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How will an Emissions Trading Scheme affect land use and planted forest management in New Zealand?

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EXECUTIVE SUMMARY

A model for New Zealand describing agricultural and forestry land use incorporating carbon sequestration and green house gas emissions was used to estimate the potential effects of an Emissions Trading Scheme (ETS) on land use and planted forest management. The key driver of land use change and forest management decisions in the model is changes in land value. The major effect of an ETS is predicted to be afforestation of sheep and beef grazing on lower productivity land. A carbon price of $25 per NZU could encourage sufficient afforestation to enable New Zealand to meets its Kyoto obligation of reducing net emissions to 1990 levels. In comparison, changes in the management (deforestation, silviculture and rotation) of existing Kyoto and non-Kyoto forests have a negligible impact on New Zealand's net emissions. The reduction in the value of land in agriculture is a second order effect compared to the increase in value of forestry land due to revenue from carbon sequestered, and it is this that drives the afforestation.

INTRODUCTION

Recently, a New Zealand Emissions Trading Scheme (ETS) has been proposed as a necessary measure to ensure New Zealand meets its Kyoto obligation of reducing average annual emissions to 1990 levels. This will have significant effects on the profitability of New Zealand's primary industries, and potentially lead to large scale land use change as enterprises thrive and perish under an unpredictable carbon price.

This study aims to quantify these potential changes to New Zealand's rural land use, emissions and production. We briefly describe the ETS, and then our methodology for describing land quality and use in New Zealand at present. We then look at the reasons for changing land use, and derive a model to describe this decision process on a single-farm level. This farm-level model is then applied to the decisions that could be made by land owners of dairy, sheep and beef land, forests planted pre-1990 and forests planted post-1989. We then scale this up to a national level and look at the national impacts of an ETS on the national forest estate, the carbon sequestered by New Zealand's forests and how this will affect New Zealand's carbon balance.

The Emissions Trading Scheme

The formative New Zealand Emissions Trading Scheme creates a tradable currency of carbon credits which are used to account for emissions and sequestrations of greenhouse gasses. All gasses are converted into tonnes of carbon dioxide equivalent (t CO_2-e) based on their impact on the atmosphere. One credit is worth one tonne of carbon dioxide equivalent. Domestic credits will be held within a single bank in New Zealand, but may be traded overseas. There is no purpose in exchanging one credit for another, so credits can be sold for money where there is a demand. Domestically, the carbon credit price (hereafter the 'carbon price') is expected to be capped at $25, although the international price may be greater than this. Only credits earned through forestry may currently be traded overseas. This 'cap and trade' system will lead to a carbon price dictated by the market, which is expected to fluctuate and create uncertainty for investors, particularly as the market takes time to mature.

Of the primary industries, forestry is included in the ETS from 2008 and agriculture from 2013, with farmers being required to report their emissions in 2012 (although they are not liable for these). In addition, the liquid fossil fuels sector will be introduced in 2009, stationary energy and industrial processes in 2010 and waste in 2013. These will also affect the primary industries through increased costs.

The 'point of obligation' – i.e. the party that is held accountable for the greenhouse gasses emitted – is expected to be downstream in most cases. This means that whilst a dairy farmer may not have to directly pay for his own emissions, the point of obligation in the supply chain will be the processors and suppliers (MAF 2007a). Thus the processor has to pay a calculated penalty for the on-farm emissions created in the process of producing the product (e.g. milk), not the actual farmer. A proportion of this penalty is then passed to the farmers in the form of a reduced commodity price, necessary for the processor to maintain profitability. For forestry, the point of obligation is the forest owner, who is immediately liable for the carbon sequestered through growth, and carbon lost through felling, fire and decay.

All sectors will be phased in by gifting each point of obligation an allocation of free credits, which may be used to offset their liabilities. In agriculture this allocation is expected to be 90% of the 2005 emissions between the years 2013 and 2019, with a gradual phase out until 2030.

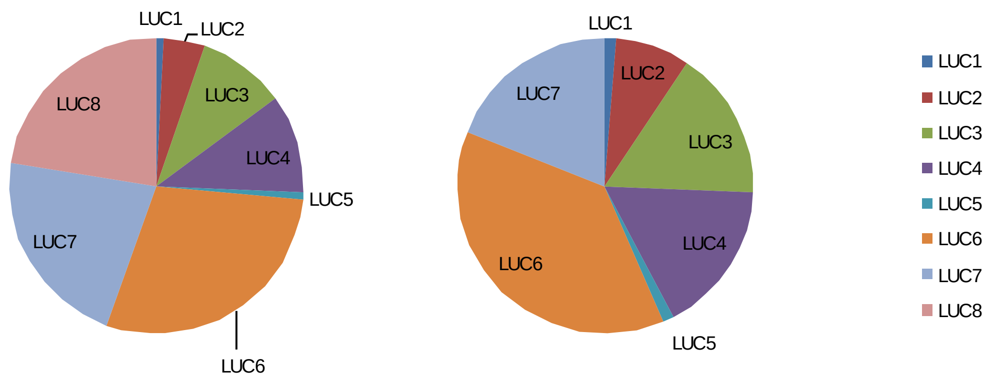
Setting the Scene – Describing land and land use in New Zealand

No two hectares of land in New Zealand are the same, and neither are their uses. Here we describe land by its quality and use. Furthermore, forested land will be described by its date of afforestation (pre-1990 or post-1989). In the next two sections, we describe our groupings of quality (land class) and land uses.

Describing Site Quality

We will use the Land Use Capability classification system to describe all productive land in New Zealand. This system aggregates land into classes 1 to 8, from most productive to least productive (NWASCO 1979). The area of New Zealand is approximately 27.8 million ha, of which 25.8 million ha has a LUC classification – Figure 1a shows the distribution of this land. Not all of this land is suitable for agriculture or forestry, and Figure 1b shows the make up of the 14.2 million ha that is suitable[1].

Figure 1 - Land Use Capability class proportions in a) New Zealand (left) and b) Suitable sites for forestry and agriculture (right).



Describing Land Use

We are concerned with two main types of primary industry – farming and planted forests.

For our purposes farming is subdivided into 'Sheep and Beef' and 'Dairy' which cover the majority of agricultural and commercial forestry land, and hence capture most of the land use change. Sheep and Beef is an amalgamation of a range of grazing systems which raise predominately sheep or cattle for meat production. Dairy is all types of farm systems where the primary product is milk solids.

Planted forest is subdivided into five management types, based on two species;

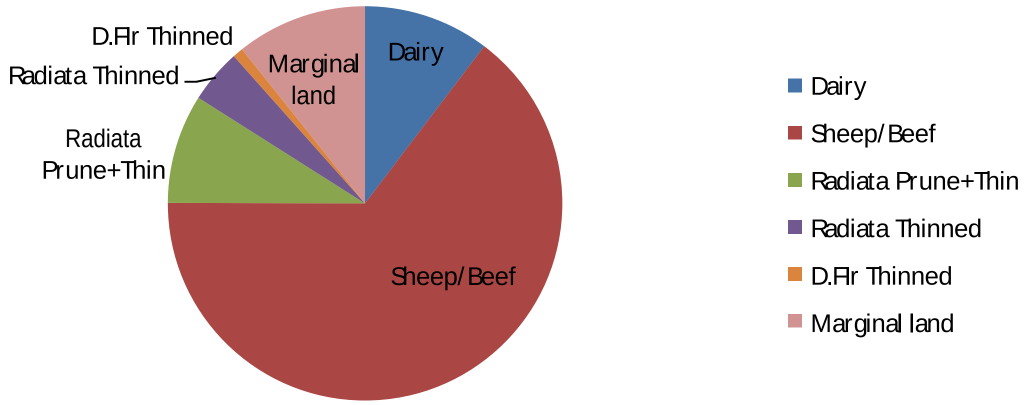
1. Radiata pine
   a. Pruned and thinned (Clearwood)
   b. Thinned only (Sawlogs)
   c. Untended (No silviculture)

2. Douglas-Fir
   a. Thinned (Sawlogs)
   b. Untended (No silviculture)

[1] Suitable land is defined as land that is LUC 1-7, with a land use in 2007 defined as cropland, grassland or forestry (non-native).

Initial land uses for the model were from a combination of Landcare's agribase-enhanced LCDB2 map (Thompson *et al*. 2003), the National Exotic Forest Description (MAF, 2007b) and LIC agricultural info (LIC, 2007). Figure 2 shows the proportion of usable land in each land use in 2002.

Figure 2 - Land use proportions in 2002

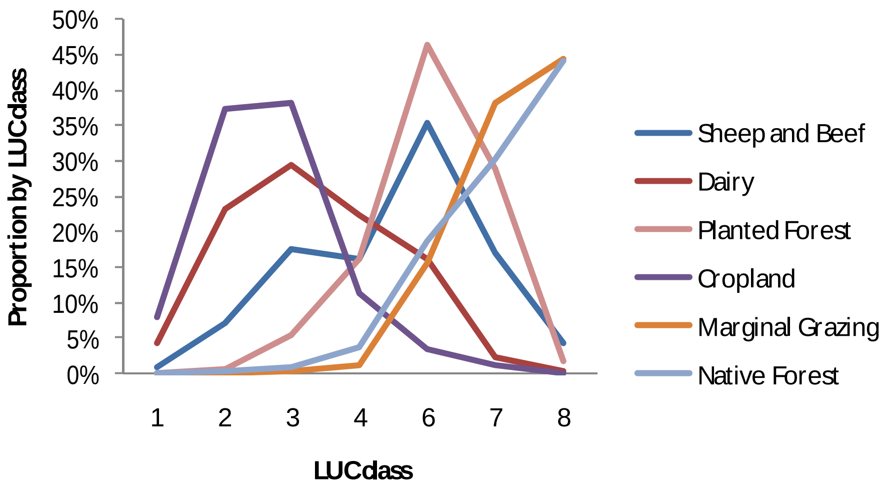


Matching Land Use to Land Quality

Data from existing land uses were used to estimate the average productivities for each land class, recognising that productivities differ across land uses. The 300 index was used for estimating radiata pine productivity (Kimberley, 2005), the 500 index for Douglas-fir productivity (Kimberley, 2005), and the stock unit carrying capacity for agriculture (NWASCO 1979).

Figure 3 shows the proportion of each land use on each land class in 2002, the point at which we start the model[2]. Cropland is most sensitive to LUC, existing only in the more productive classes. Dairy also appears to need higher LUC classes, although it is possible on LUC 6. Forestry and sheep and beef both largely use land in classes 4 to 7 (although sheep and beef does have a small share in classes up to LUC 2), whilst native forest and marginal grazing tend to exist only around LUC 6 to 8.

Figure 3 - LUC class preference by land use in 2002



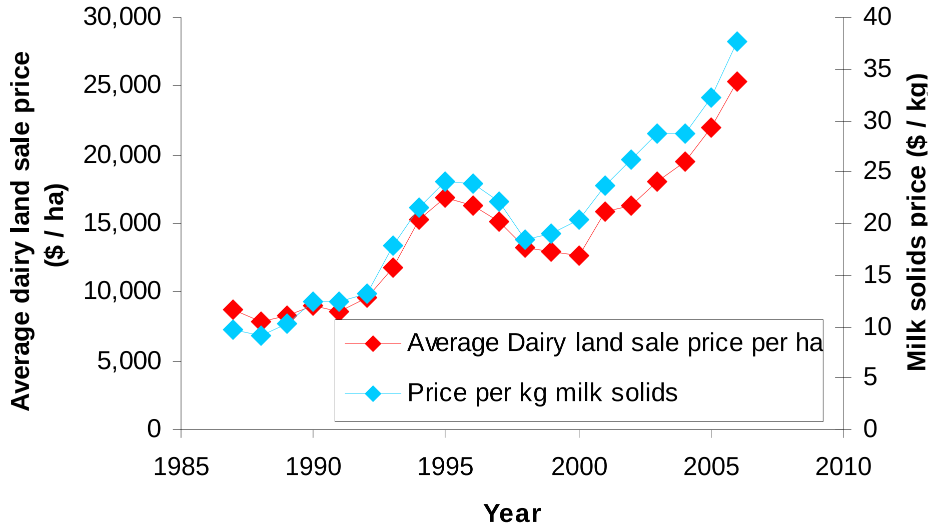
[2] LUC 5 has been removed, as there is only a small amount of class 5 land in New Zealand

WHAT CHANGES LAND USE?

In the model developed land use changes are governed by a set of "land owner decision rules", which are invariant across all land uses, site qualities, ownership changes and time. Incorporating different decision rules across these could be considered in future work.

The primary reason for changing land use is money. Throughout history, land use has generally followed the trends of the demand for its products, and hence their associated prices. Figure 4 shows how the average value of dairy land closely follows the milk solids price. This explains why in Figure 3 above, grazing can be seen on better quality land than forestry, as grazing tends to yield higher returns. Stillman (2005) found that the value of land in New Zealand is largely driven by the potential revenue that may be drawn from it.

Figure 4 – Relationship between milk solids price and average dairy land price. Source www.lic.co.nz Dairy stats



From an individual land owner's perspective the decision is not as simple as picking out the most economically optimal land use on any given day. Land use change takes time, investment and knowledge, and a myriad of case-specific reasons such as culture, aesthetics, popular opinion and local trends will influence the decision. We cannot model these, but can show how on a national level land use trends can be predicted based on the value of land under alternative uses possible on that land.

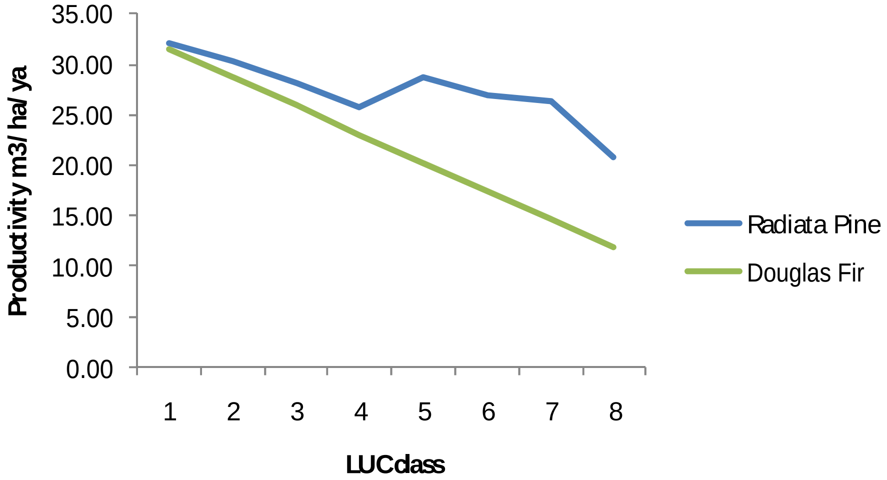
Estimating the Value of Different Land Uses – Planted Forests

The value of land in planted forest is measured by the land expectation value (LEV), which is the net present value of land producing products from a forest over perpetuity. Sills and Abt (2003) found that the value of land in forestry in the United States bears close relation to the LEV calculated for that land. Throughout this paper we use the common industry discount rate of 8%.

To estimate log yields, and carbon sequestered and lost under the five management strategies we used the Radiata pine Calculator and Douglas-fir Calculator (Kimberley, 2005). The productivities used were the mean from all land in each LUC class, so that different yields were estimated according to land class. Figure 5 shows the productivities for radiata pine and Douglas-fir over the

LUC classes[3]. Note that better data were available for radiata pine than for Douglas-fir, for which we had to use a simple scaling from best to worst.

Figure 5 - Forestry productivity vs. LUC class



Planted Forests under an ETS

Under the ETS, pre-1990 forests are encouraged to stay in forestry, with deforestation liabilities (based on the amount of carbon removed) applied if the land moves out of forestry. No credits exchange hands if this occurs, except that the land owners will be allocated an allowance of credits which may be used to offset part of the deforestation liability should they choose. Entrance into the ETS is obligatory for these forest owners.

For post-1989 forests, entrance into the ETS is optional. The owners may choose to opt in at any point, from when they will be rewarded credits for carbon sequestered on the site, but penalised for carbon removed through fire, felling or decay. No free allocation will initially be given, and entrance into the ETS is voluntary. Carbon credits owned may at any time be traded for money, giving forestry a whole new revenue stream.

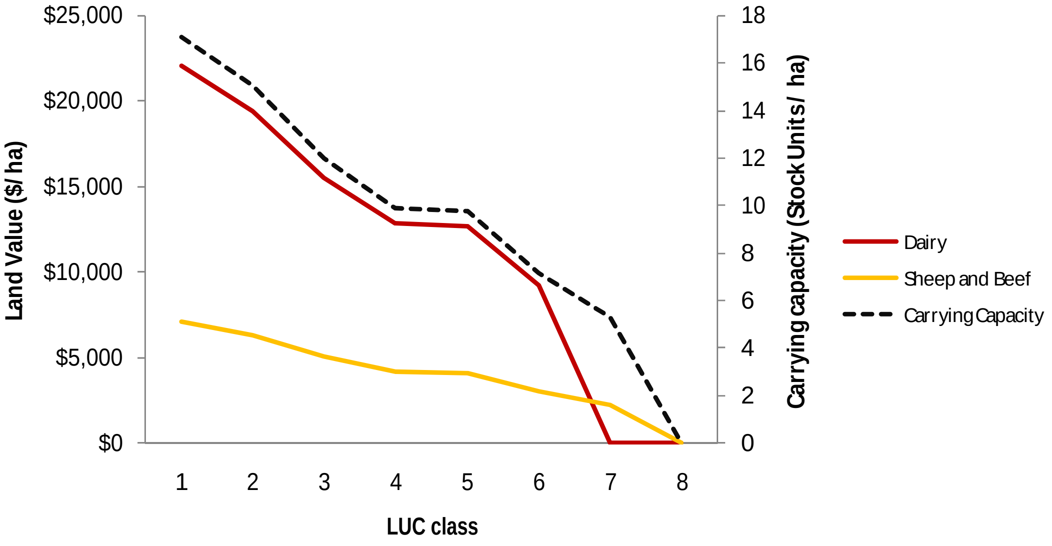
Previous studies have shown that this new revenue stream may affect forest management (e.g. Turner *et. al*., 2008, MacLaren *et. al*., 2008). This project will look at the national affects of these changes, including the potential land use impacts.

Agriculture

Land value will not be the same across all land productivities in agriculture, as more productive land will be more profitable under any kind of use. Using the New Zealand Land Resource Information (of which the LUC is a subset) we can find the average carrying capacity for each land class (Figure 6). By area-weighting these carrying capacities we can estimate the approximate land values for each land class. We used an estimated average land value in 2002 in dairy of $14,658 (LIC, 2007), and in sheep and beef of $3,550 (Stillman, 2005).

[3] Productivities defined as the mean annual increment (MAI) in m^3/ha/yr under a given management regime. For radiata pine this is the 300index – MAI from 300 stems per ha at age 30, whilst for Douglas-fir this is the 500 index, the MAI of 500 stems at age 40.

Figure 6 - Agricultural land value vs. LUC class



Dairy is assumed to not be feasible once the carrying capacity falls below 7 stock units (1 dairy cow) per hectare.

Agriculture under the ETS

Under the proposed ETS, the point of obligation for the agricultural sector will be processors – such as Fonterra or meat processors. The effect will be felt by farmers as a reduction in the price they receive for milk solids, meat and wool from these processors. For simplicity, we assume that the processors pass on their entire carbon liability to land owners. The potential impact of the ETS on the value of land in agriculture is therefore expected to be a wide scale reduction.

Given that here productivity is assumed to be proportional to carrying capacity, then so too is the carbon liability. Hence the effect on revenue will be proportional to stock numbers. From (MfE 2008) we can derive average emissions per animal:

- (i) Sheep – 332 kg CO_2-e per animal
- (ii) Beef – 1670 kg CO_2-e per animal
- (iii) Dairy – 2400 kg CO_2-e per animal

Based on the stock unit equivalent for each animal, land under sheep and beef will be liable for 0.332 t-CO_2-e per SU per year, whilst dairy will be liable for 0.343 t-CO_2-e per SU per year. This means that the value of land in agriculture (which is represented by the foreseeable future's returns from the land) is reduced by the net present value of the future carbon payouts

$$V = V_0 - E(t, C, S)$$

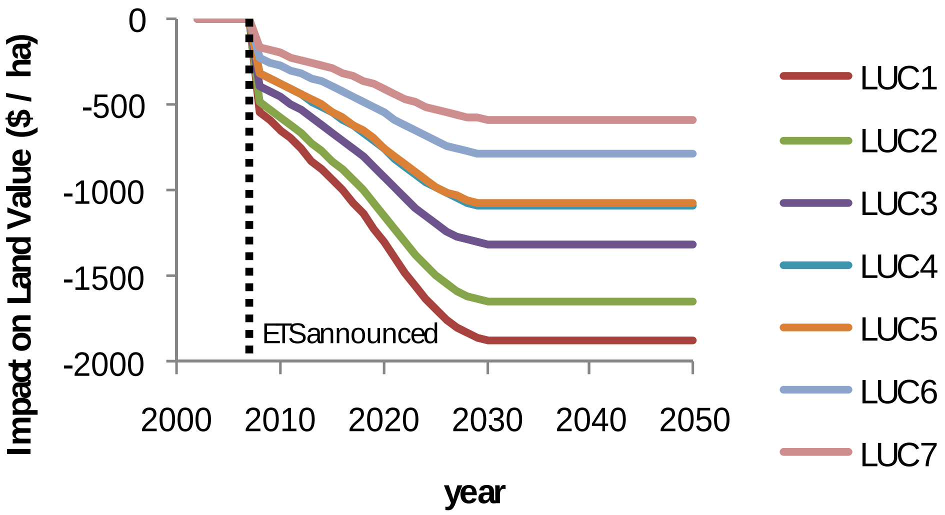
Where:

V = Land value under the ETS ($\$ha^{-1}$)
V_o = Land value prior to the ETS ($\$ha^{-1}$)
E = Discounted series of future carbon payments ($\$ha^{-1}$)
t = time / years
C = Carbon price \$ / t-CO_2-e
S = Number of stock units / SU ha^{-1}

At the time of writing, agriculture will receive an initial annual allocation of credits to account for 90% of their emissions (based on 2005 emissions levels), between 2013 and 2019. This will then be phased out linearly in the period from 2020 to 2030. We model this by scaling the emissions charge by the remaining fraction (i.e. 10% in the first seven years).

The impact on land prices (assuming a constant carbon price) will then ramp up to an asymptote in 2030, as shown in Figure 8 for sheep and beef farms under a constant carbon price of $25. Emissions per stock unit are almost identical between dairy and sheep and beef (one dairy cow is worth 7 sheep in stock units), so the impact on dairy prices will be almost the same. However the impact will be a much smaller proportion of the total land value.

Figure 8 - Reduction in sheep and beef land prices under a $25 carbon price

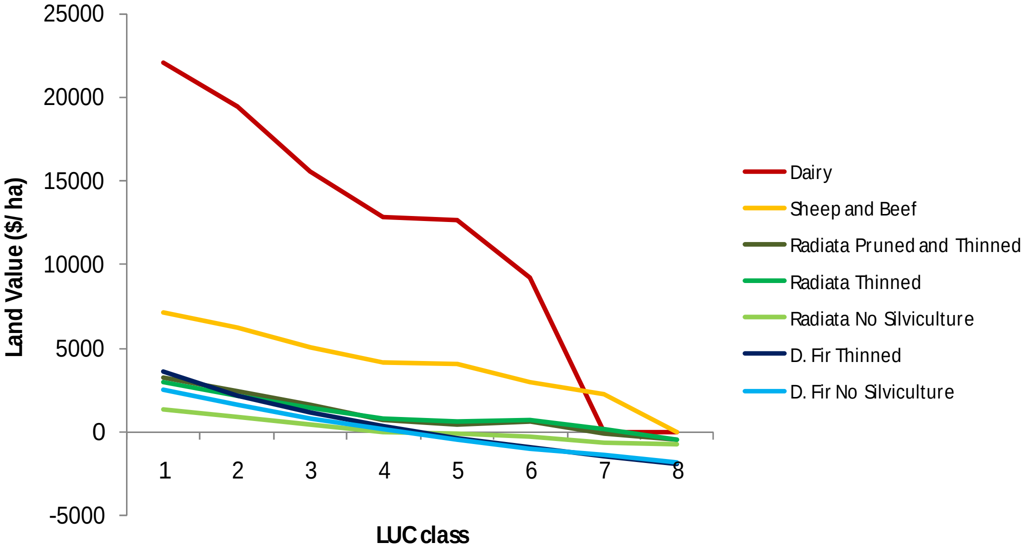


This corresponds to a fall in land value of 25% for sheep and beef by 2030, and a 9% fall in value for dairy. Given that the carbon price is capped at $25 in the first commitment period, and that we have assumed that the emissions liability from the processors is completely passed back to the farmer, this is a worst case scenario for agriculture.

DECISION PROCESS – LAND VALUE

Figure 9 shows how the value of land in each of the seven land uses varies with productivity without an ETS.

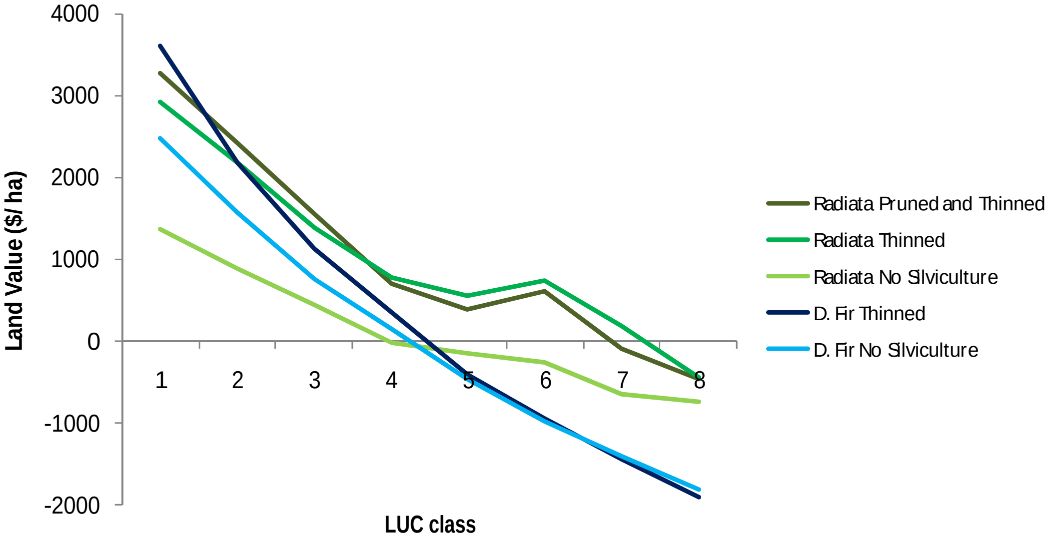
Figure 9 - Land value of land uses vs. LUC class



It is apparent that dairy is the most valuable land use up to LUC 6, whilst in LUC 7 sheep and beef grazing takes over. Forestry (using the 8% discount rate) is never a better option.

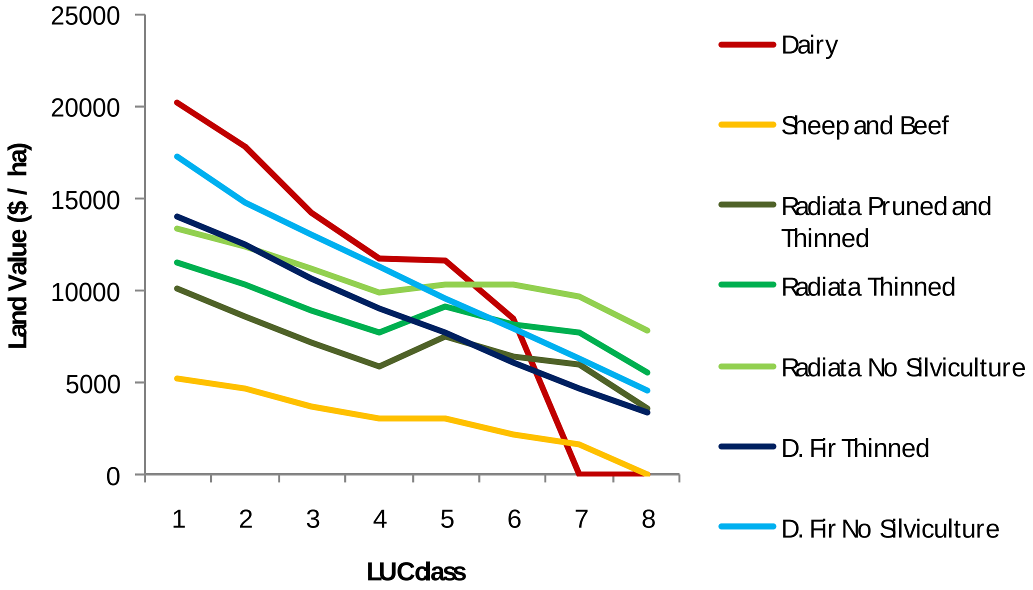
Figure 10 shows only the forestry options. On very productive lands (which are extremely unlikely to end up in forestry), land in Douglas-fir is slightly more valuable than land in radiata pine. However at the less fertile end, land in radiata pine is significantly more valuable than land in Douglas-fir, which has much longer rotations. Within radiata pine, there is a slight preference for pruned at higher LUC classes, and unpruned at the lower classes. This matches the current trend of less pruning due to low pruned-log prices. For both species, the returns from untended stands are well under par.

Figure 10 - Land value of forestry management regimes vs. LUC class



However, a $25 carbon price changes the situation markedly. Figure 11 shows the same options as figure 9 but with a $25 carbon price, taken in 2030 when agricultural liabilities are at 100%.

Figure 11 - Land value of land uses vs. LUC class with $25 carbon price in 2030



In this instance we see that dairy is still the most valuable land use on LUC 1-5, but forestry has overtaken sheep and beef on all less fertile sites. Land in untended radiata pine (maximising biomass) is predicted to have the highest value of planted land.

Stickiness

Land use change does not happen instantly. There is a general hesitancy to undergo the large scale changes involved – as well as a huge number of idiosyncratic reasons (such as heritage, knowledge, supply agreements, aesthetics, etc.). To this end we introduce stickiness – a parameter that represents the probability of a parcel of land changing from one use to another. We define this probability as

$$P_{i,j} = f(V_i, V_j, \gamma_{i,j})$$

Where:

$P_{i,j}$ = the probability of a hectare of land moving from land use *i* to land use *j*
V_i = Value of land (or suitable proxy) under land use *i*
V_j = Value of land (or suitable proxy) under land use *j* – the cost of change, including the opportunity cost of year(s) of reduced or non-productivity
$\gamma_{i,j}$ = Stickiness associated with transition from *i* to *j*.

For simplicity we assume that $V_{i,j} = V_{j,i}$ – that is the probability of transitioning from one land use to another would be the same going the other way if the finances were exactly reversed.

Using several datasets[4] and relevant price series, we can populate Table 1.

[4] LCDB1, LCDB2 Agribase enhanced, LIC statistics, Meat and Wool stats, calculated forestry returns, MAF log prices, NEFD, and QVNZ data (Stillman)

Table 1 - Area and value of primary land uses 1997 - 2007

Land Use		1997	2002	2007
Dairy	Area (million ha)	1.23	1.40	1.41
	Value ($000)	13.6	14.7	22.8
Sheep + Beef	Area (million ha)	9.25	8.81	9.20
	Value ($000)	2.50	4.00	n/a
Forestry	Area (million ha)	1.63	1.81	1.79
	Value ($000)	0.97	0.44	0.09

From this table we look for instances where one lower-valued land use was declining to the increment of another. These figures represent the percentage change in the higher valued land use per year, per $ difference in land value.

Table 2 - Land use change stickiness values

	Dairy	Sheep and Beef	Forestry
Dairy	-	2.23E-04	9.96E-06
Sheep and Beef	2.23E-04	-	1.57E-04
Forestry	9.96E-06	1.57E-04	-
Stickiness values as % $\$^{-1}yr^{-1}$			

This means that a higher value land use will grow as defined by

$$\frac{dA_j}{dt} = \sum_i A_j \left(V_j - V_i\right)\gamma_{i,j}$$

RISKINESS

As well as having an "expected" value, the ETS brings in a whole swath of unknowns, which we will characterise here as "riskiness". Riskiness is not new – commodity prices have changed throughout time – but the uncertainty in carbon price outweighs that in standard commodities. This riskiness can be expressed by the range and distribution of land values under a range of plausible scenarios. The ETS increases the riskiness of any land use as the carbon price is likely to be extremely variable, at least in the early years of the scheme as the new carbon market matures (and the scheme itself may change or even collapse).

Adaptability of Forestry to Log Price Risk (no ETS)

Over the last 15 years, log prices have varied by up to 56% over their long-term mean. However, this was the most volatile pruned log price; of the other grades. none varied by more than 36%, and all grades spent at least 68% of time within 15% of the long-term mean (MAF, 2009b).

This means we can model – to a first approximation – log prices as a normal distribution with a standard deviation of 15% of the mean. Forestry has the ability to "ride out" some changes in log prices by altering rotation ages to obtain the best prices. Figure 12 shows the same mean forestry LEVs from 2002 log prices, but also dashed lines showing the range of LEVs that *could* occur (within a 95% probability range).

Figure 12 - Forestry value variance under variable log prices

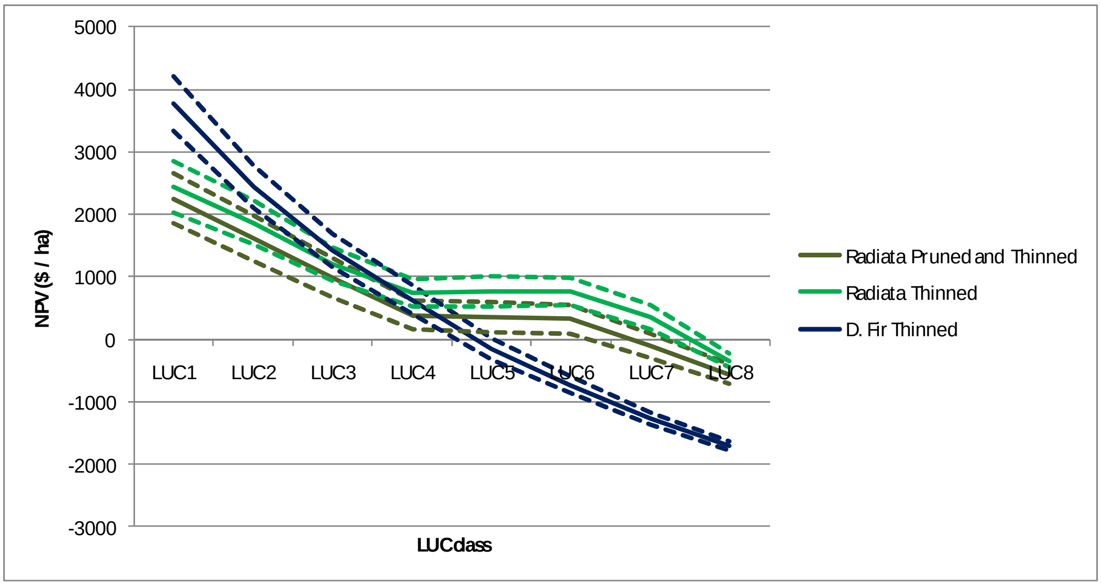
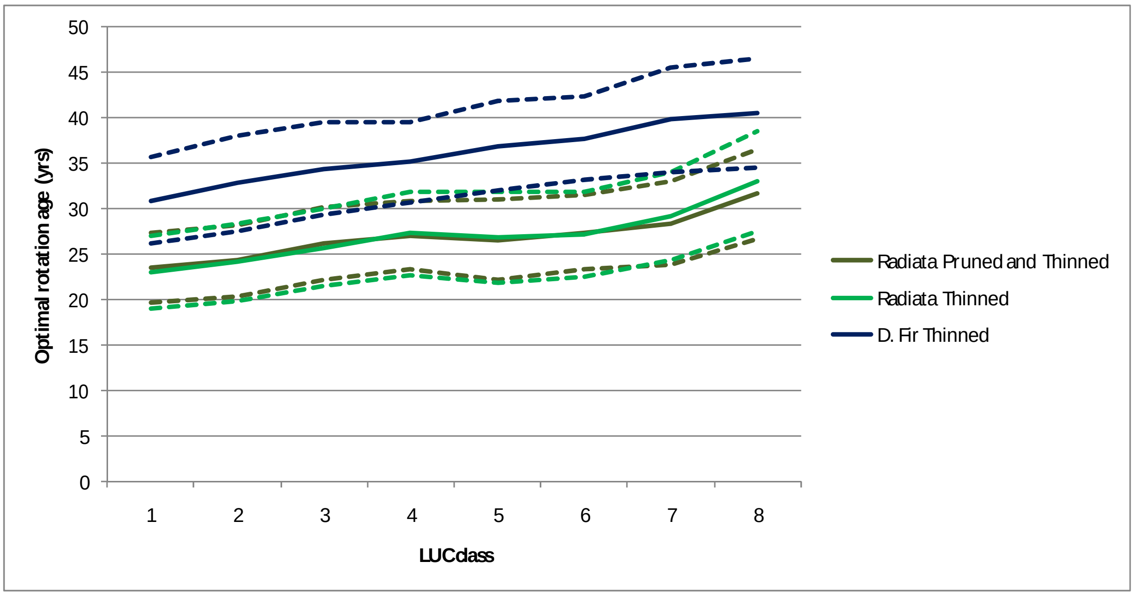


Figure 13 shows the ranges of rotation ages necessary to achieve these LEVs. Note we have not included the untended regimes as these are not practical choices without a carbon market, and they clutter the figures. Also note that we have reverted to an NPV not an LEV – if the prices form a series it does not make sense to expect the NPV of the second series to be the same as the first. But an NPV still demonstrates land value, and is a close proxy for LEV.

Figure 13 - Forestry rotation age adaptability to mediate variable log prices



Farm Level Forestry Scenarios under an ETS

There is no way of knowing what the carbon price will do. We consider three scenarios for a post-1990 forest planted in 2003:

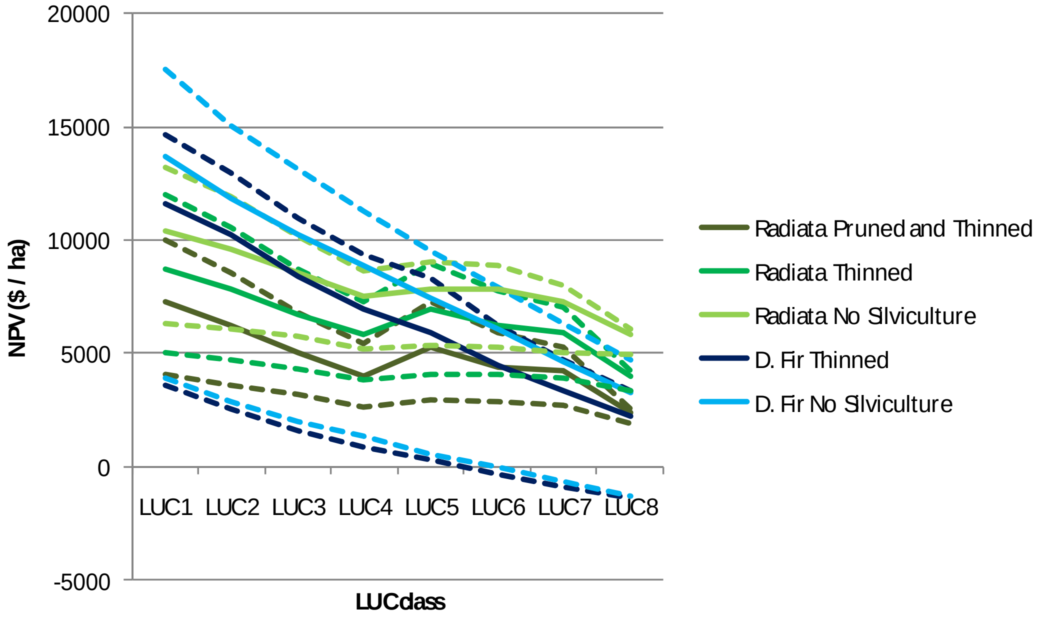
- (i) Fixed price scenario: A flat carbon price of $20 and constant log prices
- (ii) Worst case scenario. A carbon price that increases linearly from $0 in 2008 to $25 in 2030, where it stays. Log prices vary by 15% from the mean.
- (iii) Best case scenario: The carbon price stays at $25 from 2008 until 2030 when it falls to $5.

The worst case is defined as a low carbon price whilst the tree is growing, but then spikes when the harvest liability is due. This risk may be mitigated by not cashing in all of the carbon credits, which brings us closer to the no-carbon scenario (if no credits are traded it is as if the carbon price was zero). This scenario is very real. If the trees were planted in 2003, then credits would only be accumulated from 2008 onwards. Assuming a 27-year rotation, the trees would be felled in 2030 – the year that the full agricultural emissions liability is due to hit. This has the potential to cause an increase in carbon price – right when the trees are due for felling[5]. In reality, most forest owners would hold on a few years hoping the price would fall – but this may not happen.

Figure 14 shows the range of NPVs that are possible. The solid line represents the fixed price case, and the dashed lines represent the 95th percentile of NPV from the best and worst cases. It is immediately apparent that returns from ETS-compliant post-1990 forests are higher, but come with a great deal more uncertainty.

[5] One of the purposes of a staggered entry for agriculture is to minimise the chance of these price spikes. However, they are still a possibility

Figure 14 - Forestry value variance under variable log and carbon price



Farm Level Agricultural Scenarios under an ETS

On the other hand, if we run the same three carbon price scenarios against a hectare of agricultural land in 2008, the results hardly change from the non-ETS case. The phase-in process for the ETS, combined with the 8% discount rate used in this study, reduce the impact on land value. The "best case" for forestry – a high carbon price followed by a fall in 2030 – works well for agriculture as the fall matches the point at which liabilities increase. Here we see a 4% drop in sheep and beef land values, and a 1% drop in dairy land prices. The worst case produces a 7% drop in sheep and beef land prices and a 2% drop in dairy land prices. This is in comparison to an increase in forestry returns of up to $15,000 compared to a non-ETS case, although that increase could equally be as low as $2000. However, under these scenarios there was never an instance where forestry did better without the ETS.

RESULTS - THE EFFECTS OF THE ETS ON DIFFERENT LAND OWNERS

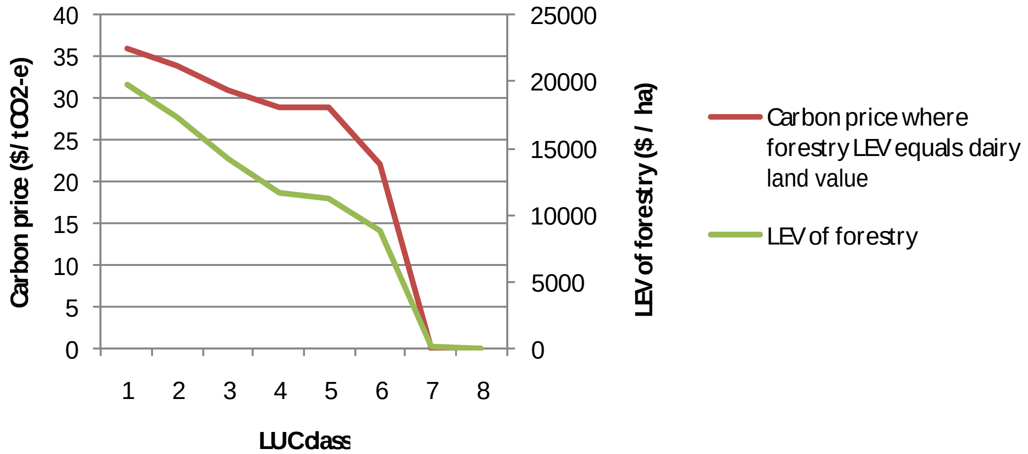
Dairy Farmers

These land owners are unlikely to convert to forestry under any carbon price less than the $25 per NZU cap. A higher carbon price has the potential to lead to some experimental conversion to forestry, but it is much more likely that this would come from sheep and beef farms.

Even at the maximum carbon price considered, dairy is still the most valuable land use on land classes 1-5 (Figure 15), which comprises 82% of all dairy land. The remaining dairy on classes 6 and 7 has the potential to be better off in carbon farming, but as shown in the riskiness section, the risks are much greater than staying in dairy. It is unlikely that the ETS will result in dairy land converting to other land uses. This may occur – such as in the Lake Rotorua catchment – due to other government regulation, but that is beyond the scope of this model.

Figure 15 shows it would take carbon prices of $30 or more for forestry LEVs to surpass dairy land values on higher land classes. Even so, given the large capital costs in creating dairy infrastructure it is unlikely under any reasonable scenario that dairy will convert to forestry any time soon.

Figure 15 - Carbon price necessary to equalise returns from forestry and dairy, by LUC class.



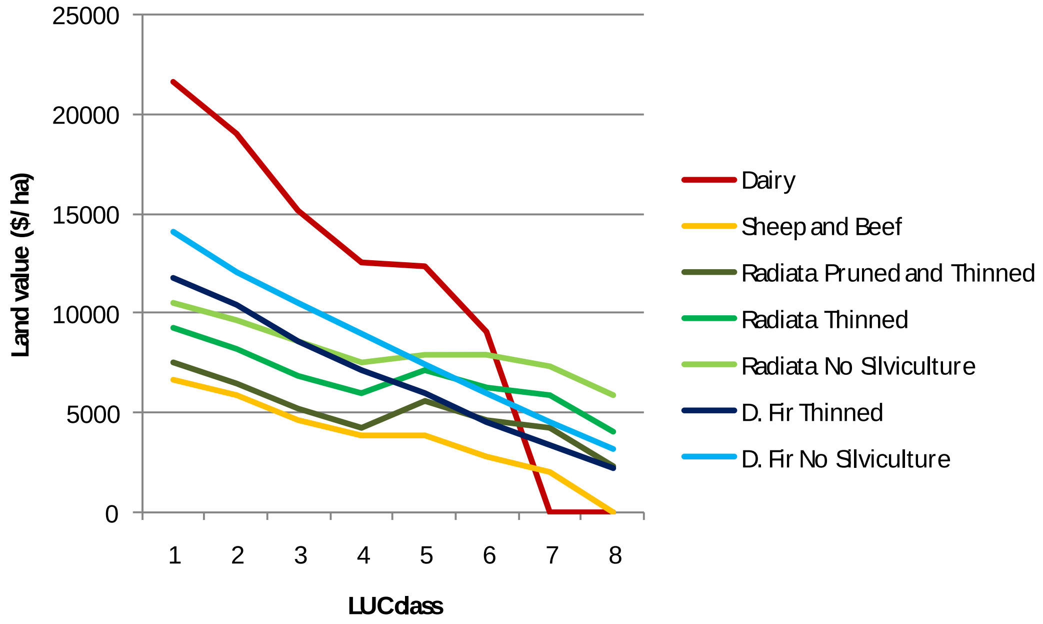
Sheep and Beef Farmers

Sheep and beef farmers on land class 7 land have a 0.83% per year chance of converting to forestry. The most profitable type of forestry available to them under a $20 carbon price is untended radiata pine, on a 48 year rotation to maximise carbon revenue.

There is significant potential for current sheep and beef land to convert to forestry under the ETS. Unlike previous drivers of land use change (urbanisation, dairy) the quality of land is not as significant, although the risks associated with the carbon price are. We make the assumption that this group of investors will try and minimise risk, but be less tied to typical forestry constraints than existing forest owners. This makes them more likely to use carbon-focused regimes involving untended high stockings with longer rotations.

From 2008, if we assume a carbon price of $20, then dairy is still the best option on LUC classes 6 and better. Forestry is only more profitable than the slightly-reduced dairy on class 7 land (figure 16), and it is the untended radiata pine that comes out on top. This means, that using the stickiness found earlier, a hectare of sheep and beef land on LUC 7 will have a 0.83% per year chance of converting to forestry.

Figure 16 - Value of land uses by LUC class under a $20 carbon price



The farmers who choose to convert their land into forestry are faced with a range of forestry options, as shown above. The option with the highest returns is untended radiata pine, which would suit farmers who may not know a lot about silvicultural practices. This regime is risky – if the carbon market crashes you would have been better off with a thinned regime – but it is possible that this group of investors will be more risk-taking than existing forest owners who have log supply contracts to uphold. The optimum rotation length for this type of forestry is 48 years to maximise carbon returns and delay the carbon liability at harvest.

Forest Owners – Pre-1990 Forests

This group has previously been deforesting for dairy conversion, but the carbon liabilities look likely to make this almost completely stop, with a 0.112% per year conversion rate. Instead, these forests will be harvested (typically around 28 years) and replanted. The historical trend toward replacing pruned stands with unpruned is expected to continue.

For these forests, entrance into the ETS is mandatory. These forests cannot accumulate carbon credits – apart from an initial allocation at the start of the ETS – but will be liable for the removal of any carbon from the site. Some of these forests were new plantings prior to 1990, but some will also be re-plantings of forests that were harvested post 1990. Therefore the majority of these forests will be older than 19, but not all.

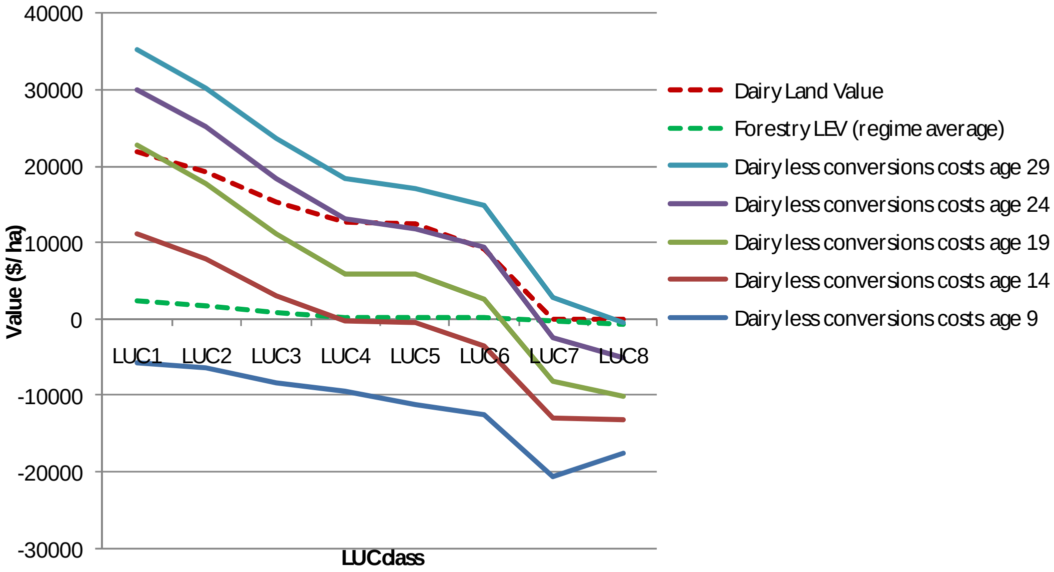
The ETS mandates that if forests are removed earlier than age 9, the land owner is liable for the carbon content of a mature forest (this is to close a loophole in the policy). By age 9, most forests will have sequestered around 230 tCO_2-e per hectare – leading to a penalty of $4600 per hectare at a $20 carbon price. As the trees get older this deforestation liability will rise up to around 800 tCO_2-e, or $16,000. On top of this the land owner is facing harvesting and conversion costs.

So, if conversion is to occur, the land in dairy must be worth more than the value of the land in forestry, plus the conversion costs and the carbon penalty, less any returns from timber. In some cases, the sale of timber is sufficient to cover the harvesting, the carbon penalty and an assumed

$5,000 per ha conversion cost. This means there is a financial incentive to convert to dairy even if it is only marginally better than forestry.

In Figure 17 we show the value of dairy less the conversion costs by LUC for a range of harvesting ages. Also shown is the value of land in forestry and dairy on those classes. If the "dairy less conversion costs" is greater than the forestry LEV, then it is financially worth a conversion. Note when the "dairy value less conversion costs" is greater than the actual dairy value, this is because revenue is generated in conversion through timber sales which offsets the costs.

Figure 17 - Comparison of dairy values and forestry values when facing conversion costs including deforestation liability



We see that conversion is never worth it at young ages when the timber revenue is small or non-existent, but conversion may be worthwhile at older ages on better class land, but very little forestry exists on the higher LUC classes.

What this result shows us though is:

(i) Deforestation of trees less than 14 years is likely to stop almost completely with carbon penalties.

(ii) Deforestation on harvest of mature forests is still financially viable on land classes all the way down to LUC 6.

Using our stickiness values (Table 2), we predict that 0.112% of pre-1990 forests will convert to dairy per annum. That which is not deforested on harvest will be replanted, and this low probability seems to match the decline in deforestation rates occurring at present. On replanting, it is likely that these forest owners will carry on with similar management to current forests, as they do not receive carbon credits and so have no incentive to change from regimes based on timber returns. From Figure 10 we see that on the lower LUC classes, where the majority of forestry exists, thinned forestry is marginally better than pruned and thinned. We can therefore expect the current trend of not pruning to continue within these forests. Rotation lengths will remain at 25 to 30 years depending on site productivity.

Post-1989 Forests

Of the post-1989 forests that are on LUC 1-5, 0.151% will convert to dairy every year. This is a higher proportion than for pre-1990 forests as they do not have to face full emissions liabilities.

At least 0.0495% of the remaining forests will opt into the ETS every year. Those that opt in will increase rotation lengths to maximise returns from carbon, although this will also depend on timber prices and supply constraints. The optimal rotation age is dependant on the species, management and land class. When post-1989 forests are harvested they are likely to be replanted in regimes that generate returns from carbon, but also have the security of timber returns. On average, the longer rotations will be 31.6 years. The remaining forests that do not opt in will continue growing trees for timber and using the same practices as the pre-1990 forests.

Existing forest owners are expected to be more risk-averse than owners of new forests, and are likely to rely on timber as well as carbon, due to contracts to supply timber and to employ harvesting crews. The vast majority of these forests would have been planted for timber, and that will be in the forefront of the owners' minds.

These forests would be no older than 18 in 2008 when the ETS came into effect for forestry. For these forests the ETS is optional. If the land owner opts in then he receives credits for any sequestration in the forest, but also must pay back credits for any emissions. However, the emissions fine can never exceed the total number of credits the land owner has received.

There are many reasons why a post-1989 forest would not enter the ETS. The two we will consider here are if they are converting to dairy, or if they expect a rapidly increasing carbon price (in which case they would not trade any credits, so there would be no point in entering), or that the ETS would not continue any significant way into the future. First we will consider the group that could convert to dairy.

Opting Out and Deforestation of Post-1989 Forests

Post-1989 forest owners have the option to not opt in to the ETS. In this case they will continue to grow trees for timber, running the same regimes as the pre-1990 forest owners. The difference for these forest owners is that they do not face the same ETS deforestation liabilities if they wish to convert their forest to grazing.

As shown in Figure 11, the value of land in forestry cannot match that in dairy if the carbon price is capped at $25 for LUC classes 5 and upwards. As these forests are younger, conversion costs will be less, although the timber revenue will not cover the harvesting costs. We assume here that conversion costs are $4,000 per ha. Now the model predicts a small chance (0.102%) that these forests could be cleared before maturity, but the chance is greater that the land owner will wait until the trees are fully mature and reap the benefit of the timber return. The predicted probability of this is 0.151% per year, and represents a slow decrease in the post-1990 estate.

Opting into the ETS.

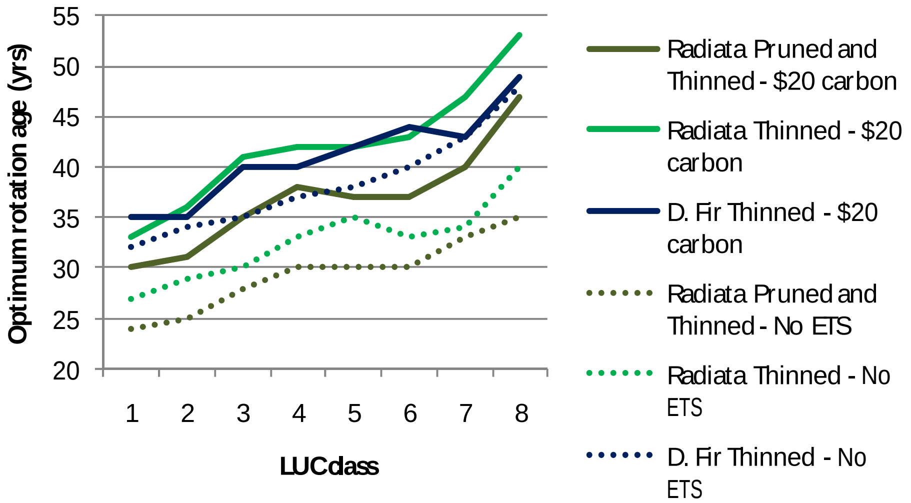
For land in LUC 6 and lower, opting in makes more economic sense than conversion to dairy. It is also an option for forest owners on LUC 1-5 who have chosen not to convert to dairy. There is a stickiness around opting into the ETS, but there are no empirical data on opt-in rates due to the newness of the scheme. To get around this we make the assumption that the stickiness towards opting in will be the same as to moving to the most similar land use available, dairy. The difference here though is that take up will be greater as the conversion costs from opting out to opting in are a mere $550 per farm (the cost of administration for entering the ETS), instead of $4,000 per hectare.

The calculated probability of a hectare of post-1989 opting into the ETS is 0.0495%, per year. This translates to a mere 290 ha per year, which may imply that our assumption of using dairy-forestry stickiness was too pessimistic. As data emerges on actual take up rates, this value will be improved.

Land that does not convert to dairy or opt in will continue as timber forestry in the same manner as pre-1990 forests, with an average rotation length of 28.1 years and a preference for thinning without pruning based on current log prices.

Land that does opt into the ETS is expected to extend its rotations to maximise the carbon return. The rotation length used depends on the carbon price, the land class and whether the stand was pruned or not. Figure 18 shows optimal rotation lengths by LUC class for the three currently practised management strategies considered in this report. Forest owners – particularly of radiata pine stands – are looking at a longer wait until harvest under the ETS. This will have national effects on sequestration, but is unlikely that it will have timber supply effects given the small proportion involved. The area and regime weighted average rotation age will be 31.6 years at a $20 carbon price.

Figure 18 - Economically optimal rotation ages with and without a $20 carbon price

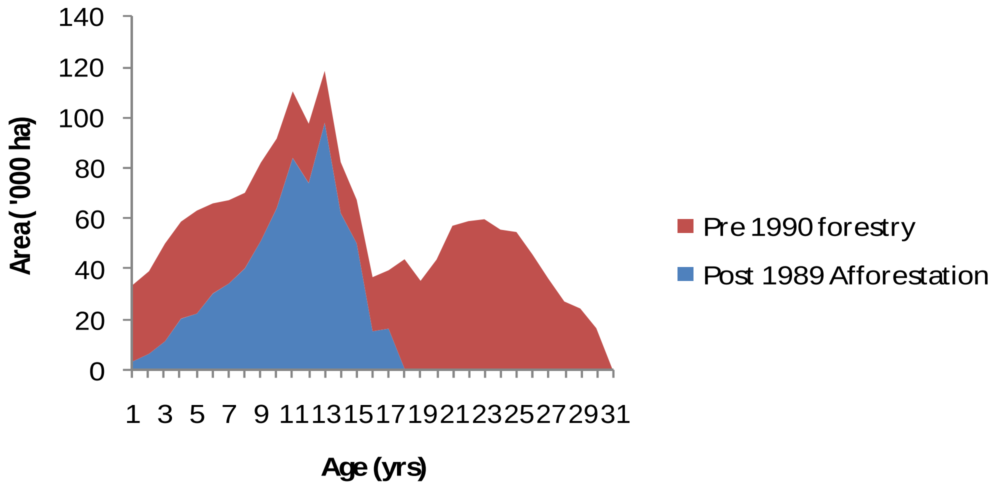


When the trees on land that has opted into the ETS have been felled, it is likely that they will be replanted with a crop that maintains the timber supply. In this way they differ from new afforestation which is likely to go for high biomass crops. Based on the charted risk in figure 11, we see that if this group are more risk-averse than new planters, these sites will be replanted with thinned regimes for timber benefits, but run on longer rotations for carbon benefits.

NATIONAL EFFECTS OF THE ETS

The current New Zealand forest estate can be described with an age-class distribution. The 2007 age class distribution is shown in Figure 19.

Figure 19 – 2007 age class distribution for New Zealand's planted forests



The effect of the ETS on the age class distribution will be via reduced deforestation and increased afforestation. It is this afforestation that will have the dominating effect in years to come. From the previous sections we have found the following farm-level outcomes of a $20 per NZU carbon price under the ETS:

(i) Sheep and beef farmers on class 7 land will convert to forestry with a 0.83% likelihood, per year per hectare. The forestry planted will largely be the "riskier" biomass-based carbon forestry, with little silviculture, on a rotation of 48 years.

(ii) There will be some conversion of pre-1990 forests to dairy, at a rate of 0.112% per year on any LUC 6 or greater land. The conversion will occur at harvest (using timber sales to offset the carbon liability), as opposed to mid-rotation conversion as has previously happened.

(iii) There will also be conversion of post-1989 forests into dairy, albeit only on sites of LUC 5 or higher, at a rate of 0.151% per year. This could be any age classes.

(iv) The remaining post-1989 forests will opt into the ETS at a rate of 0.0495% per year. Those that opt in will extend their rotation ages to an average of 31.6 years

To convert these farms-level changes to a national scale, we need to multiply through by the areas in Table 1. The results of this are shown in Table 3, under the scenarios of: no-ETS, a $20 ETS and an $50 ETS without a cap.

Land use change	No ETS	$20 ETS	$50 ETS
Sheep and Beef to Forestry	None	13100 ha per year	199000 ha per year
Pre 1990 Forestry to Dairy	1060 ha per year	116 ha per year	None
Post 1989 Forestry to Dairy	422 ha per year	20 ha per year	None
Post 1989 Forestry Opting in	N/A	290 ha per year	883 ha per year

Without the ETS, the largest land use change is forestry going into dairy. An ETS changes this, and the biggest land use movement is sheep and beef going into forestry. This increases substantially with increasing carbon price. If better data were available, the figures for opting are likely to also be greater. A $25 cap on carbon price keeps things roughly equal between forestry and agriculture – there is no clear winner between the two.

Figure 20a shows the age class distribution in 2020 without an ETS, figure 20b shows the same with an ETS and a carbon price of $20 per NZU, and figure 20c shows the $50 carbon price scenario. Again we see the dominating effect is due to sheep and beef converting to forestry – the differences due to a reduction in deforestation are negligble in comparison (as are the changes to the small proportion of post-1989 forests that opt in).

Figure 20a – Projected 2020 age class distribution without an ETS

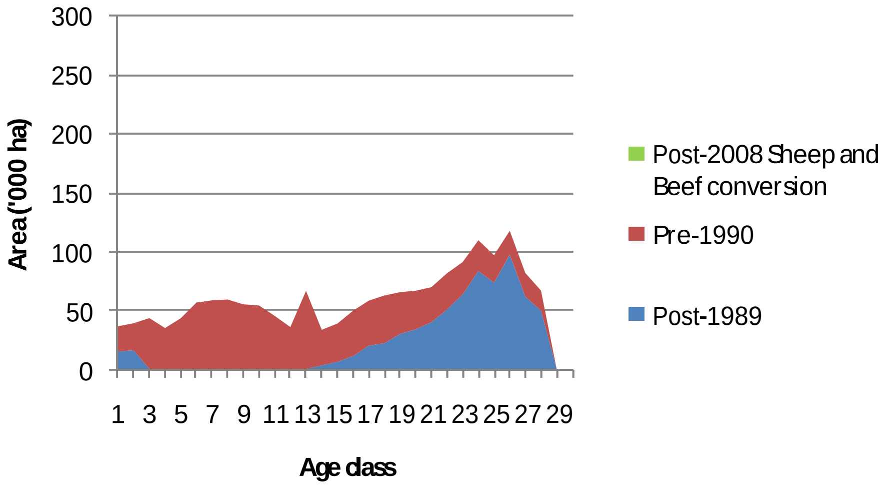


Figure 20b – Projected 2020 age class distribution with a $20 ETS

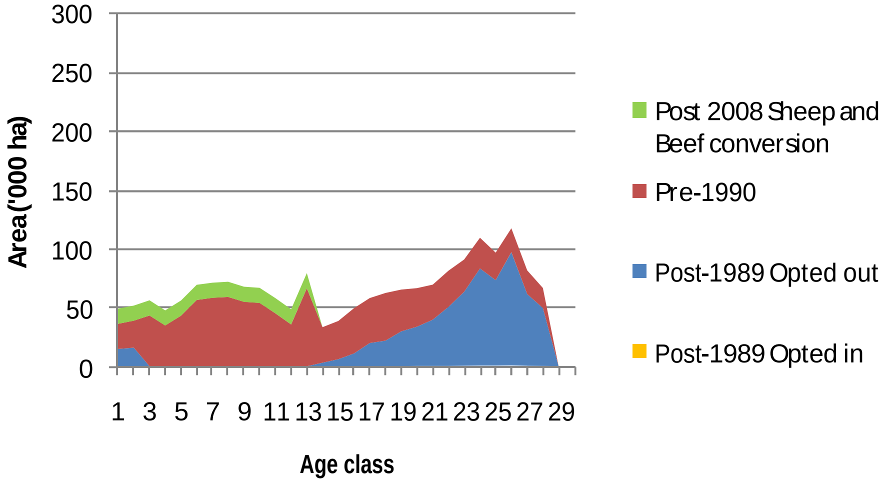


Figure 20c – Projected 2020 age class distribution with a $50 ETS

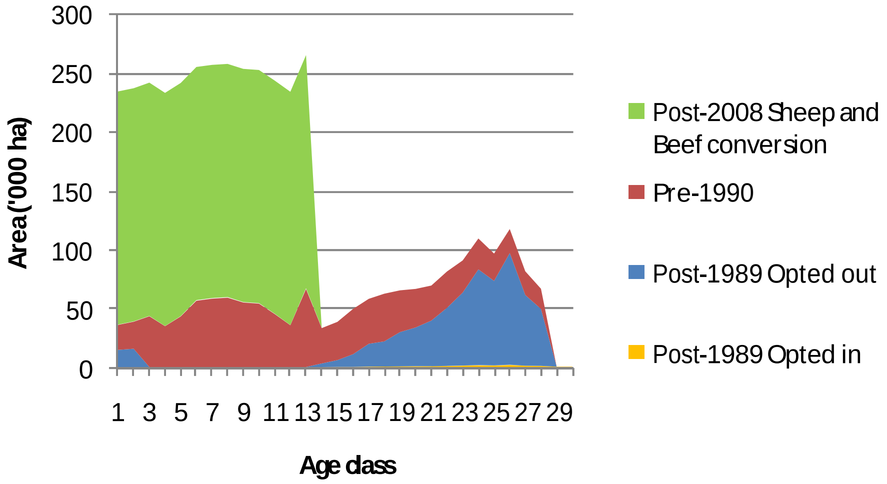
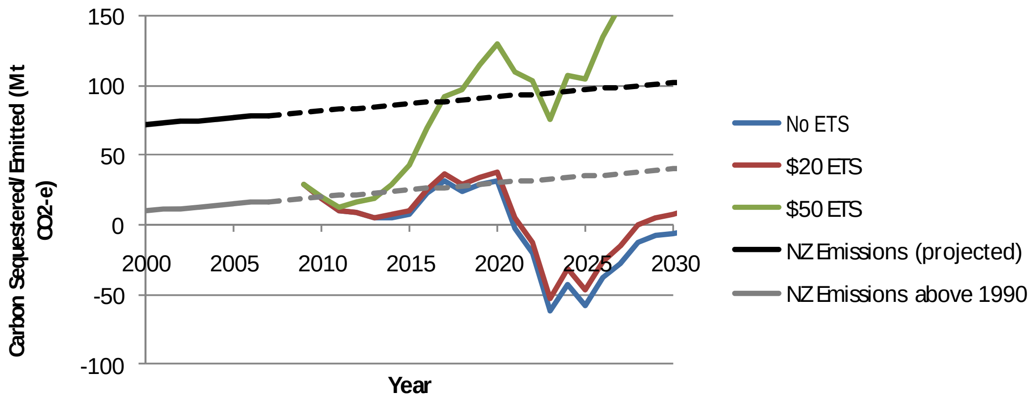


Figure 21 shows the carbon that will be sequestered by New Zealand's planted forests under the three scenarios above.

Figure 21 – Projected carbon sequestration by NZ planted forests under ETS scenarios



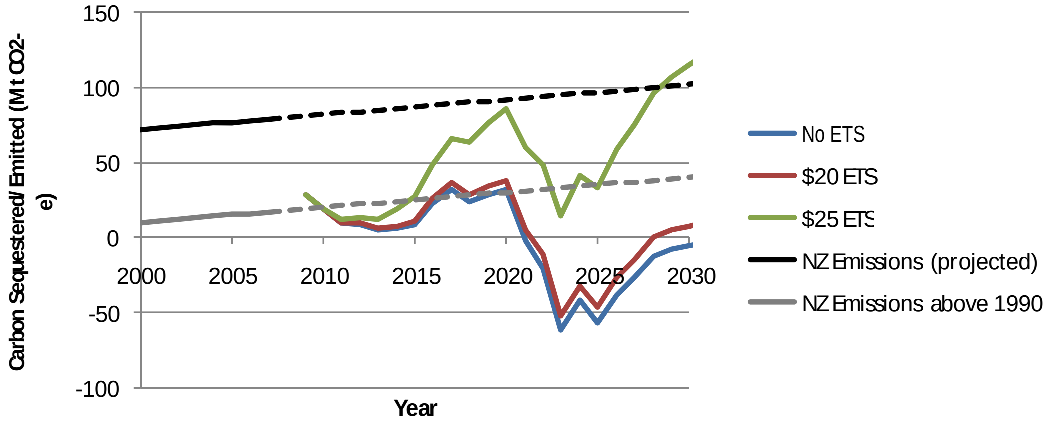
The two things to note here are:

(i) Any additional carbon sequestration is coming from afforestation, as the take-up of the ETS (and hence any subsequent changes in forest management) in existing forests is negligible.

(ii) A $20 ETS does not provide sufficient incentive to create large scale afforestation to the extent that New Zealand can meet its 1990 emissions levels. $50 is enough to make New Zealand carbon neutral.

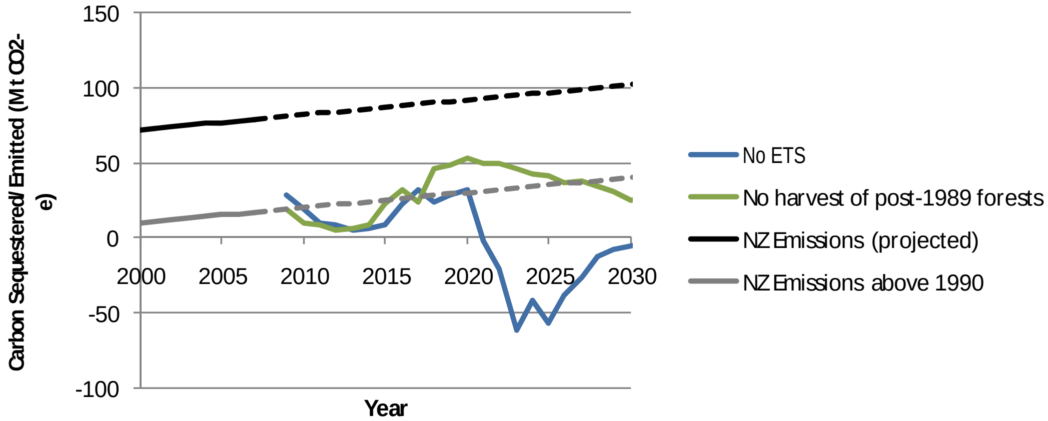
Without an ETS New Zealand will be below obligation levels for 2008-2016, but it is too late for afforestation to help here. It is after 2020, when the planting boom of the 1990s is being harvested, that changes to forestry are needed to help New Zealand meet its Kyoto obligations. By this time, an annual afforestation of 109,000 hectares per year of high biomass forestry would be sequestering an average of 41.4 tCO_2-e per hecatre per year. Interestingly, using our stickiness values, the model predicts that it would only take a carbon price of $25 to achieve this. Figure 22 shows the carbon sequestration under this scenario.

Figure 22 – Projected carbon sequestration by NZ planted forests under $25 ETS and $20 ETS scenarios



Afforestation is not the only way to increase sequestration through planted forests though. Figure 23 shows the carbon sequestered in a scenario where all post-1989 forests are not harvested, but simply left to age. In this case the 2020-2030 liability is avoided, but without any new afforestation the situation is unsustainable and the deficit post 2030 is even harder to avoid.

Figure 23 – Projected carbon sequestration by NZ planted forests with no harvesting of post-1989 forests

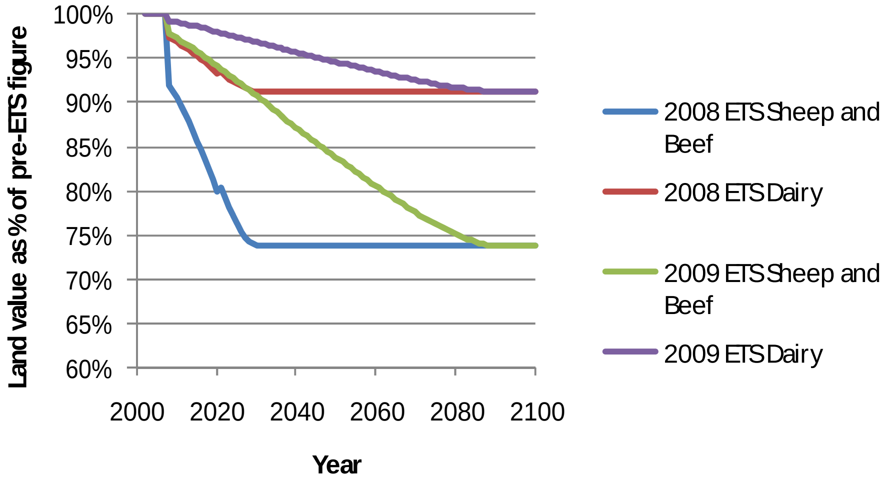


Changes to the ETS

One aspect of the ETS currently in development is the phase-in process for agriculture. In June 2009 several amendments were made to the ETS bill, which changed the phase-in for agriculture. Instead of the full phase-in by 2030 as described in section 2.4, the amendment proposes a much slower phase-in of 1.3% from 2015 to 2092. In this model, we suggest that the ETS impacts on land values are a function of carrying capacity based on GHG emissions by animal type. As the land values are also assumed to be proportional to carrying capacity, evidently the land value will be dimished proportional to carbon price. Figure 24 shows how agricultural land values are expected to scale based on the two proposed ETS approaches. Sheep and beef is hit worse as the liabilities (which are actually slightly smaller) are a greater proportion of the total land value.

As discussed previously, because we have assumed that the emissions liability from the processors is completely passed back to the farmer, this is a worst case scenario for agriculture.

Figure 24 – Effect of 2008 ETS and amended 2009 ETS on agricultural land values



In this model land use change is driven by the relative difference in the value of land under two different land uses. At worst, agricultural land values are going to decrease by a few thousand dollars, whereas land in forest under the same scenario is likely to increase in value by tens of thousands of dollars. The principal driver behind land use change under the ETS is not the decreasing value of agricultural land, but the increasing value of land in carbon forests. This means that the slight changes in this amendment will not have any significant impact on these findings. If forestry is allowed to trade credits overseas – and sidestep the $25 cap – this will only strengthen this conclusion.

CONCLUSION

A cap of $25 is not inhibiting to New Zealand meeting its Kyoto obligation of reducing GHG emissions to 1990 levels. It is estimated that a carbon price of $25 would lead to 109,000 ha of afforestation per year, taking place on marginal sheep and beef grazing land. This would be sufficient to keep New Zealand down to 1990 net emission levels at least until 2030. However, afforestation is very sensitive to carbon price, and a drop of only $5 would reduce the afforestation rate by 88.0%, making New Zealand planted forests a net emitter by 2020, leading to large scale national shortfalls in emissions targets.

If the harvest of post-1989 forests were delayed, the deficit in 2020 would occur later, but without new afforestation to match increasing emissions this situation is unsustainable. The main effect of the ETS is likely to be reduced deforestation, and increased afforestation into high biomass regimes. Changes to existing forests are important, particularly from a timber supply viewpoint, but will only have a secondary effect on the national emissions profile.

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REFERENCES

Kimberley, M. 2005. *Radiata Pine Calculator Version 3.1 pro*, Scion, Rotorua, New Zealand. www.scionresearch.com

LIC., 2007. *2006/2007 Dairy Stats*. Found online at www.lic.co.nz/lic_20062007_Dairy_Stats.cfm, december 2009

Maclaren, P., Manley, B. 2008 *Impact of the ETS on forest management* MAF contract report, found at http://www.maf.govt.nz/climatechange/slm/grants/research/2007-08/pdf/2008-10-obj1-carbon-trading.pdf

MAF, 2007a, *A New Zealand Emissions Trading Scheme: Key Messages and Strategic Issues*. Cabinet Policy Committee paper on the ETS. Found online at www. beehive.govt.nz/Documents/Files/Cab%20Paper_Emissions%20Trading.PDF in December 2009

MAF, 2007b *National Exotic Forest Description Series 2000 – 2007* Found online at http://www.maf.govt.nz/mafnet/publications/nefd/.

MAF 2009a, *A Guide to Forestry in the Emissions Trading Scheme*, found online at www.maf.govt.nz, December 2009

MAF, 2009b. *Indicative New Zealand Radiata Pine Log Prices.* Found online at www.maf.govt.nz , December 2009

MAF, 2009c, New *Zealand Forest Industry Facts and Figures 2008/2009*. Distributed by New Zealand Forest Owners Association Inc.

Meat and Wool, 2009. *Meat & Wool Sector: Domestic Trends*. Presentation to: Meat Industry Association Conference, 21 September 2009. Found online at www.meatandwoolnz.com

MfE, 2008. *Net Position Report 2008 - Projected balance of Kyoto Protocol units during the first commitment period*. Found online at www.mfe.govt.nz

NWASCO. National Water and Soil Conservation Organisation. 1979 *Our land resources.* Water and Soil Division, New Zealand Ministry of Works and Development.

Sills and Abt, 2003, *Forests in a Market economy*, 41-57. Kluwer Academic Publishers.

Stillman, S., 2005. *Examining Changes in the Value of Rural Land in New Zealand between 1989 and 2003.* Motu working paper series 05-06

Thompson S., Grüner, I., Gapare, N. 2003 *New Zealand Land Cover Database Version 2. Illustrated guide to target classes.* Ministry for the Environment.

Turner, J. A., West, G., Dungey, H., Wakelin, S., Maclaren, P., Adams, T., Silcock, P. 2008 *Managing New Zealand planted forests for carbon – a review of selected management scenarios and identification of knowledge gaps.* Report by Scion for the Ministry of Agriculture and Forestry. Scion, Rotorua.