# Afforestation responses to carbon price changes and market certainties

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Disclaimer

This report was commissioned by the Ministry for Primary Industries (MPI) to provide an expert opinion on afforestation responses to carbon price changes and market certainties. Given the deadlines for the ETS review process there was limited time to undertake the analysis. Consequently a number of afforestation model refinements could not be fully evaluated.

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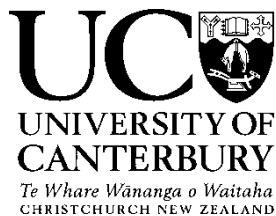
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Executive summary

MPI has requested a quantitative and qualitative analysis exploring the likely behaviour from different types of foresters in the event that NZ ETS settings are changed. Main findings are:

Opinion on the likely reaction of the forestry sector to potential NZ ETS setting changes

Carbon price is currently being suppressed by the '2 for 1' concession to emitters and the 4 million NZUs allocated each year to EITE industries. The $25 fixed price surrender option has the potential to supress carbon price in the future. Removing these factors would be viewed positively by the forestry sector and lead to greater afforestation. Conversely the application of a lower fixed price would be viewed negatively and result in less afforestation. Lowering the fixed price surrender option to $10 would consign the NZ ETS to having virtually no impact on afforestation.

The negative reaction to retaining the $25 cap would be partially ameliorated if a floor price was introduced to balance the price ceiling. The high level of applications to the Afforestation Grant Scheme in 2015 shows the reaction of forest growers to what is effectively an offer of a fixed price of about $10/NZU for the carbon sequestered in the first 10 years that is transferred to the Crown, while retaining the option value of carbon after that point in time.

Correlation between carbon price and afforestation/deforestation

Historically there has been a strong correlation between the rate of afforestation and LEV (Land Expectation Value). A key determinant of LEV is log price. The increase in afforestation in 2011 showed the potential impact of carbon price. Consequently historical data has been used to develop a model to predict the level of afforestation from log price and carbon price.

The resulting forecast has limited afforestation beneath a carbon price of $15/NZU but a level of 13,900 ha/year at $15/NZU increasing to 50,500 ha/year at $50/NZU.

Information from Deforestation Intentions Surveys has been used to estimate the impact of carbon price on the level of deforestation. Different effects are expected for large-scale owners and small-scale owners given the different liabilities that each group faces. Most deforestation by large-scale owners will be on pre-1990 forest land whereas most deforestation by small-scale owners will be on post-1989 forest land.

The forecast has deforestation of large-scale owners decreasing once carbon prices reach $7/NZU and virtually stopping, apart from carbon-equivalent offsetting using the flexible land use provision, once carbon prices exceed $15/NZU. Deforestation by small-scale owners continues, at a reduced rate, even at high carbon prices.

Other factors that can influence new forest planting

Other factors that can have a large impact on new forest planting besides log prices and carbon prices are land availability, rates of return between forestry and other land uses, government planting schemes and future international and domestic accounting rules.

Assessment of MPI's new 2015-2030 forest planting scenarios

The MPI forest planting scenarios are credible forecasts for each of the three carbon price levels. My estimates of the carbon prices necessary for long-term levels of afforestation of 5,000, 15,000 and 30,000 ha per year fall within the range of prices identified by MPI for each of the scenarios as shown below:

MPI Afforestation scenario	*MPI carbon prices ($/NZU)*	*Model carbon prices ($/NZU)*
5,000 ha/year	0 to 12.50	7.65
15,000 ha/year	12.50 to 25	16.27
30,000 ha/year	>25	32.27

Introduction

Background

As part of the New Zealand Emissions Trading Scheme (NZ ETS) review, officials have commissioned Computable General Equilibrium (CGE) modelling on the impact different potential NZ ETS settings will have on New Zealand's economic performance and its greenhouse gas emissions. A key consideration will be the expected afforestation and deforestation in hectares that may result from different settings (that will drive New Zealand Unit demand and hence carbon price, and varied levels of market certainty).

MPI are aware of the limitations of such broad economic modelling, particularly in relation to the land sector. As such, MPI's forestry projections have been used as an input into the CGE Model. MPI is also commissioning this external expert advice (quantitative and qualitative) on the likely afforestation/deforestation response from such setting changes in order to provide greater assurance about the quality of their final analysis.

Objectives

MPI requires the following quantitative and qualitative analysis exploring the likely behaviour from different types of foresters in the event that NZ ETS settings are changed:

a) Expert opinion on the likely reaction from the forestry sector to potential NZ ETS setting changes, specifically:

  i. the removal of the '2 for 1' surrender obligations.
  ii. removing, lowering ($10, $15, $20), keeping ($25) or raising ($50) the fixed price surrender option.
  iii. Changing the EITE free allocation settings.

b) Determine the (continuous) direct correlation between carbon price and afforestation/deforestation.

c) Advice on the validity and relative priority of other factors that can influence new forest planting, such as government planting schemes, log prices, nursery capacity, rates of return between forestry and other land uses, land availability, forest/land owners' future intentions, future international and domestic accounting rules.

d) Expert independent assessment of MPI's new 2015-2030 forest planting scenarios by carbon price and drivers.

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Approach

Correlation between carbon price and afforestation

The general approach taken is similar to the approach of Horgan (2007)[1] who looked at the correlation between new planting rate and IRR (Internal Rate of Return). Here LEV rather than IRR has been used in order to make it simpler to include an additive carbon effect and to provide an indicator of land affordability.

The steps involved are

1. Specify a standard silvicultural regime.
2. Analyse historic MPI log prices.
3. Analyse the correlation between historic (pre-ETS) afforestation rate in New Zealand and LEV (Land Expectation Value).
4. Use the resulting model to estimate what the afforestation rate would have been in 2011 without the ETS.
5. Estimate what afforestation rate would have been achieved if carbon prices had stayed at around $20/NZU.
6. Extend the afforestation model to include the LEV associated with the carbon trading opportunity as well as the LEV associated with selling logs.
7. Calibrate the model for carbon – i.e., Determine the proportion of the carbon LEV that is recognised given the expected afforestation rate with carbon at $20/NZU.
8. Use the calibrated model to estimate afforestation at different carbon prices.
9. Make adjustments based on responses obtained as part of the 2015 Deforestation Intentions Survey.

Silvicultural regime

An unpruned regime has been assumed:

- Plant 800 stems/ha
- Thin to 375 stems/ha at age 8 years
- Clearfell at age 28 years

An average New Zealand ex-farm site was assumed:
- Site index 30.2 m
- 300 Index of 29 m^3/ha/year

Log yields were estimated using the Radiata Pine Calculator.

Carbon yields were estimated using the Look-up table for Hawkes Bay/Southern North Island because this region aligns with the site productivity estimates.

Land Expectation Value (LEV)

LEV is the benchmark for forest profitability. It represents the maximum that can be paid for land to achieve a given rate of return from forestry. It is calculated as the NPV

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[1] G. Horgan. 2007. Financial returns and forestry planting rates.

(Net Present Value) of future revenues and costs associated with:

- Forestry on the land in perpetuity
- The land current bare of trees
- No cost included for land rental
- Best management practice

For this analysis a required rate of return of 8% has been adopted. This rate was the mid-range response in the 2013 Discount Rate Survey rate to the question "What discount rate do you use to evaluate new planting investments[2]".

In the analysis two different components of overall LEV are considered: LEV_{logs} which is the LEV associated with forestry operations and LEV_{carbon} which is the LEV associated with the carbon trading opportunity.

LEV_{logs} is the net present value at an 8% discount rate of future forestry costs and revenues in perpetuity. Revenues come from the sale of logs at the time of harvest while costs come from establishing, tending, maintaining, harvesting and managing the tree crop.

LEV_{carbon} is the net present value at an 8% discount rate of future carbon costs and revenues in perpetuity. Revenues come from annual NZU sales while costs come from joining the ETS, compliance costs and harvesting liabilities. All property and forest management/maintenance costs are included in the LEV_{logs}.

LEV_{carbon} assumes the annual sale of all NZUs received with NZUs purchased at the time of harvesting to meet surrender obligations[3]. A variation is also calculated in which NZUs are only sold up to the 'safe' level of carbon (i.e. the minimum level of carbon that occurs after harvesting when replanting is assumed) with any further NZUs retained to meet harvesting liabilities.

In calculating LEV all factors apart from log price and carbon price have been held constant.

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[2] Manley (2014): Discount rates used for forest valuation – results of 2013 survey. New Zealand Journal of Forestry 59(2):29-36

[3] The analysis undertaken is a stand-level analysis. No consideration is given to estate-level analysis to manage carbon risk.

Limitations

Time

Given the deadlines for the ETS review process there was limited time to undertake the analysis. Consequently a number of afforestation model refinements could not be fully evaluated.

Data limitation

Data from 1998 to 2008 is used to develop the afforestation model. This is a period during which log prices and afforestation rate were decreasing. A key assumption is that a model developed from data for this period is applicable to periods when forest profitability is increasing.

Modelling the impact of carbon price on forest profitability and afforestation rate is anchored by what happened in a single year, 2011. Given the limited empirical information to date on the impact of carbon price on afforestation, forecasting the impact of carbon prices above \$20/NZU involves extrapolation well beyond the range of available data.

To what extent can the past be used to predict the future

Another limitation is that the historic correlation between afforestation rate and forest profitability (LEV) is assumed to continue into the future. Further it is assumed that, under the ETS, profitability (LEV) can be calculated by combining the weighted contributions of growing logs and trading carbon. It is assumed that the same relationship will apply between afforestation rate and the 'augmented' LEV.

Use of an average site to represent the total estate

The basic premise is that an average site can be used to illustrate the inherent profitability of forestry in New Zealand under changing log prices and carbon prices. However this appears to be a reasonable assumption for prediction of the national afforestation rate.

Use of an unpruned regime

A notional unpruned regime has been used here because much of the ongoing replanting and new planting is likely to be left unpruned. However, as the majority of historical planting was pruned, the analysis should be extended to include a mixture of pruned and unpruned regimes.

Use of look-up tables

The afforestation model accounts for carbon through use of a look-up table. Participants with over 100 ha are required to account for carbon using the Field Measurement Approach (FMA) to provide site-specific data to generate a customised carbon stock table. Consequently the afforestation model will be conservative to the

extent that the average site gives greater carbon stocks under the FMA approach compared to the Look-up table used. Further work is required to quantify this.

Results

Opinion on the likely reaction of the forestry sector to potential NZ ETS setting changes

Projections (MfE 2015/16 October Baseline Update) of NZ ETS liabilities for the period 2015/16 to 2019/20 are that an average of 19.2 million NZUs will be required annually by emitters and an additional 6.6 million NZUs by deforesters of pre-1990 forest. In addition MPI estimate (September 2015) that harvesters of post-1989 plantations will need to surrender an average of 2.2 million NZUs for the period 2015/16 to 2019/20 with a step-up to 5.6 million NZUs in 2020/21. The total demand for 2015/16 to 2019/20 is an average of 28 million NZUs per year.

MPI forecast (September 2015) that the average allocation to post-1989 plantation participants for 2015/16 to 2019/20 will be 12.2 million NZUs. In addition NZUs are allocated to EITE industries – in 2014 industrial allocations totalled 4.4 million NZUs.

Given that annual demand exceeds annual allocation, upward pressure on prices would be expected. However the market is overhung by the 140 million NZUs that have been issued and not surrendered to date.

I have been asked for an opinion on the likely reaction of the forestry sector to NZ ETS setting changes, specifically:

    i.   the removal of the '2 for 1' surrender obligations.
    ii.   removing, lowering ($10, $15, $20), keeping ($25) or raising ($50) the fixed price surrender option.
   iii.   changing the EITE free allocation settings.

I am unable to provide a quantitative opinion but can provide a qualitative view:

- Removal of the '2 for 1' surrender obligation would be viewed positively and lead to greater afforestation because:
  - In principle it would end what was a transitional arrangement.
  - In practice the increase in demand would translate through into an increased price for NZUs.
- Reducing the EITE free allocation would also be viewed positively and lead to greater afforestation although the scale of the allocation means that a change would have less impact that removing the '2 for 1' arrangement.
- Lowering the fixed price surrender option to $10, $15 or $20 would, on balance, be viewed negatively and result in less afforestation. From a forest grower's perspective the only advantage of a fixed price surrender option is that it limits the risk associated with the cost of any NZUs that have to be surrendered at the time of harvest (or following a catastrophic event). However a fixed price surrender option removes the potential upside and reduces the option value associated with the carbon trading opportunity.
- A fixed price surrender option of $10 would consign the ETS to having virtually no impact on afforestation. A fixed price surrender option of $15 or $20 would also limit the uptake of the NZ ETS although to a decreasing extent.

- Conversely raising the cap to $50 or removing it would allow a potential upside to the price of NZUs to mirror the downside that has been evident since 2011.
- Keeping the cap at $25 would still be viewed negatively as an extension of what was supposed to be a transitional arrangement. However the negative perception of retaining the $25 cap would be partially ameliorated if a floor price was introduced to balance the price ceiling. The success of the Afforestation Grant Scheme in 2015 relates to it offering a fixed amount of cash up front. Not only does this help with cashflows but it also provides certainty over the price of carbon. The $1300/ha grant equates to the offering of a fixed price of about $10/NZU[4] for the carbon sequestered in the first 10 years that is transferred to the Crown.

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[4] This is the carbon price that results in carbon revenues for the first 10 years of the notional unpruned regime that, when discounted at 8%, give an NPV of $1300/ha.

Correlation between carbon price and afforestation/deforestation

## Correlation between carbon price and afforestation

MPI log prices are available for both domestic and export log grades since September 1994. The weighted average log price for the notional unpruned regime at age 28 provides a reasonable predictor ($r^2 = 0.93$) for the afforestation rate (Fig. 1). The log prices are the average of the four quarters up to March 31 of the planting year.

Figure 1: Afforestation rate in New Zealand from 1995 to 2008 plotted against average log price ($ Real March 2015).
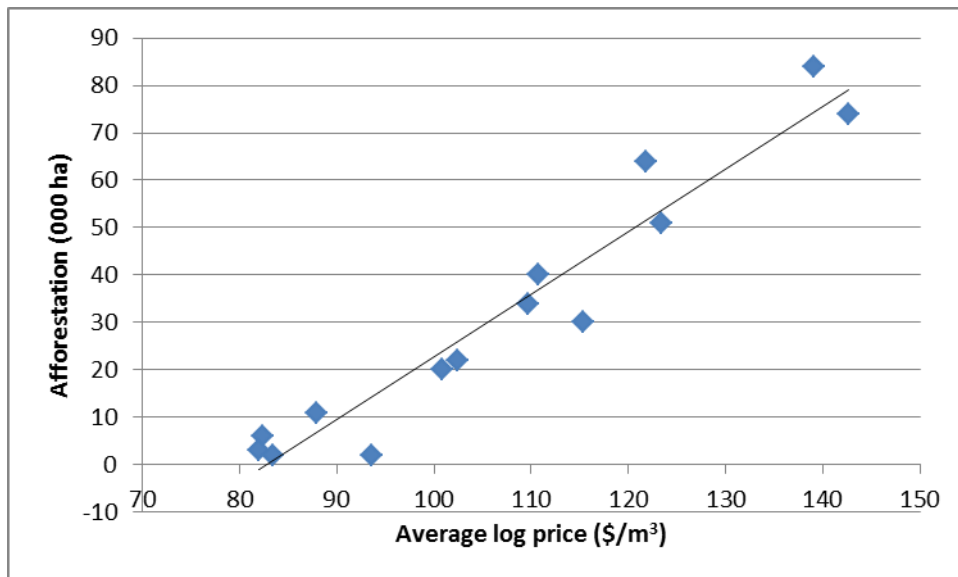

LEV is the fundamental measure of forest profitability. Given that log price is a key factor in LEV calculation, it is not surprising that it is also a good predictor of the afforestation rate from 1995 to 2008 with $r^2 = 0.93$ (Fig. 2). The LEV is calculated using average log prices (for the year to 31 March) for the year in which afforestation occurs.

Figure 2: Afforestation rate in New Zealand from 1995 to 2008 plotted against LEV ($/ha).
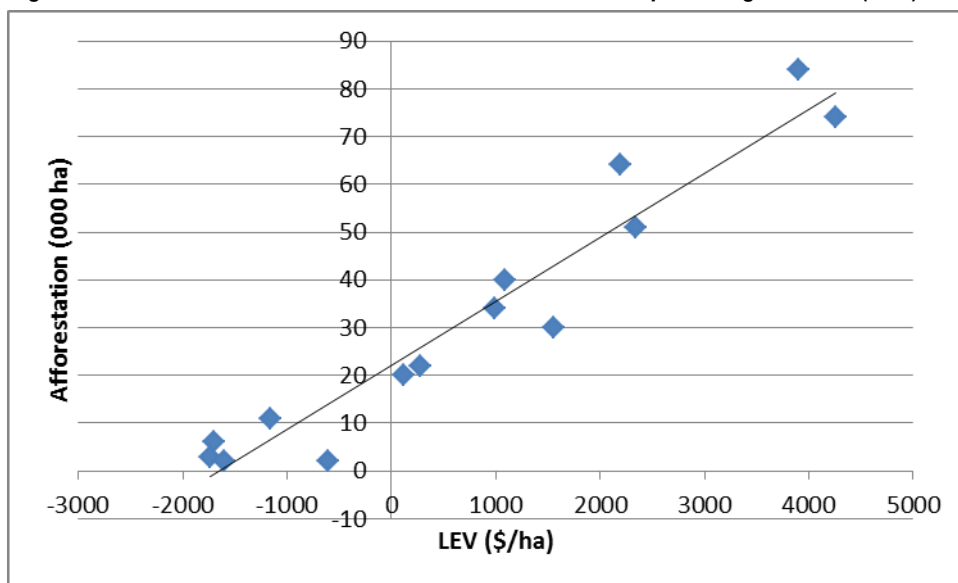
A more robust estimate of the afforestation rate is provided by the average LEV of the preceding 4 years (Fig. 3). The quadratic relationship has $r^2 = 0.99$.

Figure 3: Afforestation rate in New Zealand from 1998 to 2008 plotted against average LEV ($/ha) for the preceding four years.
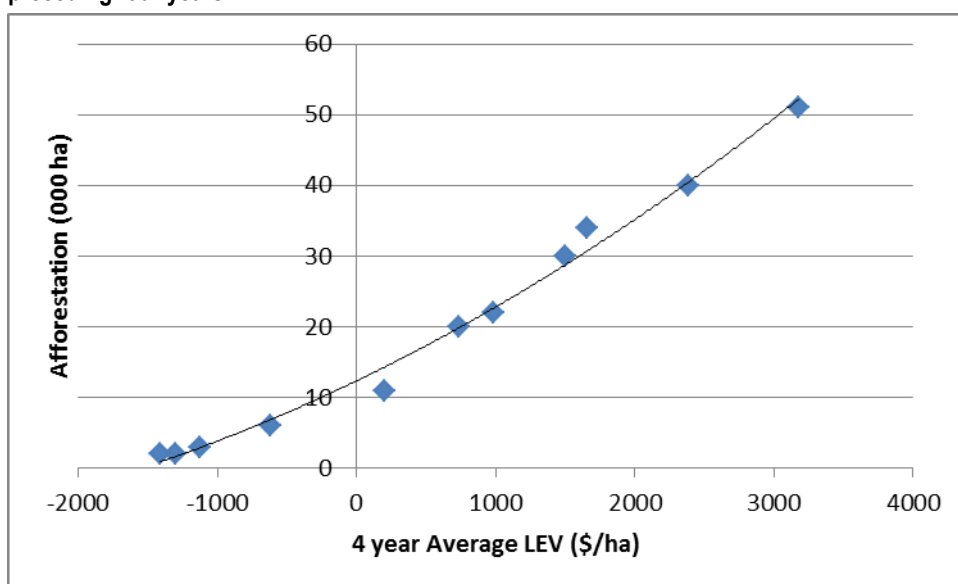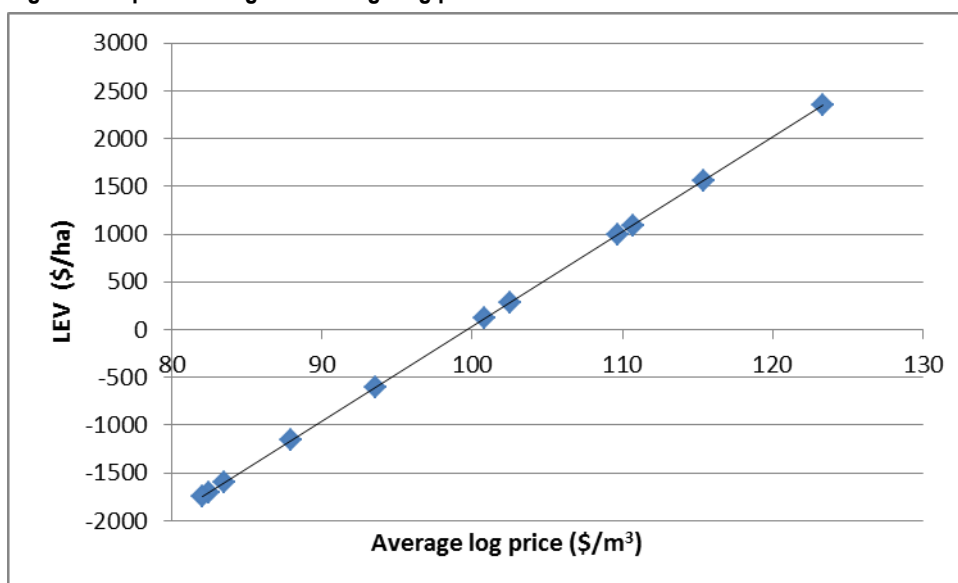

The relationship is:

Afforestation (000 ha) $= 12.357 + .00950 * LEV + 0.961 * 10^{-6} * LEV^2$ (Model 1)

This relationship provides a basis for estimating afforestation from LEV given log prices in the preceding 4 years. The relationship between LEV and weighted[5] average log price (Fig. 4) provides a pathway for predicting LEV directly from log price.

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[5] Log prices of each grade are weighted by the age 28 volumes for each grade for the unpruned regime adopted in this analysis.

Figure 4: Impact of weighted average log price on LEV.

With emitters' obligations under the NZ ETS commencing on 1 July 2010, the 2011 planting season was the first time the impact of the ETS on afforestation could be assessed.

The relationship illustrated in Fig. 3 is used to estimate the afforestation that would have occurred in 2011 based solely on log prices. Given the average log prices in the preceding 4 years, it is estimated that the afforestation rate in 2011 (without the impact of the ETS) would have been only 1,100 ha. The area that is estimated to have been afforested is 12,000 ha. Of this area some 8000 ha was planted and registered in the NZ ETS. A further 2,800 ha was planted under the Afforestation Grant Scheme. The 2011 Review of MAF afforestation Schemes indicates that about 300 ha of plantations would have been established under the PFSI in 2011.

In the 12 months to March 2011 the average NZU price was $19.30; i.e, just under $20 (Fig. 5). Subsequently the carbon price collapsed so that by March 2012 it was $7.90 and falling. It is my understanding that much of the 11,000 ha of new planting in 2012 took place because of commitments previously made.

Figure 5: NZU price from February 2010 to December 2015. (Source: AgriHQ)

In my opinion, based on events that occurred or were planned in 2011, had carbon prices continued at levels around \$20/NZU the afforestation rate would have increased to about 20,000 ha.


With the ETS the financial model needs to be expanded:

$$LEV_{logs+carbon} = LEV_{logs} + LEV_{carbon} \qquad \text{(Model 2)}$$

Where LEV_{logs} is the LEV based on revenues from the harvesting of logs

LEV_{carbon} is the LEV associated with the carbon trading opportunity

LEV_{carbon} for the notional unpruned regime varies linearly with carbon price (Fig. 6).

Figure 6: Impact of carbon price on LEV$_{carbon}$. The top line is based on the assumption that all NZUs are traded while the bottom line only has 'safe' carbon traded.
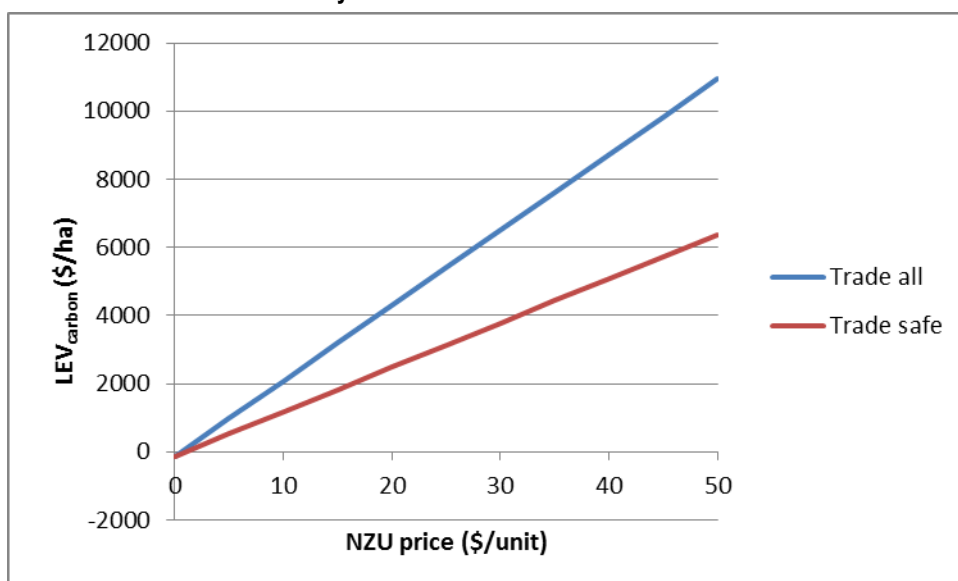
A carbon price of $20/unit results in a LEV$_{carbon}$ of $4302/ha. The average LEV$_{logs}$ calculated for the 4 years preceding 2011 is -$1377/ha resulting in a combined LEV of $2925/ha. The afforestation model would estimate an afforestation rate, given this combined LEV, of 48,400 ha. An afforestation rate of 20,000 ha implies that only 49% of the LEV$_{carbon}$ was factored into the afforestation rate.

LEV$_{safecarbon}$ when only the 'safe' level of carbon is traded is also shown in Fig. 6. At a carbon price of $20/NZU the LEV$_{safecarbon}$ is $2478/ha or 58% of the value calculated when trading of all carbon is assumed. The afforestation rate of 20,000 ha implies that not even the safe level of carbon was fully factored into the afforestation rate.

Given the novelty and uncertainty associated with the ETS it seems reasonable for a cautious approach to have been taken, and continue to be taken in afforestation.

Consequently the afforestation model[6] that I have adopted is based on

$$\text{Adjusted LEV}_{logs+carbon} = \text{LEV}_{logs} + k * \text{LEV}_{carbon} \qquad \text{(Model 3)}$$

Where LEV$_{logs}$ = 98.86 * (weighted average log price) - 9852

LEV$_{carbon}$ = 221.38 * (carbon price) – 125

In general terms, k can be considered to be a factor for uncertainty associated with carbon. My interpretation of the afforestation rate observed in 2011 together with my expectation of what would have happened if carbon price had remained at $20/NZU is that k = 0.5. However in using this model to forecast future afforestation I will scale this factor down by 25% to 0.375.

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[6] LEV$_{carbon}$ assumes the annual sale of all NZUs received with NZUs purchased at the time of harvesting to meet surrender obligations.

The additional reduction reflects the widespread concern in the forestry sector to the way in which the government has:

- Allowed emitters to meet NZ ETS obligations using lower cost international Kyoto Protocol units.
- Yet, in May 2014 stopped forest growers from using foreign carbon units to meet surrender obligations if they voluntarily left the ETS.
- Retained the '2 for 1 emitter obligation' and $25/NZU price limit beyond 2012.
- Introduced the provision for, but has not defined the detail of, an auction process to provide additional NZUs for emitters. There is concern that such an auction would reduce the price for NZUs.

Some of these concerns are summarised in a recent (27 November 2015) NZ Herald article by Brian Fallow:

The ETS is New Zealand's primary policy response to the challenge of climate change but it has been utterly subverted and rendered ineffectual by two things.

- *One is that the great majority of the country's greenhouse gas emissions escape a carbon price through various carve-outs and a buy one, get one free provision.*
- *The other is that the price incurred by the remaining emissions has been almost zero because the Government decided to allow emitters untrammelled use of imported carbon credits that cost a few cents a tonne – in the process crowding out the New Zealand units (NZUs) it issues mainly to forest owners.*

The quote is dated in the sense that the ability of emitters to use Kyoto Protocol units NZ ETS surrender obligations ended on 31 May 2015. Nevertheless the tone of Brian Fallow's article does resonate with that of many forest growers. There is certainly a degree of 'once-bitten twice-shy' scepticism.

Model 3 can be used in conjunction with Model 1 to estimate afforestation at different carbon prices (Table 1). The forecasts are based on a LEV_{logs} of -$1036/ha, the average LEV_{logs} for the 10 years to March 2015. The average of 10 years has been used to reflect the average log price over a reasonable period of time as the model is being used to estimate the long-term afforestation level – not the afforestation in 2015. If it had been the latter then a 4-year average would have been appropriate.

I have made a final adjustment to the model estimates. As part of the 2015 Deforestation Intentions Survey I have asked respondents about the carbon price threshold necessary to trigger afforestation. The consensus is that carbon prices would need to be at least $12 to $15/NZU for material levels of afforestation to occur. A typical response was "$15 and a solid outlook that the Government isn't going to interfere".

Consequently I have reduced the carbon effect of the model to zero at $5/NZU and halved the carbon effect at $10/NZU. From $15 on I have assumed the full carbon effect of the model.

Table 1: Forecast of afforestation at different carbon prices

Carbon price ($/NZU)	Afforestation (000 ha/year)	Adjusted (000 ha/year)
0	3.2	3.2
5	6.4	3.2
10	10.0	6.6
15	13.9	13.9
20	18.2	18.2
25	22.7	22.7
30	27.6	27.6
35	32.9	32.9
40	38.4	38.4
45	44.3	44.3
50	50.5	50.5

Note that a five year transition should be assumed in the implementation of these forecasts. The transition period is to allow for the afforestation rate to be stepped up from the current low rate and allow time for capital to be raised, nursery production to be stepped up, land to be prepared and new land to be purchased.

Correlation between carbon price and deforestation

The survey of deforestation intentions that I undertook at the end of 2014 provides a starting point. In the survey large-scale owners (> 1000 ha) were asked about their deforestation intentions. A forecast of deforestation by small-scale owners was calculated as 10% of the area expected to be harvested by them based on the current age-class distribution and a harvest profile. Results are shown in Fig. 7.

Of some significance, the 2014 survey was carried out at a time when the carbon price was initially $4.30/NZU, increasing over the survey period to $5.50/NZU. The price of ERUs was much lower – in the range of 5 to 15 cents per unit. Although the majority of deforestation liabilities were being met using imported units, respondents understood that, from 2015, Kyoto Protocol units could no longer be used to meet ETS surrender obligations.

For the period 2015 to 2025, the average annual deforestation was forecast to be 3,000 ha for large-scale owners and 2,400 ha for small-scale owners. In the long-term deforestation rates are about 2500 ha/year for each group.

Figure 7: Deforestation forecast for New Zealand (all owners). (Large-scale owner intentions and small-scale owners assuming 10 percent deforestation. Results will include some deforestation of post-1989 forests that are not registered under the NZ ETS that do not have any liabilities.)
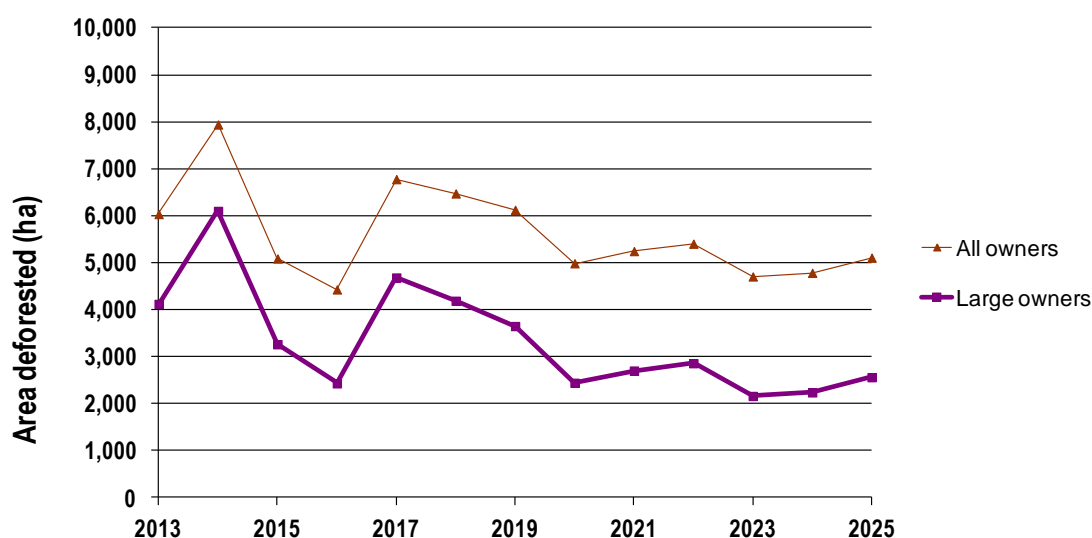
As part of the 2014 survey respondents were asked to provide their deforestation intentions under two scenarios:

1. Emissions Trading Scheme (ETS) – this assumes that the ETS legislation as amended under the Climate Change Response (Emissions Trading and Other Matters) Amendment Act 2012 (enacted on 13 November 2012) continues unchanged.

2. No ETS legislation – this assumes that the ETS is repealed and not replaced by any other comparable legislation.

The responses to the two scenarios were identical. Consequently these forecasts can be taken as the expected level of deforestation when carbon price is not a limiting factor.

Respondents were also asked about the breakeven carbon price; i.e., the carbon price at which intended deforestation would not occur. Feedback indicated that should NZU prices reach around $10/NZU deforestation intentions are likely to decrease. Even land-owners who hold sufficient NZUs to meet deforestation liabilities will reassess plans if the opportunity cost of surrendering these NZUs becomes too high.

Preliminary information from the 2015 Deforestation Intentions Survey suggests that even at November 2015 carbon prices ($7 to $7.50/NZU) some conversion plans are starting to be reassessed. There would be limited conversion (or offset planting would be used) once carbon prices reached $15/NZU and it would effectively stop with a carbon price of $20/NZU. This information has been translated into estimates of deforestation for large-scale owners (Table 2).

A finding of the 2014 Deforestation Intentions Survey was that "No respondents intend using offset planting. There is a clear preference to meet deforestation liabilities by purchasing units rather than using offset planting. Only one respondent indicated that they would consider offset planting. They would do so if the carbon price got over $13/NZU provided that they could buy land for under $3000/ha".

However in the 2015 Survey, two respondents intending deforestation have stated that offset planting is planned. Consequently the forecast includes some allowance for offsets.

Table 2: Deforestation forecast at different carbon prices for large-scale owners. Offsets refer to use of the flexible land use provision with the planting of a carbon-equivalent area of land.

Carbon price	% Intentions deforested	Area deforested	Offsets
$/NZU	%	excluding offsets	
		(ha/year)	(ha/year)
1	100	2500	0
2	100	2500	0
3	100	2500	0
4	100	2500	0
5	100	2500	0
6	100	2500	0
7	90	2250	0
8	80	2000	0
9	70	1750	0
10	60	1500	0
11	50	1250	100
12	40	1000	200
13	30	750	300
14	20	500	400
15	10	250	500
16	8	200	500
17	6	150	500
18	4	100	500
19	4	100	500
20	4	100	500
50	4	100	500

The majority of the small-scale area that will be deforested is post-1989 plantation. Consequently there will no deforestation liability. Post-1989 forestry participation is voluntary and any non-participants in the ETS do not face any carbon surrender obligations if they harvest and convert. As such the incentive to not deforest/incentive to replant is weaker. Consequently carbon price will have a lower impact than for pre-1990 plantations.

Although there is no deforestation liability the obligation for ETS participants to surrender all units will act as a deterrent at higher carbon prices. High carbon prices will also act as an incentive to replant. Some post-1989 forest owners who are currently not ETS participants would register their forests at the start of the second rotation if carbon prices increase.

The schedule developed (Table 3) reflects these factors. It includes a limited amount of deforestation using offset planting under the flexible land use provision. It also makes allowance for deforestation on liability-exempt land.

Table 3: Deforestation forecast at different carbon prices for small-scale owners. Offset refers to use of the flexible land use provision with the planting of a carbon-equivalent area of land.

Carbon price $/NZU	% of 2500	Area deforested excluding offsets (ha/year)	Offsets (ha/year)
0	100	2500	0
5	100	2500	0
10	90	2250	25
15	80	2000	50
20	70	1750	50
25	60	1500	50
30	50	1250	50
35	40	1000	50
40	40	1000	50
45	40	1000	50
50	40	1000	50

Other factors that can influence new forest planting

Government planting schemes

The two Afforestation Grant Schemes have shown how the Government can influence new forest planting even when carbon prices are low. The high application rate for the 2015 round of the second AGS indicates that there is a significant area of land that will be afforested if the establishment cost is covered. The AGS focuses on land where tree planting has environmental co-benefits. I suspect that much of the AGS planting will be on land that is already owned by the applicant; for example the planting of the most erosion-susceptible parts of farms. However I have been advised by MPI that some AGS applicants intend purchasing land for afforestation.

Log prices

The effect of log price on afforestation has already been shown in this report. Clearly log prices play an important part in the afforestation decision.

Nursery capacity

The quick step-up in new planting in 2011 showed that there is nursery capacity available. However, nursery owners are now more prudent and will generally require a substantial deposit when they take orders. There were a number of well publicised cases in 2012 and 2013 of nurseries having to plough nursery beds full of seedlings when investors changed their minds about afforestation once carbon prices started to fall.

Land availability

There is substantial land area that is potentially available for afforestation. The issue is the affordability of the land and its highest and best use. As a guide I considered the MPI Farm Monitoring reports for 2012[7]. It indicates that there is over 3.8 million ha that has a land cost (i.e. value of farm, forest and building) in the range $3400/ha to $6097/ha (table 4).

Table 4: Indicative cost of land. Data is from 2012 MPI Farm Productivity reports. Land cost is forecast value in 2012/13 Budget for Farm, forest and building

Region/type	Area (ha)	Land cost ($/ha)
Cant/Marl Hill	593725	3400
Gisborne Hill	502200	4517
CNI hill	806450	4607
Northland	298300	4968
HB/Wairarapa	1140000	5789
Southland Hill	520560	6097
Total	3861235	

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[7] This is the last available report. MPI subsequently stopped doing these studies.

Watt *et al* (2011)[8] estimated the potential area suitable for afforestation using spatial datasets. They targeted non-arable land classes that have limitations for sustainable use under perennial vegetation. Their 3 scenarios differ in terms of the land use classes and associated level of erosion included. The potential areas for afforestation were calculated as:

- Scenario 1 – severe to extreme erosion   0.7 million ha
- Scenario 2 – moderate to extreme erosion   1.1 million ha
- Scenario 3 – slight to extreme erosion   2.9 million ha

Recent acquisitions of land for afforestation include:

- $4500/ha for land in Hawkes Bay
- $3600 to $4200/ha for land in Hawkes Bay/Wairarapa
- $1500 to $1700 for land in Marlborough
- $5000 to $5500 for land in Southland

The areas involved have been relatively small but indicate the cost of land suitable for afforestation. They indicate the need for carbon prices in excess of $15 to $20/unit in order for the purchase of land to be affordable.

Rates of return between forestry and other land uses

This is closely related to land availability and affordability which was discussed above. Another aspect arises from the exclusion of agriculture from the ETS. Not only is there less demand for NZUs but it also means that the owners of the land most suitable for afforestation do not have as strong an incentive to plant trees as they would otherwise have. Many sheep and beef farms have some land that is currently being grazed but which, for environmental reasons, should be under trees. Some farmers will afforest this land using incentives available under the ETS, AGS or PFSI. However if farmers were faced with emissions liabilities they are likely to have greater incentive to afforest this land whether it be by planting or native forest reversion.

Future international and domestic accounting rules

International rules may set some parameters but the market rules and price that affect New Zealand forest owners will be ultimately determined by domestic policy. Of importance will be the 'boundaries' of the NZ ETS and permitted interactions between the NZ ETS and emission trading schemes elsewhere; i.e. whether New Zealand forest growers can sell units to foreign buyers and whether foreign units can be used by New Zealand emitters.

I note that the market for carbon in New Zealand was initiated in 2003 when agencies in the Netherlands and other European countries signed forward contracts to buy New Zealand AAUs from Joint Implementation projects (under Projects to Reduce Emissions

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[8] M. Watt, D. Palmer, B. Hock. 2011: Spatial description of potential areas suitable for afforestation within New Zealand and quantification of their productivity under *Pinus radiata*. New Zealand Journal of Forestry Science 41:115-129.

or PRE). Also, from 2009 Government agencies in Denmark and Norway sought to acquire AAUs via the purchase of AAUs converted from NZUs allocated to post-89 forest owners. This set the early price of NZUs.

We have also seen the impact on carbon price of allowing New Zealand emitters to meet their obligations using foreign units. The point is that the scope of the market ultimately determines carbon prices.

Assessment of MPI's new 2015-2030 forest planting scenarios

In my opinion the MPI forest planting scenarios are credible forecasts for each of the three carbon price levels. The long-term levels of afforestation are 5,000, 15,000 and 30,000 ha per year for carbon prices in the range 0 to $12.50, $12.50 to $25, and >$25 respectively. In terms of my model the three afforestation levels correspond to carbon prices of $7.65, $16.27 and $32.27. I note that these prices fall within the range of prices identified for each of the MPI scenarios (Table 5).

Table 5: Comparison of carbon prices from Model with the range identified for each MPI planting scenario.

MPI Afforestation scenario	*MPI carbon prices ($/NZU)*	*Model carbon prices ($/NZU)*
5,000 ha/year	0 to 12.50	7.65
15,000 ha/year	12.50 to 25	16.27
30,000 ha/year	>25	32.27

Discussion

Model is a construct

It is important to understand that the afforestation model is a construct that seeks to use past afforestation to predict the national level of afforestation. It attempts to predict the aggregate effect of individual afforestation decisions based on log price and carbon price.

The k factor

Observations of the afforestation response to the ETS in 2011 and my expectation of what would have happened had carbon prices remained at $20/NZU are used to calibrate the model. The k value of 0.5 is plausible given the novelty and uncertainty associated with carbon. Potential forest growers had a range of views about the ETS and carbon prices. Some registered in the ETS while others would not join under any circumstances. Forest growers who registered had a range of attitudes and approaches to risk. Some planned to trade all NZUs received while others planned on selling only 'safe' units.

Views on carbon and the endurance of NZ ETS settings in 2010 to 2011 were more positive than they are now. Consequently the k factor was reduced to 0.375 for forecasting future afforestation. If perceptions of return and risk (e.g. views of ETS endurance) improve over time then the k factor would increase.

Risk

In a general sense the k factor can be considered to be an indicator of the risk associated with the NZ ETS. The ETS has the potential to provide greater forest profitability as measured by LEV. However along with increasing profitability comes increasing risk. This risk takes a number of forms including:

(i) Carbon prices might be very low or the ETS might not endure.

(ii) Carbon prices may be so high at the time of harvest that owners will not be able to afford to harvest. Although the owner will benefit from the high carbon returns they may still want to harvest.

(iii) An unexpected catastrophic event will require early surrender of units and create cashflow problems for the owner.

One way to overcome the latter two risk factors would be to give forest growers the option of using a carbon averaging approach similar to that being proposed by New Zealand for international accounting. Manley & Maclaren (2009)[9] evaluated the averaging approach proposed at that time for an Australian ETS under which "the project proponent will generally not have to relinquish units after the forest is harvested or in the event that the forest is destroyed by fire or pests, provided that the forest is re-established." Although the approach reduces forest profitability the reduction is

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[9] Evaluation of the Australian ETS approach for reforestation. New Zealand Journal of Forestry 54(3):26-30.

modest given the level of risk reduction. If the averaging approach was applied to the afforestation model, LEV$_{carbon}$ would reduce from \$4302/ha to \$3997/ha at a carbon price of \$20/NZU. However the lower risk associated with this LEV might mean that the associated k factor would increase substantially.

Rotation age

The afforestation model assumes a fixed rotation age of 28 years. Past analysis, including that by students at the University of Canterbury[10] has indicated that higher carbon prices would tend to result in post-1989 forest owners extending rotation lengths. Those growers earning NZUs under the Field Measurement Approach could also potentially take steps to maximise carbon through management regimes (stocking rates, pruning and thinning decisions). LEV would be higher than that calculated at age 28. This would suggest that the afforestation model might be conservative at higher carbon prices.

Impact on land price

Conversely carbon prices sustained in excess of \$15/NZU are likely to lead to higher land prices. The increase in potential profitability is likely to at least partially be captured in land price and lead a lower afforestation rate than that indicated by the model.

Liability-exempt land

Because some land is declared exempt there will always be some deforestation, no matter what the carbon price. There are a number of categories of land which do not face deforestation liabilities or harvesting liabilities:

- Around 16,000 hectares of pre-1990 forest land has been granted a 'less than 50 hectare' exemption.
- Around 1,000 hectares of pre-1990 forest land comprised of tree weeds has been granted an exemption to de-forest since 2008 (and has been deforested). Further tree weed clearance is highly likely.
- Pre-1990 forest landowners can deforest up to 2 hectares every 5 year period without obligations under the ETS.
- Section 179A provides for some deforestation to be exempt from obligations under the ETS. Schedule 3 Part 1 exempts deforestation where pre-1990 forest is affected by a natural event that permanently prevents re-establishing a forest on that land (e.g. river changing course).
- Post-1989 forest owners who are not registered in the ETS face no carbon surrender liabilities if they harvest and convert.

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[10] P. Maclaren, B. Manley, and final year School of Forestry students. 2008. Impact of the New Zealand Emissions Trading Scheme on Forest Management. New Zealand Journal of Forestry, 53(3): 33-39.