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ON-FARM MITIGATION OF GREENHOUSE GASES

This article follows on from various articles in the previous edition around greenhouse gases (GHGs) and climate change. It discusses work investigating the implications of mitigating GHGs at an on-farm level carried out over the last four years.

The intensity of emissions is a good news story for New Zealand, as our pastoral farming is very efficient and therefore has a low intensity level.

Real farm modelling

This work involved modelling a number of real farms, and regional models, in Farmax and OVERSEER. The farms and models were developed in Farmax so changes in farm systems could be modelled as to their physical and financial effects, with the information then transferred into OVERSEER to calculate the impact on GHG emissions. Land use change, in the form of forestry and horticulture, was also modelled as part of this work. The GHGs of interest are the 'biological' gases – methane (CH_4) and nitrous oxide (N_2O). Within this, of the farms modelled, approximately 75% of the biological emissions were methane and 25% nitrous oxide.

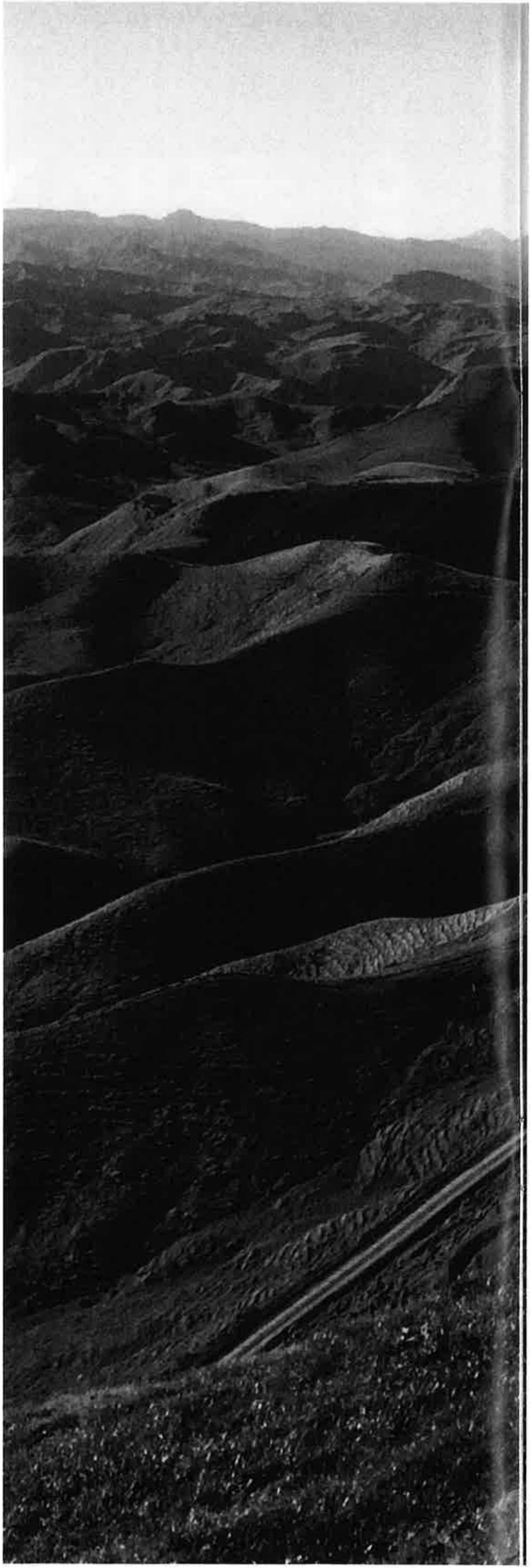
A summary of the modelling is shown in *Tables 1* and *2*. The intensity of emissions is a good news story for New Zealand, as our pastoral farming is very efficient and therefore has a low intensity level. The bad news is that all international treaties, and the ETS, deal in absolute emission levels. The ranges indicate a wide variation, largely relating to the level of intensity of farming; generally the higher the intensity of farming the higher the absolute emissions and the lower the level of intensity of emission.

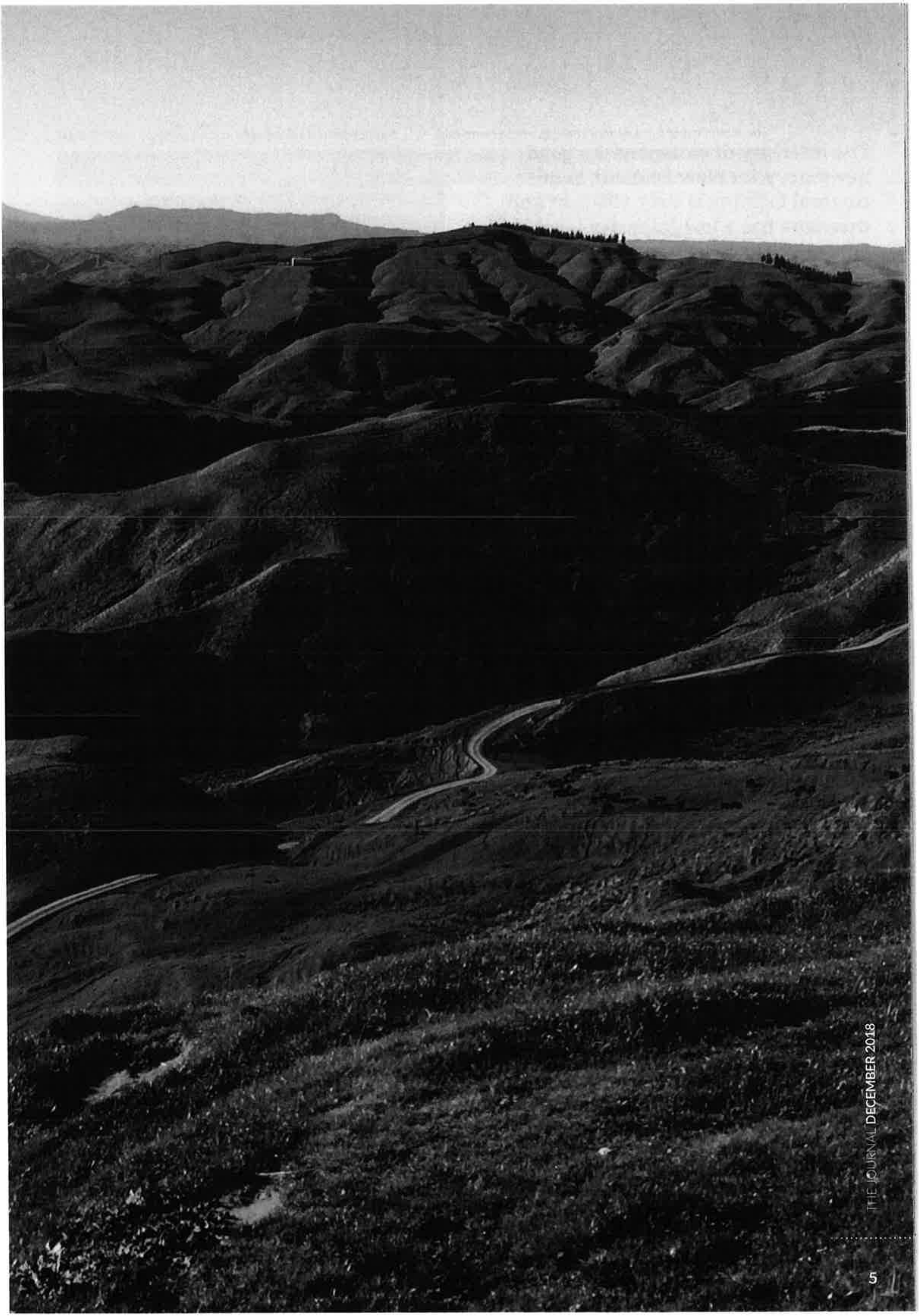
Table 1: Average GHG emissions/ha (CO_2e)

	AVERAGE TONNES GHG/HA	RANGE TONNES GHG/HA
Dairy	12.5	8.0 – 18.0
Sheep and beef	3.5	1.0 – 5.0

Table 2: Intensity of emissions kgCO_2e/kg product

	AVERAGE	RANGE
Dairy	11.5	7.5-14.5
Sheep and beef	21.0	5.0-37.0
Hill country	25.0	
Intensive	15.0	





The modelling of farm system changes at the farm level showed the impacts as illustrated in *Tables 3* and *4*. Note that the change in GHG emissions and EBIT and *Tables 3 and 4* are relative to the original base system. Also note that these are not all of the scenarios modelled, but a range to indicate the level of changes obtained. Perhaps the first point is that every farm was different; the impact of any system change depended very much on the original system and how intensive, or otherwise, it was. As a generalisation, the various changes resulted in a +/- 5-10% change in GHG emissions and a variable impact on farm profitability.

Reduction in stocking rate

A reduction in stocking rate, especially on dairy farms, is often indicated as a silver bullet to GHG (and nitrogen) emissions, which it isn't. The situation is much more nuanced; as stocking rate was reduced, the first step was to reduce supplements bought in, which saved cost. Often there was a resultant surplus of pasture, which allowed for an increase in per cow production.

Whether the farm had a resultant lift in profitability depended on where they were on the marginal cost/ marginal revenue curve. If marginal cost (MC) was greater than marginal revenue (MR), then a reduction

Table 3: Dairy on-farm system change

		CHANGE IN GHG	CHANGE IN EBIT
Reduce stocking rate by 10%	Farm 1	-6%	12%
	Farm 2	-7%	-4%
	Farm 3	-8%	-3%
	Farm 4	-3%	14%
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 PK		-4%	0%
Limit N fertiliser to 100 kgN/ha		-5%	-12%
Shift to once-a-day milking		3%	21%

Table 4: Sheep and 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	-1%	0%
Farm 2	1%	10%
Farm 3	-1%	-20%
Farm 4	0%	19%
Intensive lamb finishing	7%	22%
Increase lambing % (135 to 160)	0%	12%
Develop 100 ha techno beef unit	9%	33%
Replace breeding cows with finishing bulls and heifers	-8%	78%
Convert to dairy sheep	17%	68%

in stocking rate would (usually) result in an improvement in profitability. If the farm was operating such that MC (roughly) equalled MR, then often a reduction in stocking rate resulted in a reduction in profitability. 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. So again, every farm was different.

In a similar situation, increasing productivity levels on sheep and beef farms (i.e. increasing lambing or increasing final carcass weights, both of which improved profitability) was often offset by the need to reduce capital stock numbers to free up feed to achieve the increased productivity levels. So the goal was to achieve an equilibrium point, which may or may not reduce GHG emissions, and may or may not lift profitability. But, overall, the modelling did indicate that there was some gain (albeit limited) in reducing GHG emissions via farm system change.

A reduction in stocking rate, especially on dairy farms, is often indicated as a silver bullet to GHG (and nitrogen) emissions, which it isn't.

The largest reductions in GHG emissions were achieved via land use change, which was mostly modelled as forestry. An illustration of the results is given in *Table 5*. Forestry profitability was calculated as an annuity, discounted at 5%, to compare it to the farm EBIT (the main tree species modelled was *Pinus radiata*). This was always less than the dairy average EBIT, hence the reduction in profitability when forestry areas were planted on dairy farms.

For sheep and beef farms the situation varied, as in a number of farm cases 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 (modelled to be) planted in forestry tended to be the steeper less productive areas, and while the whole farm EBIT was used in the analysis, in many cases the specific area to be planted was probably contributing little to the overall farm income.

Within the modelling, this was accounted for to some degree by splitting the hill country farms proportionally into 'steep', 'rolling' and 'flat' land, with pasture growth adjusted accordingly (less on the steep areas, more on the flat areas), and with the trees planted on the steep area, which had a lesser impact on farm profitability.

The returns from forestry are affected by a range of issues, particularly the 'harvestability' on-farm, which often relates to access and the steepness of the terrain and the distance of the farm to mills or ports. While forestry is a means of producing significant GHG offsets, the other thing to remember is that it is not a long-term solution. In essence, it offers a (say) 30-year window to develop a more permanent solution. This is in the sense that assuming (say) 100 ha is sufficient offset; in year 28 when it is harvested, the initial 100 ha needs to be replanted, plus a further 100 ha to offset the next 28 years. And so on.

Forestry planting to offset emissions

The planting of forestry to offset farming emissions is somewhat complex and outside of this article to fully describe. Under the current ETS rules, if forestry is harvested, then approximately 80% of the sequestered carbon is deemed to be released and any credits claimed need to be repaid. Consideration of this can affect the area of land needed to be planted, as shown in *Table 6*.

In *Table 6*, 'total' carbon relates to a regime where the trees are never harvested, whereas the 'safe' carbon relates to the amount of carbon that 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.

As ***Table 6*** illustrates, dairying has something of an issue, given there is often little marginal land on most farms that can be planted, whereas most sheep and beef farms have some marginal areas that can be planted, although if a 100% offset was required the issue becomes problematic. Also, if you are a dairy farmer thinking of buying a sheep and beef farm to plant up, have a good financial analysis done, because potentially you are about to write off a lot of capital. Interestingly, many of the farms where forestry was modelled as an option were very interested in forestry, but in anything but radiata.

The forestry modelling did incorporate other species, particularly manuka, as well as totara and lusitanica. While other species have their place, generally radiata provides the greatest economic return, as well as having the fastest carbon sequestration rate.

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 largest reductions in GHG emissions were achieved via land use change, which was mostly modelled as forestry.

Table 6: Hectares of radiata forestry required as an offset

% OFFSET	5%		10%		50%		100%	
	Total	Safe	Total	Safe	Total	Safe	Total	Safe
147 ha dairy farm	3.3	15.3	6.6	30.6	32.8	153.1	65.6	306.3
627 ha sheep and beef farm	3.9	18.3	7.8	36.6	39.2	182.9	78.4	365.8

Permanent horticulture (e.g. kiwifruit, pipfruit) is also an option as an alternative low carbon emitting land use.

Permanent horticulture (e.g. kiwifruit, pipfruit) is also an option as an alternative low carbon emitting land use, as average emissions are of the order of 0.1-0.2 tonnes/CO_2e/ha. Modelling growing chestnuts (central North Island – cold winter) is shown in *Table 7*. The reduction in GHG emissions on the sheep and beef farm were relatively modest, mainly due to the size of the farm (928 ha effective). While the impact was significant on the area converted to chestnuts, the area involved was quite small relative to the size of the whole property.

Point of obligation

The point of obligation is also an important aspect which will affect how farmers react. Currently under the ETS, the point of obligation will lie with the processors. Assuming agriculture comes within the ETS, they will be required to purchase NZUs relative to their market share, and then pass the cost of this on via reduced schedules and payouts. While this approach is administratively simpler, it provides no direct incentive to individual farmers to reduce GHG emissions. In many respects this approach socialises the impact of increasing GHG emissions from a single farm; if one farm increases its GHG emissions, the cost is spread across the whole sector. To provide an incentive for individual farmers to act, the point of obligation would need to be at the farm level.

The likely impact of the point of obligation being at the processor level on meat schedules and milksolids payouts is shown in *Tables 8* and *9*. For the technically minded, the figures in *Table 8* are based on an emission intensity of 22.5 kgCO_2e/kg carcass weight (for sheepmeat) and for *Table 9* on 8.0 kgCO_2e/kg milksolids. Potentially the cost will be slightly higher, as the companies will undoubtedly look to recover their administration costs.

If the point of obligation is put down to the individual farm then the impact, based on the average emissions as shown in *Table 1*, would be as set out in *Tables 10* and *11*. What *Tables 8* to *11* illustrate is that if farming is operating in the upper left-hand quadrants, then the cost (albeit a

Table 7: Impact of permanent horticultural crop

	CHANGE IN GHG	CHANGE IN EBIT
Dairy farm		
+ 10 ha chestnuts	-5%	96%
+ 40 ha chestnuts	-24%	346%
Sheep and beef farm		
+ 10 ha chestnuts	-1%	14%
+ 40 ha chestnuts	-3%	61%

Table 8: Indicative impact on meat schedule ($/kg)

	PRICE OF CARBON ($/t/$CO_2$e)			
GHG reduction	**$20**	**$30**	**$50**	**$100**
5%	$0.02	$0.03	$0.06	$0.11
10%	$0.05	$0.07	$0.11	$0.23
50%	$0.23	$0.34	$0.56	$1.13
100%	$0.46	$0.68	$1.13	$2.25

Overall, mitigating farm GHGs is not necessarily straightforward. While altering farm systems can achieve some reductions, generally these are somewhat limited around the 5-10% level, with varying impacts on profitability.

Table 9: Indicative impact on milksolids payout ($/kg)

	PRICE OF CARBON ($/t/$CO_2$e)			
GHG reduction	**$20**	**$30**	**$50**	**$100**
5%	$0.01	$0.012	$0.02	$0.04
10%	$0.016	$0.024	$0.04	$0.08
50%	$0.08	$0.12	$0.20	$0.40
100%	$0.16	$0.24	$0.40	$0.80

Table 10: Cost/ha dairy farm

	PRICE OF CARBON ($/t/$CO_2$E)			
GHG reduction	**$20**	**$30**	**$50**	**$100**
5%	$13	$19	$31	$63
10%	$25	$38	$63	$125
50%	$125	$188	$313	$625
100%	$250	$375	$625	**$1,250**

Table 11: Cost/ha sheep and beef farm

	PRICE OF CARBON ($/t/$CO_2$e)			
GHG reduction	**$20**	**$30**	**$50**	**$100**
5%	$4	$5	$9	$18
10%	$7	$11	$18	$35
50%	$35	$53	$88	$175
100%	$70	$105	$175	**$350**

deadweight cost) is annoying but survivable. If farming ends up operating in the bottom right-hand quadrant, then the cost starts to become prohibitive.

Mitigating farm GHGs

Overall, mitigating farm GHGs is not necessarily straightforward. While altering farm systems can achieve some reductions, 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.

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