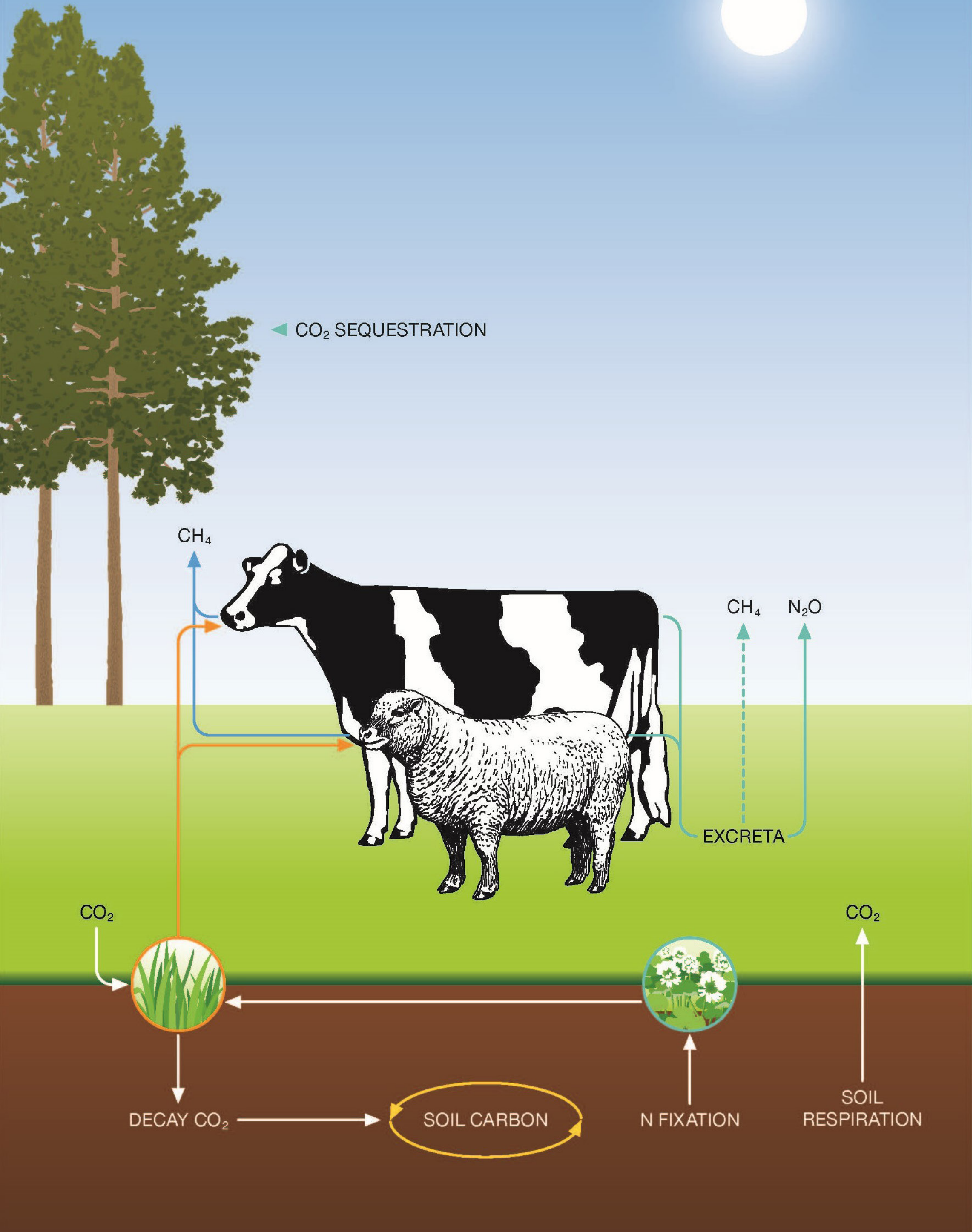
INFORMATION BROCHURE: Mitigation and cost of on-farm Greenhouse Gas Emissions

April 2019

Greenhouse Gas Flows

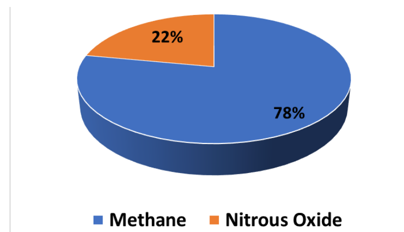


Background

This brochure reports on the modelling work done over four years on a range of dairy and sheep and beef farms, as part of a number of projects, including for the New Zealand Agricultural Greenhouse Gas Research Centre (NZAGRC). It also discusses forestry as a carbon sink and possible costs to farmers.

One of the effects of ruminant animals grazing on pasture is the discharge of greenhouse gases into the atmosphere, in the form of methane (CH_4) and nitrous oxide (N_2O). These two compounds make up the **biological** gases as described in New Zealand's Emission National Inventory.

The proportion of biological gases emitted from a farm is:



The main source of methane is from rumen digestion, with around 3 - 4 percent derived from anaerobic manure storage, with still smaller emissions from animal manure deposited directly onto soils.

Nitrous oxide is mostly produced by microbial action within the soil, feeding on manure, mostly urine and fertilisers. Some indirect emissions also come from nitrogen leaching, wetlands, and run-off.

Greenhouse Gas Modelling

The modelling has involved setting up dairy and sheep and beef farms within Farmax, to model the farm system and changes in system scenarios, as to the physical and financial impacts. The information from this was then transferred into Overseer™ to determine GHG emissions.

Results of the farm system modelling

Average emissions and intensity of emissions were:

TABLE 1: Average Biological GHG emissions per hectare (CO_2e)

	Average Tonnes GHG/ha	Range tonnes GHG/ha
Dairy	9.6	3.1 - 18.8
Sheep & Beef	3.1	0.9 - 5.1

TABLE 2: Intensity of emissions kgCO_2e/kg product

	Average	Range
Dairy	8.8	4.3 - 17.2
Sheep & Beef	16.0	3.8 - 33.7

The dairy figures are based on a DairyNZ study analysing 382 farms nationally, with the sheep and beef figures based on 32 farms analysed, mostly in the North Island. The **intensity** of the emission is the kilogrammes of CO_2 equivalent, per kilogramme of product produced.

The emissions intensity figures shown in Table 2 are good by international standards, reflecting the efficiency of our farming systems. The ranges indicate a wide variation, largely relating to the level of intensity of farming (e.g. stocking rate, amount of feed purchased in); generally, the more intense the farming system the higher the absolute emissions, and the lower the level of intensity of emissions. Note though that the ETS and international treaties all deal in absolute GHG emissions.

At the individual farm level, differing farm system scenarios had differing impacts as summarised in Tables 3 and 4.

TABLE 3: Dairy on-farm system change

	Change in GHG	Change in EBIT
Reduce stocking rate by 10%		
Farm 1 (pre: 2.7 cows/ha, 4.9 tDM/cow offered)	-6%	12%
Farm 2 (pre: 2.8 cows/ha, 5.4 tDM/cow offered)	-7%	-4%
Farm 3 (pre: 2.3 cows/ha, 5.0 tDM/cow offered)	-8%	-3%
Farm 4 (pre: 2.9 cows/ha, 5.9 tDM/cow offered)	-6%	11%
Replace N fertiliser with bought-in feed	-11%	-18%
In-shed feeding with increased cow numbers	11%	12%
In-shed feeding, no increase in cows	10%	9%
Grow maize instead of buying in PKE	-4%	0%
Limit N fertiliser to 100 kgN/ha	-5%	-12%
Shift to once-a-day milking	3%	21%

(Note that Tables 3 and 4 are a sample of farms analysed, to give an indication of results)

TABLE 4: Sheep & beef on-farm system change

	Change in GHG	Change in EBIT
All male progeny as bulls	-6%	12%
Convert to deer (finishing weaners)	0%	-19%
Shift to 50:50 sheep:beef	-10%	13%
Increase sheep:cattle ratio		
Farm 1 (NI Intensive: from 55% sheep to 67%)	-1%	0%
Farm 2 (NI Hill Country: 58% sheep to 68%)	1%	10%
Farm 3 (SI Intensive: 64% sheep to 81%)	-1%	-20%
Farm 4 (SI Hill Country: 67% sheep to 77%)	0%	19%
Intensive lamb finishing	7%	22%
Increase lambing % (135 - 160)	0%	12%
Develop 100 ha techno beef unit	9%	33%
Replace breeding cows with finishing bulls & heifers	-8%	78%
Convert to dairy sheep	17%	68%

The research showed that every farm was different; the impact of any system change depended very much on the original system and how intensively, or otherwise, it was being farmed. **As a generalisation, the various changes resulted in a ± 5% - 10% change in GHG emissions, and a variable impact on farm profitability.**

While a reduction in stocking rate is often proposed as a mitigating strategy, the resultant impact on farm profitability can vary, depending on where the farm sits on its profitability curve.

Added to this is the expertise of the farmer in grazing management. If good, often per animal production could be increased. If not, then pasture quality would decline, along with per animal production.

Reducing stocking rate therefore is not a silver bullet.

In a similar situation, increasing productivity levels on sheep and beef farms (i.e. increasing lambing percentage or increasing final carcase weights, both of which improved profitability) were often offset by the need to reduce capital stock numbers to free up feed to achieve the increased productivity levels. The goal therefore was to achieve an equilibrium point which may or may not reduce GHG emissions, and may or may not lift profitability.

Forestry

Land use change into forestry resulted in much larger reductions in GHG emissions whereby the carbon sequestered by the trees was used to offset the GHG emissions from the pastoral farming operation.

In all situations the forestry annuity (at 5%) was less than the dairy EBIT, whereas for the sheep and beef farms, this varied.

In a number of instances, the forestry annuity was greater than the farm EBIT, and the addition of forestry resulted in an improvement in farm profitability. On other farms, the areas (to be) planted in forestry tended to be the steeper less productive areas, and in many cases the specific area to be planted was probably contributing little to the overall farm income.

TABLE 5: Impact of forestry land use change

	Waikato Dairy Farm		North Island Hill Country Farm	
	Change in GHG	Change in EBIT	Change in GHG	Change in EBIT
5% forestry	-6%	-8%	-18%	-7%
10% forestry	-14%	-15%	-33%	-12%
15% forestry	-22%	-20%	-49%	-20%
20% forestry	-30%	-35%	-64%	-24%
30% forestry	-45%	-50%	-93%	-35%

The planting of forestry to offset farming emissions is complex and outside the scope of this pamphlet. Under the current ETS rules, if forestry is harvested, then approximately 80% of the sequested carbon is deemed to be released, and any credits claimed need to be repaid. Consideration of this can affect the area of land that needs to be planted, as shown in Table 6.

TABLE 6: Indicative hectares of Radiata forestry required as an offset

	Percentage Offset							
	5%		10%		50%		100%	
	Total	Safe	Total	Safe	Total	Safe	Total	Safe
147 ha dairy farm	3	12	6	24	28	118	56	235
627 ha sheep/beef farm	4	16	8	32	39	162	77	324

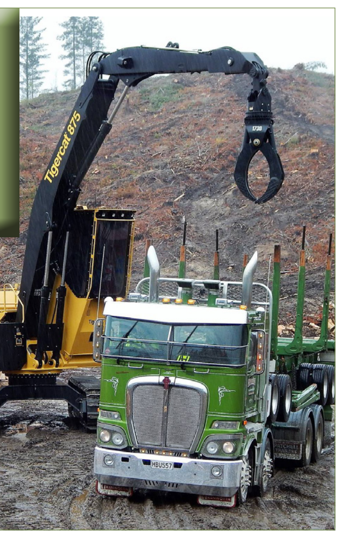
Note: The government has recently announced that forests planted from 2020 can claim half the annual average carbon sequestered as safe carbon. For Table 6, this would be twice the area shown as total carbon.

As shown in Table 6, 'total' carbon relates to a regime where the total amount of carbon sequestered is claimed, remembering that at harvest around 80% has to be paid for. An alternative to the harvest regime would be to plant up a steep unproductive area, and never harvest, thereby claiming the carbon offset for 50+ years. The **safe** carbon relates to the amount of carbon which remains after harvest (i.e. stump, roots etc.), often referred to as **trade without penalty**, which is the amount of carbon that can be sold or used as an offset without having to pay it back. Only forests planted after about 2003 will have significant safe carbon.

Currently the government is considering increasing the amount claimable as **safe carbon** up to the average amount sequestered, which would reduce the area required to be planted, as illustrated in Table 6, remembering that **safe carbon** is only claimable in the first rotation.

It also needs to be remembered that forestry is not a permanent solution; when the forest is harvested, the original area needs to be replanted, plus a further similar area needs to be planted to provide carbon offsets for the next rotation, and so on.

If you are considering forestry for carbon sequestration, seek advice from a forestry/ ETS consultant.



Permanent Horticulture

Permanent horticulture (e.g. kiwifruit, pipfruit) is also an option as an alternative low carbon emitting land use, as average emissions are in the order of 0.1 - 0.2 tonnes/CO_2e/ha.

While this could be an option, it also depends on soil types and local microclimates, and while potentially very profitable, also usually has high up-front capital costs and a delay of several years before profitability is achieved.

Some modelling work on tree crops (in this case chestnuts) in the central North Island, where an area on the farm was taken out in order to grow the crop, showed the following results:

TABLE 7: Impact of a permanent horticultural crop

	Change in GHG	Change in EBIT
Dairy Farm		
+ 10 ha chestnuts	-5%	96%
+ 40 ha chestnuts	-24%	346%
Sheep & Beef Farm		
+ 10 ha chestnuts	-1%	14%
+ 40 ha chestnuts	-3%	61%

While the impact in reducing GHG's is significant within the area involved in horticulture, this can be reduced when considered across the larger area of farms, as is the case with the sheep and beef farm modelled above.

Emissions Trading Scheme/Point of Obligation/Cost to Farmers

The Emissions Trading Scheme (ETS) is the main policy within New Zealand to reduce GHG emissions, by placing a price on GHG emissions, and allowing businesses to trade these. Within this, there is a **point of obligation**, which is the point at which the cost of carbon is paid.

Whether agriculture is brought into the ETS, and the point of obligation is currently under consideration; either the point of obligation would lie with the processing companies, or directly with farmers. If the point of obligation lies with the processors, this means that the government would require the dairy and meat companies to buy New Zealand Units (NZU's – carbon credits equivalent to 1 tonne CO_2e) relative to their throughput. They in turn would pass the cost onto supplying farmers in the form of lower schedules and payouts.

Administratively this is the simplest but provides a weak incentive for individual farmers to act.

An indication of the impact on the meat schedule and milksolids payout is shown in the following tables.

TABLE 8: Indicative impact on milksolids payout ($/kg) (based on emission factor of 8.76 kgCO_2e/kgMS)

	PRICE OF CARBON ($/T/$CO_2$E)			
% Liability	**$25**	**$30**	**$50**	**$100**
5%	$0.01	$0.01	$0.02	$0.04
10%	$0.02	$0.03	$0.04	$0.09
50%	$0.11	$0.13	$0.22	$0.44
100%	$0.22	$0.26	$0.44	$0.88

TABLE 9: Indicative impact on sheep/beef meat schedule ($/kg) (based on emission factor of 14.2 kgCO_2e/kg carcase weight)

	PRICE OF CARBON ($/T/$CO_2$E)			
% Liability	**$25**	**$30**	**$50**	**$100**
5%	$0.02	$0.02	$0.04	$0.07
10%	$0.04	$0.04	$0.07	$0.14
50%	$0.18	$0.21	$0.36	$0.71
100%	$0.36	$0.43	$0.71	$1.42

If the point of obligation is placed on individual farms, then this gives a direct incentive for individual farmers to act. The drawback is that this is administratively complex and costly. If the point of obligation is placed on individual farms, and assuming no other on-farm mitigations are put in place - farmers simply pay for NZU's, then the cost, based on the average emissions outlined in Table 1 is outlined as per Tables 10 and 11.

Table 10: Cost per hectare dairy farm

	Price of Carbon ($/t/$CO_2$e)			
% Liability	**$25**	**$30**	**$50**	**$100**
5%	$12	$14	$24	$48
10%	$24	$29	$48	$96
50%	$120	$144	$240	$480
100%	$240	$288	$480	$960

Table 11: Cost per hectare sheep and beef farm

	Price of Carbon ($/t/$CO_2$e)			
% Liability	**$25**	**$30**	**$50**	**$100**
5%	$4	$5	$8	$16
10%	$8	$9	$16	$31
50%	$39	$47	$78	$155
100%	$78	$93	$155	$310

Discussion

Currently there are a number of reviews happening; as to whether agriculture comes into the ETS, mechanisms within the ETS, emission factors, and whether any GHG charge is levied to achieve a set reduction over time, all of which could change a number of the figures presented in this brochure. They are therefore presented as indicative only.

Overall, mitigating farm-level greenhouse gases is not necessarily straight forward, and in many instances can be quite complex. While altering farm systems can achieve some reduction, generally these are somewhat limited around the 5% - 10% level, with varying impacts on profitability. Land use change into forestry offers greater levels of GHG offsetting, but again comes with issues of its own. Similarly with any permanent horticultural development.

Improving farm productivity, which is not just about production, is, as ever, a generally positive move, as while it may not necessarily reduce greenhouse gas emissions, it will improve profitability. What is important, as outlined in the tables above, is the cost of carbon could become quite high.

The modelling work has shown that each farm is different, so if you are looking for strategies to reduce or offset your greenhouse gas emissions, **seek good advice**.

Further Reading:

About the ETS:
http://www.mfe.govt.nz/climate-change/new-zealand-emissions-trading-scheme/about-nz-ets

About the ETS Review:
https://www.mfe.govt.nz/climate-change/new-zealand-emissions-trading-scheme/reviews-of-nz-ets/nz-ets-review-201516/outcomes

Review of GHG mitigation modelling on four Maori case study farms:
https://www.nzagrc.org.nz/maori,listing,469,report-mitigating-greenhouse-gases-on-mori-farms-2014-2017.html

Modelling of GHG mitigations on a range of farm systems:
https://www.mpi.govt.nz/protection-and-response/environment-and-natural-resources/biological-emissions-reference-group/

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