Allocation of New Zealand Units within Agriculture in the New Zealand Emissions Trading System

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Abstract

When agricultural emissions are included in the New Zealand Emission Trading System (ETS) the economics of farming will be significantly altered. Under the legislation current in October 2009, in the early years of the system the agricultural sector as a whole would have received NZ units equivalent to 90% of 2005 emissions to ease the transition. Amendments to the Bill passed in November have delayed the start date from 2013 to 2015 and extended the protection even further. This paper addresses one of the key issues for making an agricultural emissions trading system a success: how to use the allocation of NZ units to achieve equitable and acceptable cost sharing and a smoother transition. We first discuss the potential motivations for free allocation and the two extreme potential allocation options that could be associated with the two key motivations. The option finally chosen is likely to be somewhere between these two extremes. Empirical studies can inform assessment of options. Previous empirical studies have addressed a variety of questions, including what the economic impact of the system is and on whom, how much leakage is there likely to be, and what might be the adjustment costs. We discuss each of these, comparing different existing studies and addressing some current gaps in our understanding and knowledge with new empirical work on farm level impacts and on likely responses to the ETS. We conclude by laying out some key options for allocation design and drawing links between these and the empirical material.

JEL classification
Q12, Q52, Q54, Q58

Keywords
New Zealand, emission trading, agriculture, free allocation, trade exposure

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1 Overview

New Zealand introduced an Emissions Trading System (ETS) starting in 2008 to assist with its compliance with the Kyoto Protocol and future international climate agreements. Initially only forestry is included in the system (from 1 January 2008). Under current legislation, agricultural emissions[1] (methane and nitrous oxide) will fully enter the system from 1 January 2015. No country has included agricultural emissions before, so the design challenges are considerable. It is important for New Zealand to address agricultural emissions effectively because they make up nearly half of our gross emissions. If New Zealand is able to demonstrate how agricultural emissions can be mitigated efficiently and fairly this will be valuable to other countries where agricultural emissions are significant.

This paper addresses one of the key issues, how to achieve equitable and acceptable cost sharing within the sector. The other critical set of issues is how to report and verify emissions, including issues related to the point of obligation (who reports), the data required, and the models used to infer emissions from the data. These issues have been canvassed in the report from the Agriculture Technical Advisory Group, "Point of Obligation Designs and Allocation Methodologies for Agriculture and the New Zealand Emissions Trading Scheme (MAF, 2009). That paper also draws on an earlier version of this paper to explore some allocation issues. Allocation of nutrient allowances in water quality markets has many similar features and is also a new issue as no compulsory farm scale cap and trade system has been introduced outside New Zealand. Cost sharing in a nutrient trading market is discussed in Kerr and Lock (2009).

Under the original legislation (in force when this paper was written) the agricultural sector as a whole would have received NZ units equivalent to 90% of 2005 emissions. This is a total of 33.7m tonnes of carbon dioxide equivalent, CO_2-e. The annual allocation was intended to phase-out linearly between 2018 and 2030. This was consistent with the treatment of all other sectors. At $25 per tonne of CO_2-e this implied allocation of more than $5bn up to 2018. These free units were intended to offset part of the even greater costs of compliance and ease transition. Choices about how to allocate the units within the agricultural sector really matter.

[1] The ETS (agriculture) includes greenhouse gases from pastoral agriculture, horticulture and arable production – methane from livestock emissions and nitrous oxide from animal urine and dung and synthetic fertiliser.

The amended legislation passed in November 2009 includes intensity based allocation to agriculture which is considerably more generous and phases out much more slowly. Despite the phase out, the dollar cost of protection to the taxpayer is likely to grow at least initially as the agricultural sector continues to grow. The implications for the economy as a whole are similar to those of the subsidies to agriculture in the mid 1980s.

In this paper we first discuss the potential motivations for free allocation and the two extreme potential allocation options that could be associated with these motivations. The best option is likely to be somewhere between these two extremes.

We develop a list of criteria against which to assess allocation options. A variety of empirical studies can inform assessment against these criteria. These empirical studies have addressed different questions including what is the economic impact of the system and on whom, how much leakage is there likely to be, and what might be the adjustment costs. We discuss each of these below including comparing different existing studies and addressing some current gaps in our understanding and knowledge. We conclude by laying out some key options for allocation design and drawing links between these and the empirical material.

1.1.1 What are the motivations for free allocation?

Table 1 the government's stated motivations and links most of these to three key objectives, which we discuss more fully below. It is not clear exactly what government would regards as 'perverse', so we have not mapped 'avoid perverse incentives' as an allocation objective, although it is important.

Table 1: Summary of government's stated motivations in design of free allocation

Act	**Key Objectives for free allocation**
Avoid economic regrets	Reduce damage/minimise regret from reduced production
Avoid concentrated job losses	
Avoid perverse incentives	
Framework document	
Avoid regrets	Ease adjustment
Manage transition	Partially compensate for losses
Maintain equity	
Only compensate where there are losses	
Move to zero assistance over time	

Free allocation can address three broad objectives: to reduce damage from reductions in output; to ease adjustment into the system; and to partially compensate for losses. These can be jointly addressed to a certain extent but compromises are inevitable between the three objectives. Policy design should be informed by the relative importance of these three broad objectives.

1.2 Key allocation choices and tradeoffs

Two extreme allocation options each focus purely on one objective, but may contribute to the others.

Option 1. Allocate on basis of farmers' loss of equity – partially compensate for loss.

- This allocation would be given to the owners of agricultural land at a fixed historical date.
- It would not be contingent on any future behaviour including land use change or sale of property.
- The allocation formula would be based on geophysical characteristics and land use at the fixed date, or on estimated historical emissions.

Option 2. Allocation on output basis – minimise regret from reduced production.

- Allocation could be given at the processor level in the form of a rebate/subsidy per unit of output processed (if farmer is point of obligation) or lower emissions charges (if processor is point of obligation).
- The allocation to each processor could be targeted more closely to avoiding regrets resulting from leakage if it were made to depend on the amount of product exported in the previous period.
- The allocation per unit of output could be fixed for several periods in advance (possibly the commitment period) to minimise uncertainty as a result of growth or contraction in the agricultural sector.

Both options will provide partial compensation, but the first can be more closely targeted to those most seriously affected. Option 1 may also reduce regret to the extent that it helps avoid bankruptcy and change in production forced by capital constraints. Both options will ease adjustment for some groups. A combination of the two options could be used, or there could be a transition from one to the other.

Not all the free allocation needs to be given to farmers. Some acute impacts could occur off farms especially under option 1 which would allow production to sharply contract in regions where, for example, forestry is attractive relative to sheep/beef farming. Some of the value of the units could be used to assist communities and workers.

1.3 Financial and behavioural effects of the Emissions Trading System

We start this section by outlining the likely effects of the ETS, giving context for more in-depth discussion of motivations and for empirical work presented later in this paper.

The major financial impact of the system will be on farm profitability, and, as a consequence, on land values. Landowners are likely to bear the majority of the cost because lower land values will lead to loss of equity. In the short run, if capital markets are relatively inflexible, introducing the trading system could lead to possible bankruptcy, even for farms that would be viable in the long run. This may particularly be the case for people who bought farms recently and have large debts.

The direct impacts on farm profitability will translate to effects on rural communities. To the extent that production is reduced and land use changes, rural workers will also be affected.

Initial costs to farmers are likely to be higher than ongoing costs (unless carbon prices escalate) because farmers will gradually begin to reduce and mitigate emissions. We have evidence that the emissions trading system will induce some land use change, and that there may be a small fall in land use intensity on sheep/beef farms. These may lead to lower profitability relative to a situation with no greenhouse gas charges, but raise profitability when responses to charges are optimal.

Greenhouse emissions per unit of output vary considerably across farms, which suggests scope for mitigation. This is the case even for methane, where it is possible to change the efficiency with which grass (dry matter) is used to produce meat and milk. The question is, to what extent it will be possible for farmers to manipulate this variation to further improve their productivity and hence mitigate their emissions. These mitigation options will have a cost. However, when we factor in the reduced cost of NZ units, mitigation will lead to a net saving.

Figure 1: Emission reduction / mitigation cost curves

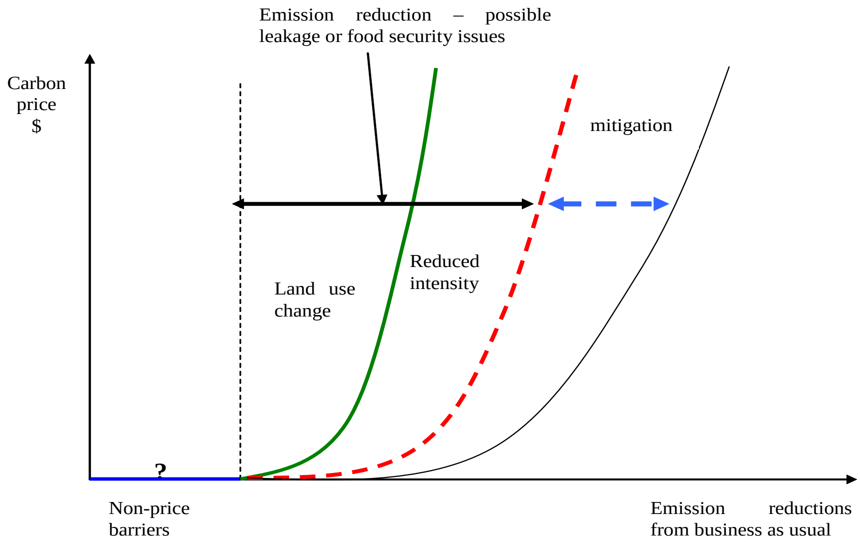

Figure 1 illustrates the different ways in which emissions can be reduced or mitigated. Some options appear to be profitable at current costs but are not taken up by farmers. This suggests there are non-price barriers that will not be addressed by the ETS alone. We will thus not consider those as responses to the system. The other three options will be price responsive. The more flexible farmers' responses are, the lower the individual and aggregate costs of the emissions trading system will be.

1.4 Objective 1: Partially compensate

If agriculture entered the emissions trading system and was responsible for surrendering NZ units to match all emissions, and there was no free allocation, there would be significant losses of farm and processor profit. Some of these losses will be capitalised into land values and some will be passed onto agricultural workers, rural communities and others.

Losses are likely to be concentrated on a relatively small group of individuals. Nearly all agricultural products are exported into an international market where New Zealand has little or no market power, so producers have limited ability to pass cost increases on to consumers. Domestic prices can be expected to rise as a direct result of the ETS but international prices will rise little, if at all. These concentrated losses impose a high share of the cost of climate change policy on a relatively small group. This can be argued to be inequitable. It will generate significant opposition which will make the system extremely difficult to implement and operate, and could cause it to collapse.

Partial compensation for loss involves two key questions for policy makers: first a philosophical question, 'What equity principles do we want to apply?'; and second an empirical question, 'Who is likely to lose and how much?'. The final cost bearing needs to be perceived as 'fair' and 'acceptable'. Researchers and policy makers need to continue exploring what this will mean in a practical sense.

1.4.1 How 'should' the cost of climate policy be shared?

There is no correct answer to this question but it is a key question if free allocation of units is used to partially compensate some of those who would otherwise bear costs. It could be argued that those who benefit from climate policy should bear the burden. Given the diffuse nature of benefits and the large uncertainties, within New Zealand this would suggest a wide base. Given that the emissions trading system is comprehensive, the appropriate burden on farmers relative to other taxpayers would then depend on how other costs of the wider regulation are borne.

Alternatively, the 'polluter pays' principle argues for putting a higher share of the burden on those who are current or historical ('legacy') polluters. In the case of greenhouse gas regulation, this still argues for a broad basis for cost sharing but suggests that costs arising from agricultural emissions should be borne within the agricultural sector. The polluter pays principle also suggests that those who have already lowered emissions should not be penalised for their positive past actions. This argues against allocation on a recent historical basis.

Within New Zealand, Maori, and particularly the owners of Maori land, are distinctive. Any allocation method needs to be sensitive to this and may need to be able to respond in a flexible way.

Principles of social justice suggest that we should take care to protect those who are poor and vulnerable. These may be smaller or highly indebted farmers, farm workers, or vulnerable people within particularly affected rural communities. This would suggest that greater weight might be given to smaller, less profitable farms (if those correlate with poorer farmers) and that the value from some free units should be used to fund programmes to assist the vulnerable as they adjust to the changes.

Legal arguments emphasise protection of existing property rights. This is used to argue for allocation on an historical basis. In contrast, others argue that landowners should have equal rights to develop properties, which could be seen as simply a different interpretation of existing property rights – the right to maintain future options as well as to continue current use. This is of particular relevance to Maori who tend to have relatively underdeveloped land – in part because of their inability to use their land as collateral for loans, in part because they have received some land only recently through Treaty settlements, and in part because some land was in forestry at the time of the settlement.

None of these arguments for how to allocate resources for free allocation is 'correct'. The challenge is to find an allocation that is widely perceived to be fair and that is acceptable to a wide enough group to facilitate compliance and constructive responses to the regulation.

1.5 Objective 2: Reduce damage from fall in production

If farmers respond by changing land use or reducing intensity and hence output, this could have negative effects in three ways. First, 'leakage' could lead to higher global emissions as a result of the ETS. Leakage arises when, as a result of carbon regulation in New Zealand and an incomplete global agreement, production falls in New Zealand and rises in a country that is not covered by the Kyoto or post-Kyoto international agreement cap. Regardless of New Zealand's relative greenhouse gas (GHG) efficiency in production, a movement of production to an un-covered country will raise their emissions above business as usual (BAU), while the sum of emissions under the international agreement cap will be unchanged. Thus global emissions will rise relative to BAU. Because of this global externality, production in New Zealand would be inefficiently penalised on the margin by the ETS (Hoel, 1996). The key question is whether the damage from leakage is greater than the costs of avoiding it.

In New Zealand, agriculture has been argued to be a potential target for leakage policy because NZ producers are largely price takers so cannot pass costs on to consumers, and because the emissions intensity of New Zealand production is low relative to the same products produced elsewhere (Saunders and Barber, 2009); on the other hand, leakage from agriculture may be fairly low. Land cannot move, and good quality land is unlikely to move out of agriculture in any significant way. Because New Zealand producers are generally price takers, a reduction in NZ production may not lead to a large change elsewhere. Because of recent rapid domestic growth (at least until late 2008), which has been straining the agricultural sector, climate change policy is unlikely to create a large excess of capital, which would otherwise have been invested in New Zealand agriculture but now will be invested offshore; it is also unlikely to send skilled agricultural labour overseas, at least in the short run. These factors reduce leakage and regrets in agriculture.

Second, the fact that we are competing with unregulated countries in the short term may lead to production leaving New Zealand, which in the long run we would regret when (or if) there is a global agreement. If New Zealand is relatively GHG efficient in agricultural production, we will have a long-term comparative advantage in this production and we will want a strong agricultural sector in the long term. Losing efficient production in the short term could lead to long term regrets if New Zealand loses key capabilities. We could regret, for example, a situation where processing capacity and the quality of herds falls in ways that are hard to quickly reverse; or we could regret a situation where land moves into forestry or indigenous regeneration, which is relatively costly to reverse in the short term. Short-term reductions in output could also lead to unnecessary social pain as small rural communities struggle to adjust to lower economic activity. Any shift in production involves adjustment costs. If these are incurred and then the issue of leakage is resolved and it is efficient for production to rise again, New Zealand will regret having borne the adjustment cost. It is also possible that a short-term loss could lead to long-term dynamic consequences through loss of market share; the short-term production loss may lead to loss of a longer-term opportunity.[2]

The previous Government indicated in its engagement material that it was most concerned to avoid the loss of economic activity where there would be long term regrets associated with firms closing or substantially reducing output levels; where there are likely to be concentrated job losses; and where there could be reputational issues for New Zealand.

Third, if the fall in New Zealand's food production is not replaced by increased production overseas, it will contribute to the global problem of food insecurity and recent high food prices, if other countries are unable to easily expand alternative food production. The less emissions leak, the more we contribute to potential food shortages. These are all reasons to avoid a fall in production. Three arguments go against this.

First, leakage is not necessarily against New Zealand's economic interests; it will make compliance with New Zealand's targets easier. The production that is lost is worth less in terms of profit than the cost of buying additional emission units. If emission obligations are not devolved this cost is borne by taxpayers as a fiscal cost.

Second, dairy and sheep/beef farming also affect other environmental goals. For example, water quality is being threatened by dairy conversions in many catchments. Biodiversity could benefit from reduced pastoral grazing, especially if some of the pasture was replaced by native regeneration. Regulation has not yet fully addressed most of these other environmental concerns. The positive side effects of reduced pastoral production on other environmental goods could partially offset environmental concerns about leakage.

[2] For a discussion of the drivers of 'regret' from leakage see Kerr and Coleman (2008).

Third, protecting production is extremely costly, especially if it is done through free allocation.[3] Each $1.00 used to provide free allocation of NZ units costs the economy around $1.40 to raise through distortionary taxation. Protection through free allocation cannot be a long term option. So what are the options if we choose to protect production?

1.5.1 Policies to address a fall in production leading to leakage and regret

Leakage can be addressed in four ways:

- border adjustments;
- output-based free allocation;
- progressive obligation; and
- an ex-post environmental correction.

All of these options treat new entrants in the same way as existing farmers.

With border adjustments, any product that is exported would be rebated at average emissions per unit of product at the border, so that New Zealand producers on average face a level playing field in international markets (equivalently imports from countries not included under the international cap could be taxed on the basis of estimated emissions from that country). This is the most efficient option because it directly corrects the source of the problem. It does not subsidise domestic consumption and preserves incentives to reduce emissions per unit of production. There are some legal issues however about whether this would be construed as a subsidy. No other country is yet using border adjustments but several are considering it (mostly to protect domestic production against imports).[4]

With output-based allocation, relative emissions per unit output would first be established across sectors (e.g. emissions per kilo milk solids versus sheep meat). Then in each year, each farmer or processor (or any other entity receiving free allocation) would be awarded NZ units based on their production the year before (or two years before if data problems arise). They would be entitled to a share of the total free allocation pool based on their production as a share of total agricultural production weighted by the relative emissions weights (which should not change over time). If free allocation is done

[3] For an analysis of the costs and benefits of different ways to address leakage in the European Trading System see Quirion and Demailly (2008).

[4] For a recent discussion of these issues see Frankel (2008).

at a late point in the value chain it is possible that allocation would be in proportion to product exported rather than total production – this would be more efficient as it does not subsidise domestic consumption of GHG intensive foods.

From a farmer's point of view, output-based allocation would mean that if they increase production they do not have to cover the full cost of the extra emissions associated with that production. This reduces the pressure for leakage. If they allow their production to fall, they are penalised by a fall in free allocation. They still have full incentives to reduce emissions per unit of production because free allocation relates only to production levels while their obligations (whether direct or passed through from processors) are related to emissions per unit of production as well as to production levels.

One effect of this system is that if one sector expands relative to another, the free allocation of the more static sector falls in total as well as per unit output – this is because they are sharing a fixed pool. If this uncertainty is considered undesirable, this effect could be minimised by setting the free allocation share based on projections and fixing them for each five-year period. Any errors would be taken into account in the share fixed for the next five-year period.

Progressive obligations achieve a similar objective. Rather than being responsible for all emissions, the point of obligation would need to cover only some percentage. This reduces leakage pressure because the increase in cost of production is lower. However, it also reduces the incentive to reduce emissions per unit of output because the effects of these reductions have lower value in reducing cost. This is exactly equivalent to allocation on the basis of current emissions. It is inferior to all other options from an efficiency point of view as well as having no obvious equity advantage.

One final option, an ex-post environmental correction, addresses emisisons leakage but not regret. No effort would be made to protect production. The actual change in production could be compared to predicted counterfactual production if the playing field had been level. The government could voluntarily surrender additional units to the United Nations to offset the estimated environmental effect of leakage. This would fully address the environmental concern and be very low cost relative to the alternatives.

The leakage policy will also partially define the compensation policy. To the extent that free allocation is allocated through output based allocation, border rebates or progressive obligation, less of the pool will be available for compensation based on loss of asset value, or compensation or transition assistance to critically affected workers and communities.

1.6 Objective 3: Ease adjustment

Complying with the emissions trading system will be a significant challenge for the agricultural sector. Understanding greenhouse gas emissions, emissions trading and what they mean for land use and farm management will require farmers to learn new skills. If they need to do this quickly they are likely to incur unnecessary economic costs and make serious errors which could have long term consequences. Large changes in farmers' balance sheets and the need to change behaviour rapidly will also impose larger than necessary costs. Communities would also be adversely affected by a rapid change in economic activity and employment in their area. Large reductions in output might lead to significant concentrated adjustment costs.

The form of free allocation could ease this transition by allowing farmers to adopt a 'wait and see' approach for a year or two and not change their behaviour substantially until they have more information. If they choose to act fast they could still benefit from doing this. It also allows them to pay off some recently incurred debt which was incurred on the assumption of historical rates of profitability. Farmer adjustment costs can and should also be reduced in other ways such as through education, development of credible information sources and early action – these should be explored in more depth.

Community adjustment costs would be eased with a more gradual reduction in output and hence employment and economic activity.[5] It may also be able to be eased through programmes directly targeted at vulnerable communities and workers.

1.7 Criteria for assessing free allocation options

We have three basic criteria: achieving the goals defined by the balance between the three objectives; behavioural incentives; and convenience - administrative feasibility (for farmer and government). The bullet points below flesh out these criteria. Each allocation option needs to be assessed against these.

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[5] The introduction of an emissions charge is conceptually similar to the removal of government farming subsidies in New Zealand after 1984. See "Economic reform in New Zealand 1984-85: The Pursuit of Efficiency" (Evans et al, 1996). For more on this historical context and on adjustment costs generally see sections beginning on p.31 and p.50 respectively. .

A Achievement of goals

Partial Compensation

- Who will actually receive/benefit from free allocations? Will it be those who bear losses – mostly land owners?
- Will it penalise those who are already GHG efficient?
- Will it be perceived as equitable?

Reduce damage from fall in production

- What production is likely to fall and or 'leak' (be replaced offshore)?
- How much damage would this cause?
- How well does the allocation option address the fall in production and leakage?

Adjustment

- How large will the difference between the farmer's obligation to surrender NZ units (directly or indirectly) and his/her free allocation in the first years be?
- What does the farmer have to do immediately to be in compliance?
- What would be the consequences of a farmer's inaction? Fine? Loss of potential profit?
- Will some communities suffer concentrated asset and employment losses under this option?

B Behavioural incentives

- What effect will the allocation have on behaviour/land use change and hence total cost?
- Will new investment be efficient – is it treated equally with expansion of incumbents?
- Are incentives to reduce emission intensity/adopt new technology and management practices efficient?
- Is there a perverse incentive to sustain/expand output or emissions or to lock in land use?

C Convenience - Feasibility

- What data are required to implement this option? Are they unambiguous and verifiable?
- What will the additional cost of collecting and reporting these data be for farmers/processors and government?
- Is it dependent on science and if so, how credible/acceptable is that?

- What are the incentives for farmers/processors to bias the data they provide in response?

In any system it is critical to make allocation rules simple and base them on readily available data that cannot be challenged.

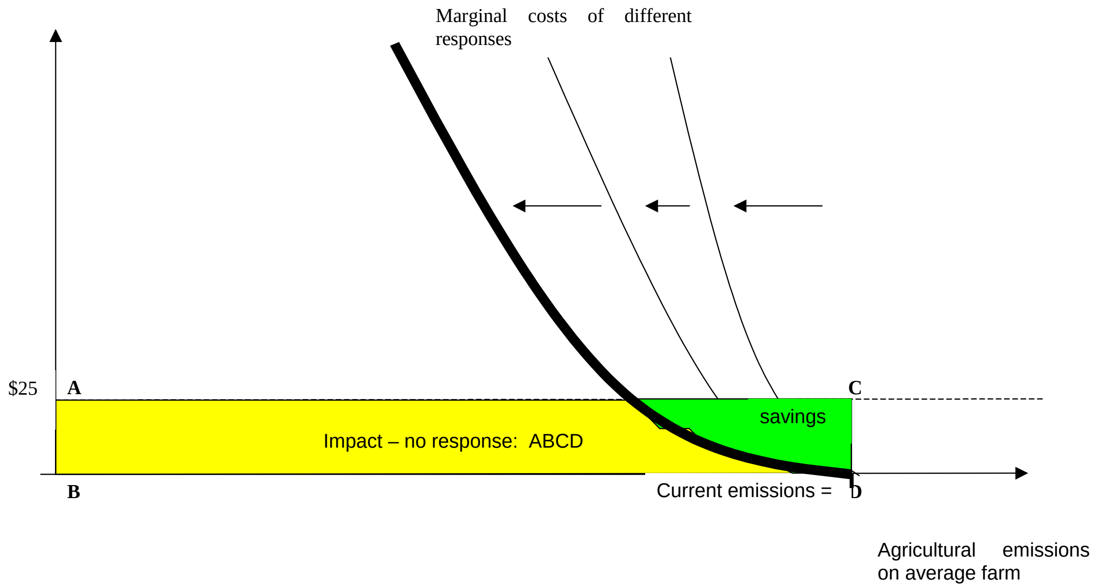
2 Empirical evidence relevant to designing free allocation

Here we consider empirical evidence relevant to the three motivations.

2.1 What is the economic impact and on whom?

We first consider the impact on profits if farmers do not change their behaviour in any way and there is no free allocation. This is the area ABCD in Figure 2. We then consider the potential to reduce emission liability and hence reduce impact on profit. Within this we consider possible land use change; then changes in intensity and particularly stocking rates; and finally the potential for mitigation – reducing emissions per unit output. In this section we present the numbers with no free allocation because we do not want to prejudge the form of that free allocation. The total amount of free allocation is equal to nearly 90% of 2006 liability so will be able to blunt the impact considerably particularly in the early years. The aggregate net liability will depend on growth in agricultural production and our ability to mitigate emissions.

Figure 2: Impact on profitability without and with responses



The impacts of an emissions trading system vary depending on the type of farm (e.g. sheep/beef vs. dairy; region; intensity) that is being considered as well as within different farm types. Studies to date focus on a variety of different farm types and use different assumptions. The results we present here are from work within Motu that almost replicates work by (MAF, 2008b) and Meat and Wool New Zealand (unpublished) but is recreated to allow us to present consistent results in a variety of ways. To be consistent with their work we include all on-farm greenhouse gas emissions (e.g. from fuel and electricity use), not only methane and nitrous oxide. We include only on-farm emissions because we do not have measures of off-farm impacts (e.g. through transport and processing) for sectors other than dairy. In the dairy sector, Fonterra (New Zealand's largest dairy processor) estimate that the off-farm impact adds an additional 15% to the emissions liability. In the sheep/beef sector the off-farm impacts are likely to be much lower.

2.1.1 Farm profit before tax' vs. 'earnings before interest and tax'

The impact can be measured in two basic ways. Farm profit before tax (henceforth 'cash profit') defines the financial profitability of the farm business taking into account the level of indebtedness.[6] If cash profit falls significantly, and particularly if it falls below zero for an extended period, we would anticipate that the current farmer would be forced to sell and may go bankrupt. However, the land use may not change as a result. The current farmer may have bought the land at a high price and have high debt levels. A new farmer may be able to buy the land cheaply and continue to operate.

Economic profit or 'earnings before interest and tax' (EBIT) determines the long-term economic viability of the land use, excluding the cost of purchasing the land.[7] If land were valued only according to its potential stream of agricultural profits, percentage changes in economic profit would imply percentage changes in land values. Thus the change in economic profit gives an indicator of loss of equity. A significant loss of economic profit could be expected to lead to changes in land use.

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[6] Farm profit before tax = Gross Farm Revenue (including the change in livestock value) – Total Farm Expenditure (including Interest and Depreciation but excluding any internal wages paid to the owners or imputed management fees). From farm profit before tax farm (business) owner meet their tax payments, debt payments (principal), capital purchases and living expenses. Any shortfall can only be met by increased overdraft facilities, refinancing (including asset sales) or new capital.

[7] EBIT is calculated by *EBIT = Farm profit before tax + Interest +Rent.*

The percentage impact of the ETS on cash profit will always be greater than on economic profit. Over the last eight years impact on cash profit was on average 53 % (sheep/beef) and 32% (dairy) larger than on economic profit. We present both results to distinguish between effects on current farmers and effects on long term sectoral viability and also to avoid the effect of different levels of indebtedness on comparisons of economic impact.

2.1.2 Differences in impact across sectors

We see in Table 2 that in 2006, with a \$25 CO_2-e price, the emissions liability is around \$36,000 per year in dairy and \$40,000 per year in sheep/beef.[8] All of these estimates assume that no costs are passed on to either consumers or workers. The after tax impact on profit will also be lower by as much as 39% of the dollar impact.

Over the last seven years, the sheep/beef sector would have faced nearly twice the impact on both cash and economic profit relative to the dairy sector. In 2008 the percentage impacts were strikingly different because of the very high profits in dairy. This illustrates the danger of looking at individual years of data.

We include 2006 results because these can be compared with MAF (2008) estimates for a wide range of agricultural sectors. Deer seem to be affected similarly to sheep/beef in the North Island. South Island deer farms are less affected in percentage terms simply because they are more profitable.

Horticulture is affected mostly by energy costs which are not the focus of this paper. Most of the N fertiliser is applied to 'grain' (520 farms) and 'grain-sheep and grain-beef cattle'(250 farms) farming (Catalyst R&D, 2008). Those growing grain for livestock may also have some costs passed on to them from the livestock producers so may face indirect impacts. Most of the remaining N is applied to vegetables with a high per ha application rate but with a cost per farm of only a third of that on farms with grain.

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[8] Our emissions are slightly lower than the MAF modelling for dairy as a result of our different method of calculation. In 2006, MAF estimates a loss of cash profit in dairy of 61% while we estimate 32%. For sheep beef our estimated losses are high relative to MAF but almost identical to Meat and Wool NZ (which uses a lower profit figure to MAF). We do not believe ours are more accurate than either alternative method but we are able to explore other analyses using our method.

Table 2: On-farm impact of \$25 per tonne CO_2-e with no free allocation

Sector	**Emissions Liability (\$) 2006**	**Liability as % cash profit**			**Liability as % economic profit**		
		2001 - 2008 average	**2006**	**2008**	**2001 - 2008 average**	**2006**	**2008**
Sheep/beef	\$40,000	49%	94%	162%	33%	44%	56%
Dairy	\$36,000	26%	32%	10%	17%	19%	7.1%
	2006	**2006**					
North Island Deer	22,000	100%					
South Island Deer	24,000	53%					
Canterbury Arable		29.3%					
Bay of Plenty Kiwifruit		9.8%					
Hawkes Bay Pipfruit		2%					
NI Greenhouse Tomatoes		37%					
SI Greenhouse Tomatoes		99%					
Marlborough Viticulture		1%					

2.1.3 Effects of different carbon prices

With no behavioural response, changes in carbon prices simply alter the dollar value of liability linearly. A \$50 price with no free allocation would make the average sheep/beef operation marginally economically profitable (or not) leading to significant land use change, and might drive many sheep/beef and deer operators out of business as a result of negative cash surpluses. The average dairy farm would lose around 50% of economic profit.

2.1.4 Regional and farm class differences in impacts

In this section we consider dairy and sheep/beef alone because we have detailed modelling on those. In Table 3 we see that for the dairy sector, ignoring Taranaki where data only covers 2007-08, the regional differences are not great. Regional differences are greater for cash profit than for economic profit. For example, it appears that farmers in the Waikato and Lower North Island are more heavily indebted relative to their profit levels. Data for all years is given in Appendix A.

Table 3: Dairy by region: Average impacts on economic and cash profit from 2001-2008, at $25 per tonne CO_2-e, in 2007 dollars

	Economic profit per ha	Economic profit after emission cost per ha	Cash profit per ha	Cash profit after emission cost per ha	%change in economic profit	%change in cash profit
Northland	$951	$721	$679	$449	-24%	-34%
Waikato Bay of Plenty	$1,156	$866	$575	$284	-25%	-51%
Taranaki[9]	$2,484	$2,215	$1,863	$1,594	-11%	-14%
Lower North Island	$1,279	$995	$732	$447	-22%	-39%
Canterbury	$2,251	$1,915	$1,399	$1,064	-15%	-24%
Southland	$1,965	$1,671	$1,151	$857	-15%	-26%
National	$1,432	$1,141	$781	$490	-20%	-37%

For sheep/beef farming, we see in Tables 4 and 5 that the average impacts on profit over the last eight years are much more variable. Cash losses vary from 32% to 180% at a $25 CO_2-e price (Table 5). Losses of economic profit range from 14% to 79% (Table 4). Table 6 provides results that are directly comparable to the dairy results in Table 3. The large differences primarily arise between farm classes (columns) rather than between regions (rows).[10] Regional differences within farm class are more similar to differences between dairy regions. These numbers assume that hill farms which face the highest percentage losses are unable to pass any of their costs on to the more intensive farms. In fact the cost of lambs that are sold from farms that are focused more on breeding (e.g. hill farms), to intensive finishing farms, is likely to rise to reflect the higher costs of carrying ewes. This rise in output price for breeding farms and input cost for finishing farms will reduce the profit impact differences across farm classes.

Of course no commercial farm will actually suffer a loss of economic profit of more than 100% in an ongoing sense – they will change their land use or simply abandon the land. The lowest the economic profit can go is the value in the next alternative use which will be forestry, indigenous regeneration or potentially development for lifestyle or tourist uses.

[9] Taranaki data is available only for 2007-08.

[10] The definitions of farm classes are given in Table 15 in the Appendix.

Table 4: Sheep/beef – % change in economic profit by region and class: Average (2001-2008) at \$25 per tonne CO_2-e

	Class							
Region	1	2	3	4	5	6	7	8
East Coast			61%	38%	32%			
Taranaki-Manawatu			48%	40%	38%			
Northland-Waikato-BoP			49%	41%	27%			
Marlborough-Canterbury	67%	54%				41%		14%
Otago/Southland	79%	48%				35%	30%	
New Zealand	70%	50%	52%	39%	31%	38%	30%	14%

Table 5: Sheep/beef – % change in cash profit by region and class: Average(2000-2007) at \$25 per tonne CO_2-e

	Class							
Region	1	2	3	4	5	6	7	8
East Coast			88%	52%	43%			
Taranaki-Manawatu			93%	54%	41%			
Northland-Waikato-BoP			71%	57%	34%			
Marlborough-Canterbury	94%	79%				65%		32%
Otago/Southland	180%	61%				44%	36%	
New Zealand	116%	73%	83%	55%	39%	54%	36%	32%

Table 6: Sheep/Beef by class: average impacts on economic and cash profit from 2001-2008, at \$25 per tonne CO_2-e, in 2007 dollars

Class	EBIT per ha	EBIT after emission cost per ha	Cash profit per ha	Cash profit after emission cost per ha	%change in EBIT	%change in cash profit
1	\$16	\$5	\$9	-\$2	-68%	-122%
2	\$90	\$49	\$62	\$21	-46%	-66%
3	\$170	\$90	\$98	\$18	-47%	-82%
4	\$272	\$174	\$180	\$82	-36%	-54%
5	\$382	\$273	\$281	\$171	-29%	-39%
6	\$240	\$154	\$162	\$76	-36%	-53%
7	\$455	\$336	\$329	\$210	-26%	-36%
8	\$511	\$441	\$223	\$153	-14%	-32%
National	\$211	\$137	\$139	\$64	-35%	-54%

Note: for each class, the figures are weighted average across regions.

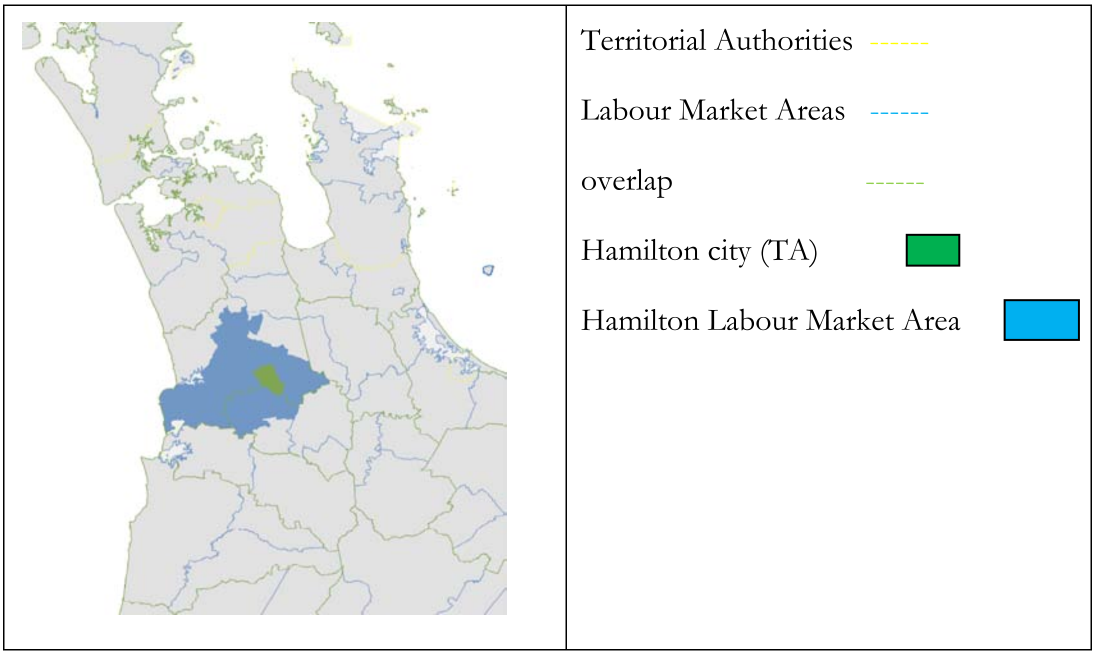
2.1.5 Regional impacts on communities

The primary impacts will be on farmers and farm values, but as farmers reduce their local labour demand and expenditures local communities will also face impacts. The intensity of these impacts will depend partly on the extent of farming in their local area but also on alternative employment opportunities and sources of consumer demand in the area. An isolated area that is dominated by pastoral farming will be more severely affected that an area with the same amount of farming that is on the edge of a town with a wider range of economic activities.

Sin et al (2005) estimated the impact of the introduction of a price for carbon on agricultural emissions in New Zealand through a rural land use change model, Land Use in Rural New Zealand-climate (LURNZ-climate). They mapped these direct impacts on a map of labour market areas, which are areas defined so that most people who live there work there and most people who work there live there. Labour market areas are better units of analysis than territorial authorities which have arbitrary boundaries.

For example, the use of labour market areas will make a large difference around Hamilton where the territorial authority is narrowly defined around the urban area while the labour market area is broader. Many people who live in the heavily affected rural areas around Hamilton city will have the opportunity to seek work in Hamilton city if they lose their rural jobs.

Figure 3: Territorial authority map

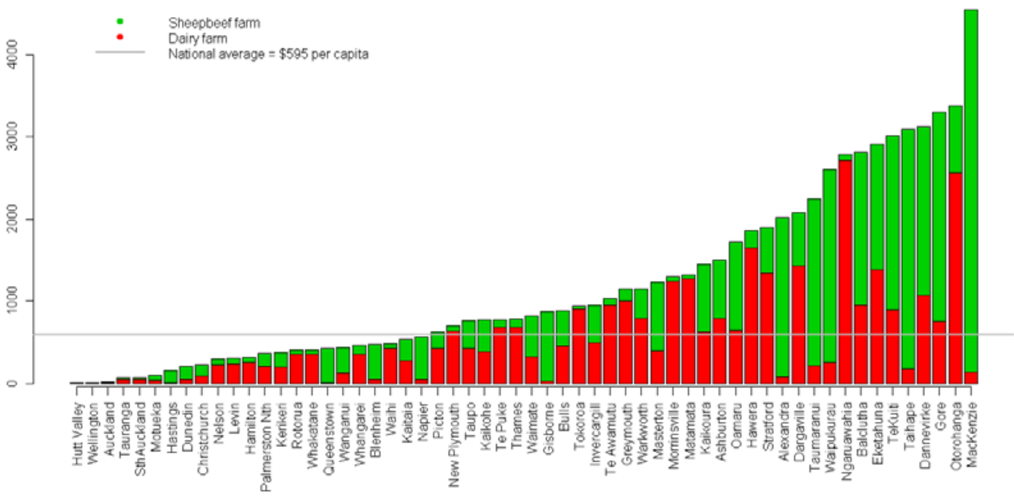


Grimes and Young (2009) find that the characteristics around the area that suffers a shock are important for how that area is affected. They found that the impacts of such a charge, whether through a trading system or carbon charge, would differentially hurt different communities. In the South Island, Gore and the Mackenzie District would be the hardest hit per person by the introduction of this policy while Taihape, Waipukurau, Te Kuiti and Dannevirke are the most affected in the North Island.

In many respects, for example median income, ethnic mix, and percentage of working people with a university degree, the rural areas most affected have very similar socio-economic characteristics to other parts of rural New Zealand. Only in two ways do they appear to differ. Their findings indicate that areas with high emission costs tend to have high employment rates, but that they also have a disproportionately high number of unqualified people.

Updating this analysis we found very similar regional effects with the per capita impacts by community summarised in Figure 4. Complete data and a map of total emission liability for each community are given in the Appendix.

Figure 4: Emission liability per capita within each LMA, in 2007 dollars, average over 2001-2008



All these analyses have shown the direct impact on farms and given indicators of the flow-on impacts on communities assuming that farmers to do not respond to the emissions price (and that there is no free allocation).

2.2 What are potential and likely behavioural responses?

We begin this section by comparing the simulated farm impacts above with New Zealand's experience with the agricultural reforms of the mid 1980s. We then look at other empirical evidence that directly explores each of the possible behavioural responses: land use change, on-farm mitigation and new technology, and general equilibrium responses.

2.2.1 What can we learn from history? The effects of withdrawing the government farm subsidies in 1984

The effects on farms of an emissions charge could resemble the effects of withdrawing the government subsidies to farming after 1984; both represent a substantial drop in the farm gate price of agriculture products. Table 7 shows estimates of the producer equivalent subsidies and how they fell over time. The subsidies were at a peak around 1983/84 for sheep. They were lower for wool, beef and dairy and peaked earlier. The two separate estimates for sheep meat are quite different in the critical period. Given the timing of the estimates, Tyler and Lattimore (1990) may more accurately reflect what was expected during the period. We consider the impacts of each.

Table 7: Producer Subsidy Equivalents

	% increase in farmer returns				
	Sheep[a]	Sheep [b]	Wool	Beef	Dairy
1980	14	15	10	5	32
1981	14	15	10	17	10
1982	23.4	36	26	24	17
1983	54.6	84	30	19	18
1984	58.5	90	19	13	13
1985	52	80	10	9	11
1986	48.8	75	14	16	16
1987	16	16	11	13	14
1988	14	14	11	12	12
1989	8	8	5	5	5
1990	5	5	3	3	3

a. Anderson et al (2007); b. Tyler and Lattimore (1990) (based on MAF and AERU data).
Data from Anderson et al (2007) in Appendix Table 6b: Nominal rates of assistance (including product-specific subsidies), all agricultural products, New Zealand, annual, 1955 to 2005.

Examining farm profitability changes pre- and post- the subsidy removal could help predict the changes that might be caused by an emissions charge. We consider only the impacts on the sheep-beef sector as we have consistent long term data on profitability in that sector. Anecdotally, there were widespread effects, concentrated particularly in the sheep farming sector, and the transition took at least six years.

"It is estimated that around 800 farmers—or 1% of the total number of commercial farmers in operation—were forced to leave the land. Sheep farmers, who as a group were the most heavily subsidized, were (not surprisingly) hardest hit by the elimination of subsidies. Those farmers who were heavily in debt at the start of the reform period were hit hard by rising interest rates, and a transition program was negotiated to ease their situation. Farm-related sectors like packing and processing, equipment and chemical supply, and off-farm transport also suffered, but this was regarded as evidence of their previous inefficiency. Overall the 'transition period' lasted about six years, with land values, commodity prices, and farm profitability indices stabilizing or rising steadily by 1990."[11]

Figure 5: Changes in average EBIT over the reform period

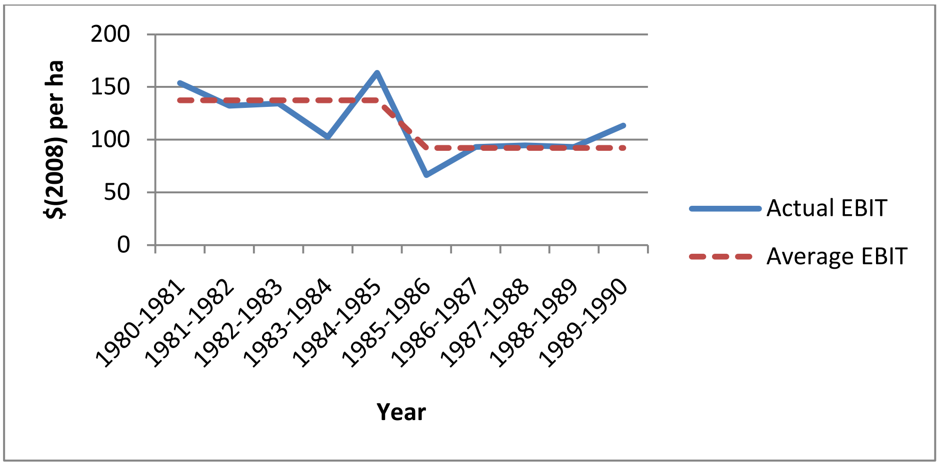


Figure 5 shows that average sheep beef farm EBIT fell 33% from the period 1980/81-1984/85 to 1985/86-1989/90. Is this what would have been expected in 1984? To provide roughly comparable impact numbers for the subsidy removal to those calculated above for the impact of emissions trading, we first construct an average farm for the period from 1980/81 to 1984/85 (the control period) by averaging all aspects of their budget over the period. We then, for each year from 1985/86 to 1990/91 reduce revenue from each product (wool, sheep, cattle, grain etc.) in our 'average farm' according to the reduction in equivalent producer subsidy relative to the control period. Thus simulated EBIT from 1985/86 to 1998/90 is calculated by simulated revenue from 1985/86 to 1998/90 minus average cost from 1980/81 to 1984/85. This approach replicates the methodology we use to estimate the impacts of the ETS as closely as possible.

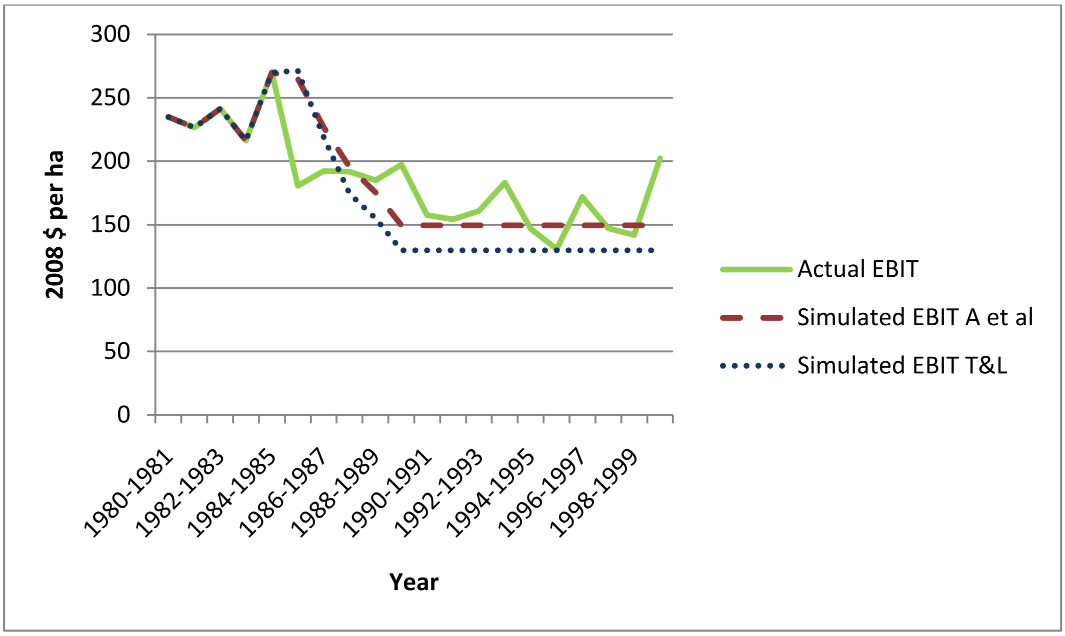
[11] From: http://newfarm.rodaleinstitute.org/features/0303/newzealand_subsidies.shtml

In reality, the reduction in subsidy is a combination of reduced revenue and changes in costs because withdrawing agricultural subsidies was part of a wider programme removing protection. We are assuming a specific form of expectations about revenue net of subsidies. In fact it would have been hard to determine the level of net subsidy in advance.

We are using the PSEs as though they were a planned path of subsidy removal rather than an ex-post estimate of the actual path of subsidies. The actual path will embody some behavioural responses by farmers such as changes in input mix. For example, as fertiliser subsidies were removed, farmers would have used less fertiliser. This will make the apparent impact on cost higher than the real loss of benefit to farmers, particularly if they were using more fertiliser than was optimal simply because it was so heavily subsidised.

The lowest dashed curve in Figure 6 suggests that, with no response by farmers, farm economic profit should have fallen by 37% by 1991, relative to the period 1980-85 (according to the Anderson et al estimates and around 45% according to Tyler and Lattimore estimates). In contrast, actual EBIT fell by 33% in the first year and then more or less stabilised at an average EBIT 30% lower than the period 1980-85.

Figure 6: National actual revenue, cost, EBIT per ha and simulated EBIT, in 2008 dollars



Anderson et al (2007); Tyler and Lattimore (1990).

Part of the difference between simulated and actual EBIT in the first few years may simply be data timing. However, in addition, between 1985 and 1986, both export prices and volumes for sheep fell significantly so that the export value of sheep meat fell by 30% in one year. Actual costs also fell more slowly than revenue, leading to initially overshooting EBIT loss.

The longer term difference between the estimated and actual impact seems likely to be at least partly behavioural response. Some of this response may be implicitly built into the later Anderson et al (2007) estimates. The simulated impacts were 34-100% greater than the long run actual impacts. This is a reassuring result, but more analysis is needed to understand exactly how farmers responded in order to know whether those responses can be repeated and how costly the responses themselves were. The net cost also hides high individual costs including to the estimated 1% of farmers who had to leave their land. Some of these farmers will have gone bankrupt while their farms continued to operate.

Table 8: Actual percentage changes in real EBIT per ha in 1989/90 relative to 80/81 – 84/85 average

	Class								
Production Region	1	2	3	4	5	6	7	8	9
East Coast			-45.1%	-44.0%	-48.1%				-43.3%
Marlborough-Canterbury	79.1%	2.9%				-19.1%		-9.6%	-1.9%
Northland-Waikato-BoP			-9.9%	-8.8%	-41.5%				-19.7%
Otago/Southland	37.2%					-13.4%	-7.8%		-3.4%
Taranaki-Manawatu			-22.1%	-31.9%	-29.7%				-31.7%
New Zealand	64.2%	10.1%	-31.7%	-29.6%	-41.2%	-15.7%	-7.8%	-9.6%	-17.0%

In Table 8 the farm EBIT pre- and post-1984/85 is broken into regions and classes. We do not have separate subsidy estimates for different farm classes. The PSE would vary because of the different cost structures. Applying the same estimate of subsidy withdrawal in Table 9 shows how the simulated impact varies across farm classes. EBIT for classes 1 and 2 actually grew during this period – possibly because they are heavily focused on wool production (although our predictions in Table 9 do account for the sources of income and did not pick this up).

Table 9: Predicted percentage changes in real EBIT per ha in 1989/90 relative to 80/81 – 84/85 average

	Class								
Production Region	1	2	3	4	5	6	7	8	9
East Coast			-48.6%	-38.4%	-42.6%				-40.9%
Marlborough-Canterbury	-43.4%	-51.6%				-47.2%		-22.4%	-25.4%
Northland-Waikato-BoP			-42.5%	-43.9%	-41.2%				-42.5%
Otago/Southland	-52.0%					-56.1%	-38.0%		-46.2%
Taranaki-Manawatu			-53.3%	-40.1%	-38.1%				-41.6%
New Zealand	-41.0%	-50.0%	-46.8%	-39.3%	-41.1%	-49.9%	-38.0%	-22.4%	-37.2%

By taking the difference between the two tables above, Table 10 suggests that behavioural responses to the subsidy withdrawal helped farmers to reduce economic profit losses by 20% nationally. Farms in the South Island (Class 1, 2, 6, 7 and 8) seemed to respond more than in the North Island. Differences at a regional level may however reflect the different regional effects of policy as well as behavioural responses. This needs to be explored in more depth.

Table 10: Difference between actual and simulated percentage change in real EBIT

	Class								
Production Region	1	2	3	4	5	6	7	8	9
East Coast			3.5%	-5.6%	-5.5%				-2.4%
Marlborough-Canterbury	122.4%	54.5%				28.2%		12.8%	23.5%
Northland-Waikato-BoP			32.6%	35.2%	-0.2%				22.8%
Otago/Southland	89.2%					42.7%	30.2%		42.8%
Taranaki-Manawatu			31.1%	8.2%	8.4%				9.9%
New Zealand	105.2%	60.1%	15.2%	9.7%	-0.1%	34.1%	30.2%	12.8%	20.1%

Overall, if we had used the producer subsidy equivalent estimates to simulate the impact of the reforms on agriculture from 1985 forward, we would have overestimated the damage to farm EBIT. We will need to explore the causes of this difference further to understand whether this seemingly successful adaptation of the agricultural sector to change could be repeated in response to emissions trading.

Withdrawal of subsidies involves different levels of uncertainty than does the imposition of a greenhouse gas price. Also the options for mitigation are quite different now than the options for response were in 1984. What are the current options for greenhouse gas mitigation?

2.2.2 Greenhouse gas on-farm mitigation options

Table 11 lists the options that have a strong scientific basis and are possible to include in the National Inventory in the short term.[12] We explore the potential use of these options.

Table 11: Pastoral farming options that could reduce agricultural emissions in a reasonably well-determined way in the short term

Methane
Reduce animal numbers and / or output
Increase output per unit of dry matter intake • reduce replacement rate – higher reproduction; more milking years • faster growing animals for meat • smaller breeding animals including cows • higher milk solids per cow
Nitrous oxide
Reduce animal numbers and / or output
Increase output per unit of dry matter intake – as above Nitrification inhibitors Manipulate diet Cattle winter management: • stand off / feed pads • moving livestock production to lower emissions locations – including wintering off (within or off a farm)

2.2.3 Potential to change land use and hence output

The most recent simulations from Motu's Land Use in Rural New Zealand (LURNZ) model (Shepherd et al, 2008) suggest nationally that with a \$25 CO_2-e price, by 2015 we could lose around 33,047 ha of dairy (2% of current dairy; 38% less growth from 2007) relative to the reference case (i.e. still significant growth in absolute terms); we could lose 242,000 ha more sheep and beef farms (3.6% of current sheep/beef land; 108% more decline from 2007); and we could have around 260,000 ha more scrub/regenerating native forest. In Shepherd et al we did not model the impact of the return to plantation forestry because we were not comfortable with the robustness of our empirical results. The model is roughly linear in response, so doubling the price would roughly double the impact. We do not include any land use change or output reduction

[12] This list was generated with advice from Cecile deKlein, Frank Kelliher and Harry Clark at AgResearch.

results at $50 per tonne, however, as this would be such a large structural change in the economy that it is outside of the scope of current models to predict with any confidence.

MAF (2008b) studies the potential for sheep and beef farmers to offset some of their emissions through forestry. At $25 per tonne they estimate that farmers can reduce their profit loss by between one half (simply offsetting livestock emissions – 8.7% of land into forestry) and two thirds (converting 20% to forestry).

Meat and Wool New Zealand work suggests that the area required to offset emissions varies considerably by farm class: from around 1% to 15% and the highest percentages are required on the most productive land. For many farms it will not make sense to offset emissions on their own farm both because they may have high quality land and because, if they are considering plantation forestry, they may not have good access, appropriate slopes for harvesting or the appropriate scale for efficient forestry. Thus while this is a potential mitigation option for the country and a potential opportunity for some farmers with appropriate land, it is not a general mitigation option. Farmers have this option now as a result of the forestry component of the ETS – it will simply become more attractive as returns fall in sheep and beef farming.

Several commentators have pointed out that forestry provides an offset for only around 30 years. At that point either the farmer faces a liability if they harvest and replant (of around 80% of the original offset if replanting; 100% if not) or must decide to leave it permanently in forest and bear temporary liability when the radiata forest ages and loses carbon while it transitions to a more sustainable forest. If they want to offset emissions after this, they must put more land into forest.

Forestry is also risky both because forests can blow down or (less often) burn and because returns if harvested are highly uncertain. Plantation forests also face resource consent issues in some areas because of water use and aesthetics. Forestry planting rates are generally well below those that are suggested by simple models of the relative profitability of plantations relative to marginal sheep and beef farming probably as a result of these hidden costs. The increased return to woody biofuels may increase forestry profitability and lower its risk but this option is still in development (Todd et al, 2008).

2.2.4 Ability to reduce production intensity and hence output

The Agribusiness Group et al (2007) estimated the impacts on profitability from reducing intensity (measured as % reductions in stocking rates) on a range of MAF farms. We have combined these with our earlier analysis of emissions liabilities (Table 3 and Table 6) to estimate the gains to farms from responding to GHG costs by reducing intensity.

Table 12 shows that reducing intensity by 10% is not profitable for any of the modelled farms at $25 but may be for an average Waikato dairy and average Central North Island Hill sheep and beef farm at $50.[13] These results are dependent on specific assumptions and are only for one year's prices. They do not estimate very small reductions in stocking rates which could possibly be profitable. They are also calculated simply by changing stocking rates and hence output per animal and variable farm operating costs – thus they do not have the full sophistication of a potential change in farming system which would affect many variables. Emissions are assumed to be proportional to output.

Table 12: Profitability impacts of reducing stocking rates by 10% in response to $25 and $50 charge (2005/06)

Region	cash surplus	Emissions liability (at $25)*	% fall in output*	gain at $ 25†	gain at $50†
Waikato Dairy	$103,964	$33,010	4%	-$1,014	$374
Canterbury Dairy	$272,338	$48,718	11%	-$55,520	-$50,400
Waikato Intensive Sheep Beef	$104,662	$28,600	7%	-$5,821	-$3,877
Central North Island Hill	$206,049	$79,474	8%	-$6,368	$73
Southland Otago Hill farm	$93,675	$36,739	7%	-$15,073	-$12,347

*From tables 3 and 6; **From Agribusiness et al.; † inferred from combination of both

Barry Ridler did new work for MAF using a linear programming model which allows continuous and more flexible responses (McCall et al, 1999). His work suggests that at $7 per kilo milk solid payout, reoptimising a Waikato dairy farm to respond to an emissions charge on output leads to very little response and hence gain in profit. The emissions liability and hence loss of profit is reduced by 1.5%. At higher payouts he found larger responses.

Results from AgResearch modelling by Smeaton and deKlein (2008) using Udder (a dairy farm system model) on the same farm broadly confirm this at a $7 payout. They find that the farm should not be using supplements. Because marginal

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[13] Reducing intensity becomes even less profitable as the % reduction increases.

output is provided using N fertiliser which is cheap, marginal output is highly profitable and the emissions charge does not alter output. At very low payouts it may be profitable to cut back on N and output. At higher payouts (above $7), marginal production would use supplements. Because these are more expensive and because they have diminishing marginal value, output is more likely to be sensitive to emissions payouts. Thus Ridler and Smeaton and deKlein's results on stocking rate changes broadly confirm the work by the Agribusiness group.

Smeaton and deKlein (2008) explore a number of different farm systems which vary in production intensity in ways that are not limited to changes in stocking rate. The details of the systems are given in Table 19 in the Appendix. Figure 7 orders the farm systems by intensity of production. The base case is normalised to 100 for all three variables: production intensity, baseline profit and profit with emissions charge. All systems are more profitable than the base (actual) system both with and without the greenhouse gas charge.

While all systems are less profitable with the greenhouse gas charge than without, the most profitable alternative system is so much more profitable than the current system that, according to the model, farmers could alter their systems under a $25 per tonne emission charge and be more profitable than they are at present with no charge. The fact that they have not yet changed systems suggests either barriers to or costs of implementing the new farm system that are not incorporated in the model, uncertainty about the benefits and risks of the new system, or irrationally slow adoption of the new system. These barriers will not automatically disappear with a greenhouse gas charge but it may increase the incentives to overcome them.

Some of the systems analysed are more intensive and some less. The three most profitable systems are more intensive. This suggests that there are currently incentives to intensify in dairy. The emissions charge makes the two most profitable systems even more attractive relative to the base case but also increases the relative attractiveness of one of the less intensive system.

Figure 7: Relative profitability across dairy farm systems with different levels of productivity and as the ETS is implemented ($25 per tonne CO_2-e with no free allocation; $6 dairy payout).

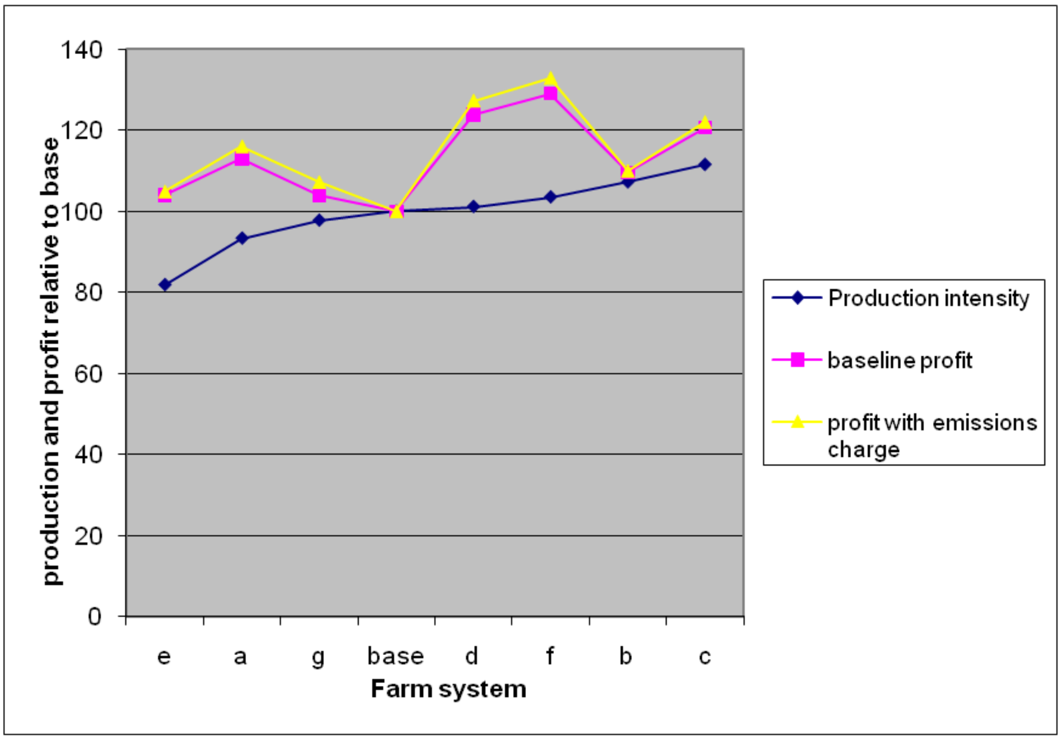
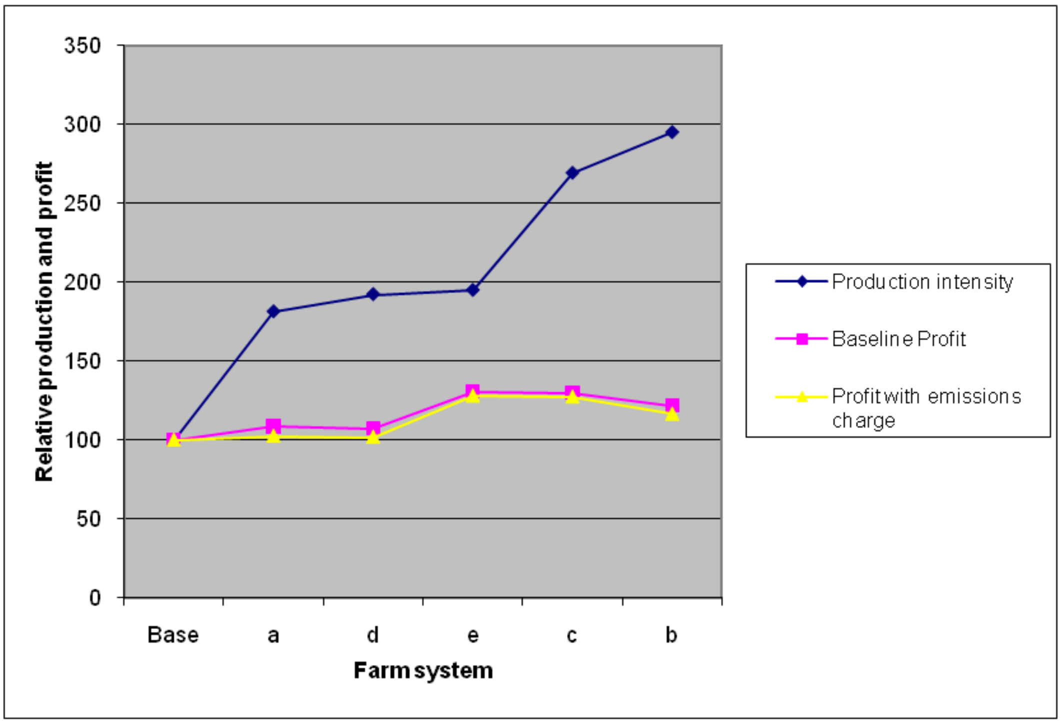


Figure 7 is done for one dairy payout and one greenhouse gas charge. As the GHG charge rises relative to payout, the least intensive system becomes relatively most profitable. This occurred, for example, when payout was $6, and GHG charge was greater than $218 per tonne of CO_2-e. With lower payouts, the critical value of the GHG charge could be much lower.

In contrast, for sheep-beef farming (Central North Island King Country), in Figure 8 we can see that all alternative farm systems are both more intensive and more profitable than the base farm though the slightly more intensive farms have basically the same profit. The application of the $25 charge reduces the incentive to intensify, especially on the least intensive alternatives. At a high carbon price (around $90) the base case becomes the most profitable system (not shown).

Figure 8: Relative profitability across sheep beef farm systems with different levels of productivity and as the ETS is implemented ($25 per tonne CO_2-e with no free allocation).



2.2.5 General equilibrium modelling

General equilibrium (GE) analysis should pick up both land use change and changes in intensity of land use, but through responsiveness of total production to prices rather than directly. The New Zealand GE models are not ideally suited for this analysis as they were primarily developed for different types of analysis.

Most New Zealand GE analysis of emissions trading has been done by Adolf Stroombergen at Infometrics (e.g. Stroombergen et al, 2007; Stroombergen et al, 2009). His 2007 modelling suggests that at NZ$25/tonne with no free allocation, sheep and beef real gross output falls 3.4% relative to business as usual, and dairy farming falls by 2.5%. At $100, sheep and beef would be down 12.1% and dairy down 9.5% from business as usual.

MAF did some work using the OECD AgLink model (Conforti and Londero, 2001) and their Pastoral Supply Response Model (Gardiner and Su, 2003). The following is excerpted from their report (MAF, 2007).

'The following table estimates farmers' production response to reduced output supply prices, and increased direct energy[14] *and nitrogen fertiliser prices. Given that the impacts of the ETS will be spread across all agriculture industries and that land use options are limited in some areas, it is unclear whether the impacts on output will be as great as shown, at least in the short run. Previous experience shows that farm businesses may well attempt to maintain output, absorbing increased costs through reduced input use and/or by supplementing with off-farm income.'*

Table 13: MAF estimated output impacts [1]

OUTPUT IMPACTS	Carbon price	Full Pricing
Milk	$15	-3.80%
	$50	-12.70%
Beef	$15	-3.00%
	$50	-10.00%
Sheep meat	$15	-0.60%
	$50	-2.10%
Venison [2]	$15	-5.35%
	$50	-9.49%

1. These represent the estimated changes in farm output as a result of changes in supply price before account is taken of possible additional longer run changes in land use due to switches to non-pastoral farming activities such as forestry.
2. The output impacts for venison were estimated using a different model (the Pastoral Supply Response Model) because OECD Aglink does not model deer.

These results suggest somewhat higher reductions in milk production (around 6.3% at $25) than other models. Beef production would fall around 5% (consistent with fewer dairy farms) at $25 but sheep meat is anticipated to fall by only around 1%. When combined, these are of a similar total size to the other models' predictions for meat.

NZIER[15] produced some new results for this report. These results, shown in Table 14, suggest even lower impacts on output at $25 than the previous models: less than 2% reduction in all sectors. They suggest that many horticultural activities will benefit from the ETS.

[14] The indirect impacts of increased energy costs throughout the supply chain have not been taken into account

[15] John Stephenson, personal communication.

Table 14: NZIER: Changes in industry value added, $25 per tonne, no free allocation

Agricultural Sector	% change relative to BAU
Sheep Beef	-1.541
Dairy Cattle	-1.205
Other Farming	-0.532
Agricultural Services	-0.347
Meat	-1.181
Dairy Production	-1.138
Other Horticulture	0.185
Apple and Pear	1.264
Kiwifruit	0.101
Other Fruit	0.126
Mixed Farming	0.018

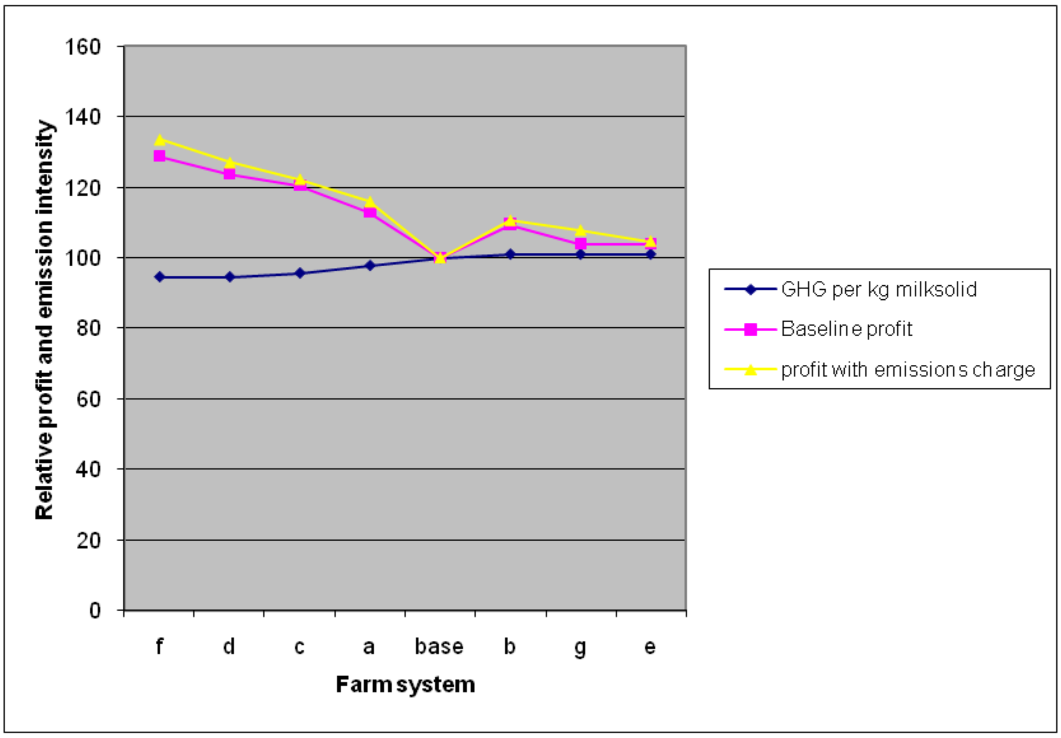
2.2.6 Reducing emissions per unit output

The only current option for mitigating methane per unit output is increasing productivity (output per unit dry matter input) beyond business as usual. We know that productivity varies significantly across farms but do not have strong evidence on the drivers and to what extent they will be responsive to GHG costs.

The only strong evidence on the potential profitability of mitigation through raising productivity comes from Smeaton and deKlein (2008). For dairy, in Figure 9 we can see that production on most alternative more profitable farm systems has lower emissions intensity than the base case and that the ETS increases this effect. The greatest increase in relative profitability with the implementation of the ETS comes in the second lowest GHG per unit output system which is also the most profitable system. Thus the ETS does not change the order of attractiveness of the farm systems but increases the existing incentives to move toward a more GHG efficient system.

Over time, this response will reduce the impact of the GHG charge on dairy farmers but we cannot say how rapidly or how extensively this new system would be adopted. All the systems modelled were chosen so that it would be possible in the long run for all New Zealand farms to adopt this system – for example, they do not winter off any animals because that would imply that other farms must have more animals in winter than currently. The lowest GHG emissions intensity farm has large birthweight animals (for example, Friesian bulls), which could not immediately be implemented on all farms but could be implemented with selective breeding over approximately a decade.

Figure 9: Dairy: relative profitability across farm systems ordered by GHG emissions intensity per unit output[16]

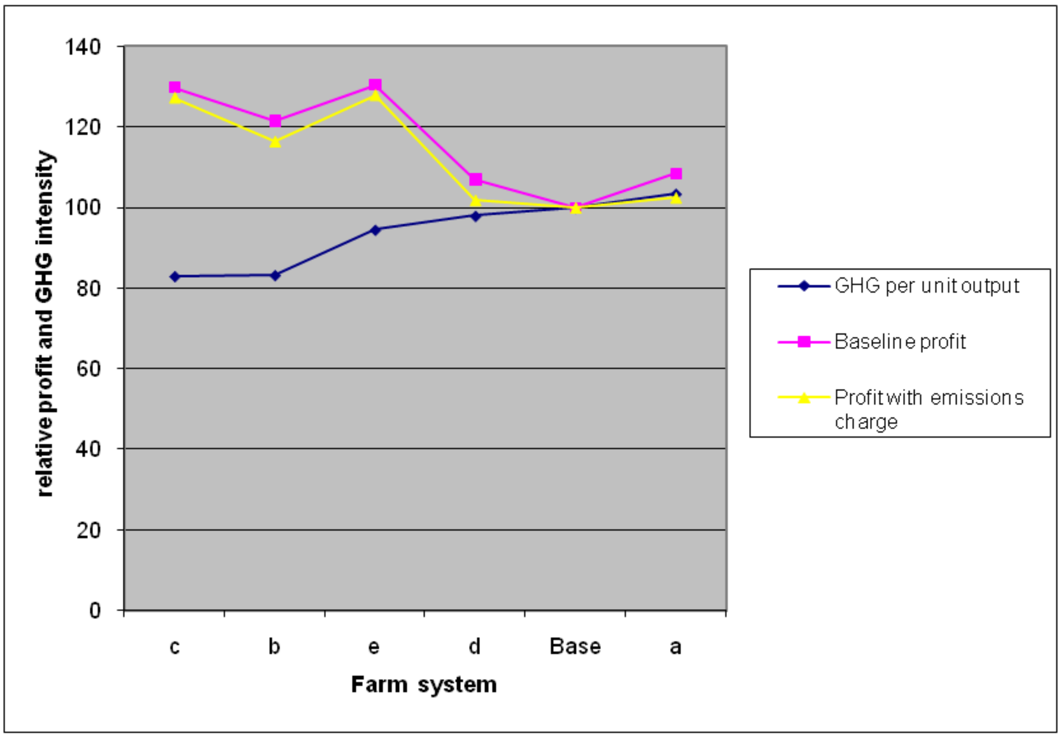


Source: Derived from Smeaton and deKlein (2008).

Similarly, Smeaton and deKlein have modelled a range of systems on sheep/beef farms. In Figure 10 we see that all but one alternative farm system has lower greenhouse gas intensity than the base case. The most profitable farm systems have emissions per unit output that are 17% lower than the base case. Despite this, these systems become relatively less attractive with the emissions trading system because they are more intensive. Thus if sheep/beef farmers respond to the GHG charge by staying in or moving to less intensive systems, they will not benefit from a fall in GHG intensity and hence emissions liability per unit output.

[16] Emissions as measured in scenario 4 without application of DCDs.

Figure 10: Sheep/beef: relative profitability across farm systems ordered by GHG emissions intensity per unit output[17]



Source: Derived from Smeaton and deKlein (2008).

2.2.6.a Nitrification inhibitors

MAF (2008b) looks at the role that nitrification inhibitors can have to reduce the financial impact of the emissions trading system on dairy farms. Nitrification inhibitors reduce nitrous oxide emissions and raise pasture productivity. The nitrification inhibitors work uses effectiveness estimates that may overestimate the impacts in some regions. They assume 100% uptake on dairy farms outside of Northland and the West Coast. They assume 50% in direct nitrous oxide emissions per kilo of milk solids for excreta and fertiliser for 5 months and 35% reduction in nitrous oxide per kilo of milk solids through leaching for five months. They either use the productivity impact to increase milk solid production by 10% or hold production constant. They find that at \$25 per tonne CO_2-e, the reduction in profit in 06/07 as a result of the ETS reduces from 61% to around 20%. However, their analysis suggests that nitrification inhibitors should be adopted regardless of the carbon price, so these should really be included in their business as usual case, reducing the direct impact over time rather than considered as a response.

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[17] Emissions as measured in scenario 4 without application of DCDs.

The Agribusiness Group et al (2007) explores the effect on nitrates rather than nitrous oxide, but the effects are correlated. They find that dairy farmers should adopt nitrification inhibitors in Waikato and Canterbury even without a GHG charge but that they are costly on sheep and beef and deer farms. Their current analysis does not allow us to assess adoption in response to nitrous oxide prices but they are currently working on similar analysis for greenhouse gases.

Barry Ridler (McCall et al, 1999) uses a linear programming model with the same set of effectiveness assumptions for a Waikato dairy farm and finds that the nitrification inhibitors would not be profitably adopted. The reason for the difference between his result and the MAF result appears to be that he has a time sensitive model and the boost in productivity from the N inhibitors that drives its profitability comes at a time that is of low value to farms – i.e. mostly in spring when there is no shortage of grass.

Smeaton and deKlein (2008) found that using DCDs (a nitrification inhibitor) may on average be marginally profitable for dairy farms even without a GHG charge. Two of their farm systems significantly benefit from DCDs and the reduction in GHG charge the farm would benefit from if they use DCDs. One farm system that benefits from DCDs is the lowest GHG intensity, highest profit system. For this farm system the GHG charge provides yet another incentive to mitigate which is encouraging. The other farm system that benefits from DCDs, however, is a high GHG intensity system with the second highest profit. Thus the existence of DCDs will likely reduce greenhouse gas intensity within existing farm systems (in the business as usual scenario) but could encourage farmers to move toward either high or low GHG intensity systems. The net effect on mitigation in response to the GHG charge is ambiguous.

2.2.6.b Other options that mitigate emissions per unit output

- Feed/standoff pads

The Agribusiness Group et al (2007) finds that standoff pads are profitable on the Waikato and Canterbury dairy farms they study even with a zero carbon price. The net reduction in greenhouse gases from feed pads within a whole farm system is, however, still uncertain.[18] Standoff pads are unprofitable on sheep and beef farms.

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[18] Cecile deKlein – personal communication.

- Manipulate diet

We do not have the science basis to model this accurately yet.

- Move livestock production to lower emission soils (wintering off)

We do not have any modelling results for this currently. It requires a regional model to take account of emissions on the farms to which the stock are moved, and the transport costs of moving them.

2.2.7 Effects of mitigation in general equilibrium

Infometrics ran two scenarios (13 and 14) to consider the impacts of mitigation in agriculture. These do not predict mitigation potential but, assuming a given level of technology-driven mitigation, explore the impacts on the sector and the wider economy. Both scenarios assume a price of NZ$100 and no free allocation.

1. Reductions in methane emissions per unit output of 10% in dairy, beef and sheep farming, brought about by breeding for lower emissions;
2. Reductions in nitrous oxide emissions per unit output of 11% in dairy farming, and 2% in sheep and beef farming brought about by the use of nitrification inhibitors.

These reductions in emissions are not intended to be precise forecasts of what will occur; they are order of magnitude estimates of what is considered by MAF to be plausible under a carbon price of $100 (or less) per tonne of CO_2-e. As the section above suggests, some nitrification inhibitors could be adopted even without a CO_2 price.

With no mitigation, a NZ$100 CO_2 price is estimated to reduce emissions of both methane and nitrous oxide by nearly 11%, achieved almost exclusively by reductions in agricultural output. Incorporating the two technological advances (breeding for lower methane emission and using nitrification inhibitors) raises these figures to around 19% for methane and 15% for nitrous oxide respectively.

A fall in methane emissions of 10% with no behavioural response translates to a reduction of only 8% after behaviour responds. This is because the reduced emissions intensity is roughly equivalent to a 10% fall in CO_2 price. Some of the effect of nitrification inhibitors will also be offset by a behavioural response both because of the lower effective CO_2 price per unit (modelled) and because of the increase in pasture productivity (not modelled).

The new technologies would, by assumption, lower emissions liabilities. In absolute terms, improved breeding reduces emissions, and hence emissions liability, in 2025 by 4.9 Mt (CO_2-e), with nitrogen inhibitors reducing emissions by 2.8 Mt.

2.3 Summary of evidence on impacts

At $25, with no free allocation and no behavioural response, the on-farm impacts on dairy economic profit would be around 20% (with off-farm impacts an additional 3% of profit); the on-farm impacts on the average sheep/beef farm (and possibly deer are similar) would be around 40%. This hides some variation by region and enormous differences across classes of sheep-beef farms as well as variation between individual properties. These impacts may have a concentrated effect in some rural, relatively isolated communities. At $50, with no free allocation or behavioural response, dairy loses around 40% of economic profit and the average sheep and beef farm may be non-viable.

The evidence in the sections above suggests that at $25 per tonne CO_2-e, the combination of land use change and reduced intensity of land use might reduce dairy output by between 1 and 6% relative to business as usual (still high growth) and combined sheep and beef output by around 3-4% (larger decline). Mostly this is driven by land use change, not by changes in intensity – so the landowner could receive some returns from the carbon by reverting to indigenous or plantation forestry. At high CO_2-e prices, sheep beef farms may also be come less intensive. These reductions would reduce emissions liabilities commensurately and significantly reduce the losses to farmers.

The potential for reducing the impact through mitigation within current land uses is still highly unclear though there is some evidence that nitrification inhibitors could have a significant effect on farmers' losses from the ETS. In the dairy sector there will be increased incentives to move toward new farming systems. These systems may be so much more profitable than the base farm that even with a $25 CO_2-e price, they could be more profitable than the current base farm with no ETS. This begs the question of the barriers that explain why farmers are not moving to these apparently superior farm systems. This informs our decisions relating to the compensation and adjustment costs motivations.

2.4 How much is production likely to fall?

The flip side to the benefit of reducing emission liability by reducing output is that these reductions can have negative effects through economic regret, adjustment costs and affects on global food insecurity. At $25 the reduction in output does not appear to be very severe and with some assistance adjustment seems feasible for communities to bear. At $50 the effects are much less predictable and could be severe for both farmers and communities.

Similarly, at $25 the likelihood of severe environmental leakage or damage to our long term infrastructure or skills base seems relatively low, but at $50 relatively irreversible large scale movements in land use may be induced in the sheep and beef sector. We have no evidence on how these changes in production are likely to affect global food insecurity other than an indication that change is likely to be small at $25 per tonne.

2.5 Adjustment costs

New Zealand agriculture suffered a similar, though possibly larger, shock in the 1980s with the removal of protection. Adjustment costs at that time were severe. Some banks smoothed adjustment by protecting some viable farms from bankruptcy at least in the short term but many still went bankrupt and many small communities suffered. Have we learned anything about helping people and communities adjust after the mid-1980s experience? Four Motu papers are relevant for this.

The first, Grimes et al (2007) looks at how migration mitigates the effect of a shock to a region. Much of the labour market effect of a shock is quickly mitigated through migration of excess labour. The second, Velamuri et al (2008) looks at the long run impacts of shocks. Some effects on average incomes in affected communities persist in the long term. Thus adjustment to shocks should be encouraged not hindered and some groups may need some long term assistance. A third paper, Sin and Stillman (2005), suggests that the less mobile groups – who may suffer long term effects – tend to be older, less educated, and potentially Maori with strong local Iwi affiliations. Finally, current work, Grimes and Young (2009), finds that between two towns (Whakatu and Patea) that suffered similar employment shocks with the closure of meat works, the more isolated town (Patea) suffered the greatest disruption to long term employment rates and population.

Our criteria for assessing allocation options were:

a. Achieving the goals defined by the balance between the three objectives:

    i. to partially compensate for losses

    ii. to reduce damage from reductions in output

    iii. to ease adjustment into the system.

b. Behavioural incentives.

c. Convenience – administrative feasibility (for farmer and government).

The empirical work we have summarised gives us a clearer idea of who is affected, how easily they can offset that effect, how great leakage may be, and which communities and individual may suffer most from adjustment costs. These inform our weightings on the first criteria for choices among allocation options. The next section outlines key allocation options and assesses them against these criteria in a preliminary way.

3 Allocation options

3.1 What are key free allocation options?

Allocation options can be categorised in terms of who receives allocations, on what basis they receive them, and how they change over time.

3.1.1 Who are units allocated to?

a. Farmers – owners of farm businesses

b. Agricultural land owners

c. Processors

d. Other groups – e.g. agricultural workers or communities.

The key distinctions between these options depend on how these groups overlap - for instance, whether processing companies are owned by farmers and by which farmers, and how wealth and prices are passed between these groups. If processing companies are owned by farmers (for example cooperatives), allocation to processors is a direct allocation to at least some farmers. If not, the benefit to farmers will depend on how wealth and costs are passed from processors to farmers. The latter will depend on market structures and legal relationships.

Ideally, allocation will be given directly to those whom the system aims to compensate, whose adjustment it aims to ease, and where it aims to encourage behavioural change. If the objective is partial compensation, this suggests allocating to landowners; if the objective is to avoid output reduction, this suggests allocating to the operators of farm businesses; and if community adjustment is of foremost concern, some allocation should go to local communities and workers.

The most convenient group to give allocation to may depend on the point of obligation – who reports data and surrenders NZ units – because these actors will be registered and will be providing potentially relevant data. This criteria is especially relevant if the point of obligation is the processor, the objective of free allocation is partial compensation to landowners and we are not sure that a free allocation to processors would be passed on to landowners. Only an allocation to landowners would directly achieve the compensation objective, but if the point of obligation is the processor the data on which an allocation to landowners is based may need to be simpler than it would be if the point of obligation were the landowner. The data used needs to take into account the cost of reporting and verifying data that is not needed for other purposes.[19]

In contrast, if the objective is protection of output and the processing market is competitive, allocation could be provided to farmers through processors via a defined reduction in the emissions levy on output (if the processor is the point of obligation). Equivalently, allocation could be provided through a defined subsidy per unit of output (if the point of obligation is on the farm). Each is equally convenient because the allocation and data collection are co-located. If the processing market is not competitive, some of the value of the free allocation would not be passed on to farmers creating inefficiency; this is, however, a more general problem with the way prices are passed through non-competitive markets and is not specific to emissions trading.

[19] Similarly, if the point of obligation were farm businesses or stock owners, in some cases, free allocation would need to go to the landowner from whom they lease land if the objective was to compensate them for loss of land value. This would create administrative complexity. If the objective were to reduce leakage, there would be no conflict.

3.1.2 On what basis are allocations made?

1. Where allocation is fixed – does not change over time.

a. Exemptions – de minimus/threshold rules

De minimus rules for free allocation (for example, not giving any free allocation to farms below a certain number of hectares), would be appropriate if allocation is to landowners and some landowners are exempt from the system. Those who do not bear cost under the system would not be compensated; those whose production is not affected would not be protected. Otherwise it could be justified only by government's administrative convenience concerns. Landowners' applications can be voluntary, so the cost to them of applying for free allocation can never exceed the value of compensation.

a. Historical emissions or historical output

Allocation could be based on historical data if the key motivation is partial compensation. If the point of obligation is processors, and hence we do not have detailed farm level information, we can calculate emissions only through the proxies of output, region (if there are significant regional variations in emissions intensity), and animal numbers as reported to the Inland Revenue Department. Thus the choice is how much of this information we would want to use. Liability will be proportional only to output if the point of obligation is the processor because they do not have access to other relevant data.

If the farm is the point of obligation, using the same emissions calculation to assess allocation as will be used to calculate emissions liability will minimise adjustment costs and minimise incentives to distort the model that determines emissions liability.

b. Fixed land characteristics

Because land values are likely to fall based on potential land use, not only current actual land use, using land characteristics as a basis for allocation rather than historical emissions or output is more closely aligned to addressing long-term losses in equity. This approach would particularly benefit those whose current land use is low intensity relative to its potential, for example some Maori land and some land that is currently in forestry. It would, however, require creating a formula linking fixed land characteristics to emissions liabilities, and may lead to some free allocation going to currently forested land, both of which may be controversial.[20] In addition, in the short term it will lead to higher adjustment costs because there will be greater differences between free allocations and emissions liability in the early years.

2. Options where the allocation formula is updated over time

a. Current Output – i.e. updating

Updating is appropriate only where we want the free allocation to alter behaviour. If the free allocation is aimed at avoiding reductions in output, output is the appropriate basis for allocation. If the aim is to minimise long term economic losses arising from leakage ('regret') and the products are not facing significant import substitution pressure (such as for most meat and dairy products), output that is exported is the best target because that is the output most vulnerable to leakage. However, this essentially becomes a border rebate and may face legal issues. It is also technically challenging to relate exported products to meat and milk production.

b. Current emissions – progressive obligation

This creates perverse incentives because it does not reward reductions in emissions intensity. Those who reduce the emissions intensity of their production are penalised because they receive fewer free NZ units. This option faces the same design challenges as current output-based allocation.

4 Summary and conclusion

Allocation of any free units within an emissions trading system is always the most politically contentious aspect of programme design. In the case of greenhouse gases from New Zealand agriculture, it potentially has economic and environmental effects (through emissions leakage and economic regret) as well as providing the potential to partially compensate some of those who bear disproportionate costs or who will find adjustment to change difficult. The empirical evidence suggests that for CO_2-e prices of around $25 and no free allocation, the impacts on the profitability of dairy and sheep-beef farms would be large. This will have particular impact on some farm classes (for example, on extensive farms) and concentrated geographical impact in communities strongly dependent on pastoral agriculture.

[20] This is however the approach being taken by Horizons Regional Council for regulation of nitrate loss and is being considered also for the Lake Rotorua catchment. See Kerr and Lock (2009).

The evidence suggests that there are, however, unlikely to be large changes in production intensity or land use as a result of a $25 price. At higher prices the empirical evidence becomes weaker and we are less confident at predicting effects.

There are some options to mitigate emissions, particularly through increasing productivity. These do not substantially change the distributional picture in the short run; however, greenhouse gas charges will, on the whole, increase the incentive toward more intensive but lower greenhouse gas intensity production in the dairy sector (including uptake of nitrification inhibitors in some regions); and will decrease the incentive to intensify in the sheep/beef sector.

Together, the evidence may suggest making allocation decisions with a greater emphasis on compensation motivations and assistance with adjustment in the most vulnerable communities. If the point of obligation is at farm level, this suggests allocation on a combination of historical output and fixed land characteristics as well as some direct assistance to vulnerable communities. It also suggests providing allocation to groups that most merit compensation and assistance. More research on the distribution of mitigation potential is needed before these should be translated into policy implications. Our inability to confidently assess the potential effects of higher prices might, however, suggest more weight on protecting against the full impact of prices on output, as least during an adjustment period.

4.1 Suggestions for further empirical research

1. Model the implications of farmers' abilities to gain credit from post-1990 native sequestration or plantation forestry for the burden of the ETS on extensive (low productivity) sheep/beef farms.
2. Model the implications of land use and management changes for the level and distribution of costs.
    - Simulate mitigation options on a wider range of farms.
    - Use different methodologies to explore potential movements in land use and management.
3. Model the implications of different allocation methods for the total net impact and distribution of net impact under different dynamic scenarios. This would build on recent MAF work.

4. Empirically explore the likely effect of contractions in New Zealand production for the price we receive for dairy and meat products using export data on volume and value of exports by destination across years.

Appendix A: Calculating profits and emissions

Dairy

We collected dairy data from the dairy section from the MAF Farm Monitoring Report (MAF, 2008a). It divides New Zealand into six regions: Northland, Waikato and Bay of Plenty, Taranaki, Lower North Island, Canterbury, Southland; and also the nation as a whole. However, it was not until the 2007/08 report that the Taranaki region first entered the report. It was previously part of lower North Island.

For each region, MAF collects data on 'effective area', 'number of milking cows', 'profit before tax', and 'interest payments'. At the national level, the value of 'effective area' and 'number of milking cows' are calculated by value weighting each region's data, where the weights are provided in each report.

The economic profit per hectare (EBIT) data are calculated by

$$\textbf{EBIT per ha} = (\textbf{Profit before tax} + \textbf{Interest} + \textbf{Rent})/\textbf{total effective area} \quad (1)$$

The emissions per hectare data are calculated mostly using data and methodology from the LURNZ model. There are three sources of emissions from dairy cattle: methane emissions from enteric activity, nitrous oxide emissions from manure, and nitrous oxide emissions from fertiliser use. LURNZ has estimated Implied Emission Factors (IEF) measured in tonnes of CO_2-e for each source of emission per milking cow.[21]

For methane emissions from enteric activity and nitrous oxide emissions from manure, we multiply the sum of the average IEFs from 1999 to 2007 by 'number of milking cows' to get total emissions for each region. We then divide total emissions by 'effective area' to obtain emissions per effective hectare.

The nitrous oxide emissions from fertiliser usage is trickier to calculate. LURNZv1 predicts fertiliser usage per hectare for each sector from 2001-07. We combine the IEF for fertiliser with usage per hectare estimates to obtain the fertiliser emissions per hectare estimates.[22]

[21] For more information see Hendy and Kerr (2005)

[22] We ignore 1999 and 2000 for estimating average emissions from fertiliser. This will create a small upward bias but these are a small share of total emissions.

The total emissions per hectare data from 1999-2007 are the sum of CH_4 emissions from enteric activity; NO_2 emissions from manure; and NO_2 emissions from fertiliser use.

Finally, the profit after accounting for the emission cost can be expressed as

$$\textbf{Net profit} = \textbf{EBIT per ha} - \textbf{Total emission per ha} \times \mathbf{CO_2}\ \textbf{price} \quad (2)$$

Sheep-beef

Sheep-beef data were purchased from Meat and Wool Ltd[23] (Meat and Wool Economic Service, 2008). The methodology used to generate the regional emissions costs is based on the Meat and Wool Economic Service model with small changes.[24] The model assigns a hypothetical price for a tonne of CO_2-e. By identifying the sources of CO_2-e emissions for a sheep/beef farm, the model calculates the emission costs from each source.

There are four difference sources of CO_2-e emissions: fuel usage, electricity usage, N fertiliser, and livestock. Livestock includes sheep, beef cattle, deer, and dairy cattle.

Fuel emissions

For fuel emissions, the raw data only provides fuel expenses data. The model assumes that 36% of fuel is petrol consumption while 64% is diesel consumption. For 2006 data, the petrol price is assumed to be $1.48 per litre and the diesel price is assumed to be $1 per litre. The number of litres of petrol and diesel usage is calculated by dividing expenses on both kinds of fuel by their prices.

The Emissions Factors (EF) for petrol and diesel are 0.0024 and 0.0027 per litre. The emissions from fuel consumption is therefore calculated by

$$\textbf{Fuel emission} = \textbf{petrol usage} \times \mathbf{0.0024} + \textbf{Diesel usage} \times \mathbf{0.0027} \quad (2)$$

Table 16 shows the emissions costs from fuel given the 2006 data and assuming $25 cost per tonne of CO_2-e.

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23 The contact person for the dataset is Rob Davison (Rob.Davison@meatandwoolnz.com) from Meat and Wool Ltd.

24 The model is an MS Excel based computer model from Meat and Wool Ltd. The contact person for the model is Con Williams (con.williams@meatandwoolnz.com)

Table 15: Class definition for sheep-beef farms in New Zealand

Class	ES Farm Class	Characteristics
1	South Island High Country	Extensive run country located at high altitude carrying fine wool sheep, with wool as the main source of revenue. Located mainly in Marlborough, Canterbury and Otago.
2	South Island Hill Country	Mainly mid micron wool sheep mostly carrying between two and seven stock units per hectare. Three quarters of the stock units wintered are sheep and one quarter beef cattle.
3	North Island Hard Hill Country	Steep hill country or low fertility soils with most farms carrying six to ten stock units per hectare. While some stock are finished a significant proportion are sold in store condition.
4	North Island Hill Country	Easier hill country or higher fertility soils than Class 3. Mostly carrying between eight and thirteen stock units per hectare. A high proportion of sale stock sold is in forward store or prime condition.
5	North Island Intensive Finishing Farms	Easy contour farmland with the potential for high production. Mostly carrying between eight and fourteen stock units per hectare. A high proportion of stock is sent to slaughter and replacements are often bought in.
6	South Island Finishing-Breeding Farms	A more extensive type of finishing farm, also encompassing some irrigation units and frequently with some cash cropping. Carrying capacity ranges from six to eleven stock units per hectare on dryland farms and over twelve stock units per hectare on irrigated units. Mainly in Canterbury and Otago. This is the dominant farm class in the South Island.
7	South Island Intensive Finishing Farms	High producing grassland farms carrying about ten to fourteen stock units per hectare with some cash crop. Located mainly in Southland, South and West Otago.
8	South Island Mixed Finishing Farms	Mainly on the Canterbury plains with a high proportion of the revenue are derived from grain and small seed production as well as stock finishing.
9	Average	Average

Source: Meat and Wool Economic Service Ltd New Zealand

Table 16: Regional emissions costs for petrol and diesel for 2006 (per ha)

	Class/Petrol emission costs per ha								
Production Region	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
East Coast			$0.07	$0.16	$0.26				$0.14
Marlborough-Canterbury	$0.02	$0.07				$0.33		$1.06	$0.19
New Zealand	$0.02	$0.08	$0.10	$0.19	$0.28	$0.30	$0.46	$1.06	$0.18
Northland-Waikato-BoP			$0.11	$0.22	$0.33				$0.21
Otago/Southland	$0.03	$0.12				$0.25	$0.46		$0.17
Taranaki-Manawatu			$0.14	$0.19	$0.28				$0.18

	Class/Diesel emission costs per ha								
Production Region	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
East Coast			$0.22	$0.47	$0.76				$0.42
Marlborough-Canterbury	$0.06	$0.21				$0.98		$3.13	$0.55
New Zealand	$0.07	$0.24	$0.30	$0.57	$0.84	$0.88	$1.37	$3.13	$0.52
Northland-Waikato-BoP			$0.33	$0.65	$0.97				$0.63
Otago/Southland	$0.09	$0.36				$0.74	$1.37		$0.50
Taranaki-Manawatu			$0.41	$0.57	$0.84				$0.54

	Class/Total fuel emission costs per ha								
Production Region	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
East Coast			$0.30	$0.63	$1.02				$0.56
Marlborough-Canterbury	$0.07	$0.28				$1.31		$4.18	$0.74
New Zealand	$0.09	$0.32	$0.40	$0.76	$1.12	$1.17	$1.83	$4.18	$0.69
Northland-Waikato-BoP			$0.44	$0.88	$1.29				$0.84
Otago/Southland	$0.11	$0.48				$0.98	$1.83		$0.67
Taranaki-Manawatu			$0.55	$0.76	$1.13				$0.72

Electricity emissions

The raw data provides information on electricity expenses. The model breaks the expenses into two categories: fixed charges and electricity charges. The fixed charge is calculated by

$$\textbf{Fixed charge} = \$\mathbf{1.5} \times \mathbf{365}\ \textbf{(days)} \quad (3)$$

The electricity charge is calculated by

$$\textbf{Electricity charge} = \textbf{Total electricity expense} - \textbf{Fixed charge} \quad (4)$$

By assuming the price of electricity is $0.2 per Kwh, the electricity usage is then calculated by dividing electricity charges by the assumed price. Using this method, we calculate the EF for electricity to be 0.00023325 tonne of CO_2-e per Kwh.

[25] The emission factor for electricity is from Table 1 of Page 9 in a CRA report -- Impact of the NZ ETS on Cement Manufacturing.

Table 17: Regional emissions costs for electricity for 2006 (per ha)

	Class/Electricity emission costs								
Production Region	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
East Coast			$0.05	$0.09	$0.18				$0.09
Marlborough-Canterbury	$0.01	$0.06				$0.33		$1.41	$0.20
New Zealand	$0.02	$0.07	$0.06	$0.10	$0.15	$0.22	$0.16	$1.41	$0.12
Northland-Waikato-BoP			$0.04	$0.10	$0.09				$0.09
Otago/Southland	$0.02	$0.08				$0.07	$0.16		$0.07
Taranaki-Manawatu			$0.07	$0.11	$0.11				$0.09

N fertiliser emissions

The data on tonnes of N fertiliser used is directly extracted from the model, where the usage measure by tonne is given for each class from Class 1 to Class 9 at year 2006. The EF for N fertiliser emissions is assumed to be 5.27 tonne of CO_2-e per one tonne usage of fertiliser.

Table 18: Regional emissions costs for N fertiliser for 2006 (per ha)

	Class								
Production Region	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
East Coast			$0.76	$1.27	$1.93				$1.25
Marlborough-Canterbury	$0.04	$0.34				$1.86		$11.69	$0.88
New Zealand	$0.05	$0.37	$0.94	$1.60	$2.46	$1.50	$0.91	$11.69	$1.17
Northland-Waikato-BoP			$1.21	$1.95	$2.79				$2.06
Otago/Southland	$0.05	$0.48				$0.99	$0.91		$0.92
Taranaki-Manawatu			$1.04	$1.46	$3.42				$1.58

Note: As the model only gives the usage of N fertiliser for difference classes, there is no regional effect (i.e. for the same class, the different regions will have the same emission costs from the use of N fertiliser).

Livestock emissions

The raw data provides the number of animals at open date (July 1) each year. Four types of animal are accounted for: sheep, beef cattle, deer, and dairy cattle. By using the animal number to stock unit factor from the LURNZ model, the number of animals is transferred to stock units. The conversion factors are

Dairy cattle = 6.15 Stock Unit (su, hereafter)

Beef cattle = 4.874 su

Sheep = 0.923 su

Assume: deer = 0.923 su as well

(Note: The Meat and Wool Economic Service model includes stock unit data, which are not included in the raw data. Moreover, the model does not factor deer into the calculation. However, what we have produced using the method described above is not significantly different from the results produced by Meat and Wool Economic Service's model).

The EFs for each type of animal are given as

EF_sheep = 0.359 tonnes of CO_2-e per SU of sheep

EF_beefcattle = 0.35 tonnes of CO_2-e per SU of beef cattle

EF_dairycattle = 0.381 tonnes of CO_2-e per SU of dairy cattle

EF_deer = 0.362 tonnes of CO_2-e per SU of deer.

Appendix B: Additional tables and maps

Table 19: Description of simulated dairy models used in Smeaton and deKlein (2008)

Note 1: 'Profit ranking' is measured so that 1 is most profitable and 8 is least profitable.
Note 2: Payout used = $6/kg ms.

System description	SR cows/ha	N used kg/ha	Imp feed t DM/ha	Cow Wt kg	Cow BW % of avg	Production kg ms/ha	Production kg ms/cow	GM profit $/ha	FWEs $/kg ms	Profit ranking
Base farm: avg N, imported feed	2.97	119	1.3	480	100	974	328	2047	3.92	8
Avg N, imp feed, big cows, high BW -System f	2.45	119	1.0	550	110	1008	411	2639	3.40	1
Even more N, no imp feed -System d	2.69	188	0.0	480	100	985	366	2534	3.47	2
Even more N, more imp feed -System c	2.95	188	1.4	480	100	1086	368	2469	3.77	3
Avg N, no imported feed –System a	2.69	119	0.0	480	100	909	338	2313	3.49	4
More N, more imp feed –System b	3.02	158	1.3	480	100	1044	346	2243	3.88	5
Average N, imp feed, big cows -System e	2.69	119	1.2	550	100	952	354	2128	3.79	6
No N, no imp feed –System g	2.41	0	0.0	480	100	797	331	2125	3.36	7

Keys to abbreviations:

- SR = stocking rate
- N used = Nitrogen fertiliser applied per year
- Imp feed = amount of feed imported onto the farm per year
- Cow BW = cow breeding worth or genetic merit
- Prod = production, ms = milk solids per year
- GM = gross margin profit per year
- FWEs = cash farm working expenses per year
- GHG = green house gas

Table 20: Descriptive data for the model of the all-classes Central North Island King Country sheep & beef farm. The rows in the table show the base model and the intensification options 'a to e'

System description	GM profit $/ha	Production net, kg/ha	No of cows	No of ewes	No of bulls	No of heifers	N used kg N/ha	Total SU/ha	Sheep SU/ha	Beef SU/ha	F bulls SU/ha	Heifers SU/ha	Wool kg/ha
Base = Monitor farm Scen 0	415	190	145	2700	30	0	7	10.0	6.3	3.8	0.2	0	28
Increase prod with more N -System a	450	237	182	3398	38	0	40	12.5	7.8	4.7	0.3	0	35
Increase N, incr bull nos only -System b	504	317	145	2700	455	0	40	13.4	6.3	7.1	3.6	0	28
Incr N, use crop, incr bulls only -System c	539	318	145	2700	458	0	37	13.4	6.3	7.1	3.6	0	28
Increase N, incr hfrs only -System d	444	242	145	2700	0	300	40	12.0	6.3	3.5	0	2.2	28
Incr N, use crop, incr hfrs only -System e	541	279	145	2700	0	470	37	13.4	6.3	3.5	0	3.6	28

Keys to abbreviations:

- GM profit = gross margin profit per ha per year
- Production net = all beef, sheep liveweight and wool production inclusive of sales and purchases and includes dairy heifer liveweight gain
- Cows = breeding cows
- Heifers = dairy heifer grazers
- N used = Nitrogen fertiliser applied per year
- SU = stock units
- Bulls, F bulls = Friesian bulls
- Beef = all beef animals excluding F bulls and dairy heifer grazers

Table 21: Dairy farms across regions and years: economic profit (EBIT) per hectare and EBIT per hectare net of emissions costs, at $25 per tonne CO_2-e, in 2007 dollars

Year	Northland	Waikato BayofPlenty	Taranaki	Lower North Island	Canterbury	Southland	National
2001	$2,267	$2,505		$2,765	$3,126	$3,616	$2,687
	($2,058)	($2,221)		($2,486)	($2,813)	($3,325)	($2,411)
2002	$1,933	$2,858		$2,724	$2,978	$3,119	$2,683
	($1,701)	($2,549)		($2,429)	($2,643)	($2,810)	($2,385)
2003	$1,089	$1,337		$993	$1,397	$1,016	$956
	($848)	($1,029)		($700)	($1,046)	($710)	($649)
2004	$948	$1,539		$1,464	$1,807	$1,548	$1,516
	($708)	($1,249)		($1,172)	($1,471)	($1,246)	($1,220)
2005	$1,277	$1,519		$1,423	$2,391	$1,555	$1,637
	($1,038)	($1,234)		($1,131)	($2,037)	($1,260)	($1,341)
2006	$1,114	$1,290		$1,534	$2,182	$1,820	$1,578
	($877)	($1,000)		($1,256)	($1,831)	($1,536)	($1,283)
2007	$1,048	$1,095		$1,387	$1,796	$1,749	$1,405
	($818)	($813)		($1,110)	($1,445)	($1,473)	($1,113)
2008	$2,821	$3,089	$3,360	$3,413	$5,347	$4,660	$3,882
	($2,600)	($2,814)	($3,091)	($3,143)	($5,009)	($4,376)	($3,597)
Average	$1,502	$1,836	$3,360	$1,940	$2,553	$2,315	$1,991
	($1,272)	($1,546)	($3,091)	($1,656)	($2,217)	($2,021)	($1,700)

Derived from MAF Farm Monitoring Reports

Table 22: Dairy farms across regions and years: cash profit per hectare and cash profit per hectare net of emissions costs, at \$25 per tonne CO_2-e, in 2007 dollars

Year	Northland	Waikato BayofPlenty	Taranaki	Lower North Island	Canterbury	Southland	National
2001	$2,039 ($1,830)	$2,073 ($1,788)		$2,440 ($2,161)	$2,695 ($2,381)	$3,104 ($2,813)	$2,302 ($2,026)
2002	$1,721 ($1,489)	$2,452 ($2,143)		$2,304 ($2,009)	$2,505 ($2,170)	$2,408 ($2,099)	$2,264 ($1,967)
2003	$887 ($645)	$976 ($667)		$571 ($279)	$628 ($277)	$300 (-$6)	$496 ($189)
2004	$740 ($500)	$999 ($710)		$1,053 ($761)	$1,023 ($687)	$973 ($671)	$932 ($636)
2005	$1,037 ($798)	$950 ($666)		$977 ($685)	$1,557 ($1,203)	$663 ($368)	$1,018 ($722)
2006	$871 ($634)	$712 ($422)		$959 ($681)	$1,305 ($954)	$897 ($614)	$919 ($624)
2007	$788 ($558)	$483 ($201)		$746 ($469)	$488 ($137)	$559 ($283)	$571 ($279)
2008	$2,334 ($2,113)	$2,099 ($1,824)	$2,714 ($2,445)	$2,299 ($2,029)	$3,997 ($3,658)	$3,272 ($2,988)	$2,808 ($2,522)
Average	$1,247 ($1,017)	$1,290 ($999)	$2,714 ($2,445)	$1,421 ($1,137)	$1,746 ($1,410)	$1,540 ($1,246)	$1,378 ($1,086)

Derived from MAF Farm Monitoring Reports

Table 23: Dairy: Average farm emissions costs, EBIT and farm profit before tax, in 2007 dollars

Year	Total emission costs	EBIT	Farm profit before tax
2001	$25,387	$246,952	$211,581
2002	$28,419	$256,533	$216,495
2003	$33,733	$105,072	$54,451
2004	$34,268	$175,516	$107,955
2005	$34,479	$190,719	$118,658
2006	$36,115	$193,394	$112,565
2007	$36,627	$176,503	$71,689
2008	$39,423	$556,862	$407,875

Note: the numbers are calculated by taking weighted average by regions

Table 24: Dairy by region and year: Percentage impacts on economic profit, $25 per tonne CO_2-e

Year	Northland	Waikato BayofPlenty	Taranaki	Lower North Island	Canterbury	Southland	National
2001	-9.2%	-11%		-10%	-10%	-8.0%	-10%
2002	-12%	-11%		-11%	-11%	-10%	-11%
2003	-22%	-23%		-29%	-25%	-30%	-32%
2004	-25%	-19%		-20%	-19%	-19%	-20%
2005	-19%	-19%		-21%	-15%	-19%	-18%
2006	-21%	-22%		-18%	-16%	-16%	-19%
2007	-22%	-26%		-20%	-20%	-16%	-21%
2008	-7.8%	-8.9%	-8.0%	-7.9%	-6.3%	-6.1%	-7.4%
Average	-15%	-16%	-8.0%	-15%	-13%	-13%	-15%

Table 25: Dairy by region and year: Percentage impacts on cash profit at $25 per tonne CO_2-e

Year	Northland	Waikato BayofPlenty	Taranaki	Lower North Island	Canterbury	Southland	National
2001	-10%	-14%		-11%	-12%	-9%	-12%
2002	-14%	-13%		-13%	-13%	-13%	-13%
2003	-27%	-32%		-51%	-56%	-102%	-62%
2004	-32%	-29%		-28%	-33%	-31%	-32%
2005	-23%	-30%		-30%	-23%	-45%	-29%
2006	-27%	-41%		-29%	-27%	-32%	-32%
2007	-29%	-58%		-37%	-72%	-49%	-51%
2008	-9.5%	-13%	-10%	-12%	-8.5%	-8.7%	-10%
Average %change	-18%	-23%	-10%	-20%	-19%	-19%	-21%

Table 26: Sheep/Beef: Average farm emission liability, economic and cash profits, in 2007 dollars

Year	Total emission costs	Economic Profit	Cash Profit
2001	$41,336	$143,879	$112,292
2002	$40,953	$167,214	$134,626
2003	$42,526	$138,942	$100,254
2004	$40,480	$110,302	$72,873
2005	$40,453	$121,253	$77,682
2006	$40,000	$90,528	$42,532
2007	$40,398	$92,798	$45,400
2008	$44,966	$80,505	$27,799

Note: the numbers are calculated by taking area-weighted average by regions and class

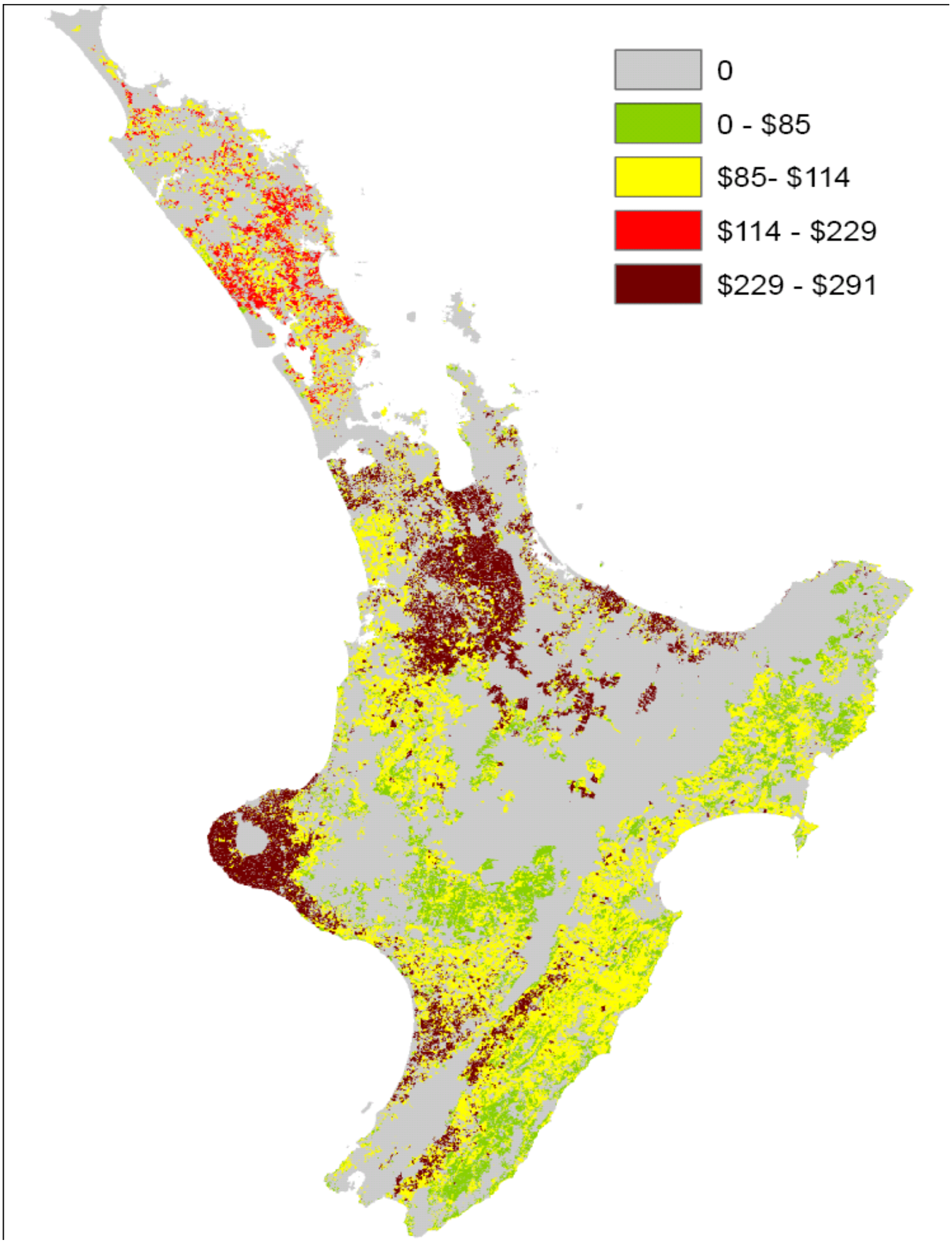
Table 27: Sheep/beef by region and class: Average (2001-2008) economic profit per hectare and (economic profit per hectare net of emission costs), at $25 per tonne CO_2-e, in 2007 dollars

	Class							
	1	2	3	4	5	6	7	8
East Coast			$147 ($81)	$276 ($199)	$351 ($272)			
Marlborough-Canterbury	$16 ($7)	$69 ($40)				$223 ($148)		$511 ($470)
Northland-Waikato-BoP			$187 ($111)	$264 ($178)	$453 ($371)			
Otago/Southland	$16 ($4)	$123 ($73)				$259 ($191)	$455 ($369)	
Taranaki-Manawatu			$181 ($109)	$276 ($195)	$346 ($256)			

Table 28: Sheep/beef by region and class: Average (2001-2008) sheep-beef farm cash profit per hectare and (cash profit per hectare net of emission costs), at $25 per tonne CO_2-e, in 2007 dollars

	Class							
	1	2	3	4	5	6	7	8
East Coast			$87 ($17)	$185 ($102)	$240 ($155)			
Marlborough-Canterbury	$11 ($1)	$44 ($13)				$132 ($51)		$223 ($164)
Northland-Waikato-BoP			$121 ($40)	$175 ($85)	$339 ($249)			
Otago/Southland	$7 (-$6)	$90 ($39)				$196 ($124)	$329 ($235)	
Taranaki-Manawatu			$89 ($11)	$181 ($94)	$271 ($175)			

Figure 11: Dairy and sheep/beef combined liability map: Average (2001-2008) emission liability per ha, in 2007 dollars



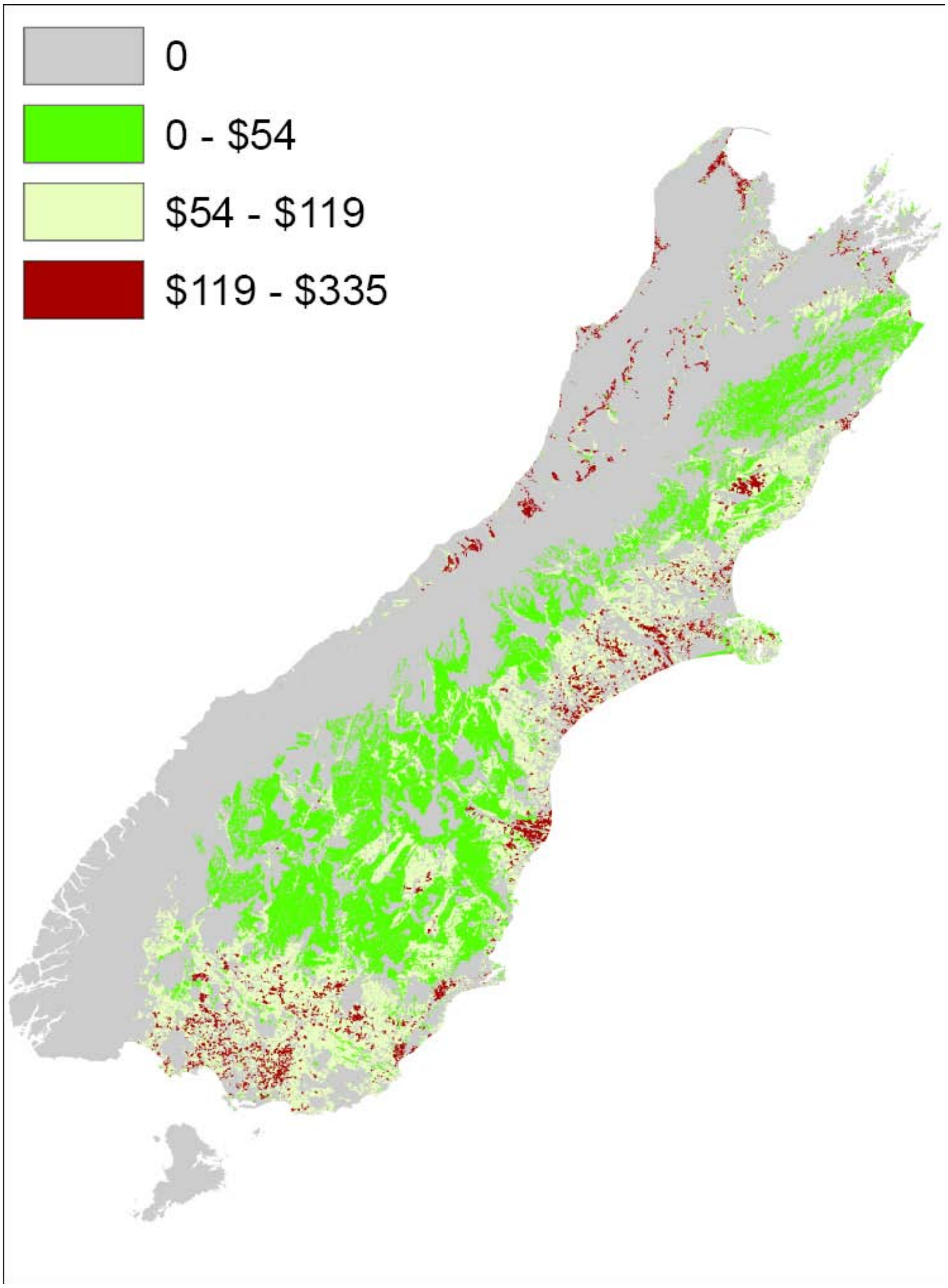

0
0 - $54
$54 - $119
$119 - $335

Table 29: Dairy and sheep/beef combined liability (2000-07 average in thousands in 2007 dollars) and population (16 to 65 in thousands) by labour market area

Labour Market Area	Liability from dairy	Liability from sheep-beef	Liability from both sectors	Population
Kaitaia	2856.0	2789.8	5645.8	10.6
Kerikeri	2494.7	2322.4	4817.1	13.0
Kaikohe	3160.0	3242.8	6402.8	8.3
Whangarei	15398.4	4983.5	20381.9	43.6
Dargaville	8505.0	3873.0	12378.0	6.0
Warkworth	12668.5	5703.9	18372.5	15.9
Auckland	2328.2	2604.7	4933.0	465.6
SthAuckland	13564.0	6342.8	19906.8	310.2
Thames	12466.4	1936.6	14403.0	18.4
Waihi	3586.7	512.5	4099.2	8.5
Ngaruawahia	17919.1	469.4	18388.5	6.6
Morrinsville	6570.8	289.6	6860.4	5.3
Matamata	7710.7	302.6	8013.3	6.1
Hamilton	29782.8	7032.4	36815.2	117.1
Te Awamutu	10310.0	831.6	11141.6	10.8
Otorohanga	15406.9	4881.8	20288.7	6.0
Tokoroa	13649.8	677.5	14327.4	15.2
TeKuiti	5278.4	12526.9	17805.3	5.9
Taupo	8104.6	6539.6	14644.2	19.2
Te Puke	6236.8	863.5	7100.3	9.2
Tauranga	2831.6	1317.0	4148.6	68.2
Rotorua	15102.0	2246.5	17348.5	43.1
Whakatane	9823.5	1329.1	11152.7	27.6
Gisborne	735.8	22583.9	23319.7	26.7
Hastings	334.1	5528.2	5862.3	38.4
Napier	1961.6	22256.1	24217.7	42.9
Waipukurau	2089.6	19139.5	21229.1	8.2
New Plymouth	28067.9	3228.5	31296.4	44.4
Stratford	9033.5	3786.4	12819.9	6.8
Hawera	19371.1	2457.4	21828.5	11.7
Taumaranui	1176.2	11321.8	12498.0	5.6
Taihape	1179.0	19804.2	20983.2	6.8
Wanganui	3467.7	8685.7	12153.4	27.7
Bulls	2629.7	2539.3	5169.0	5.8
Palmerston Nth	14157.9	11183.2	25341.1	69.7
Dannevirke	6744.9	12970.9	19715.8	6.3
Eketahuna	6354.0	7079.8	13433.8	4.6
Levin	4221.8	1260.3	5482.1	18.2
Hutt Valley	248.8	310.0	558.7	83.1
Wellington	71.1	1134.4	1205.4	174.3
Masterton	8727.9	18623.0	27350.9	22.2
Motueka	262.3	446.5	708.8	7.9

Nelson	11314.1	3407.7	14721.8	50.3
Picton	2141.9	975.7	3117.6	5.0
Blenheim	998.1	8517.5	9515.6	20.1
Kaikoura	1400.7	1848.4	3249.1	2.3
Greymouth	14293.8	2113.8	16407.6	14.3
Christchurch	21882.8	37581.3	59464.1	265.6
Ashburton	12623.1	11305.8	23928.9	16.0
Waimate	9644.5	14946.7	24591.1	30.1
MacKenzie	360.7	11847.1	12207.7	2.7
Oamaru	7137.7	11874.7	19012.4	11.1
Alexandra	947.1	24118.8	25065.9	12.4
Queenstown	51.0	3854.3	3905.3	9.1
Dunedin	3395.3	12603.4	15998.7	79.0
Balclutha	8564.3	16857.5	25421.8	9.1
Gore	12134.0	41498.6	53632.5	16.2
Invercargill	21807.3	20230.9	42038.2	44.2

Population data – 2001 Census

Figure 12: Combined total emissions liability by labour market area: average over 2001-07, in 2007 dollars

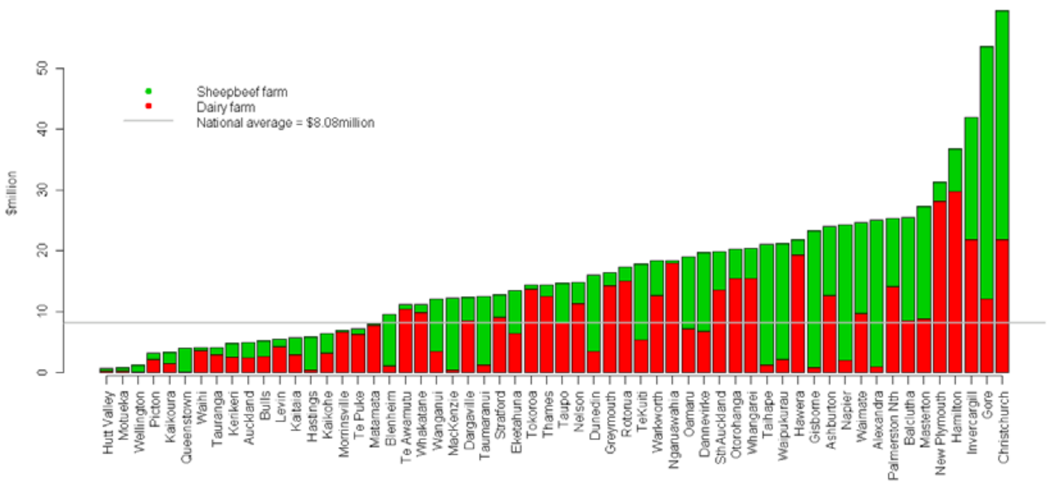


Table 30: Revenue in different account from 1980/81 to 1989/90, real dollar per hectare, at 2008 dollars

Year	Wool Account	Sheep Account	Cattle Account	Dee rAccount	Goat Account	GoatFiber Account	GrainSeed Account	Other Account	Total Revenue
1980-81	226.9	200.6	98.3	0.4	.	.	53.0	10.5	589.7
1981-82	241.2	198.2	90.5	-0.2	.	.	50.8	10.0	590.4
1982-83	226.3	198.1	102.2	0.2	.	.	66.9	11.0	604.7
1983-84	214.1	201.4	78.1	-2.5	0.1	0.1	79.1	12.9	583.6
1984-85	224.3	212.1	103.9	0.4	1.3	0.1	78.5	12.6	633.4
1985-86	183.4	108.0	81.4	3.6	0.6	0.2	67.4	15.0	459.9
1986-87	171.5	110.8	75.6	4.1	0.8	0.1	47.8	10.6	421.6
1987-88	189.5	102.4	69.3	5.1	0.7	0.6	38.9	11.4	418.6
1988-89	197.2	87.7	80.2	4.0	-0.1	1.0	38.6	13.0	422.6
1989-90	156.0	121.4	90.0	4.7	-0.1	0.7	49.2	12.6	436.1

Table 31: Average real EBIT per ha from 1980/81 to 1984/85 in 2008 dollars

	Class								
	1	2	3	4	5	6	7	8	9
East Coast			168.6	344.8	502.7				304.2
Marlborough-Canterbury	16.7	70.3				280.6		622.8	170.1
Northland-Waikato-BoP			233.1	317.4	593.4				361.5
Otago/Southland	22.8					355.1	636.8		206.5
Taranaki-Manwatu			188.7	384.8	557.9				389.4
New Zealand	18.6	68.1	182.5	346.0	541.4	292.6	636.8	622.8	237.7

Table 32: Average real EBIT per ha from 1985/86 to 1989/90 in 2008 dollars

	Class								
	1	2	3	4	5	6	7	8	9
East Coast			131.7	238.6	371.4				227.1
Marlborough-Canterbury	23.8	67.4				205.5		417.0	134.7
Northland-Waikato-BoP			209.3	273.7	397.3				290.4
Otago/Southland	35.0					288.5	514.0		180.4
Taranaki-Manwatu			176.9	278.9	375.1				281.0
New Zealand	27.5	69.1	151.4	260.5	378.9	224.1	514.0	417.0	189.4

Table 33: Revenue in different account from 1980/81 to 1984/85 and simulated revenue from 1985/86 to 1989/90, real dollar per hectare, in 2008 dollars

Year	Wool Account	Sheep Account	Cattle Account	Dee rAccount	Goat Account	GoatFiber Account	GrainSeed Account	Other Account	Total Revenue
1980-81	226.9	200.6	98.3	0.4			53.0	10.5	589.7
1981-82	241.2	198.2	90.5	-0.2			50.8	10.0	590.4
1982-83	226.3	198.1	102.2	0.2			66.9	11.0	604.7
1983-84	214.1	201.4	78.1	-2.5	0.1	0.1	79.1	12.9	583.3
1984-85	224.3	212.1	103.9	0.4	1.3	0.1	78.5	12.6	633.2
1985-86	213.2	216.3	91.4	0.4	1.3	0.1	78.5	12.6	614.0
1986-87	214.2	190.4	93.0	0.4	1.3	0.1	78.5	12.6	590.7
1987-88	211.3	165.4	91.4	0.4	1.3	0.1	78.5	12.6	561.1
1988-89	205.6	159.6	88.2	0.4	1.3	0.1	78.5	12.6	546.4
1989-90	198.0	153.2	84.5	0.4	1.3	0.1	78.5	12.6	528.7

Note: For example, the simulated revenue for Wool Account in 1985/86 will equal Average revenue (1980/81 to 84/85) from Wool Account * (1+decrease in PSE in Wool from 84 to 85), where decrease in PSE in Wool from 84 to 85 = ($PSE_{85,wool}$ – $PSE_{84,wool}$)/$PSE_{84,wool}$.

Appendix C: Data Set References

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