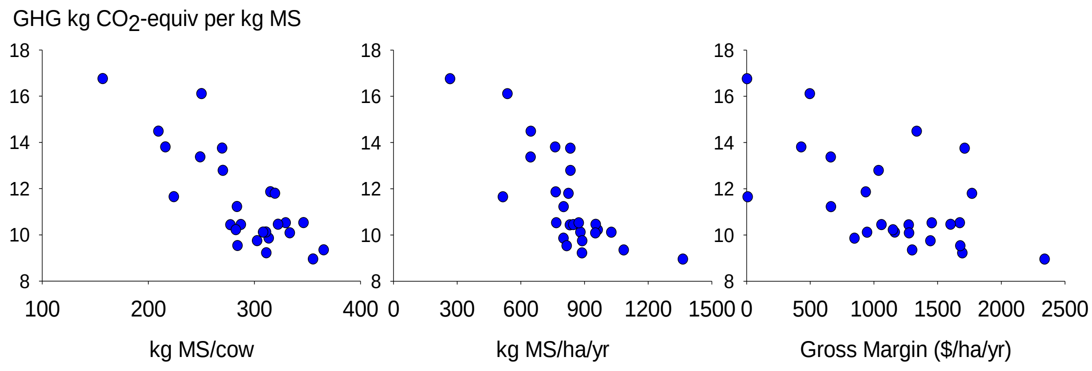
- The 26 dairy farms showed a 5-fold variation in annual milksolids production per ha, 4-fold variation in N leaching per ha, 3-fold range in GHG emissions per ha and 2-fold variation in GHG emissions per kg milksolids.

	N fertiliser (kg/ha)	Milksolids production (kgMS/ha)	N leached (kg/ha)	Methane	N_2O	CO_2	Total GHG	GHG per kg milksolids ($kg\ CO_2$-equiv/kg MS)
				($kg\ CO_2$-equivalents/ha)				
Average	168	824	57	5,137	3,195	735	9,067	11.4
Minimum	0	269	24	3,034	1,411	59	4,504	8.9
Maximum	277	1,366	95	7,044	4,101	1,074	12,198	16.9

- Decreasing GHG emissions/ha was strongly correlated with decreasing N leaching/ha.

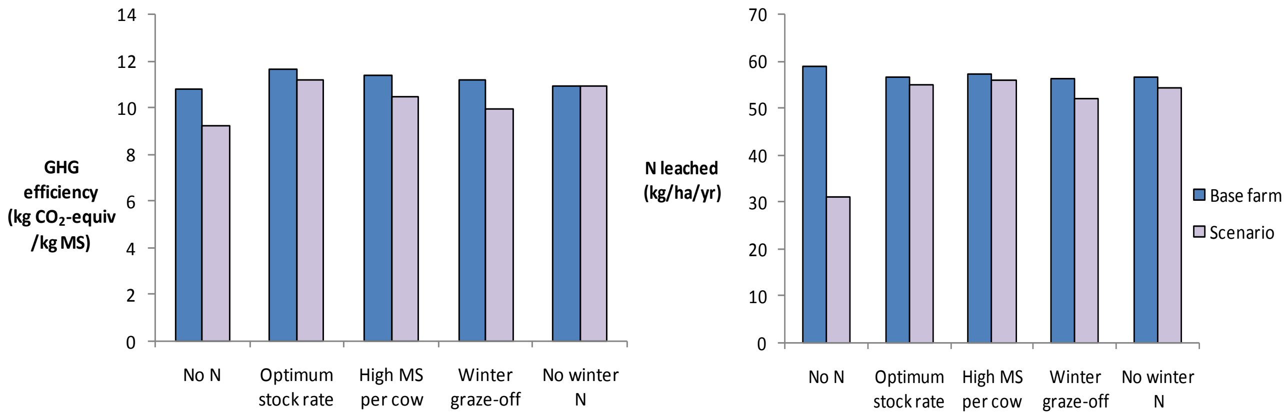


- The GHG emissions/kg milksolids varied between 8.9 and 16.9 kg CO_2-equivalents/kg milksolids (average 11.4). In general, this decreased with increasing milksolids production per cow and per hectare, and with increasing profitability/ha. (corresponding GHG values for methane and N_2O only, as per ETS, were 8.1-16.5 with average of 10.5 kg CO_2-equivalents/kg milksolids).



General effects of some management practices

- On average across farms, ceasing N fertiliser use resulted in large reductions in per-hectare GHG emissions (c. -31%) and N leaching (-47%) but less difference in GHG efficiency (-15%) due to a reduction in milksolids production (*see figures below*).
- Increased winter grazing-off of dairy cows reduced on-farm GHG emissions/kg milksolids (–11%), but it would not reduce total system emissions (note that most farms already had some wintering off).
- Increased cow productivity (optimum stocking rate or high MS/cow) decreased GHG emissions/kg milksolids by 4-8%, but had less effect on N leaching (up to 3% reduction).



Carbon footprint model

- The Carbon Footprint (CF) model developed for Fonterra and MAF was used to calculate the "cradle-to-farm-gate" carbon footprint of the 26 farms, which averaged 14.2 kg CO_2-equivalents/kg milksolids with a range of 11.1-21.4 kg CO_2-equivalents/kg milksolids.
- These values are higher than from OVERSEER (which covers on-farm only) because they account for all animals (including replacements and cows grazed off-farm) and all emissions from brought-in products such as supplementary feed and fertilisers.
- The CF model showed clearer benefits in reducing GHG emissions/kg milksolids with improved cow efficiency factors such as higher per cow production and reduced replacement rate compared to that using OVERSEER.
- Previous research on the Carbon Footprint of milk products for Fonterra showed the on-farm stage as the main contributor through the life cycle with relative emissions from the farm : milk processing : distribution/shipping stages at 85 : 10 : 5.

Farm case studies

- Detailed scenario analyses on six farms with varying base GHG efficiency showed variation in effectiveness of a range of different scenarios, depending on their current practices
- The largest reduction in GHG emissions/kg milksolids was from a nil N fertiliser scenario, with the greatest reduction on the farm with highest base N fertiliser use (*see Table 1; farm number 24*). The second largest reduction was from increasing per-cow milk production using maize silage. In contrast, increasing per-cow production using more N fertiliser increased GHG emissions/kg milksolids in two of the three scenarios examined. The other scenarios relating to increased cow productivity (smaller cows, increased genetic gain) gave moderate reductions up to about 0.8 kg CO_2-equivalents/kg milksolids. Reducing replacement rate gave similar reductions in GHG emissions/kg milksolids, which would be even greater if a whole system or carbon footprint method was used because it would account for the lower off-farm emissions from fewer replacements (grazed off-farm). Optimising stocking rate had variable results.
- The scenarios examined had variable effects on farm profitability (*see Table 2*). Ceasing N fertiliser use decreased profitability on all farms. A change to smaller Jersey cows was estimated to reduce profitability on half of the farm

scenarios. In contrast, all other scenarios relating to increased cow productivity or optimising stocking rate resulted in increased profitability.

Table 1: Effect of scenarios on change in GHG emissions/kg milksolids (kg CO_2 equiv/kg MS) from Base farm for all case study farms

	Farm number					
	3	**8**	**10**	**12**	**17**	**24**
Base Farm (kg CO_2 equiv/kg MS)	*10.5*	*8.9*	*9.5*	*10.1*	*13.2*	*12.8*
Change in GHG efficiency (kg CO_2 equiv/kg MS) for different scenarios:						
No N fertiliser use	-1.2	-1.4	-0.9	-0.3	-2.1	-2.1
Increasing MS/cow using N fertiliser			0.3	0.6	-0.2	
Increasing MS/cow using maize silage	-0.4		-0.5	-0.6	-0.9	-1.6
Increased wintering off			-1.0	-0.7	-1.4	-1.8
Smaller Jersey (360 kg) cows	-0.6	-0.5	-0.3			-0.5
Optimising stocking rate for farm system	0.2		0.4	-0.01	-0.6	-0.4
Increased genetic gains in animals	-0.3	-0.4	-0.6	-0.8		-0.8
Reducing replacement rate	-0.4	0.03	-0.3		-0.8	-0.4

Table 2: Effect of scenarios on change in Gross Margin ($/ha/year) from Base farm for all case study farms

	Farm					
	3	**8**	**10**	**12**	**17**	**24**
Base Farm($/ha/year)	*1678*	*2344*	*951*	*1674*	*665*	*1041*
Change in GM ($/ha/year) for different scenarios:						
No N fertiliser use	-144	-428	-63	-46	-151	-207
Increasing MS/cow using N fertiliser			350	352	197	
Increasing MS/cow using maize silage	313		139	223	268	306
Increased wintering off			76	266	116	411
Smaller Jersey (360 kg) cows	96	-143	-101			57
Optimising stocking rate for farm system	41		47	24	113	100
Increased genetic gains in animals	47	628	474	508		456
Reducing replacement rate	118	363	524		123	276

- The relative effects of scenarios on N leaching (*see Table 3*) were similar to those for GHG emissions/kg milksolids (*Table 1*), although increasing milksolids production/cow was much less effective in reducing N leaching.

Table 3: Effect of scenarios on change in N leaching (kg N/ha/yr) from Base farm for all case study farms

	Farm					
	3	**8**	**10**	**12**	**17**	**24**
Base Farm(kg N/ha/yr)	*49*	*77*	*39*	*40*	*57*	*95*
Change in N leaching (kg N/ha/yr) for different scenarios:						
No N fertiliser use	-13	-43	-10	-4	-30	-57
Increasing MS/cow using N fertiliser			15	24	10	
Increasing MS/cow using maize silage	4		-1	1	2	-1
Increased wintering off			-6	-1	-6	-6
Smaller Jersey (360 kg) cows	0	-1	-1			2
Optimising stocking rate for farm system	2		2	0	-3	-5
Increased genetic gains in animals	-1	-2	-1	-2		-2
Reducing replacement rate	-1	1	-1		-3	-3

Implications:

- Farm practices that reduce N leaching also generally decrease GHG emissions.
- Practices to increase cow productivity (higher milksolids/cow, using genetic gain, reduced replacement rate) reduce GHG emissions per kg milksolids (by up to 13%) and can increase farm profitability. However, reductions in N leaching are relatively less (up to 5%).
- In future, the ETS means that the dairy sector (and probably individual farms) will be responsible for the cost of increased GHG emissions. These costs will decrease on farms with decreased GHG emissions/kg milksolids.
- The ETS may lead to a financial incentive from introducing practices that reduce N leaching through their effects on reducing GHG emissions/kg milksolids.

Reference to full report:

Judge A, Ledgard S, Smeaton D and Boyes M 2010 Greenhouse gas emissions from Rotorua dairy farms. Report to MAF. AgResearch, Hamilton. 120 pages.