Land Use Options and Economic returns for Marginal Hill Country in Northland

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Northland REGIONAL COUNCIL
Te Kaunihera ā rohe o Te Taitokerau

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Executive summary

This report compares economic returns from pastoral production with plantation forestry on steeper Northland hill country, to help inform decisions on land use change. The economic analysis specifically targets high erosion risk pastoral land and appraises two plantation forest options. These are radiata pine clearfell and permanent tōtara forest. Permanent (continuous cover) forestry offers improved environmental outcomes compared with clearfell forestry, by mitigating erosion and sedimentation of water bodies.

Based on the assumptions as defined in the appendices:

1. New radiata clearfell forestry provides significantly higher returns than pasture at interest rates of between 3% and 10%, a carbon price between $30 and $50 and a transport distance of up to 200km from port. However, if the plantation radiata does not receive emission units under the NZ Emissions Trading Scheme, profitability is only slightly higher than pasture with an interest rate of 7%, especially in the case where the pastoral land use does incur any cost for carbon emissions. As interest rate increases, profitability of forestry land uses declines relative to pasture.
2. Clearfell radiata forestry provides higher returns than permanent tōtara forestry. Profitability for tōtara relative to pasture is dependent on interest rate and carbon price. With a carbon price of $50, at a 10% interest rate totara is less profitable than pasture, whereas at a 3% interest rate tōtara is between 2 – 4 times more profitable than pasture, depending on whether the pastoral land use faces carbon emission costs.
3. By subsidising half of the establishment cost for permanent tōtara forest (e.g. via soil conservation grants) tōtara becomes more profitable than pasture at all interest rates and carbon prices, even where cost of pastoral carbon emissions is excluded from the analysis. This is because of the long period of time between the capital outlay for planting and income from tree harvest. Unless the initial capital expenditure is subsidised, the "time value of money" compromises profitability.

Introduction

Good land use decisions depend on being well informed and understanding the tradeoffs between profitability and environmental sustainability. Importantly, soil erosion and resulting sedimentation of water bodies negatively affect both the environment and the landowner's bottom line.

Sedimentation is the key water quality pollutant in Northland. Eroding steepland soils generate significant quantities of sediment that enters water bodies causing environmental degradation. For example, 70% of the sediment load entering water bodies comes from only 23% of the Kaipara Catchment with a slope of greater than 16 degrees (Sorenson & Mitchell, 2018). This steeper land offers the lowest hanging fruit in terms of addressing sedimentation in Northland.

Once an erosion event occurs the productivity of the eroded land is permanently impaired, regardless of land use. Prevention of erosion retains farm soil capital and the land's productivity into the future. Forest cover mitigates erosion and retains soil capital. The question is, can environmental outcomes and economic returns both be improved by converting steep erodible farmland to plantation forestry?

Productivity of land in context

To achieve both the environmental and economic sustainability of farming systems, a site-specific mosaic of land uses may be required across the rural landscape in Northland. Forestry and grazing can complement each other at both the farm and landscape scale within a mosaic that ultimately has the potential to:

- spread financial risk for the landowner by diversifying investment;
- reduce the environmental footprint of individual farms; and
- improve the overall sustainability of pastoral farming in the region.

However, for land owners to be confident that land use change offers both financial and environmental benefits, careful analysis of returns is required for competing land uses according to slope and productivity.

Pastoral land use and stock carrying capacity

Factors that determine the stock carrying capacity of land include soil type, slope, aspect, climate, pasture quality and required fertiliser inputs. Slope is a key determinant for pastoral productivity, with Praat (2011) reporting that the stock carrying capacity in Northland reduces from 11 stock units on moderate sloping land to 6 stock units per hectare for steep land.

As slope increases, expenses such as fertiliser, fencing, water reticulation and weed control will eventually exceed the returns from grazing, which combined with higher levels of erosion, topsoil and nutrient loss results in the generation of more water-borne sediment. This loss of soil negates the effects of fertiliser applications to the point where the land should be retired from pastoral production or a change of land use considered.

Plantation forestry as an alternative land use

Trees are a more environmentally sustainable option than pasture on steeper slopes, because they reduce erosion, retain the topsoil and preserve natural soil fertility over time, with little if any fertiliser inputs required (Satchell, 2018). However, clearfell harvesting will generate sediment for a period of time before the replanted forest achieves canopy closure, from soil disturbance and as tree roots decay.

The tree species employed and the method for harvesting both influence the level of erosion and sedimentation. Faster-growing species tend to be harvested with a higher frequency and may therefore generate higher levels of sediment. In addition, clearfell harvesting produces significantly higher levels of erosion than continuous cover forest harvesting (Satchell, 2018).

Exotic timber species tend to grow much faster than native species. The economic case for selecting indigenous or exotic species will likely depend on the land owner’s time horizon for a return on investment, the relative cost of establishing the forest and the expected returns from the timber. Payments for accrued forest carbon may improve the attractiveness of slower-growing species to the investor, especially if they value co-benefits such as biodiversity and control of sediment. Land owner preferences for amenity values may also influence species selection.

Plantation forests and carbon

Revenue is available to growers of new forest on pastoral land from the accumulation and sale of carbon units under the New Zealand Emissions Trading Scheme (NZ ETS). Two methods are used in this economic analysis for classifying such forests:

1. Standard post-1989 forest for clearfell radiata pine – the ‘averaging’ option.
2. Indigenous post-1989 forest (tōtara) – the ‘permanent forest’ option.

Both accounting rules offer options to harvest without incurring carbon liabilities.

Standard post-1989 forest (averaging) under the ETS

Under the new ETS rules, growers of new clearfell forest on pastoral land will receive New Zealand Units (NZUs), up to an average level of carbon storage from growth and clearfell of their forest over time. Provided the forest is replanted and managed into the future on the same rotation, participants face no liabilities at harvest and earn no more NZUs for subsequent rotations. The forest can be harvested and replanted without the participant needing to buy NZU's.

Permanent forests under the Emissions Trading Scheme

Permanent forests (i.e. "continuous cover forests") may not be clear-felled and must keep a minimum of 30 percent of the canopy (per hectare) for at least 50 years. Because permanent forests use carbon stock-change accounting, participants earn NZUs as trees grow, but they also need to surrender NZUs upon harvesting or deforestation. As carbon is sequestered by the forest more units are earned and harvest liabilities increase, providing a strong financial incentive to maintain a higher canopy (tree crown) cover.

By highlighting environmental co-benefits, NZUs identified and tagged as coming from a permanent forest could even command a price premium in the carbon market.

Economic analysis

This economic analysis compares returns from pastoral land on steep erodible slopes with plantation forestry. Net returns are estimated for erodible land under three land use scenarios:

- Pasture;
- Radiata pine clearfell, including carbon revenue from averaging; and
- Tōtara permanent plantation forest, including carbon revenue from permanent forest accounting. The tōtara plantation option includes a nurse crop of manuka which provides early income from honey production.

When comparing returns from the two afforestation options with pasture, the foregone benefit or opportunity cost of continuing with pastoral production provides the benchmark for financial comparison.

Because of the long-term nature of tōtara production forestry, returns for each land use are compared over 150 years. Returns from the three land uses (pastoral production, radiata clearfell, permanent tōtara plantation) are estimated by compounding net annual returns forward with interest for 150 years, including approximately five 28-year radiata pine rotations with one year fallow between each rotation. That is, for comparative purposes all net returns for each land use are assumed to be saved and earn interest over time.

The central analysis uses a carbon price of \$30 per tonne (CO_2 equivalent) and a real interest rate of 3% per annum. A sensitivity analysis also provides returns for a range of carbon prices and interest rates, to show how these influence relative returns.

The model is intended to provide insight, not forecasts. Although the results in this report represent the author's best projection of long-term returns from each land use, the user of these results must exercise care and judgment in their accuracy. Future returns will vary significantly from the results presented here because of the long timeframes involved. The purpose of this study is to put the competing land uses on an economic "level playing field", to directly compare relative returns with all other factors being equal, while acknowledging the high level of uncertainty. It is acknowledged that:

1. The fundamental assumption, that market changes would affect all land uses equally, is not tenable. This can be illustrated hypothetically: Demand for meat products may decrease over time because of a global trend towards vegetarian diets, while timber as a carbon sequestering natural material might increase in

price relative to meat, at the same time that demand increases and supply from natural forests decreases because of environmental concerns about endangered species habitats.
2. It cannot be expected that an interest rate or carbon price will remain stable over 150 years.

Details of the assumptions made to provide an economic "level playing field" between land uses are described in Appendix 1: General economic assumptions.

Carbon

To provide a level playing field between costs and revenues for farming vs forestry, biotic sources and sinks of carbon are included in the economic analysis as costs and revenues. Therefore carbon emissions from livestock are assumed to be a cost of farming in the central analysis. The model has also been run with these costs excluded, to measure their effect. The level to which the New Zealand agricultural sector will be exposed to the costs this country faces for emissions is difficult to estimate because of the political nature of such decisions.

The Government has committed to providing 95 per cent free allocation of emissions units if agricultural emissions were included in the NZ ETS (MfE, 2019). This means the agriculture sector would for the short term only be exposed to 5 per cent of the costs of their emissions. Free allocation (where the Government provides emissions units to emitters at no cost) is used to mitigate negative impacts on international competitiveness for the agricultural sector. However, because the cost of carbon emissions is picked up by the NZ taxpayer and land use change is influenced by costs, the current status of agriculture largely remaining free of emission liabilities cannot be assumed to be "safe" into the future.

Pastoral farming

For this report net returns per hectare from pastoral farming were quantified as Earnings (Profit) Before Interest, Tax, Rent and manager wage (EBITRm, see Appendix 2: Pastoral farm earnings). EBITRm is a metric used by Beef + Lamb NZ for measuring farm returns, defined as gross farm revenue less farm operating expenditure less depreciation. Land rental costs or mortgage interest is therefore not included.

Radiata pine clearfell

Cost and income data for a radiata pine clearfell regime was produced using the ZBase model (Jenkins, 2017). Estimates were sourced on returns for radiata clearfell forestry for steep land with high erosion risk (hard access, high forest costs, low site yield) and distance to port of 100 km. These costs take into account estimates of tracking costs and harvesting difficulty. See Appendix 5: Costs and returns for radiata pine clearfell.

Under the averaging accounting rules for clearfell harvesting, "… the participant will account for the long-term changes in carbon in their forest. This means participants will earn NZUs up until their forest reaches its long-term average carbon storage (based on several cycles of growth and harvest). Participants will not usually need to pay any NZUs back to the Government when they harvest" (MPI, 2019). The Ministry for Primary Industries (MPI) have not yet finalised what the average age is for a radiata forest in Northland harvested at 28 years old, but for this analysis it is assumed to be 17 years, which equates to 435 tonnes of carbon per hectare based on the Auckland/Northland lookup tables (MPI, 2017).

Native forest (continuous cover/permanent forest)

Establishment cost estimates for a tōtara plantation with a mānuka nurse crop are provided in Appendix 4: Costs and returns for tōtara plantation.

A model for carbon and accumulated volume as a continuous cover (permanent) forest is provided in Appendix 4: Costs and returns for tōtara plantation. This model uses predicted growth for tōtara plantations provided by Horgan and Bergin (2017) rather than carbon accrual from the MPI lookup tables for Indigenous forest. This is because the MPI lookup tables grossly underestimate accumulated volumes for plantation tōtara when compared with empirical models developed by Tāne's Tree Trust.

Tōtara trees are planted at 833 stems per hectare (sph) and it is assumed these will not require thinning or pruning.

Returns as stumpage for tōtara logs are conservatively estimated at $200 per log cubic metre (Dunningham et al, 2020).

Mānuka trees are interplanted with the tōtara as a nurse crop at a rate of 1,666 stems per hectare. Because of the side shading provided by the manuka nurse crop it is assumed that it is not necessary to form prune the tōtara. Honey production from the mānuka nurse crop is limited to the first 20 years, which is the age when the tōtara begin to out-compete the mānuka. It is assumed that nectar production from planted manuka on hill country farmland is a bell-curve and peaks at year 10 (Figure 1).

Results and discussion

The focus of this report is to produce returns for the two forestry land uses, relative to existing pastoral land use in steep erodible Northland hill country. Since the landowner can choose to earn annual interest rather than invest in a forest, the comparison must take into account the returns from each land use over the long period of forest investment. Table 1 shows relative profitability under the central analysis of 3% per annum real interest and $30 per NZU carbon price for a 150-year time period:

Table 1: Relative profitability of new forestry land uses compared with existing pasture (3% pa interest and $30/NZU carbon price)

	Radiata clearfell forest (excluding sale of carbon)	Radiata clearfell forest (including sale of carbon)	Tōtara permanent forest (including sale of carbon)
Excluding cost of pastoral carbon emissions	141%	278%	141%
Including cost of pastoral carbon emissions	204%	403%	204%

Radiata pine provides the highest profitability, with tōtara more profitable than pastoral grazing under this low interest rate scenario. Plantation forestry, as would be expected, shows increased profitability relative to pastoral production once the cost of carbon emissions is included as a cost in the pastoral grazing land use regime.

Forestry, being a long-term crop that can take decades to mature and produce returns for the grower with a high up-front investment, is highly sensitive to the time value of money (i.e. interest rate). Existing pasture on the other hand, tends to produce returns annually while the historical costs incurred in breaking in the land, such as land clearance, fencing and capital fertiliser become tied to land value rather than being a year one cost of production tied to this year's returns. Over time, regardless of land use, the initial costs of executing the land use change diminish into the past. To be consistent between land uses, the costs of permanent land use change should perhaps be written off from any future value the new land use (i.e. permanent forest) offers.

If the land-owner can avoid the initial cost of establishing the permanent tōtara plantation (e.g., by receiving a soil conservation planting grant), and can accrue carbon units for the growing permanent forest along with income from manuka honey in the early years and timber as the tōtara forest matures, profitability relative to pastoral land use is significantly higher than pastoral land use alone (Table 2).

Table 2: New tōtara plantation permanent forest excluding establishment costs, compared with existing pasture

Tōtara plantation permanent forest		Excluding cost of pastoral carbon emissions	Including cost of pastoral carbon emissions
$30 carbon price	3% pa interest	271%	393%
	7% pa interest	264%	376%
	10% pa interest	266%	374%
$50 carbon price	3% pa interest	323%	667%
	7% pa interest	294%	586%
	10% pa interest	286%	554%

If the land-owner incurs half the cost of establishing the tōtara plantation (e.g. from a soil conservation grant), and can accrue carbon units for the growing permanent forest along with income from manuka honey in the early years and timber as the tōtara forest matures, profitability relative to pastoral land use remains higher than pastoral grazing for most interest rates and carbon prices (Table 3).

Table 3: New tōtara plantation permanent forest excluding 50% of establishment costs compared with existing pasture

Tōtara plantation permanent forest		Excluding cost of pastoral carbon emissions	Including cost of pastoral carbon emissions
$30 carbon price	3% pa interest	206%	299%
	7% pa interest	116%	165%
	10% pa interest	57%	80%
$50 carbon price	3% pa interest	257%	532%
	7% pa interest	146%	291%
	10% pa interest	77%	149%

Sensitivity analysis – interest rate and carbon price

Table 4 shows how a range of interest rates and carbon prices influence relative profitability under the scenario where the land-owner plants a bare pastoral site in trees, registers for the ETS and sells accrued carbon and harvested logs:

Table 4: Relative profitability of new plantation forest vs existing pasture

		Radiata clearfell forest		**Tōtara permanent forest**	
		Excluding cost of pastoral carbon emissions	Including cost of pastoral carbon emissions	Excluding cost of pastoral carbon emissions	Including cost of pastoral carbon emissions
$30 carbon price	3% pa interest	278%	403%	141%	204%
	7% pa interest	242%	345%	Not profitable	Not profitable
	10% pa interest	202%	285%	Not profitable	Not profitable
	3% pa interest	371%	767%	192%	397%

$50 carbon price	7% pa interest	388%	772%	Not profitable	Not profitable
	10% pa interest	363%	703%	Not profitable	Not profitable

Higher interest rates tend to reduce profitability of tōtara permanent forest because of the high up-front costs of establishing the forest and the long time period before receiving harvest revenues.

If the land owner does not register for the ETS or is planting clearfell radiata pine on pastoral land that cannot accrue emissions units, interest rate has a much higher effect on relative profitability (Table 5).

Table 5: New radiata clearfell forest profitability compared with existing pasture where the new forest is not entered into the ETS

Radiata pine clearfell land use with 100 km transport distance			
	Pastoral land not incurring cost of carbon emissions	Pastoral land use incurs cost of carbon emissions ($30 carbon price)	Pastoral land use incurs cost of carbon emissions ($50 carbon price)
3% interest rate	141%	204%	292%
7% interest rate	26%	37%	52%

Forestry produces higher returns if the establishment expenses are lower and the rotation length is shorter. On steeper hill country radiata pine tends to be less productive in terms of annualised volumes, and the costs of extraction and transport tend to be higher, especially when distance to market increases. By increasing the transport distance from 100 km to 200 km, stumpage at 28 years decreases from $18,178 to $9,499 per hectare. However, profitability is still very high relative to pastoral land use (

Table 6).

The relative profitability is far more sensitive to carbon price than interest rate. Indeed, without the carbon revenue, steep hill country radiata clearfell forestry with a transport distance of 200 km produces positive returns only at the 3% pa interest rate.

Table 6: New radiata clearfell forest profitability compared with existing pasture where the new forest is entered into the ETS

Radiata pine clearfell land use with 200 km transport distance			
		Excluding cost of pastoral carbon emissions	Including cost of pastoral carbon emissions
$30 carbon price	3% pa interest	184%	266%
	7% pa interest	191%	272%
	10% pa interest	171%	242%
$50 carbon price	3% pa interest	276%	571%
	7% pa interest	337%	671%
	10% pa interest	332%	644%

However, it is important to understand that carbon units are effectively generated from cashing up part of the pastoral land's capital value (i.e. the land value reduces once carbon units are sold). Although the total asset value should increase for a permanent forest by converting land value to tree value, the asset value only produces returns if sold.

Of course, carbon values can change as a result of market forces (demand and supply), but once carbon units are received they cannot earn interest. Only once the units are sold can their value be realised and invested to earn interest, which then compounds. A decision to delay changing land use from pasture to forest is equivalent to the loss of benefit from planting the land in trees now and earning interest from cashing the carbon. This is an opportunity cost that land owners may not currently consider when making land use decisions.

Conclusions

Financial returns from converting pasture to forestry will likely exceed those from continuing to graze steep pastoral hill country in Northland. The results in this report offer landowners some confidence that they can change land use from pasture to forestry on steep erodible hill country in accordance with environmental drivers, without reducing the financial viability of their whole farm operation. Although permanent native forestry offers lower returns than clearfell radiata, clearfell forestry produces less environmental benefit, so choosing a forest type (permanent vs clearfell) is a tradeoff between the environment and profit.

Carbon is an important component for including in land use decision making. The opportunity to accrue and sell carbon units opens opportunities for land owners to plant trees on steeper slopes that would otherwise give poor returns. We are entering a brave new world with a market-based strategy for mitigating greenhouse gases and where the toolbox encourages a mosaic of land uses that achieve regional economic goals and environmental aspirations while also meeting land owner's needs.

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Appendices-Economic assumptions

Appendix 1: General economic assumptions

1 m³ wood stores 1 tonne CO_2

Carbon units are traded as they become available (every 5 years).

All expenditure, revenue and net returns are before tax and GST. The implications of tax on land use returns and interest are not considered in the analysis. This is consistent between land uses.

Management cost is assumed to be equal for each land use and not considered in the economic analysis.

Land value is not included in the economic analysis. It is assumed that the land is freehold and unencumbered for all competing land uses.

NZ ETS participation costs are assumed to be $488 to register and $86 for each return. Because the analysis is per hectare, assumed land area registered is 10 hectares, thus $8.60 per hectare cost for a return.

Interest is assumed to be real interest rate (excluding inflation).

Appendix 2: Pastoral farm earnings

Quintile Analysis Ranked by Earning Before Interest, Tax, Rent and manager wage per hectare (Beef + Lamb New Zealand, 2019, Table 7):

Table 7: Pastoral earnings (Source Beef + Lamb NZ)

Earnings Before Interest, Tax, Rent and manager wage (EBITRm) 2018-19							
	Unit	Q1 low	Q2	Q3	Q4	Q5 high	Mean
Class 4 Hill Country Northland.	$/ha	-10.87	216.13	331.49	409.94	695.39	347.45

Earnings Before Interest, Tax, Rent and manager wage (EBITRm) is defined as Gross Farm Revenue less Farm Operating Expenditure less depreciation[1].

Class 4 North Island Hill Country is defined as easier hill country or higher fertility soils than Class 3, carrying between eight and thirteen stock units per hectare[1]. Class 3 North Island Hard Hill Country is defined as steep hill country or low fertility soils with most farms carrying six to nine stock units per hectare[1].

Mean EBITRm was adjusted for steep land in Northland using data from Praat (2011):

Table 8: Pastoral productivity according to slope

Contour	Pasture production (KgDM/ha/yr)	SU/ha	Product/ha (kg)
Moderate	7250	11	250
Steep	4350	6	150

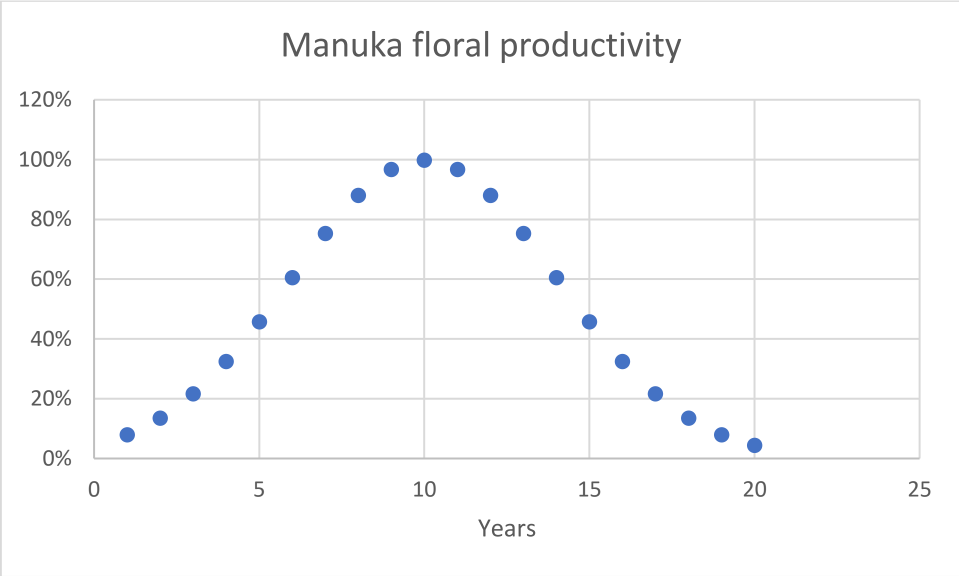
This data provides a 6/10 adjustment to EBITRm to reflect the lower productivity of steep hill country. Pastoral earnings (EBITRm) used for this analysis = $208.47 per hectare.

Carbon costs are based on emissions of 0.37 tonnes CO2 equivalent per stock unit per annum (Timar and Kerr, 2014).

Appendix 3: Manuka nectar production

In the absence of data on floral productivity for manuka plantations of different ages, this is assumed to be a bell curve with peak productivity at 10 years old and a normal distribution, with a standard deviation of 4:

Figure 1: Estimated manuka floral nectar production curve



Net returns from floral manuka production for honey are assumed to peak at $1360 per hectare at year 10, based on estimated revenue of $2060 per hectare per year, less hive costs of $700 per hectare per year (Kauri Park Nurseries, 2017).

Appendix 4: Costs and returns for tōtara plantation

The manuka nurse crop is planted at 1,666 stems per hectare. Cost per tree is $0.80

The tōtara crop is planted at 833 stems per hectare. Cost per tree is $1.20

Pre-plant spot spraying of herbicide costs $0.50 per spot (2,499 spots)

Planting cost is $0.80 per tree (2,499 trees)

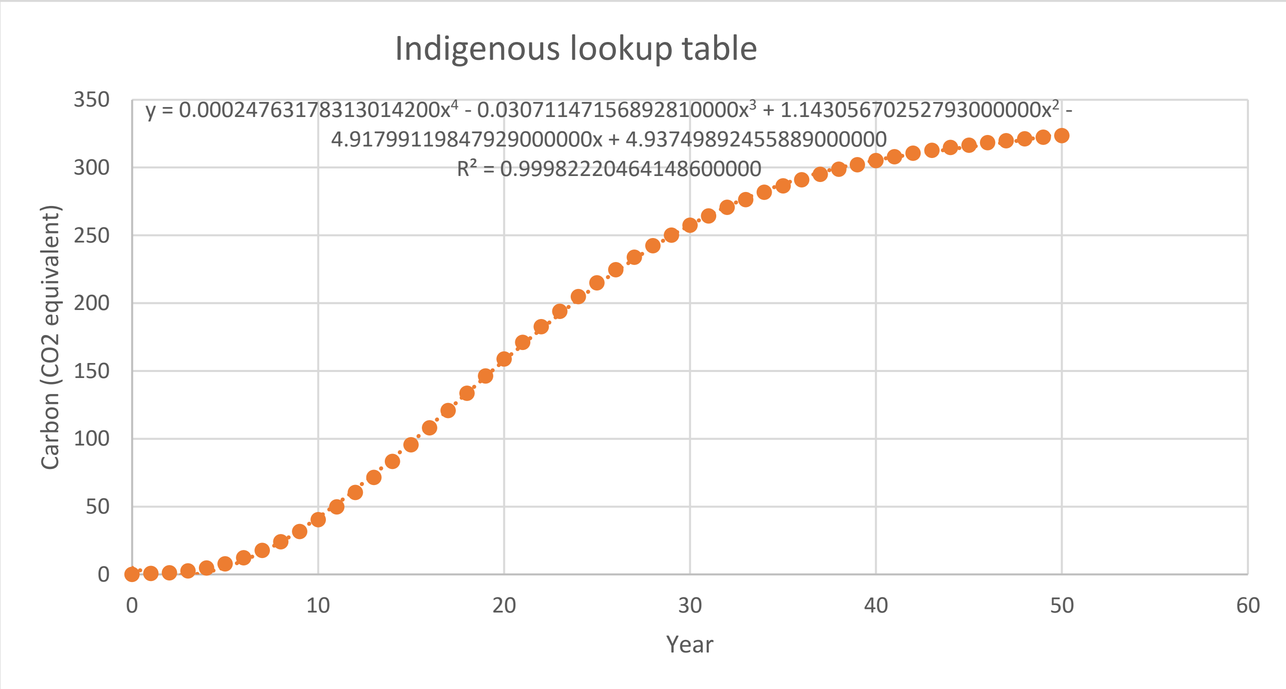
Bamboo canes for tōtara cost $0.20 (833 trees)

Release spraying is undertaken twice in the first year on all trees (cost $0.50 per tree)

Release spraying in the second year is undertaken twice on all tōtara trees (cost $0.50 per tree)

Stumpage per log cubic metre: $200 regardless of transport distance or harvest difficulty

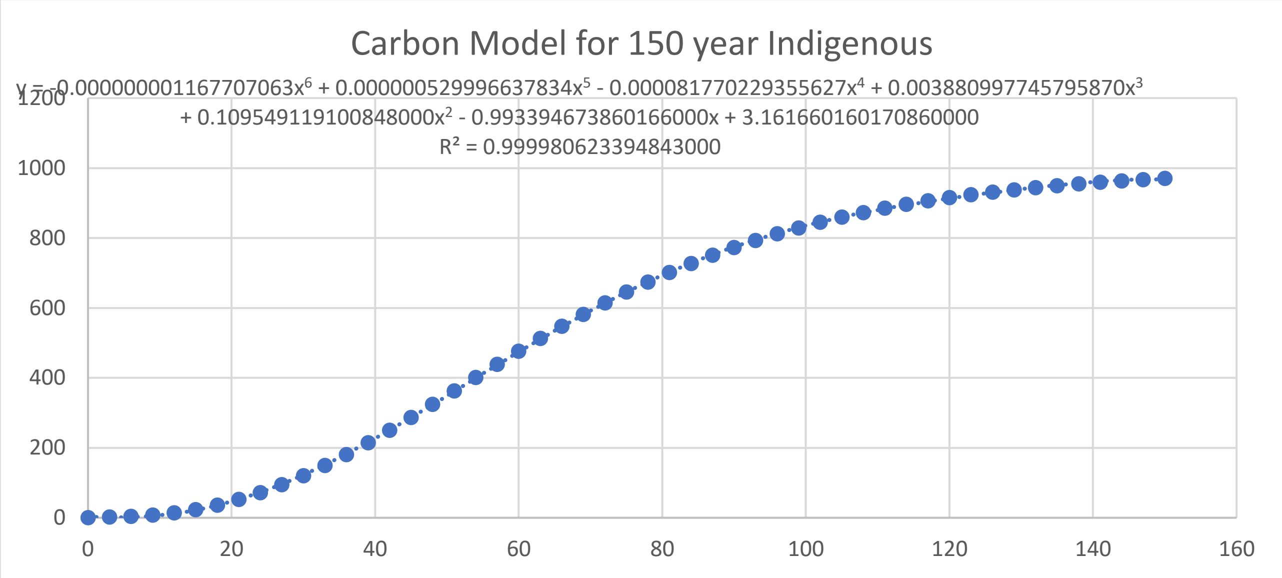
Figure 2: Indigenous lookup table (MPI, 2017)



For this report The MPI lookup tables are modified to use the same curve as the MPI lookup tables for Indigenous plantation forest, but over 150 years (

Figure *3*).

Figure 3: Carbon model modified from MPI lookup tables for indigenous (MPI, 2017)



The tōtara carbon model for this analysis (

Figure 3) uses the data from MPI's indigenous lookup tables but each year is multiplied by 3 and the corresponding volume is also multiplied by 3. This provides a stem volume/carbon table with a curve that closely matches predicted carbon sequestration (figure 7 in Horgan and Bergin, 2017) and importantly, the tōtara plantation will produce 470 m^3/ha at 60 years of age (as per table 8, Horgan and Bergin, 2017).

It is assumed that at 85 years old 43.2 m^3 of stem volume is removed. Every 5 years after that 43.2 m^3 of stem volume is harvested to retain a standing volume of no less than 693.2 cubic metres. The ratio for converting stem volume to merchantable volume is 8.86/10, from table 9.6 Bergin (2001), so harvested merchantable volume is assumed to be 38.27 m^3.

Carbon returns are submitted every five years.

Figure 4: Modelled volume increment/carbon accrual for tōtara between 80 and 85 years. This equates to a harvest every 5 years of 43.2 m³

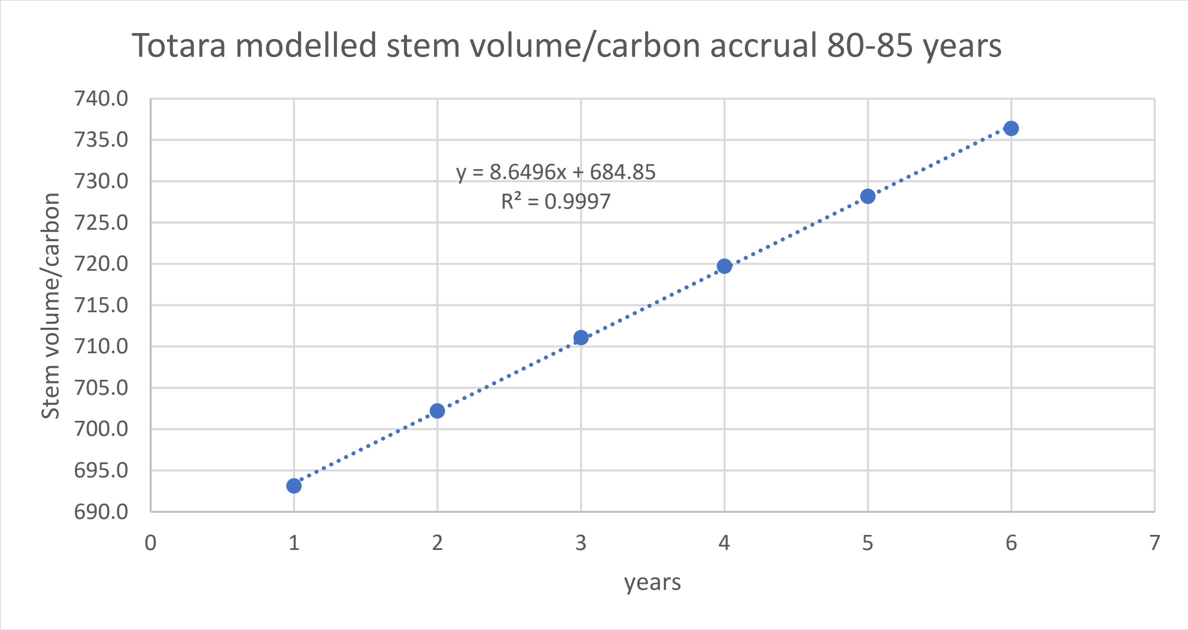
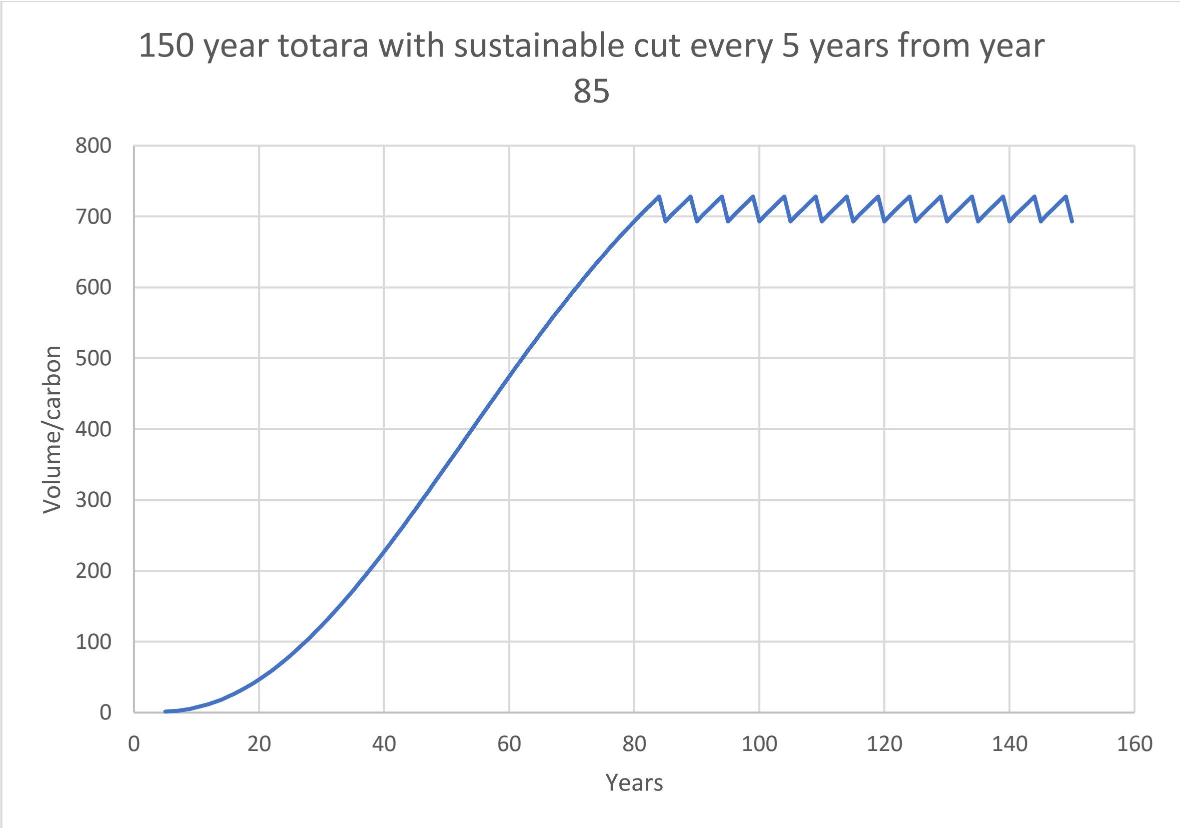


Figure 5: harvest of 43.2 m³ every 5 years from year 85 to year 150.



Appendix 5: Costs and returns for radiata pine clearfell

Management regime: Plant 1000 stems per hectare (sph), structural regime (ie no pruning) with single waste thin at age 9 yrs to 450 sph, grow to and harvest at age 28 years.

Pre-plant spraying (aerial) with glyphosate/metsulfuron in March-April preceding planting. Assumed cost of $250/ha.

Planting 1,000 sph radiata pine seedlings – cost includes tree stocks, delivery and planting contract labour in July-August. Assumed cost of $1,000/ha, including hand fertiliser (DAP tabs) application at planting.

Aerial releasing assumed in November-December following planting to control weed and grass competition with new tree crop (assumed cost of $350/ha) and follow up releasing later (20% of the area) as required.

Thin to waste to approximately 450 sph assumed at around age 9, when trees are at 12-14m height. Assumed cost of $750/ha.

Pre-harvest inventory (PHI) at age 25 - $100/ha (assuming 50 hectares net stocked forest area)

Table 9: Zbase selections

Field	Selection	Description
Access	Hard	Small to mid-sized block, with longer distance and/or steeper broken terrain
Forest costs	High	Small to mid-sized block, with more difficult access, terrain and hindrance
Site yield	Low	A poorer site (MAI <18)

Distance to port is assumed to be 100 km. The tree crop will produce an estimated TRV (total recoverable volume) at a harvest age of 28 years of 500 m^3/ha over a range of log grades (Table 10).

Table 10: Log grades and prices

	Pruned	Large structural (S30)	Large utility (Export A)	Small structural (S20)	Small utility (Export K)	Industrial KI	Industrial KIS	Pulp
Log mix (%)	0%	17%	27%	12%	23%	10%	6%	5%
Delivered price ($/m3)	$164.10	$127.00	$130.80	$117.00	$117.10	$108.20	$94.30	$51.20

The approach taken in this evaluation is to use longer-term average log prices. This is because log prices fluctuate and can be volatile in response to factors in both domestic and export log markets. Forestry is a long-term business and using short-term spot prices for green field evaluations is likely to provide variable and unrealistic assessments, noting that harvest timing can be managed to some degree.

Harvesting costs include roading (assumed cost of $10.00/$m^3$), logging (assumed cost of $44/$m^3$), transport ($21.96/m^3 for a distance of 100km to port). Harvesting costs also include engaging a suitably experienced Harvesting and Marketing agent to organise the tree crop harvest (assumed cost of $4.50/$m^3$).

A transport distance of 200 km costs $39.45/$m^3$ for cartage and reduces stumpage per hectare to $9,499.

The net harvest revenue as stumpage is estimated to be $36.36/$m^3$ or $18,178 per hectare.

Average carbon stored for a 28-year rotation is assumed to be 435 tonnes carbon at 17 years from MPI's lookup tables (Figure 6). The woodlot is assumed to use the averaging regime under the ETS and annual returns are submitted for the first seventeen years.

Figure 6: Radiata pine carbon lookup table for Northland/Auckland (Source: MPI, 2017)