Land use options and economic returns for marginal hill country in Northland

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Figure 1: Steep unproductive pastoral country in Northland

Abstract

This paper compares economic returns from existing pastoral production with plantation forestry on steep 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 – radiata pine clearfell and permanent tōtara forest. Permanent (continuous cover) forestry offers improved environmental outcomes compared with clearfell forestry, by mitigating erosion and the sedimentation of water bodies. Because permanent forests are long-term investments, the analysis is over 150 years. Results compare relative profitability of existing pasture with new plantation forests and consider sensitivity to interest rate, carbon price, planting subsidies and a price on pastoral carbon emissions.

Introduction

Good land use decisions depend on being well informed and understanding the trade-offs between profitability and environmental sustainability. Importantly, soil erosion and the 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 steep land soils generate significant quantities of sediment that enter 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° (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
- Improve the overall sustainability of pastoral farming in the region.

However, for landowners 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/ha on moderate sloping land to six stock units/ha 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 from soil disturbance, soil compaction and canopy removal (slopewash). Sediment is also likely to be generated by soil slip events occurring during the 'window of vulnerability', estimated to be greatest between one and six years after clearfelling radiata pine (Phillips et al., 2012).

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 landowner'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. Landowner preferences for amenity values may also influence species selection.

Plantation forests and carbon – two methods

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:

- Standard post-1989 forest for clearfell radiata pine (*Pinus radiata*) – the 'averaging' option
- Indigenous post-1989 forest (tōtara, *Podocarpus 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 NZUs.

Permanent forests under the ETS

Permanent forests (i.e. 'continuous cover forests') may not be clearfelled and must keep a minimum of 30% 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
- Tōtara permanent plantation forest, including carbon revenue from permanent forest accounting. The tōtara plantation option includes a nurse crop of mānuka (*Leptospermum scoparium*), 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 presumed 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 and 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 $30/tonne ($CO_2$ equivalent) and a real interest rate of 3% p.a. 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 paper represent the author's best projection of long-term returns from each land use, the user of these results must exercise care and judgement 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:

- 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
- It cannot be expected that an interest rate or carbon price will remain stable over 150 years.

Assumptions made to provide an economic 'level playing field' between land uses are described in Satchell (2021, 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% free allocation of emissions units if agricultural emissions were included in the ETS (MfE, 2019). This means the agriculture sector would for the short term only be exposed to 5% 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 New Zealand 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 paper, net returns per hectare from pastoral farming were quantified as Earnings (Profit) Before Interest, Tax, Rent and manager wage (EBITRm), described in Satchell (2021, Appendix 2: Pastoral farm earnings). EBITRm is a metric used by Beef + Lamb NZ (2019) 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.

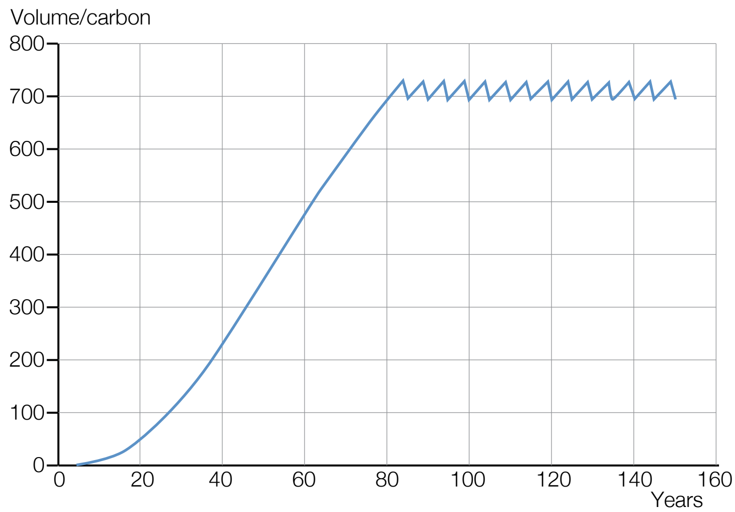

Figure 2: 150-year tōtara with sustainable cut five years from year 85

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 (Satchell 2021, 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/ha 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 Satchell (2021, Appendix 4: Costs and returns for tōtara plantation). A model for carbon and accumulated volume as a continuous cover (permanent) forest is provided in Satchell (2021, Appendix 4: Costs and returns for tōtara plantation). It is assumed that harvesting will target larger diameter trees for a consistent log product over time. 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/ha (SPH) and it is assumed these will not require thinning or pruning. This is because mānuka trees are interplanted with the tōtara as a nurse crop at a rate of 1,666 SPH, following current best practice establishment methods for Northland. The side shading provided by the mānuka nurse crop is assumed to provide good form to the tōtara which would emerge as the canopy.

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 mānuka on hill country farmland is a bell curve with a normal distribution that peaks at year 10, with a standard deviation of 4 (Satchell 2021, Appendix 3: Mānuka nectar production).

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

Results and discussion

The focus of this paper 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% p.a. real interest and $30 per NZU carbon price for a 150-year time period.

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.

Table 1: Relative profitability of new forestry land uses compared with existing pasture (3% p.a. 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%

If the landowner 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 mānuka 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).

If the landowner 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 mānuka 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).

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 landowner plants a bare pastoral site in trees, registers for the ETS, and sells accrued carbon and harvested logs.

Higher interest rates tend to reduce profitability of tōtara permanent forest because of the high upfront costs of establishing the forest and the long time period before receiving harvest revenues. If the landowner does not register for the ETS or is planting clearfell radiata pine on pastoral land that cannot accrue emissions units, the interest rate has a much higher effect on relative profitability (Table 5).

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% p.a. interest	271%	393%
	7% p.a. interest	264%	376%
	10% p.a. interest	266%	374%
$50 carbon price	3% p.a. interest	323%	667%
	7% p.a. interest	294%	586%
	10% p.a. interest	286%	554%

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% p.a. interest	206%	299%
	7% p.a. interest	116%	165%
	10% p.a. interest	57%	80%
$50 carbon price	3% p.a. interest	257%	532%
	7% p.a. interest	146%	291%
	10% p.a. interest	77%	149%

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% p.a interest	278%	403%	141%	204%
	7% p.a. interest	242%	345%	Not profitable	Not profitable
	10% p.a. interest	202%	285%	Not profitable	Not profitable
$50 carbon price	3% p.a. interest	371%	767%	192%	397%
	7% p.a. interest	388%	772%	Not profitable	Not profitable
	10% p.a. interest	363%	703%	Not profitable	Not profitable

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%

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% p.a. interest	184%	266%
	7% p.a. interest	191%	272%
	10% p.a. interest	171%	242%
$50 carbon price	3% p.a. interest	276%	571%
	7% p.a. interest	337%	671%
	10% p.a. interest	332%	644%

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/ha to $9,499/ha. 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% p.a. interest rate.

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 landowners 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 paper 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 trade-off between the environment and profit.

Carbon is an important component to include in land use decision-making. The opportunity to accrue and sell carbon units opens opportunities for landowners 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 should encourage a mosaic of land uses that achieve regional economic goals and environmental aspirations while also meeting landowner's needs.

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