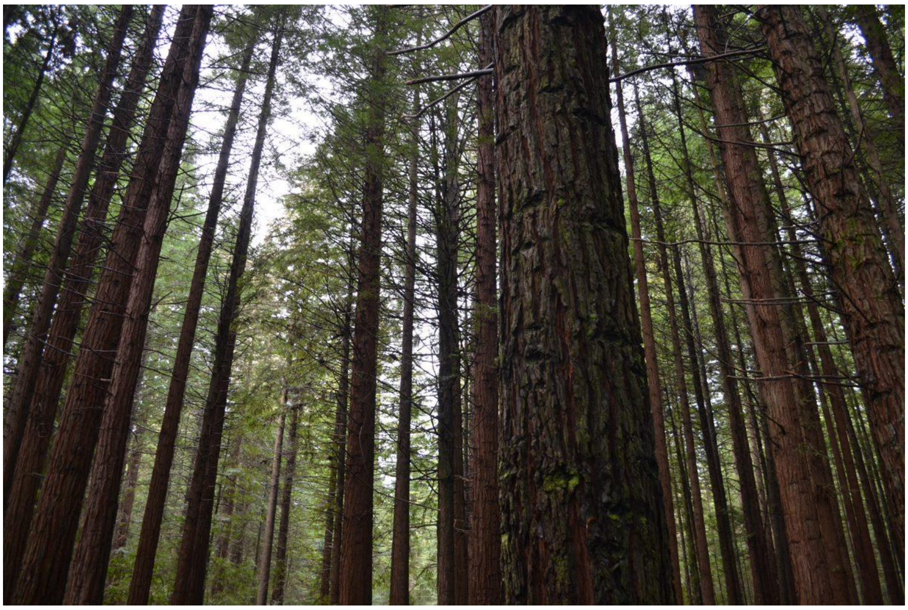
Modelling the financial impacts of the proposed changes to the Emissions Trading Scheme



ENFO410

Final Research Report

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Abstract

There is a growing global consensus that lowering greenhouse gas emission volumes is key to limiting the harmful effects of climate change. New Zealand's primary response has been the implementation of the Emissions Trading Scheme (ETS), which aims to regulate emissions from different sectors through the transfer of credits at a cost to emitting businesses. In 2015 the government commenced a review of how the scheme is run with a view to simplifying it to encourage more participants. One of the proposed changes to the ETS was a new carbon accounting method employed for forestry.

The profitability of both the current approach and this proposed new method (averaging) were assessed for both single age class and plant and leave scenarios. The long-term carbon averages for different rotation ages were calculated in the Canterbury/West Coast, Bay of Plenty, and Gisborne regions. These regions were chosen as they reflect a range of sequestration rates and gave averages of 256, 337, and 450 tonnes of carbon dioxide per hectare respectively for a 28 year rotation.

Further profitability analysis in the Gisborne region showed that averaging was slightly less profitable than the current approach for a single age-class, 28 year rotation, with land expectation values (LEVs) of $4,140 and $4,470 per hectare respectively. A plant and leave scenario yielded a positive net present value (NPV) of $1,130/ha over a 50 year period. An indigenous plant and leave scenario under the same assumptions was less profitable (-$3470/ha) because sequestration rates are less than half of those of radiata. The discount rate and carbon price used throughout the analyses were 8% and $20 per tonne respectively.

Based on these results, a submission to the Ministry for the Environment was made in response to their discussion paper published in August 2018, and can be found in Appendix A. Increasing the debate around how the ETS is run and its corresponding effectiveness is critical if it is to remain New Zealand's primary response to climate change. In theory, making the ETS less risky and simpler to understand with little change in long-term profitability will encourage more forest owners to enter the scheme. However, the real measure of success will be determined by the levels of afforestation that may or may not occur in the future as a result of these proposed changes.

Acknowledgements

First and foremost, a sincere thank you to Associate Professor David Evison for his supervision and direction on this project. Without his knowledge, encouragement, and enthusiasm its completion would not have been possible.

Thanks also to Professor Bruce Manley for his invaluable assistance with some of the finer details, and tolerance of my numerous early questions.

Finally, to Professor Rien Visser for his continued support throughout the years: thank you.

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1. Introduction

As the threat of climate change becomes more of a reality, the scientific community has agreed that a reduction in greenhouse gas (GHG) emissions is key to limiting global temperature rise and its associated environmental consequences (United Nations 2015). Because these emissions come from many different sources – some of which are crucial to New Zealand's economy – there has been some difficulty in establishing a response that balances environmental effectiveness with New Zealand's economic objectives.

The Emissions Trading Scheme (ETS) is a cap and trade-type scheme designed to assist in fulfilling international GHG commitments at the lowest cost to the country. It does this by putting a price on GHG emissions in the form of carbon credits, and some businesses are required to obtain and then surrender these to account for their emitting activities. Credits are claimed by forest owners through new forestry planting, which are then sold to emitters. One credit is traded as a New Zealand Unit (NZU), which represents one tonne of carbon dioxide.

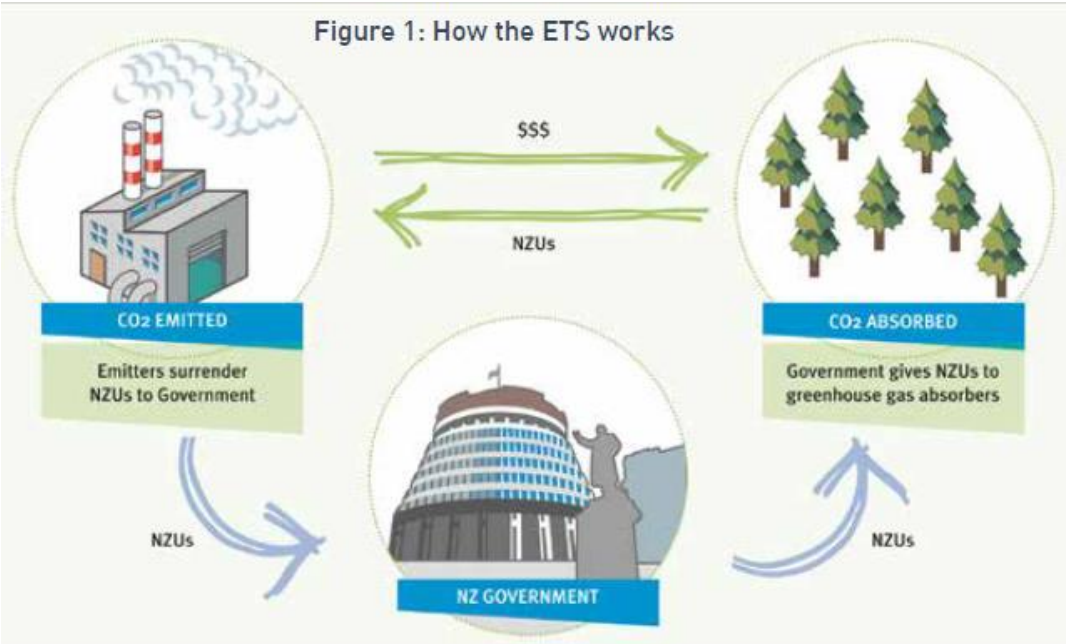

Figure 1: Basic overview of the New Zealand ETS (Te Uru Rakāu 2018)

However, the effectiveness of the scheme has been questioned for several reasons. There is no national carbon cap, and special considerations exist for industries that are emissions intensive or trade exposed. Previously, international credits could be purchased to offset emissions, but this policy has since been abandoned as it caused an oversupply of credits and the price of NZUs dropped. There is also currently a fixed price option for emitters of $25 per tonne, which means emitters can pay this instead of surrendering credits, and effectively caps the price of carbon at $25 per unit.

The Paris Agreement is a global agreement signed in April 2016 that seeks to "chart a new course in the climate change effort" (UNFCCC 2018), by encouraging all countries to undertake ambitious climate change plans. The aim is to collectively limit the warming of the planet to below two degrees Celsius by the end of the century. Each country is required to submit their own plans in the form of nationally determined contributions (NDCs), and report regularly on emissions volumes and other mitigation plans.

New Zealand has set a current target under this agreement to reduce national net GHG emissions to 11% below 1990 levels by 2030. The previous target was to reduce these emissions to 5% below 1990 levels by 2020 (MFE 2018). Because the use of forestry and the ETS has been the country's key response mechanism to climate change, the government has sought to improve the operation of the scheme. Currently, a significant proportion of forest owners are not involved in the ETS, and the government is aiming to encourage new planting as well as provide more regulatory predictability to stakeholders. The ambitious One Billion Trees program also relies heavily upon new planting in order to be successful. As such, changes to the ETS are important if it is to remain New Zealand's key climate change instrument.

In August 2018, the government released a consultation document discussing proposed amendments to the Climate Change Response Act (Te Uru Rakāu 2018). It contained more information about accounting approaches, called for opinions on the proposed options, and described the various scenarios that could be enacted. It marked the first time since the 2015/16 review that more detailed information was made available about future ETS policies. It contained three questions pertinent to this project, namely:

1. How is the long-term average storage capacity calculated under averaging accounting?
2. How is the long-term average carbon storage age calculated?
3. What is the preferred approach to introduce a new activity into the ETS for permanent, post-1989 forests?

The submission to the Ministry for the Environment can be found in Appendix A at the conclusion of this document.

2. Background

The government has anticipated that international obligations will increase over time as a "new ethic of environmental responsibility emerges" (MFE 1997). As such, several reports have been commissioned by the government to establish how the country can best transition to a low carbon economy, as well as the risks and opportunities associated with such a change.

2.1 The possibility for net zero

New Zealand has proposed a Zero Carbon Act, which legally commits the country to abide by the Paris Agreement in ensuring that net emissions are zero by 2050. The bill is expected to go before Parliament in 2019. It has relevance to the project as the ETS and forestry are both critical parts of the country's climate change plan.

A report commissioned by GLOBE - a cross-party working group - identified that New Zealand is in a unique position when it comes to achieving domestic emissions neutrality in the future. This is due, in part, to its already highly decarbonised energy sector. Whilst many other countries have spent significant time and effort on reducing emissions from this sector, approximately 85% of New Zealand's power generation comes from renewable resources that produce little to no emissions through generation (MBIE 2017). This places the country at a significant advantage over others in this regard. However, agricultural emissions make up almost half of New Zealand's gross emissions, which is a higher proportion than any other developed country.

The importance of the pastoral agricultural sector both socially and economically presents a significant challenge, although it does contain opportunity. The report also identified that whilst forestry in New Zealand is extremely useful for environmental purposes (sequestering approximately 30% of gross emissions), the largely private-ownership of the sector produces difficulties as it is subject to commercial pressures (Vivid Economics 2017). The report identified three possible approaches to limiting emissions, largely differing through various levels of technological development.

The Off Track scenario is slightly more ambitious than a "business-as-usual trajectory", however it only focusses on low or medium cost emission reduction opportunities. It does not involve a significant change in land use, which only leads to a reduction by 2050 of 10 – 25% of today's emission levels. The Innovative scenario occurs where emissions intensity is reduced through technological advancement and a reduction in pastoral agriculture. This comes through a decrease in the number of livestock, as well as developments such as vaccines to reduce methane emissions. Additional afforestation also creates a renewed carbon sink, and consequently New Zealand's emissions would reduce to approximately 70 – 80% of today's levels. Finally, the

Resourceful scenario relies heavily on afforestation, converting excess pastoral land to forestry and allowing other land to revert to native forest. Other than this, the scenario is like the Off Track, by continuing to promote renewable energy sources and electrifying New Zealand's transport fleet.

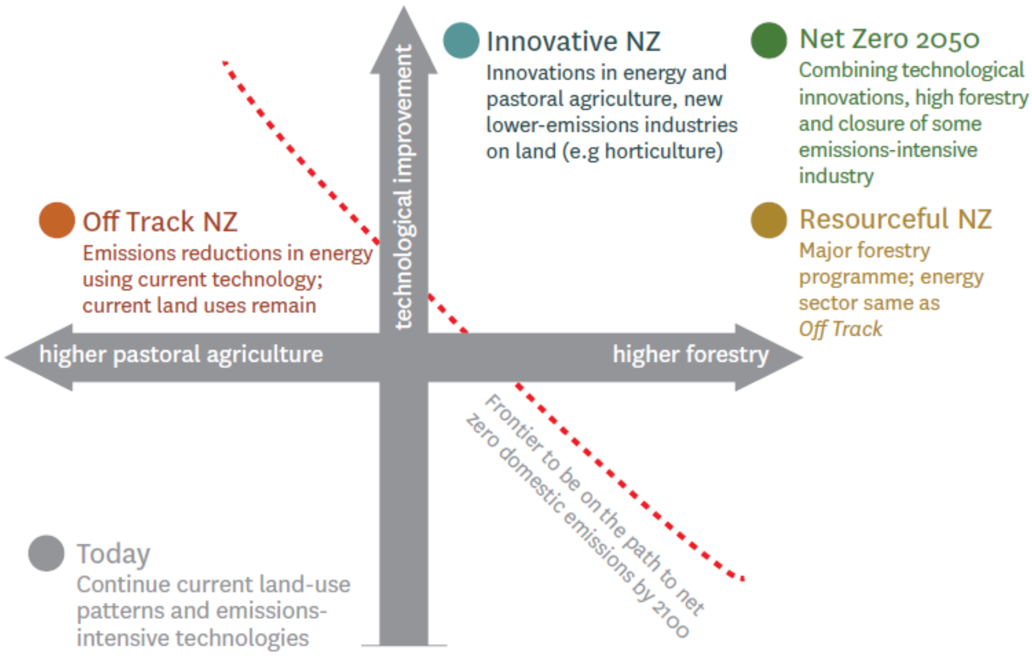

Figure 2: Different scenarios dependent on technological progress and land-use patterns (Vivid Economics 2017)

2.2 Lower net emissions in New Zealand

Another paper commissioned by Motu Economic Research (Vivid Economics 2018) agreed that the continued expansion of the forestry sector is critical to achieving larger reductions in net GHG emissions. It also noted that an over-reliance of forestry would be to the country's detriment in the long term; proposing that forestry should only be used to reach a certain emissions target sooner, rather than act as the only solution to a net zero future.

Three key uncertainties were discussed with regards to how the external environment may change as the country develops a decarbonisation strategy. These are fossil fuel and commodity prices, technological changes, and international emissions prices. Technological development will generally result in a decrease of emission mitigation costs, depending on the industry.

In an ideal scenario, low fossil fuel prices, low costs for carbon negative forest products and high costs for carbon-intensive manufactured goods would represent a world consistent with the Paris Agreement (Vivid Economics 2018). Government policy will be key when it comes to determining New Zealand's response and action when it comes to climate change and emissions. Carbon pricing is the most important of these, however other policies could be considered such as support for electric vehicles or investment in new renewable energy plants. This paper also outlined three different pathways, depending on the level of technology and policy adopted by New Zealand:

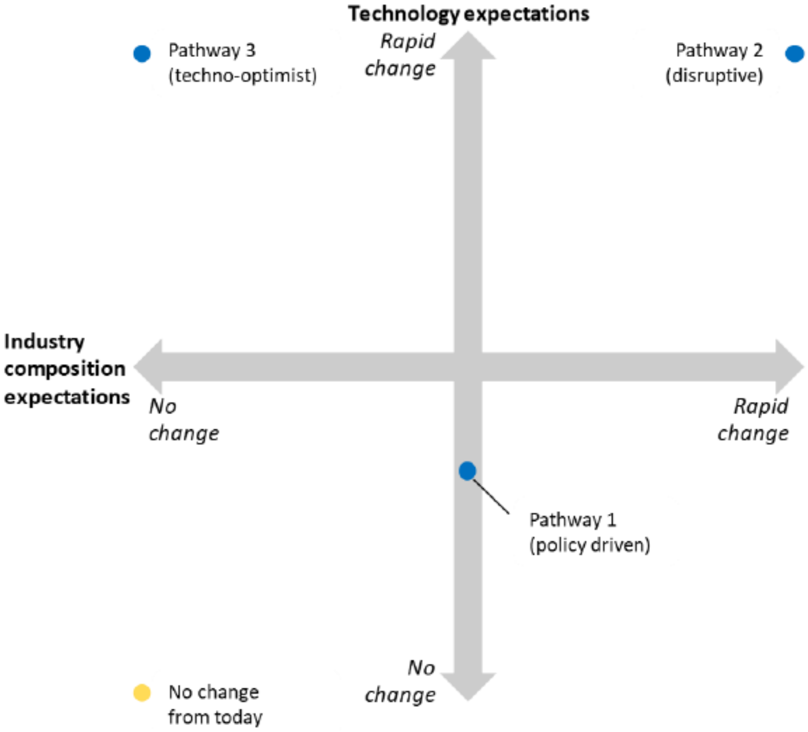

Figure 3: Pathways vs. expectations driving decision-making (Vivid Economics 2018)

The study made various assumptions about model inputs for the ETS, depending on the pathway:

Table 1: A selection of pathway assumptions. Note some similarities in pathway inputs (Vivid Economics 2018)

Assumptions	**Policy Driven**	**Disruptive Decarbonisation**	**Techno-optimist**
ETS coverage	All sectors including agriculture	All sectors including agriculture	All sectors including agriculture
ETS free allocation	From 2015-20, allocation as per NZ ETS, with agriculture receiving a 90 per cent allocation. From 2020, fast withdrawal of assistance, withdrawn at 3 percentage points from 2020 to 2030 and 5 percentage points a year thereafter	From 2015-20, allocation as per NZ ETS, with agriculture receiving a 90 per cent allocation. From 2020, fast withdrawal of assistance, withdrawn at 3 percentage points from 2020 to 2030 and 5 percentage points a year thereafter	From 2015-20, allocation as per NZ ETS, with agriculture receiving a 90 per cent allocation. From 2020, slow withdrawal of assistance, withdrawn at 1 percentage points from 2020 to 2030 and 3 percentage points a year thereafter
Rate of renewable technology (wind, solar, geothermal) cost improvement	Annual cost improvement for wind, solar and geothermal is 1.25 per cent, 2.5 per cent and 0.25 per cent respectively.	Cost reductions of 1.5 times the rates in the Policy Driven pathway	Cost reductions of 0.5 times the rates in the Policy Driven pathway

Emissions intensity	Continuous improvement (year on year) in the efficiency of GHG emission per unit of product produced, with dairy and sheep/beef intensity based on the 'minimum efficiency' baseline scenario from Reisinger et al (2016).	Continuous improvement (year on year) in the efficiency of GHG emission per unit of product produced, with dairy and sheep/beef intensity based on the 'minimum efficiency' baseline scenario from Reisinger et al (2016).	Continuous improvement (year on year) in the efficiency of GHG emission per unit of product produced, with dairy and sheep/beef intensity based on the 'minimum efficiency' baseline scenario from Reisinger et al (2016). In addition, methane vaccine available after 2030: reduces dairy livestock emissions by 30 per cent, sheep/beef livestock emissions by 20 per cent. 100 per cent adoption rate assumed.

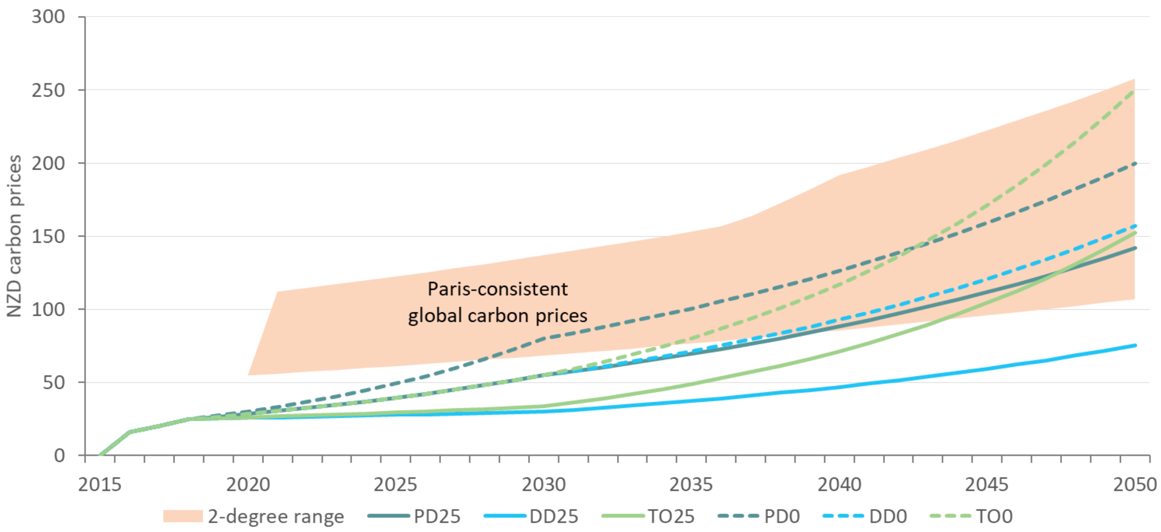

Figure 4: Emissions price increase trajectories, assuming pricing scenarios shown in Table 1 (Vivid Economics 2018). Note the 0 and 25 suffixes refer to either 0 or 25 million tonnes of CO_{2e} by 2050 targets respectively. PD, DD, and TO refer to each of the three pathways (Policy Driven, Disruptive Decarbonisation, and Techno-optimist).

Figure 4 considers two carbon level target scenarios. Achieving net zero emissions by 2050 - rather than 25 million tonnes of CO_{2e} - is the more disruptive approach from business as usual, and therefore it is unsurprising that emissions prices must be higher to more strongly dissuade emitters. The significant pricing differences by 2050 essentially show what prices are required to meet emissions targets by this time. The Paris-consistent area shows that New Zealand should be able to decarbonise its economy at similar costs to the rest of the developed world. DD25 and TO25 have lower carbon prices initially, as they are far more reliant on technological change in the future.

This study also noted that land used for beef and sheep farming would decline under all the proposed pathways. Land for dairy farming would increase under the Techno-optimist pathway (presumably due to the developments such as vaccines which would allow for more stock at reduced emissions levels), but would decrease under the other two. The feature common to each of the pathways was that reductions came chiefly from three sources: agriculture, forestry, and transport, implying that any future solutions should focus on these sectors.

2.3 Provisional carbon budgets

The provisional carbon budget (Figure 5) is part of the Paris Agreement in the form of an NDC. This budget has been determined by the government, and is a long-term assessment of New Zealand's carbon obligations throughout the next decade. The NDC is 58.65 megatons of CO_2-e emissions per year by 2030. The forecast free allocation volumes are distributed to energy intensive, trade-exposed industries, and the emissions outside the ETS cover other sectors like agriculture and waste. The forecast abatement required is the difference between gross and net emissions, where the net emissions (i.e. the provisional carbon budget) have already been decided through the Paris Agreement. It is planned that this abatement will come through a reduction in domestic emissions, forestry contributions, and the purchase of international credits. The size of this abatement essentially determines how much it will cost to meet the target (MFE 2018).

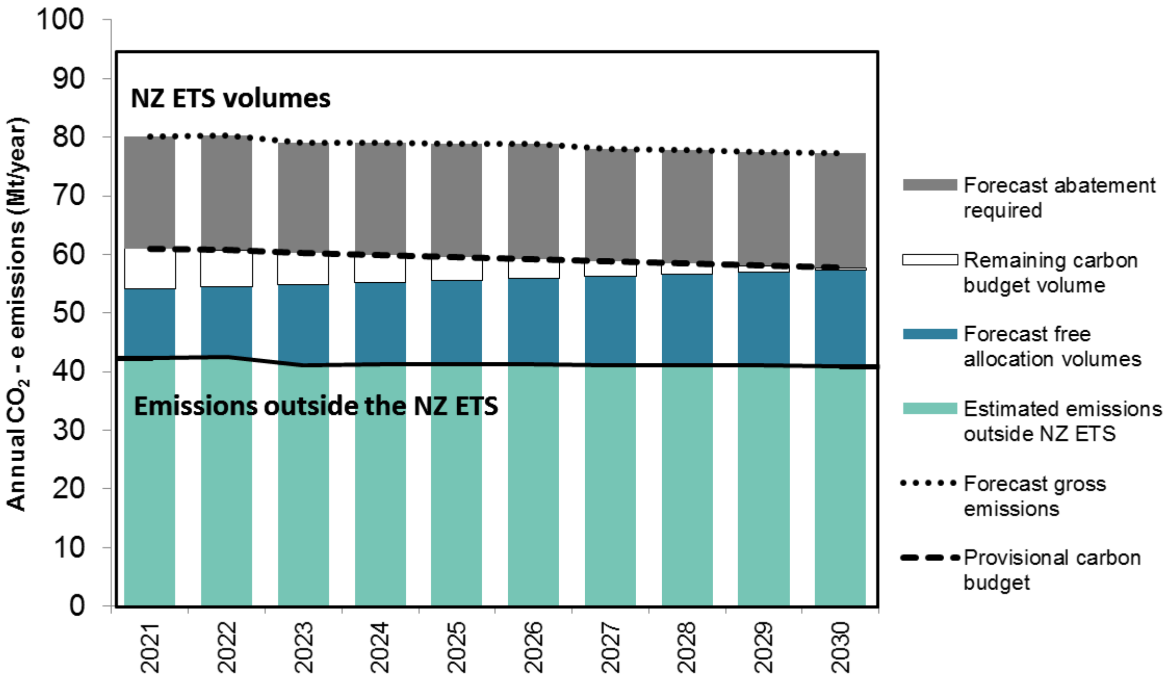

Figure 5: Distribution of the carbon budget under current policies and ETS settings (MFE 2018)

2.4 Productivity commission

The productivity commission was asked to provide recommendations to the government about how New Zealand can minimise risks and maximise opportunities through its transition to a lower net-emissions economy. It also aimed to identify options to reduce domestic GHG emissions. The key questions it acknowledged relating to the ETS were with regards to land use and waste. It questioned whether agricultural emissions should be included, and at what points of obligation – for example, whether the processors or farmers should have to surrender carbon units. It queried the feasibility and cost-effectiveness of adding smaller planting sections into the ETS, such as riparian strips. It also considered the extension of the ETS to cover wastewater plants (New Zealand Productivity Commission 2018).

New Zealand has not yet seen a large drop in gross emissions. Whilst forestry offsets almost a third of these, the planting boom in the 1990s and resulting decline in planting rates means that offsets are likely to decrease in coming years, without a significant increase in planting rates. The report also made the point that a combination of approaches is best suited to achieving New Zealand's long-term emissions goals. Remaining adaptable to future changes whilst giving a degree of predictability with regards to policy was proposed as the best method to ensure the country can effectively deal with new challenges over time. It agreed with other studies that New Zealand can achieve low net emissions by 2050 by relying on three drivers: electrification of the transport network, an expansion of forestry, and changes in the agricultural industry. Net emissions of 25 million tonnes of CO_{2e} in 2050 could be achieved at a cost of between $75 and $152 per tonne of CO_{2e}. Emissions could drop to zero by this time if the cost increased to between $157 and $250 per tonne (New Zealand Productivity Commission 2018).

Any future use of international credits in the ETS must also be carefully considered. If these credits come from reputable sources with a high integrity, their inclusion could be an effective way for New Zealand to meet its emission responsibilities. The point of obligation when it comes to who surrenders units must also be well-balanced, to ensure that neither the consumer nor the producer is placed under undue financial burden. Shifting these points either up or downstream from the source could be a good option to ensure that this load is effectively spread (New Zealand Productivity Commission 2018).

2.5 Market governance of the ETS

A report presented to the Ministry for the Environment in 2017 discussed the ETS with regards to the carbon market, and whether or not this market could be subject to fraudulent activity or money laundering through carbon credits (Covec et al. 2017). It noted the relative lack of market transparency, as well as evidence of poor advice given to small woodlot owners when it came to whether or not to sell the carbon units from post-1989 forests. Again, the lack of government policy and direction was also explicitly questioned. It found that information about the ETS could be found through at least six different websites, resulting in different parties receiving different information depending on where they looked.

The report recommended that market intermediaries be introduced (as carbon brokers) to buy and sell credits, and bridge the gap between suppliers (the government, forestry companies) and customers (those companies with surrender obligations). It also proposed that these brokers be registered with an industry body, and that NZUs become financial advice products under current law.

2.6 Government decisions

Despite the different approaches considered by a number of these reports, there was a general agreement surrounding future solutions to the issue of climate change, especially when it came to the role of forestry. A change in New Zealand's net emissions is clearly possible with a concerted effort through government policy and industry participation. A reduction in agricultural emissions could occur through both technological developments and a drop in livestock numbers. Combined with the electrification of New Zealand's transport fleet and an increase in afforestation, net zero by 2050 is entirely feasible.

From a government perspective, changing the ETS is the key way to achieve these emissions targets sooner, especially through the proposed Zero Carbon Bill. This is planned to be introduced to parliament in October 2018 after public consultation occurred in June/July of 2018. An effective cap on the volume of tradeable emissions would ensure that the value of carbon would be directly related to the number of available units. More predictability with regards to policy was also cited as one way to increase the confidence and number of participants in the scheme.

The 2015/16 government-led review of the ETS led to in principle decisions on four different proposals. These included the auctioning of credits, the re-introduction of international credits to the scheme, an increased price ceiling, and an increase in regulatory predictability when it comes to the ETS' settings and unit volumes (MFE 2018). Changing the accounting approach to allow for the averaging of carbon returns was also proposed as a way to avoid the uncertainty that many forest owners face from the variable price of carbon. The consultation document released in 2018 (Te Uru Rakāu 2018) provided more information about averaging and how this change might affect forest owners.

2.7 Carbon accounting

The current method of carbon accounting is by carbon stock change, where units are earned as the forest grows. When it comes to harvest time, the landowner or entity must surrender units to the government that equal the "deemed emissions", or carbon harvested and taken off site. Because there is always woody biomass and residuals left over after harvesting, a forest that has multiple rotations will eventually show a 'saw-tooth' shape.

However, there can be a large amount of associated risk due to the uncertainty in carbon prices. Because of the time difference between earning and surrendering credits, forest owners are susceptible to changes in the price of carbon, which can drastically influence overall profitability. In 2011 the New Zealand market was flooded with cheap overseas credits, and this had significant effects on the resulting carbon price – for some large emitters the price dropped to just 17 cents per tonne (Carbon Forest Services 2014). The uncertainty in carbon prices presents a financial risk to forest owners, and the complexity of the calculations for carbon stocks and changes (especially if different ages and species are present) does not incentivise selling units throughout a forest's life.

2.8 Averaging

Because of these risks, the government is considering changing the accounting approach employed by the ETS. This proposed new system would be averaging, which essentially gives a consistent value for carbon stocks once a certain age is reached. Asymptotic averaging without harvested wood products assumes that the average value at which new carbon sequestration stops is equal to the average net carbon stock of the second rotation. This results in a stock that increases through a stand's development, before levelling off once this long-term average is reached. It means that no unit liability is faced upon harvesting so long as the area is replanted.

"Asymptotic" refers to the long term trend that occurs during modelling. When a rotation is extended over a few hundred years, the average of the net carbon stock (essentially the 'saw-tooth' shape) tends towards a long-term value. This value is very similar to the second rotation average, as only the first rotation has a different shape due to residuals following harvesting. As such, when the net carbon stock is extended the effects of the first rotation reduce over time. This is best illustrated in Figures 6 and 7.

The long term average changes depending on the rotation age. For the purposes of this project, four ages have been considered in the Gisborne region. These have all been calculated according to the available look-up tables, however the method remains the same and could be replicated for a different set of carbon sequestration values.

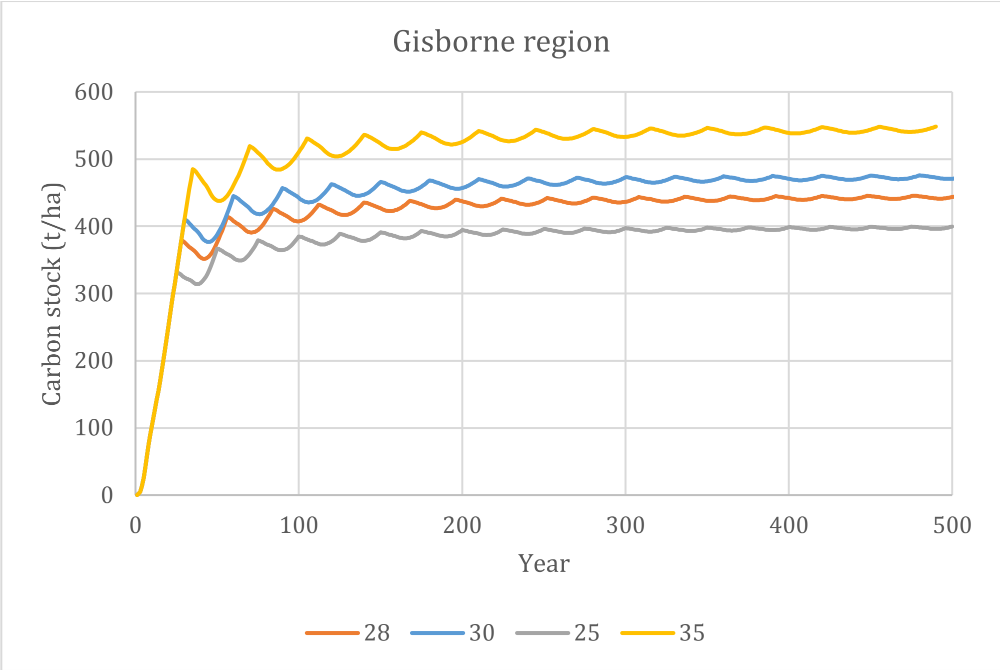

Figure 6: Long-term asymptotic averages for different rotation ages in the Gisborne region

Safe carbon is the term given to carbon which under the current accounting approach, never has to be surrendered. This is assuming that a new forest is planted, and the area remains forested (save for harvesting and replanting). The safe carbon stock level is usually reached after ten years of growth, and represents the intersection between future residual decays from harvesting, and new growth from replanting. The carbon stocks of each accounting method over multiple rotations are shown in Figure 7:

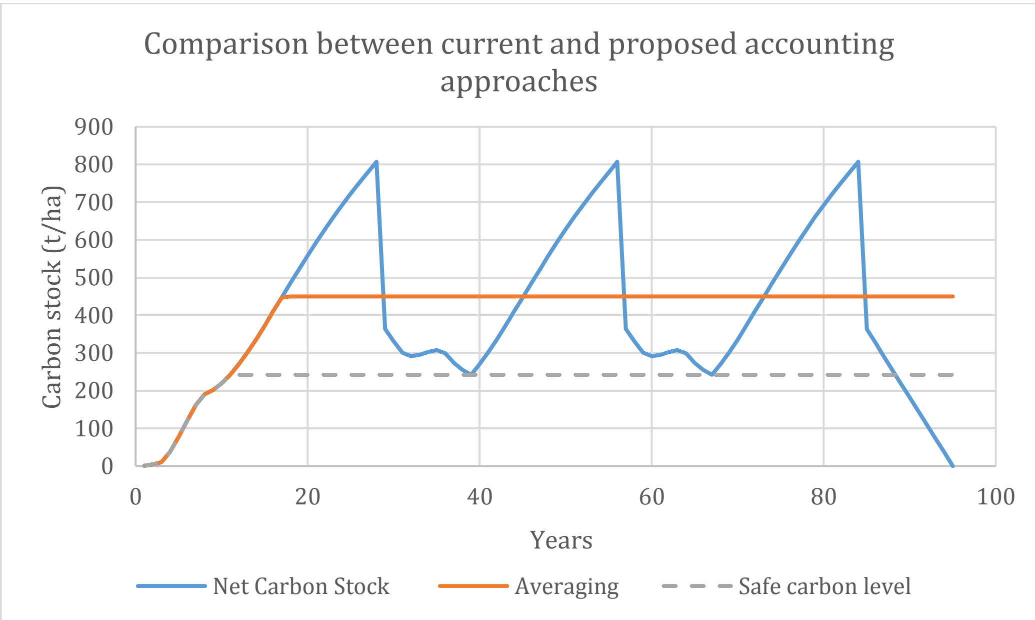

Figure 7: Variations in carbon stock from different accounting methods over multiple rotations. Using averaging essentially shifts the volume of safe carbon up.

3. Methods

Firstly, the effect of averaging in different regions was examined. The look-up tables provided by MPI were compared with regards to the long term average values in Canterbury/West Coast, the Bay of Plenty, and Gisborne. These regions were chosen because they reflect low, medium, and high growth rates respectively (see Figure 16). Different scenarios were then modelled to assess the differences in profitability. These were:

- A single age class forest not involved in the ETS
- A single age class forest in the ETS, with the current accounting approach
- A single age class forest in the ETS, with the new averaging accounting approach
- A plant and leave scenario

Standard discounted cashflow (DCF) analysis was performed in each case to determine profitability. DCF discounts all of the projected costs and revenues over a time period by accounting for the time value of money, giving these future cash flows their equivalent present values. The sum of these incoming and outgoing cash flows then gives the net present value (NPV). A higher NPV represents a more attractive investment, whilst an NPV of zero indicates a rate of return equal to the discount rate used (Investopedia 2018). The discount rate reflects both the time value of money, and the risk premium that an investor demands because future cash flows may not materialise.

$$NPV = \sum_{t=0}^{n} \frac{C_t}{(1+i)^t}$$

Equation 1: Calculating the net present value, where C_t is the cashflow (revenue – costs), t is the number of years, n is the rotation age, and i is the discount rate

The land expectation value (LEV) is another DCF approach which is particularly pertinent to forestry investments, as it calculates the value of bare land becoming a forest in perpetuity. It is especially useful as it can compare two forestry investments that have different rotation lengths.

$$LEV = NPV \times \frac{(1+i)^n}{(1+i)^n - 1}$$

Equation 2: The land expectation value is found by using the NPV and parameters found in (1)

The models developed in this project rely heavily on the carbon look-up tables provided by MPI, and it is generally accepted in the industry that the values in these tables are slightly conservative. The tables only apply to forests less than 100 ha, and for areas larger than this, forest owners must perform their own field measurement analysis to give more accurate carbon sequestration values. As a result, all profitability values have been calculated on a single-hectare basis with carbon inputs from these tables.

3.1 Regional differences

Each region has a corresponding look-up table due to the differences in growth rates around the country. Averaging in three regions was assessed with a 28 year rotation against the current accounting approach to determine how location affected profitability. The Gisborne, Canterbury/West Coast, and Bay of Plenty regions were chosen as their growth rates (and corresponding sequestration abilities) represented a good range. Harvesting costs and revenues were not included in this part of the analysis - rather the carbon cash flows only - hence the limitation here is that the total cost is not assessed. The goal was to look at the approximate differences between regions, rather than the exact profitability values.

3.2 Extended carbon modelling

For a plant and leave-type scenario, a model had to be created that mimicked the growth of radiata pine over a period of more than 50 years, as this is the last value in the MPI look-up tables. A combination of the Pinus radiata calculator, look-up table extension, and curve-fitting was employed to create such a model. This was then applied to the plant and leave scenario to determine the profitability of this situation. An indigenous forest was also assessed using values purely from the look-up tables to age 50.

There is little information available about long-term radiata pine carbon sequestration, so it was assumed that a stand will eventually tend towards a steady-state, mixed podocarp native forest. A NPV projection 150 years into the future was calculated, however the NPV at age 50 is 95% of the value of the NPV at age 150. As such, any fluctuation in the future will have little effect on the NPV because of discounting, so the accuracy of these estimates is not paramount.

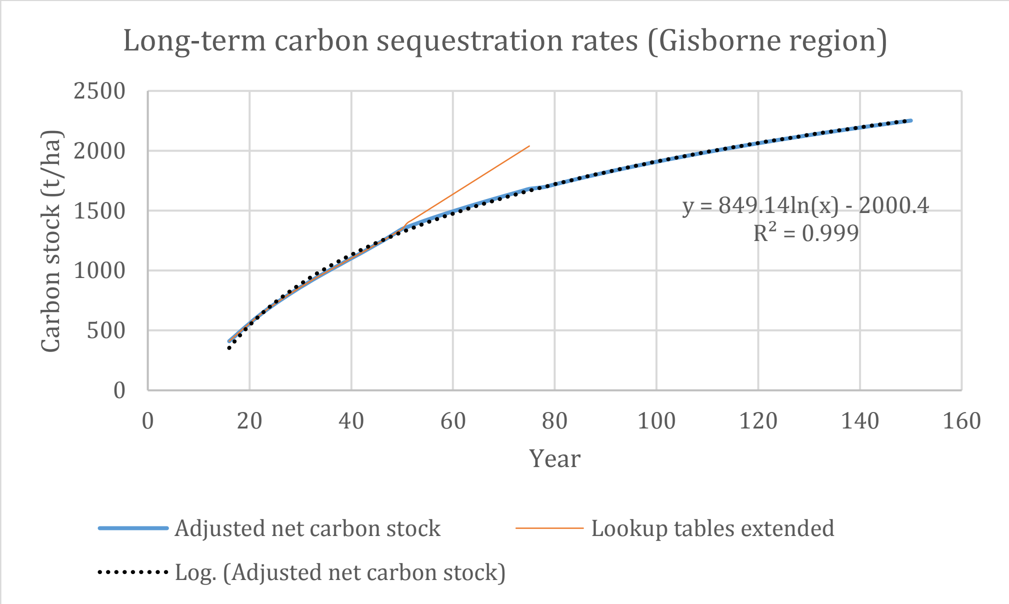

Figure 8: The model that was used to determine future carbon sequestration rates from radiata pine. It is likely that this is a conservative estimate.

3.3 Permanent Forest Sink Initiative (PFSI)

The PFSI is a scheme that the government began in 2007 to encourage long-term planting, especially on erosion-prone land. It involves entering a forest into a legal covenant that requires the land to remain forested for at least 50 years. However, 20% of the total basal area may be harvested at any time (Figure 9), resulting in small fluctuations in the basal area of the forest over time (Te Uru Rakāu 2018). Not all participants in the PFSI will choose to harvest, especially as the scheme allows native and other species to enter and claim carbon units, and not all of these species will be suitable for harvesting.

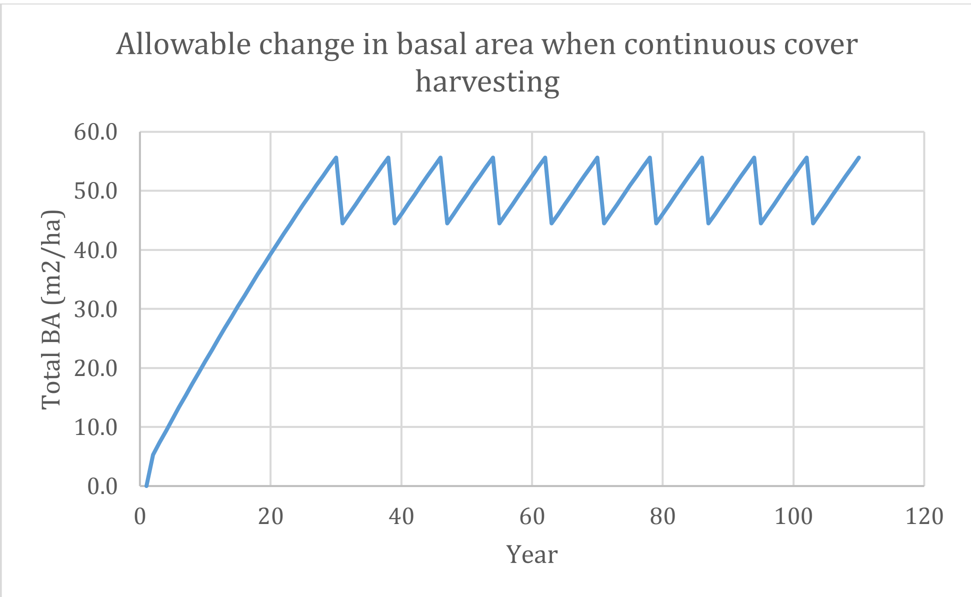

Figure 9: Example of a forest entered in the PFSI scheme with continuous harvesting

The government presented four options regarding the PFSI in the 2018 discussion paper: keeping the PFSI, retaining and improving it, discontinuing it entirely, or discontinuing and replacing it with a new, permanent activity in the ETS (stated as the preferred option). If a new PFSI-type scheme was entered into the ETS, the carbon stock method of accounting would likely be retained, rather than averaging which would presumably apply to the rest of the ETS. This is because there wouldn't necessarily be an incentive to leave forests for longer than a standard rotation age if averaging were employed in a long-term context.

3.4 Data

The MPI look-up tables were used as the basis for carbon modelling, and a carbon price of $20 was assumed (except where stated otherwise). Discounted cash flow analysis was used to provide a forecast of future values. A discount rate of 8% was adopted following 2015 and 2017 surveys (Manley 2018). Industry sources provided indications of approximate annual and ETS compliance costs of $25 and $70/ha/annum respectively. The look-up tables are only usable for forests less than 100 hectares in size, so plotting costs for carbon field measurement analysis were not included as larger forests were deemed beyond the scope of the project. Land costs of $2,000/ha were used, and average harvest, silviculture, and establishment costs as well as recoverable volumes were provided by Professor Bruce Manley. Log prices (Table 2) were taken from the August 2018 Log Price Report (AgriHQ 2018).

Both the costs and log prices chosen had large effects on the overall LEV. Certain assumptions were made that may not precisely represent current or future market conditions. However, it is hoped that the results will show the overall scale of profitability and how different scenarios rank, rather than provide exact values.

Table 2: Log prices (AgriHQ 2018)

Grade	At wharf gate $NZD/m^3
Pruned	185
A	133
KS	124
KI	121
KIS	127
Chip	53

4. Results & Analysis

4.1 Regional variations in long-term averages

Because of the regional variations in radiata growth rates (and therefore carbon sequestration), there are significant differences in the long term carbon averages in each region. Figure 10 shows how the long-term carbon average increases with rotation age in each region:

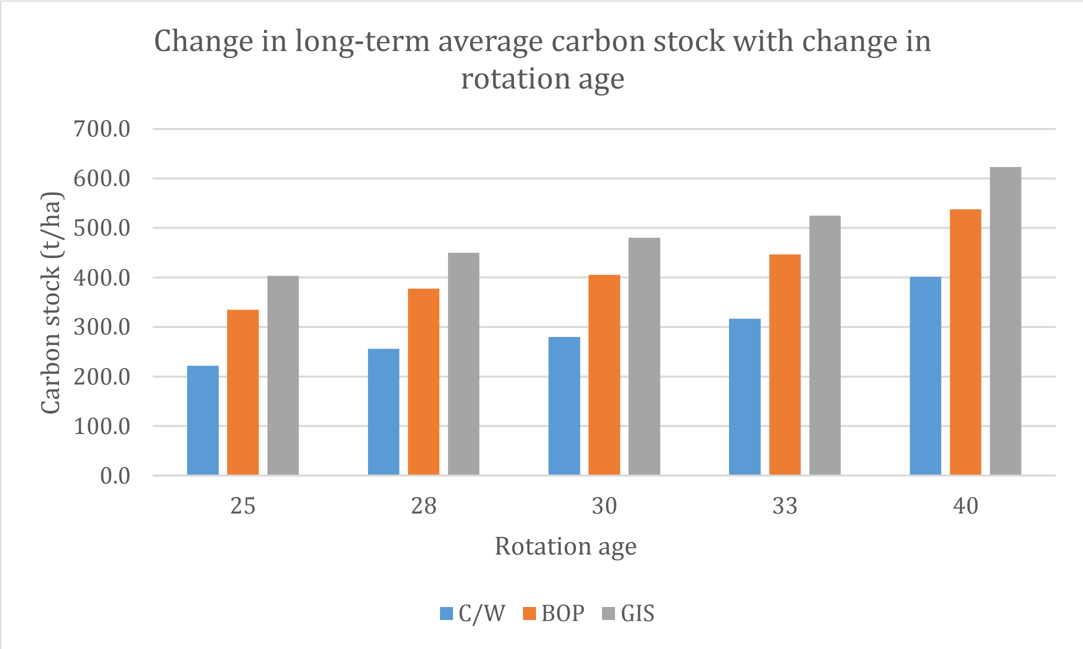

Figure 10: How the rotation age affects the long-term average value in each region

Under the current look-up tables for the Gisborne region, Table 3 results show that the long term average would be reached at age 18, regardless of whether the rotation age was as 28, 29, or 30. This could be beneficial for forest owners who used averaging, as it means that more carbon credits (i.e. the difference between the long-term average at ages 28 and 30) would be received at age 18, rather than a year or two later as is the case in other regions:

Table 3: Differences in the long-term carbon average in different regions

	Rotation age	Long-term carbon average (t/ha)	Age this occurs on look-up tables
Bay of Plenty (BOP)	28	337.4	18
	30	405.4	19
Canterbury/West Coast (CW)	28	256.0	19
	30	279.8	20
Gisborne (GIS)	28	449.9	18
	30	480.2	18

This also occurs in Gisborne between the rotation ages of 33 to 35, shown in Figure 11:

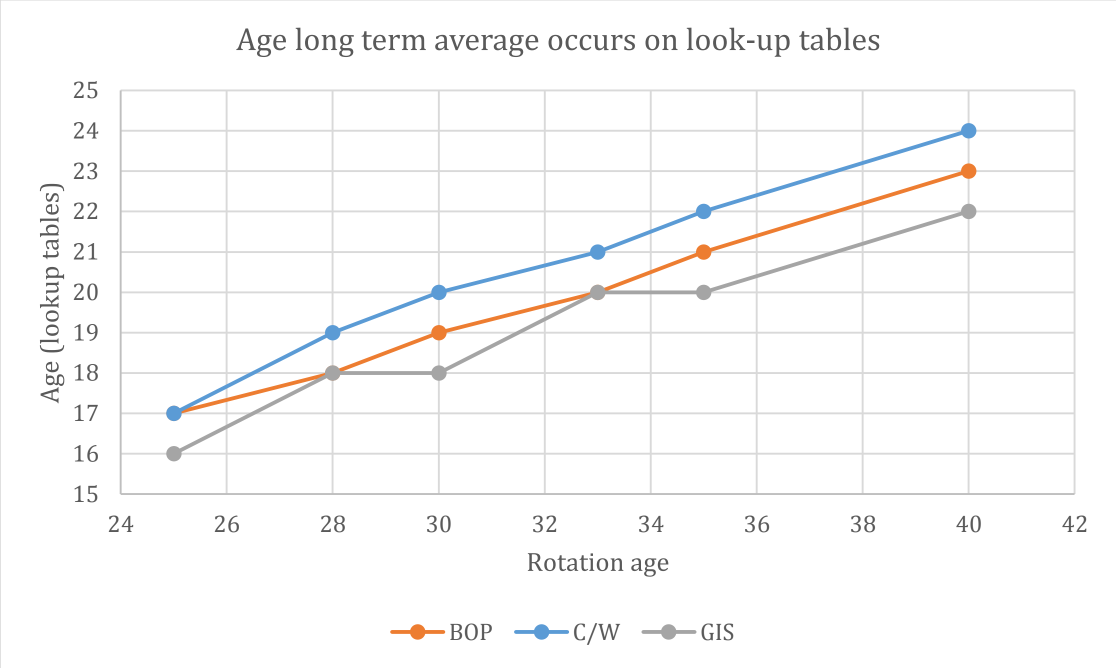

Figure 11: Ages long-term averages could claim carbon until, according to the look-up tables

In its 2018 discussion paper, the government considered the best method to calculate average carbon crediting and storage age. Two options were presented: to provide default tables and long term averages (1), or to set a series of default age bands based on forest type, allowing participants to nominate a rotation age (2). Option 1 does not incentivise increasing rotation age to earn more credits from carbon sequestration, because there is one long-term average which only changes with species or region, rather than rotation age. However, adding different age bands (proposed in option 2) could result in extra administration and complexity. The optimum band length would be hard to determine, as a broad band would lessen the chance of accidentally shifting bands from one rotation to the next, but would also reduce the incentive to increase the rotation age.

A possible solution to these two options would be partially combine them, by creating a new default look-up table that is categorised by region and species. A list of rotation ages and their corresponding long-term carbon averages not dissimilar to Table 3 would then show the exact carbon average for each rotation age.

4.2 Profitability of averaging

Table 4 shows the returns from just forestry and forestry + carbon schemes in the Gisborne region using averaging, as well as the current accounting approach with a 28 year rotation age. The current approach is slightly more profitable than using averaging for the same age.

Table 4: Returns from both forestry and forestry + carbon schemes. All of the values are in $/ha using data for the Gisborne region.

	Forestry only		Carbon only		Forestry + Carbon
Rotation age	NPV	LEV	NPV	LEV	LEV
25	135	159	3702	3705	3863
28	160	181	3956	3959	4140
30	-101	-112	4108	4110	4000
35	-1016	-1090	4438	4441	4351
Current approach (28)		181		4291	4472

Figure 12 shows the trade-off between increasing the rotation age and how this affects returns from both forestry and carbon. The optimum age for a forest involved in the ETS using averaging in Gisborne (which is less than 100ha in size) is 28 years. Whilst the profitability of carbon alone continues to increase over time, the LEV of forestry-only begins to decline as harvesting costs increase.

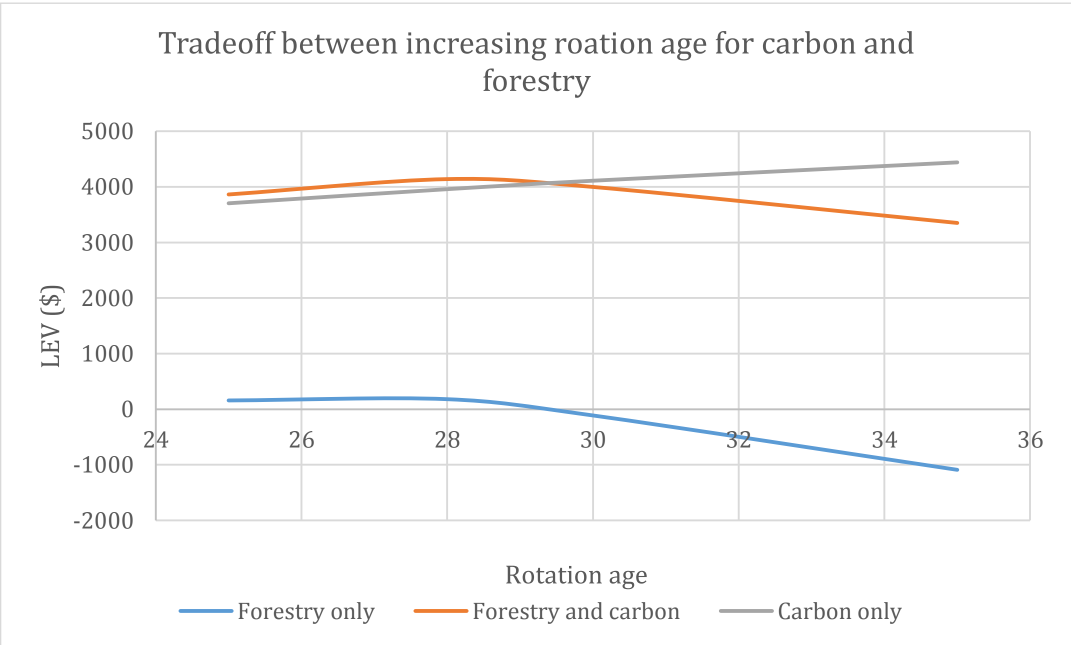

Figure 12: Effect of increasing the rotation age on overall profitability

If the government was to lift the current price ceiling on emissions and the carbon price increased, so too would the profitability of carbon sequestration. The effects of this are shown in Table 5 and Figure 13 respectively:

Table 5: Comparison of LEVs in a forestry + carbon regime as carbon price increases in Gisborne region, assuming averaging

	LEVs ($/ha) depending on price of carbon ($/t)		
Rotation age	20	35	50
25	3863	6877	9890
28	4140	7343	10546
30	4000	7316	10633
35	4351	6916	10481
Current approach (28)	4472	7924	11377

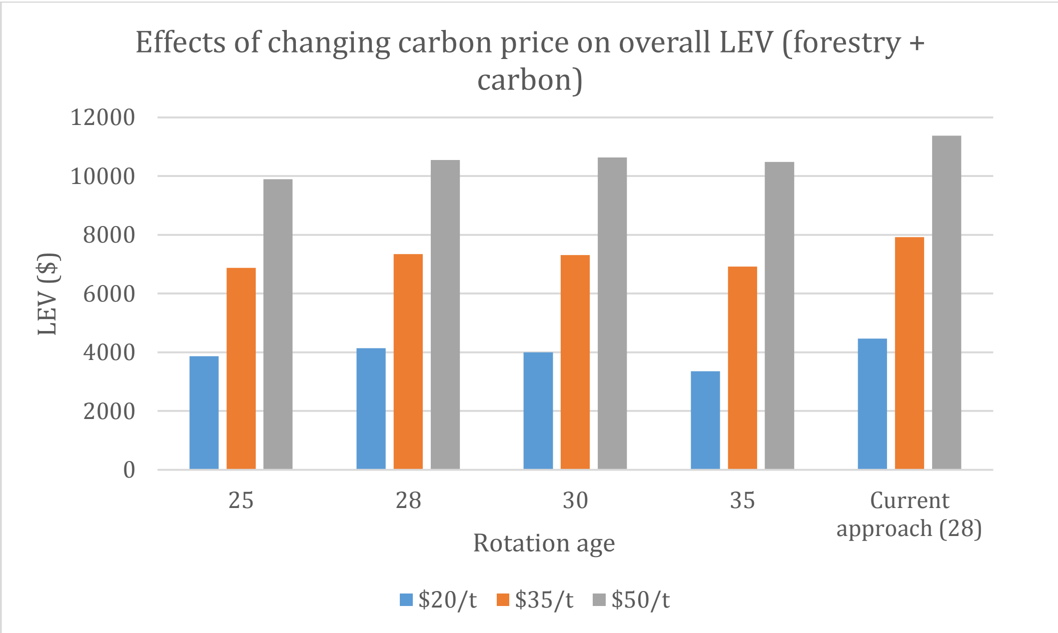

Figure 13: Comparison of LEVs in a forestry + carbon regime as carbon price increases in Gisborne region, assuming averaging

Figure 13 shows that as the carbon price increases, the income from carbon-only increases and begins to counteract the decline in forestry-only LEVs shown earlier in Figure 12. This means that overall profitability fluctuates less over time with an increase in carbon price (Figure 14). However, as previously mentioned, in some situations more credits can be claimed at the same age depending on the look-up tables. This changes the immediate cashflow, but not the long term LEV. Table 6 shows the sum of undiscounted cashflow values seen in Figure 15.

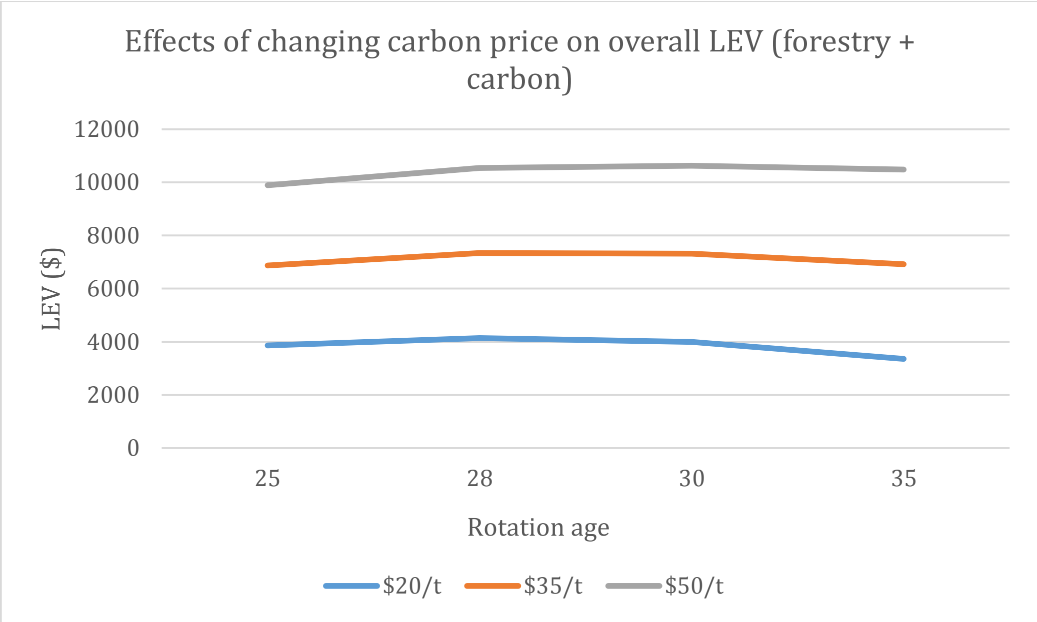

Figure 14: Relationship between LEV and rotation age with a change in carbon price.

Table 6: How cashflow changes with different long-term averages (assuming carbon price of $20/t)

Rotation age	Cashflow from year 16 onwards
25	630
28	1560
30	2160
35	3630

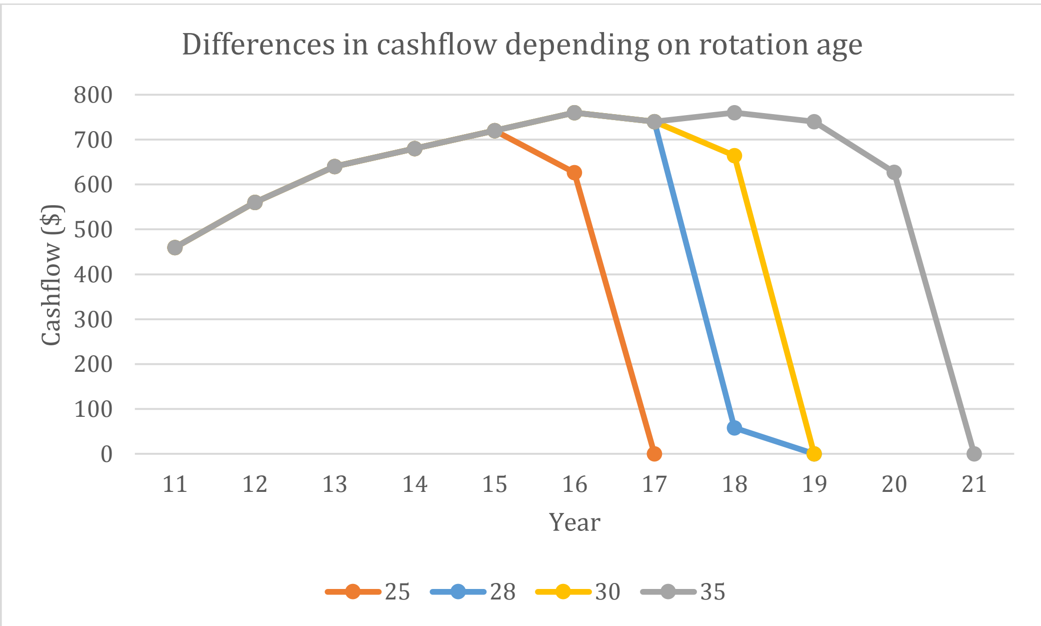

Figure 15: Cashflow for different rotation ages with averaging in the Gisborne region

4.3 Plant and leave scenario

The plant and leave scenario over a 150 year period in the Gisborne region gave an NPV of $1180/ha. Assuming annual costs of $60, this gives a rate of return (IRR) of 10.1%. Table 3 shows the effect of an increased carbon price on NPVs if the government were to lift the current price ceiling of $25/tonne:

Table 7: Profitability of plant and leave scenario given changes in carbon price. Annual costs were assumed to be $60/ha.

Carbon price ($)	NPV ($/ha)	IRR
10	-1920	4.1%
20	1180	10.1%
35	5830	17.2%
50	10490	23.2%

These results show that 'carbon farming' with radiata pine can be profitable. Creating a new category in the ETS for long-term forests which followed a similar carbon sequestration rate to that shown earlier in Figure 8 could be a viable option to encourage afforestation, especially in erosion-prone areas such as Gisborne.

A brief analysis with indigenous species was also carried out to determine approximate profitability. The costs were assumed to be the same as in the previous scenario, and the look-up table values from MPI were used. A 50 year period was used as this is the last value given by MPI. An investor would essentially only break even with a carbon price of around $27 per tonne. Comparisons with radiata pine (also in over a 50 year period) are shown in Table 8:

Table 8: Comparison between indigenous and radiata pine plant and leave scenarios over 50 years (nationwide average from lookup tables vs. Gisborne). The IRR for an indigenous forest with a $10/ha carbon price was nonsensical, as it is impossible for the NPV to ever reach zero due to the inputs.

Carbon price ($/t)	NPV ($/ha) Indigenous	IRR Indigenous	NPV ($/ha) Radiata pine	IRR Radiata pine
10	-4240	/	-1940	3.8%
20	-3470	-2.2%	1130	10.1%
35	-2320	2.9%	5730	17.2%
50	-1170	5.8%	10330	23.2%

It is highly unlikely the costs of establishment and silviculture would be the same for the two different categories. As such, these results are not indicative of exact values. A more likely scenario would assume that the costs of establishing an indigenous forest are higher than that of a commercial pine plantation. A recent study placed native establishment costs at between $5,000 and $10,000 per hectare, compared with $1,300/ha used in this analysis (Davis et al. 2009). This would therefore result in a lower NPV and lower rates of return for an indigenous plant and leave scenario. The similarities between the two NPVs of radiata pine at ages 50 and 150 ($1,130/ha vs. $1,180/ha) further reinforce the effect of time on long-term investments, and that from a purely financial standpoint, what happens in excess of 50 years into the future has very little impact on current profitability.

Further limitations for this analysis also lie in the look-up tables. The current category for native softwood trees is not necessarily comprehensive: the values have been taken from regenerating shrublands dominated by manuka and kanuka and averaged nationwide. MPI recognises that all of the "indigenous forest species are covered within the single generalised forest type, indigenous forest" (MPI 2017). Figure 16 shows a carbon sequestration rate that is less than half of what is sequestered by radiata pine in Canterbury. Because the indigenous values provided by MPI are national averages there are significant limitations with the accuracy of this analysis.

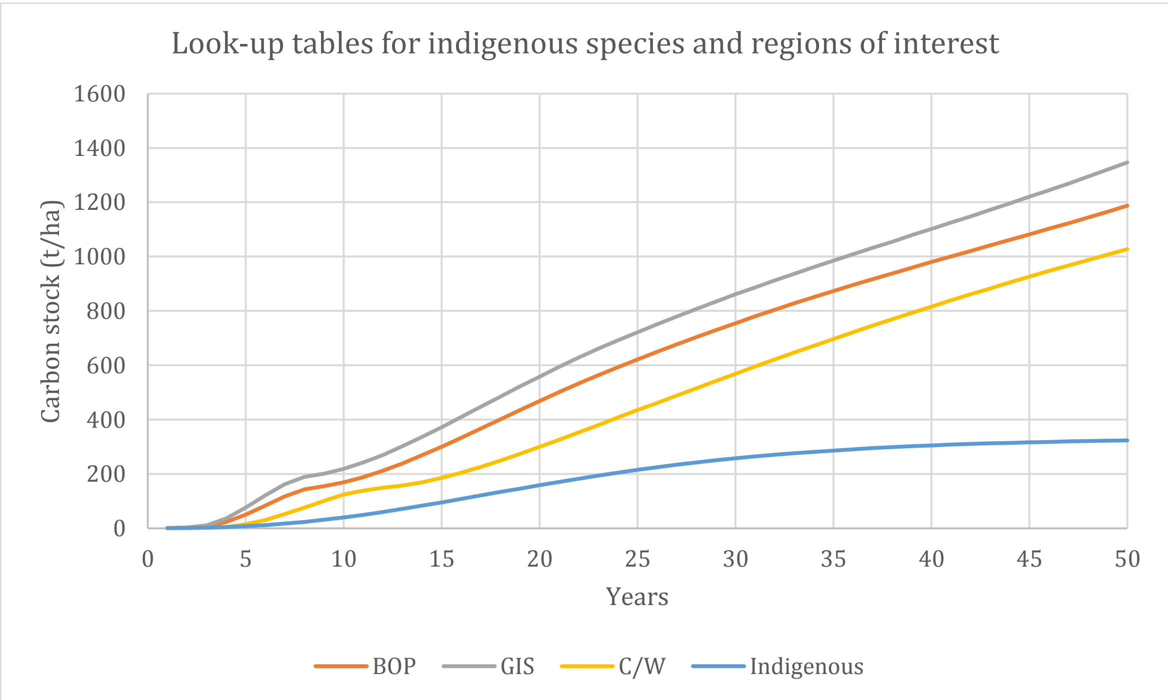

Figure 16: MPI look-up tables (MPI 2017)

The optimum species for a plant and leave scenario essentially depends on what the desired functions of the forest is. A fast-growing, low-cost species such as radiata pine will give the best possible return from carbon. Indigenous forest sequesters carbon at a rate much slower than radiata, so financial returns from carbon will be lower. It may provide other benefits; however, compatibility with the primary goal of carbon sequestration should be considered. Other benefits that indigenous forestry may provide such as biodiversity have not been taken into consideration in this analysis. It is therefore important to establish early what the primary goals of a forest are before planting to ensure that the best outcomes are reached.

5. Conclusions

The two preferred carbon accounting methods for the government have been analysed in this project: averaging for forests that will be continuously harvested, and a long term approach that could replace the PFSI (plant and leave). The key findings are as follows.

When compared to the current carbon stock accounting method, averaging is slightly less profitable for the same rotation age by order of a few hundred dollars per hectare. Profitability increases with a corresponding increase in carbon price, and this price increase also results in less variation in LEV values as rotation age is extended. However, short-term cashflow increases dramatically by increasing the rotation age; this could benefit forest owners in regions such as Gisborne where the credits from different long term averages are claimed at the same age. There is also significant variation between long term averages in the three regions analysed due to the differences in growth rates.

Planting radiata pine solely for carbon can be financially feasible. An increase in the price of carbon increases the profitability of a plant and leave scenario, which retains a positive rate of return even if prices halve to $10 per tonne. It could be a viable option for erosion-prone areas where harvesting is not recommended, especially if the government works to strengthen the framework surrounding it through a new PFSI-type initiative. Indigenous forestry is not as profitable as radiata for a plant and leave scenario due to its comparably low sequestration rates. More work is required to develop an accurate sequestration model across regions and species types, as the current single national average allows for significant discrepancies. Advanced land use planning would also clarify the desired outcomes for marginal areas.

The main limitations from these results lie in the financial assumptions that were made during parts of the analysis, some of which came from forecasted or historical values. Every effort was made to use the most up-to-date inputs possible, however every harvesting operation will be different due to various environmental and market factors. Overall profitability was sensitive to both the costs and log prices used, which should be taken into consideration when interpreting the results. The lack of information surrounding long-term radiata planting also made it difficult to project carbon stock values in the long term. Whilst this had little effect on profitability due to the factor of time (as previously mentioned), it should not be disregarded. There is a risk that using the carbon stock method (rather than averaging) for this scenario could result in future liabilities if a decline in carbon stock occurs through natural mortality or the transition to an indigenous forest.

The objective of this project was to model the financial impacts of the government's proposed ETS changes, and in doing so assess the broad effects on forest owners. There is further scope to investigate indigenous additions to the ETS, as well as provide a more comprehensive set of long term averages for different rotation ages and regions. If the ETS is to remain the key mechanism that encourages afforestation and partially offsets emissions created by other industries, the government must ensure that it is easy to understand and appropriately incentivised to forest owners.

In summary, changes to the accounting approach could, in principle, simplify the scheme and reduce individual risk, whilst generating a small negative effect on overall profit and a potentially large positive effect on cashflow. Encouraging discussion about the overall value of the ETS is critical when it comes to the fight against climate change, with the effectiveness of these proposed changes ultimately being tested through the amount of new planting that occurs in the future on previously non-forested land.

6. Appendices

6.1 Appendix A

Proposed improvements to the Emissions Trading Scheme: Forestry proposals submission form

Forestry - Simplified Accounting Approach for the ETS (A Better ETS for Forestry)

5. Do you agree with the Government's preferred option to continue to require all ETS post-1989 forestry participants with land below 100 hectares to use default look-up tables and those with land over 100 hectares to use the FMA approach to measure carbon storage in their forests? If you disagree, could you please provide your reasons why? What do you think will be the main impacts of this option for you or other land owners?

With regards to averaging accounting, using a default look-up table would provide the most administrative simplicity to Te Uru Rakāu. However, using the FMA is also appropriate for larger forest owners where a generalisation such as look-up values would not be accurate enough. Some consideration should go to the 100 hectare limit, and whether this should be changed to a higher or lower value.

6. Out of the two options presented regarding how to calculate the long term average carbon storage age what is your preferred option? Could you please explain below why it is your preferred option? What do you think will be the main impacts of this option for you or other land owners? If there are other options you think we should consider, please list them below.

When considering the best method to calculate average carbon crediting and storage age, two options have been presented: to provide default tables and long term averages (1), or to set a series of default age bands based on forest type, allowing participants to nominate a rotation age (2). Option 1 does not incentivise increasing rotation age to earn more credits from carbon sequestration, because there is one long-term average which only changes with species or region, rather than rotation age. However, adding different age bands (proposed in option 2) could result in extra administration and complexity. The optimum band length would be hard to determine, as a broad band would lessen the chance of accidentally shifting bands from one rotation to the next, but would also reduce the incentive to increase the rotation age.

Using asymptotic averaging would be the best way to determine a long-term average value for a forest. Asymptotic averaging without harvested wood products assumes that the average value at which new carbon sequestration stops is equal to the average net carbon stock of the second rotation. This results in a stock that increases through a stand's development, before levelling off once this long-term average is reached. It means that no unit liability is faced upon harvesting so long as the area is replanted.

"Asymptotic" refers to the long term trend that occurs during modelling. When a rotation is extended over a few hundred years, the average of the net carbon stock (essentially the 'saw-tooth' shape) tends towards a long-term value. This is very similar to the second rotation average, as only the first rotation has a different net stock due to residuals following harvesting. As such, when the net carbon stock is extended the effects of the first rotation reduce over time. This is best illustrated in Figure 1:

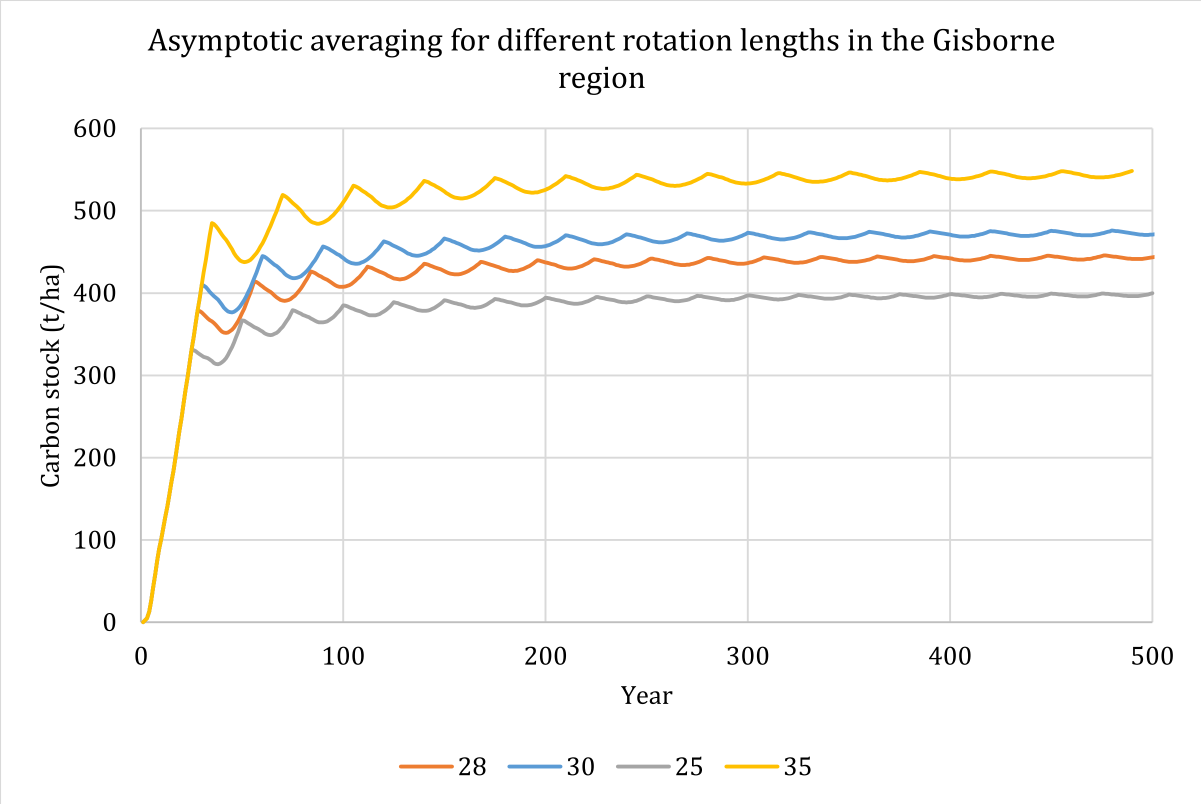

Figure 1: Long-term asymptotic averages for different rotation ages in the Gisborne region, following the MPI look-up tables (radiata pine).

A possible solution to the two options presented by Te Uru Rakāu would be to partially combine them, by creating a new default look-up table that is categorised by region and species. A list of rotation ages and their corresponding long-term carbon averages not dissimilar to Table 1 could then show the exact carbon average for each rotation age. This would ensure that increases in rotation ages were incentivised whilst still maintaining a degree of administrative simplicity due to the default values.

Table 9: Differences in the long-term carbon average in different regions (radiata pine).

	Rotation age	Long-term carbon average (t/ha)	Age this occurs on look-up tables
Bay of Plenty (BOP)	28	337.4	18
	30	405.4	19
Canterbury/West Coast (CW)	28	256.0	19
	30	279.8	20
Gisborne (GIS)	28	449.9	18
	30	480.2	18

A review of the look-up tables and their corresponding carbon sequestration values would be required to ensure their accuracy. For example, because of the current values in the Gisborne region the long-term average values for 28, 29, and 30-year rotations all fall within the same year on the MPI look-up table (18). This means that if averaging were employed, a forest owner with less than 100 hectares in Gisborne would receive more credits per hectare if a 30 year rotation was declared rather than a 28 year rotation. This is as it should be, but the key point is that these different credit values would all be received in the same year. In other words, there would be a financial advantage to declaring a longer rotation age in order to claim the maximum number of credits as soon as possible due to the time value of money.

This could be an advantage for the Gisborne region, to act as an extra incentive for planting radiata pine with extended rotation ages. However, other species and regions should also be checked to determine whether this is a unique case.

Forestry - Creating a Permanent Forests Category in the ETS (A Better ETS for Forestry)

15. Do you agree with the Government's preferred approach to introduce a new activity into the ETS for permanent post-1989 forests? If you disagree, could you please provide your reasons why? Could you also tell us below how you expect this change will affect you or other land owners?

Yes. If the PFSI does not currently have the legal framework to support extensive changes as Te Uru Rakāu suggests, then it should be discontinued and replaced with an additional scheme. Merging the new PFSI into the ETS would provide simplicity in the overall carbon outlook, especially for forest owners who are considering leaving their trees for a period of time longer than a standard rotation. Care must be taken to ensure that there remain benefits to a longer-term or permanent forest, so that it remains a sound investment.

16. Do you agree with the Government's preferred approach to use the existing stock change accounting process for permanent forests? If you disagree, could you please provide your reasons why? Could you also tell us below how you expect this change will affect you or other land owners?

Yes. A long-term carbon storage equation needs to be developed for forests that remain permanent for more than fifty years. Extending the look-up tables would be an easy way to simplify the ETS for permanent forests. An approximate relationship such as the one shown in Figure 2 is an example:

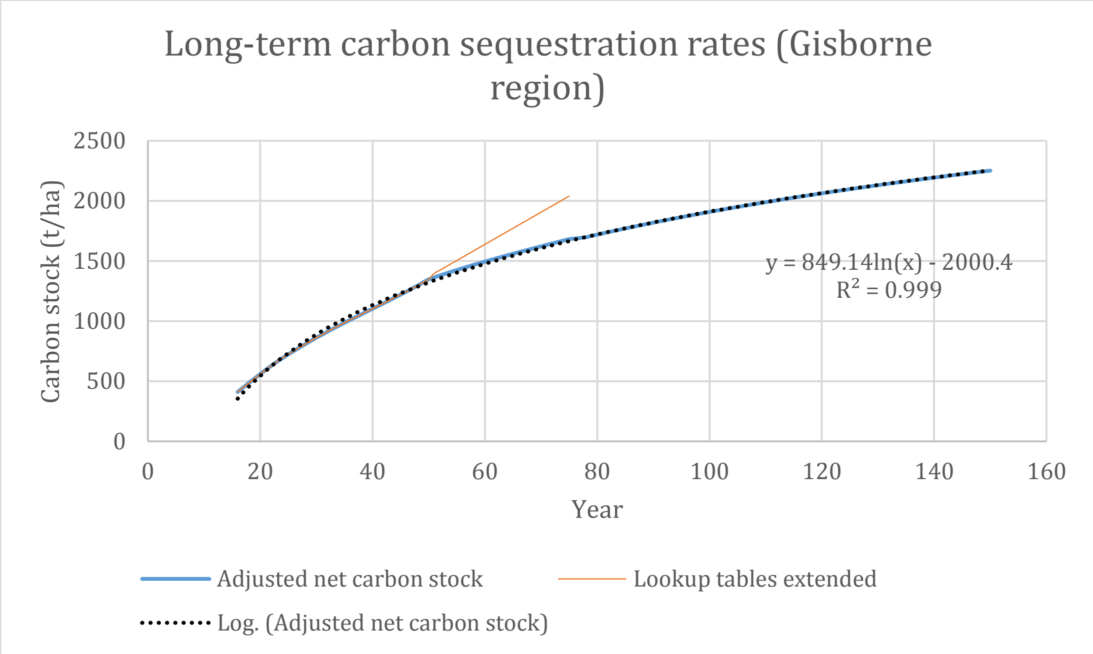

Figure 2: The model that was used to determine future carbon sequestration rates from radiata pine. It is likely that this is a conservative estimate.

18. Do you agree with the restrictions proposed for permanent forests? If you disagree, could you please provide the reasons why? Could you also tell us below how you expect this change will affect you or other land owners?

Limiting the ability to clearfell is key for long-term, permanent forests. However, there may need to be some added incentive for forest owners considering entering into the PFSI (or similar), because of the loss of revenue from clearfell harvesting. This could simply be in the continuous accrual of carbon credits from stock change accounting.

19. Do you agree that 50 years is an appropriate non-harvest period for ETS registered permanent forests? If you disagree, could you please provide the reasons why? Could you also tell us below how you expect this change will affect you or other land owners?

Yes, 50 years is an appropriate non-harvest period.

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