Economic Impact of Forestry in New Zealand

Te Uru Rākau

May 2020

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Te Uru Rākau
1 The Terrace
Wellington Central, 6011
Attn: Harry Livesey

25 May 2020

Forestry Economic Impact Assessment

Dear Harry

In accordance with our contract dated 20 August 2019, we present our report on the economic impact assessment of forestry. We have completed a base case and scenario analysis, as discussed, and provide quantitative information as well as some discussion.

Please note that this document should be read in conjunction with the Restrictions in Appendix F.

Thank you for engaging us to conduct this analysis. We have enjoyed the engagement and hope that you find the results helpful for your endeavours.

Yours sincerely

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Executive Summary

Overview – Background and Purpose

New Zealand is currently experiencing an increase in forestry as a land-use. This follows a period of rapid planting in the 1990s and early 2000s and a decade of low planting and deforestation since the mid-2000s. The current resurgence in planting has raised concerns by sheep and beef farmers that afforestation will reduce employment in rural communities and impact the quality of life for those who remain working and living in these communities. Because of the impacts on rural communities and the sheep and beef sector, questions have also been raised about afforestation's impact on New Zealand's economy as a whole.

This report principally addresses the question of the national economic impacts of forestry through calculating and comparing the national level impacts of the forestry and sheep and beef value chains (which includes the on-land production and downstream industries), using a multiplier analysis (also referred to as Input-Output analysis). It also considers potential impacts arising from permanent carbon forestry and integrating forestry into sheep and beef farming. As these are effectively "steady state" analyses of economic impacts, we also touch briefly on the relative financial attractiveness of these scenarios and the differences in cash flow profiles arising from forestry and sheep and beef farming.

Key Terms

We define the following terms in the context of this report as:

- Plantation forestry – *pinus radiata* forest planted with the intention to harvest at 28-years;
- Permanent carbon forestry – forestry planted with the intention of generating carbon units and not to be harvested; and
- Forestry integrated into sheep and beef farming – sheep and beef farming with some type of forestry on the land.

Analysis Undertaken

This report provides the following.

A comparison of the national economic impact of the forestry and sheep and beef industries, including their downstream processing industries.	This analysis is undertaken at a national level, based on 2018 data, and using multipliers to estimate the direct, indirect and induced effects of each industry, including the downstream processing industries. It provides a "steady state" view of these industries. The results are presented on an aggregate national basis, and per 1,000 hectares.
An estimation of the economic impact of permanent carbon forestry.	This is presented on a per 1,000 hectares basis and takes account of carbon unit revenues. Results are provided for three different tree species.
An estimation of the economic impact of integrating some forestry activity into sheep and beef farming.	Forestry is assumed to replace the least productive 10% of sheep and beef farming. The analysis considers plantation and permanent carbon forestry. The analysis is presented per 1,000 hectares.
A high-level financial analysis comparing the cash flows from sheep and beef farming and forestry.	The previous analysis does not consider the relative attractiveness of the land uses from a financial perspective or consider the differences in annual cash flows.

A key challenge in comparing the forestry and sheep and beef value chains is the dramatic difference in the production cycles of each land use: annual for sheep and beef, multi-decade for forestry. Forestry generates economic impacts in the planting cycle, and in thinning and pruning, but economic impacts are otherwise negligible until harvest, at which point they are very high per hectare. A fair comparison of economic impacts therefore needs to assume a mix of forest ages. In this case, we have used the current national forest mix, and assumed this is representative in the comparison of plantation forestry with other land uses.

Economic Modelling Approach

Multiplier Analysis

The principal methodology used is multiplier analysis. This is based on Statistics New Zealand's Input-Output tables, which provide a sector by sector representation of the New Zealand economy, and of the relationships between each sector. From these tables, multipliers are calculated to enable estimation of the GDP and employment effects of expenditure within a sector (direct effects), from that sector's purchases from other sectors (indirect effects) and from the spending of income earned by those sectors in the rest of the economy (induced effects).

The analysis seeks to identify the impacts of the combined production and processing value chains. Direct economic impacts are therefore those generated by estimating the revenue impacts in both production and processing value chains, and applying the relevant direct multipliers. Indirect and induced multipliers are applied, but only at the point furthest down the value chain, so as not to double-count those generated by the production sectors. Further, the results are then adjusted downwards to remove the direct impacts of the production sector from indirect impacts, which would otherwise be double counted.

Treatment of Carbon Units

The main national multiplier analysis excludes the impact of revenue from the sale of carbon units. This aligns with the normal approach for economic impact analysis and focuses the analysis on the way that the forestry and sheep and beef value chains create value in the New Zealand economy. On a national basis, carbon unit revenues are arguably a transfer payment, created through a regulatory system – the benefit received in one sector is mirrored directly by costs in other sectors. Further, the extent to which the impact of carbon credits is reflected in current multipliers is not clear.

Revenues from carbon units nonetheless play a significant and growing role in forestry investment decisions (both plantation and permanent carbon forestry). We have therefore included their impact in the remainder of the analysis, and on a basis that this provides consistent treatment across the analysis of permanent carbon forestry, forestry integrated into sheep and beef farming, and the financial analysis. In these analyses, net carbon unit revenue is recognised as economic value-added in the hands of the recipient, but flow-on effects into the rest of the economy are only recognised at the induced level. It should be noted that the economic impacts are acutely sensitive to the assumed price of carbon credits.

Data Sources and Key Assumptions

The production values for different industries are calculated using data from Statistics NZ, Beef + Lamb New Zealand and the Forest Owners Association. Multipliers are derived from Statistics New Zealand's 2015 Input-Output tables.

The variable to which the analysis is most sensitive is the price of carbon units, which is assumed to be NZ$25, the current ceiling price. Further assumptions used in the modelling are detailed in Appendix A.

National Analysis

Currently, the sheep and beef farming value chain contribute a greater aggregate value-add (in GDP terms) and employment impact to the New Zealand economy, as shown in Table 1.

Table 1: Annual aggregate economic impacts – forestry and sheep and beef value chain

	Direct	Indirect	Induced	Total
Forestry value chain				
Value-add ($m)	2,877	3,107	1,941	7,926
Employment (FTEs)	18,460	30,629	15,800	64,889
Sheep and beef value chain				
Value-add ($m)	4,908	4,395	3,475	12,777
Employment (FTEs)	55,187	41,223	28,142	124,551

While the total economic impacts in the sheep and beef value chain are greater than in the forestry value chain, the hectares of land used to produce these impacts varies significantly and is shown in Table 2 below.

Table 2: Hectares of land used in the forestry and sheep and beef value chains

	Forestry value chain	Sheep and beef value chain
Hectares of land (millions)	1.7	7.5

Table 3 provides the economic impacts on a per 1,000 hectares basis.

Table 3: Annual economic impacts – forestry and sheep and beef value chain per 1,000 hectares

	Direct	Indirect	Induced	Total
Forestry value chain				
Value-add ($m)	1.7	1.8	1.1	4.6
FTEs	11	18	9	38
Sheep and beef value chain				
Value-add ($m)	0.7	0.6	0.5	1.7
FTEs	7	6	4	17

Note: There may be small discrepancies due to rounding

Overall, the forestry value chain is a smaller industry than the sheep and beef farming industry, but generates significantly more value-add on a per hectare basis. Some caution needs to be taken in generalising from these results - the figures are national averages for the whole supply chain and do not reflect the specific impacts from any particular 1,000 hectares. The land-uses are also not entirely substitutable. For instance, sheep and beef farming uses large areas of low productivity land, such as South Island High Country, which is not suitable for forestry. Land is also just one factor of production, and the value chain comparison by 1,000 hectares does not reflect, for instance, the relative capital intensity (use of building, plant and equipment) of each value chain.

The direct FTEs figure estimates both the on-land employment (such as silviculture, forestry services, management and harvesting) and the wider employment in supporting forestry operations. One limitation of Input-Output modelling is that it does not break down FTEs employed on-land and FTEs supported elsewhere.

Other Scenarios

The national analysis compares the forestry and sheep and beef industries, based on the state of the industry as represented in 2018 data. The following sections provide a theoretical comparison, on a per 1,000 hectares basis, of:

- Plantation forestry;
- Permanent carbon forestry;
- Sheep and beef farming;
- Plantation forestry integrated into sheep and beef farming; and
- Permanent carbon forest integrated into sheep and beef farming.

As noted above, this analysis includes the impact of carbon unit revenues on the forestry land use. These are treated as having a direct value-add multiplier of 1, no indirect multiplier, and an induced multiplier (calculated as the average of forestry and sheep and beef value chain induced multipliers). The figures and table directly below provide the results of this analysis.

Figure 1: Annual total value chain impact per 1,000 hectares – value-add by land-use

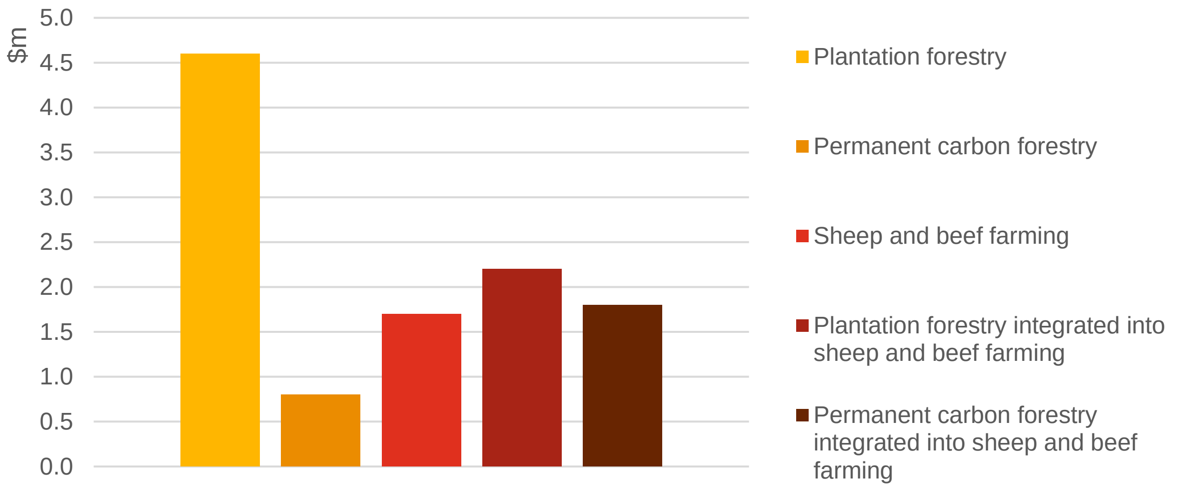


Figure 2: Annual total value chain impact per 1,000 hectares – FTEs by land-use

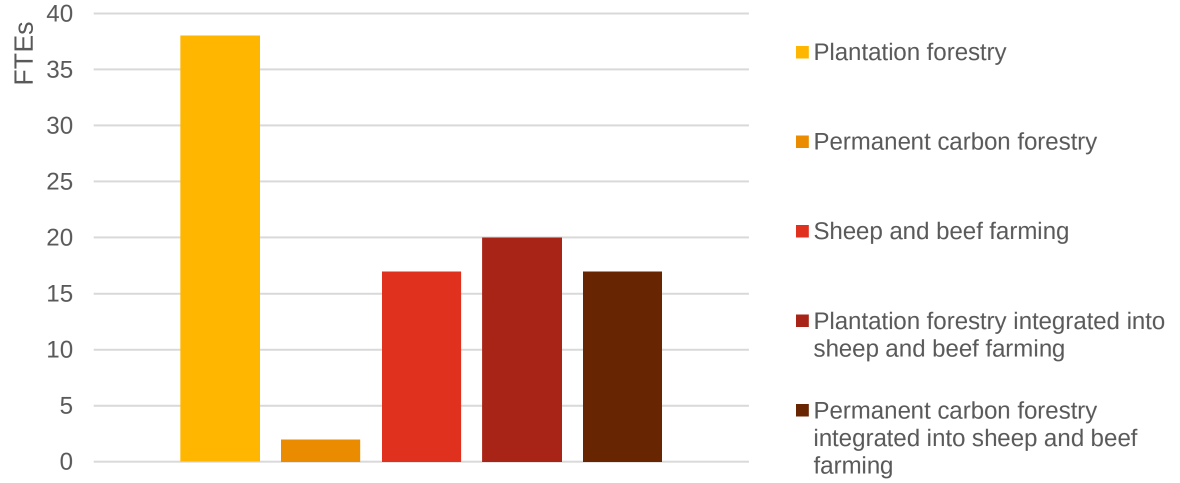


Table 4: Annual total value chain economic impacts per 1,000 hectares – by land-use

	Plantation forestry	Permanent carbon forestry	Sheep and beef farming	Plantation forestry integrated into sheep and beef farming	Permanent carbon forestry integrated into sheep and beef farming
Value-add ($m)	4.6	0.8	1.7	2.2	1.8
FTE	38	2	17	20	17

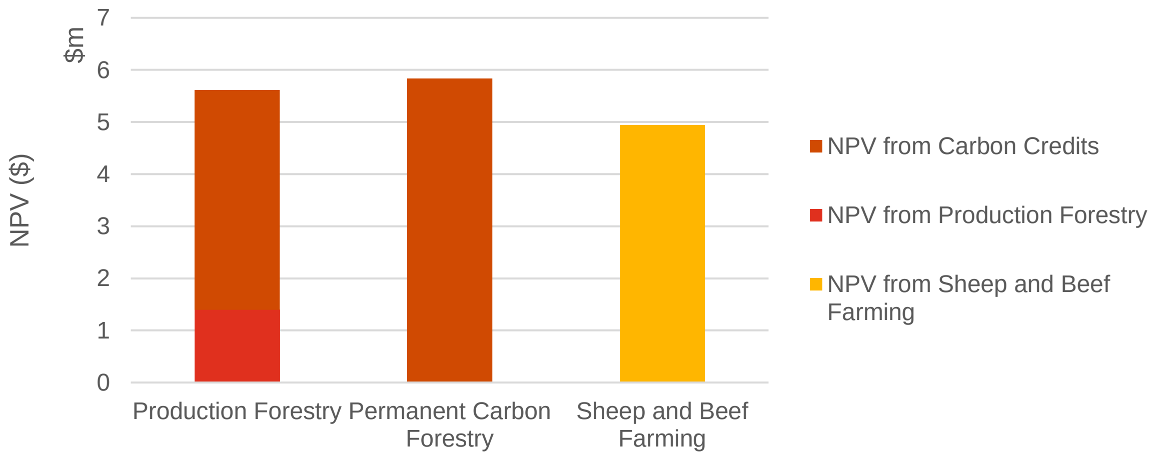
Note: There may be small discrepancies due to rounding

Financial Analysis

The previous analyses looked at the economic impacts, including the value chains upstream and downstream of the land-based production. This analysis assumed a mix of forest ages throughout, and that this represented a “steady state”. The challenge with the economic comparison is that it doesn’t consider potential issues of transition, when the two industries operate on different lifecycles: annual for sheep and beef, and multi-decade for forestry. The typical challenge with forestry has been the long lead times required before revenue can be earned. This situation, as well as the relative economics, is changed significantly by carbon units, when priced at NZ$25 per unit.

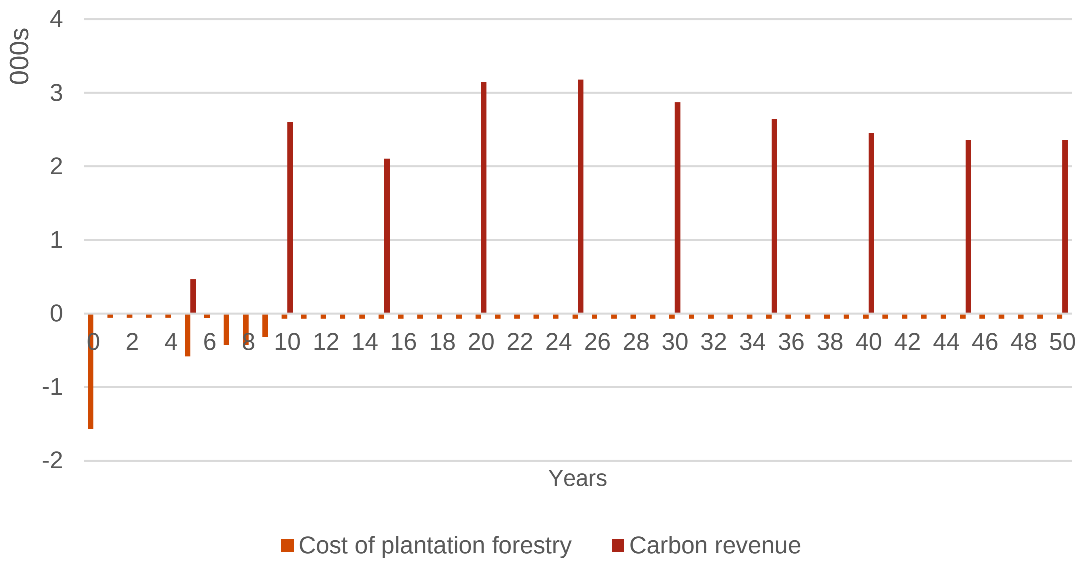
Figure 3 provides high level financial net present values for 1,000 hectares of each of the three main land uses (we do not replicate the integrated scenarios here).

Figure 3: Long run (60 year) NPV per 1,000 hectares – by land use, including carbon unit revenues



The graph illustrates the material influence that carbon units (at the assumed price point) can have on the relative attractiveness of each land use. Permanent carbon forestry also outperforms plantation production forestry, due to lower establishment and early years costs, and receipt of carbon unit revenues over a 50-year period (illustrated in the figure below).

Figure 4: Estimated cashflows ($000s) per hectare – average new pinus radiata permanent carbon forestry



Limitations

The analysis reported here attempts to measure the economic impacts of forestry and sheep and beef farming and meat processing. It is subject to a number of limitations.

- Input-Output analysis – there are well-known qualifications to this approach, including that it tends to produce higher estimates of economic impacts than other approaches;
- On-land versus employment elsewhere – the FTE figures do not distinguish between on-land employment and employment supported by the industry elsewhere;
- National averages – as the analysis has focussed on the national-level impacts, the impacts in districts and regions are areas for further research;
- Data at a point in time – a change in data inputs over time will change the results and analysis; and
- Data from public sources – figures used from Statistics NZ, Beef + Lamb New Zealand and Forest Owners Association have not been independently verified.

These assumptions are not likely to change the overall conclusion from the analysis.

Overall Conclusions

The results presented here are dependent on the data and assumptions used. Any real-life comparisons of alternative uses for a specific piece of land can be expected to be different, reflecting the productivity derived from actual circumstances. From the modelling, we conclude that, on average, the forestry value chain has a larger economic impact per hectare than the sheep and beef value chain.

A very simple financial comparison of the relative attractiveness of plantation forestry, permanent carbon forestry and sheep and beef farming suggests that for some land types (in this case hard hill country), forestry generally offers greater returns, which are enhanced by carbon unit revenue. Within this analysis, plantation forestry and permanent carbon forestry offer comparable returns over the long term, but significantly different economic impacts, with permanent carbon forestry having comparatively low impacts, compared to sheep and beef and plantation forestry. The split of the value between returns to capital and returns to labour is also shifted almost completely in favour of capital: almost no employment impacts are generated from permanent carbon forestry, by comparison to sheep and beef and plantation forestry.

Overall, this analysis suggests that, with carbon unit prices at or in the range of NZ$25, permanent carbon forestry can offer comparable returns to plantation forestry, and both can offer superior returns to sheep and beef. The GDP impacts, however, are materially different. A move from plantation to permanent carbon forestry significantly reduces the GDP impacts, and reduces employment impacts to negligible. This is the natural effect of converting land to a use that is not economically productive.

Introduction

Context

New Zealand's plantation forestry estate has been through several periods of expansion in the 1930s, 1970s, early 1980s, 1990s and early 2000s. After low rates of new planting and significant deforestation over the last fifteen years, New Zealand looks poised to experience another forestry expansion. This is driven by a number of factors, including the Emissions Trading Scheme (ETS)[1], and environmental protection of soils, water and biodiversity and recent high log prices. More recent government initiatives, such as the One Billion Trees Programme[2] have the effect of promoting forestry as a sector and as a land-use.

However, increasing forest area relies on using land already utilised by other primary sector industries. There is concern from sheep and beef farmers about the potential social and economic impact of the shift toward forestry.

Scope

This report uses Input-Output modelling to estimate the economic impact of different types of forestry and sheep and beef farming. We focus on quantifying the potential value-add (GDP) and employment impact at a national level.

This report primarily focuses on the economic impacts. It does not discuss the wider social, environmental or wellbeing impacts. For these impacts, especially those that affect local communities, further questions could be formulated to better understand the quantitative and qualitative consequences of increased forestry in New Zealand. These questions are not in the scope of this report.

Input-Output modelling also has several limitations. It uses a snapshot of the current state of the economy to estimate the economic impacts at a point in time. It aims to provide an estimate of the size of the impacts given the inputs and assumptions used and are not intended to be deterministic. This also means that advances in technology, such as increased mechanisation in the forestry and sheep and beef sectors, are acknowledged but cannot be modelled.

Further, the results of the modelling are at the steady state. A steady-state analysis describes the impacts on the economy in the long run. The analysis of the transition towards forestry is not the primary focus of this report but is briefly addressed in the Discussion section.

Given the interest in this piece of work, the modelling and report aims to be robust, transparent and based on verifiable information. In order to be replicable and serve as a platform for future research, publicly available data and information has been used where possible. There is no single internally consistent dataset that links all the inputs used in the modelling together. This means we use data from different sources and use assumptions to link the data together.

This report should be read in conjunction with the restrictions in Appendix F.

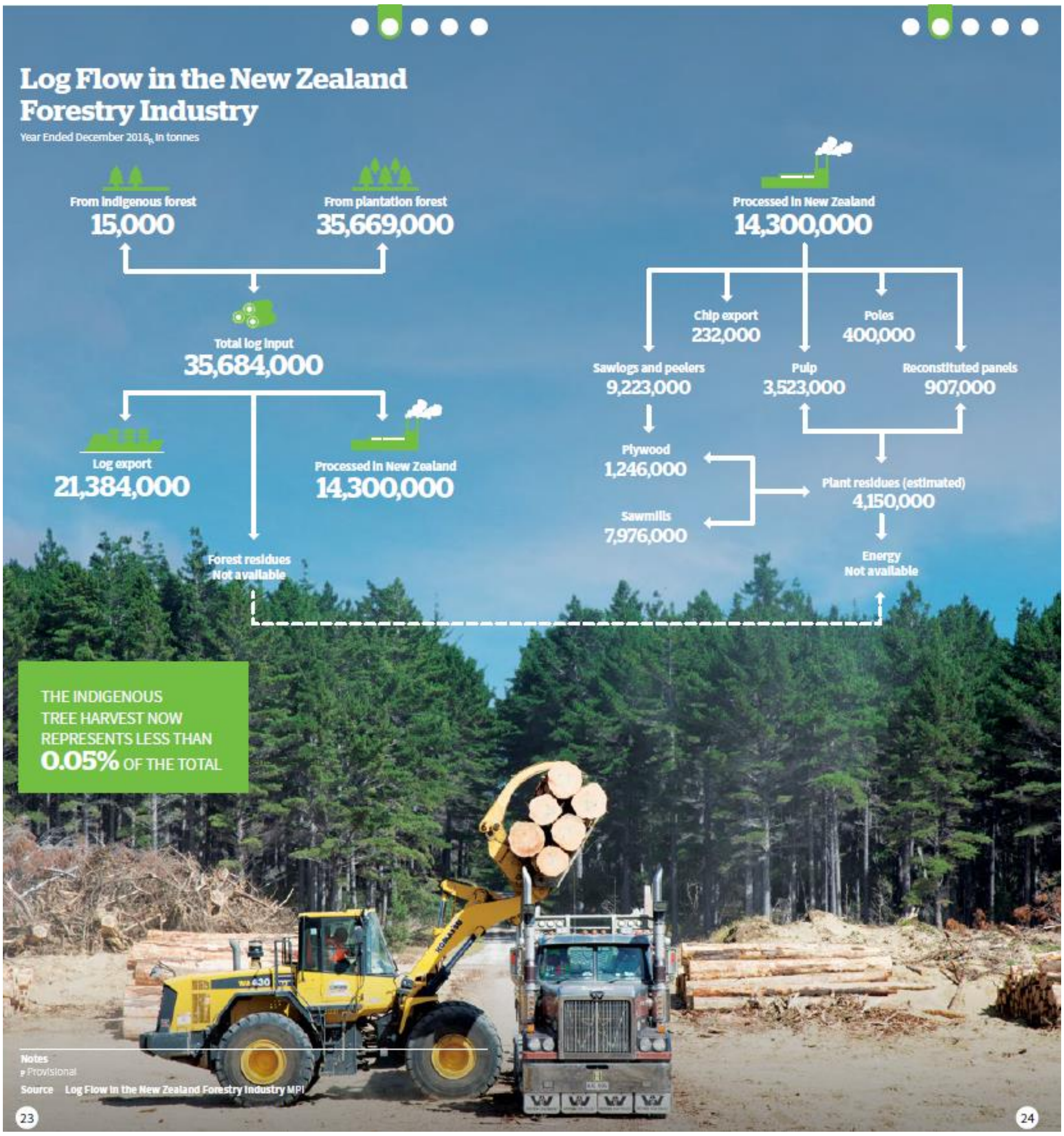
[1] Ministry for the Environment. *New Zealand Emissions Trading Scheme*. Retrieved from https://www.mfe.govt.nz/ets.
[2] Te Uru Rākau. *One Billion Trees Programme*. Retrieved from https://www.mpi.govt.nz/funding-and-programmes/forestry/one-billion-trees-programme/.

Background

Forestry

The forestry sector forms an increasingly significant part of the New Zealand economy. As a result of planting in the 1990s and early 2000s, forestry production has risen from 10 million cubic meters in 1989 to over 35 million cubic meters in 2019. The sector is characterised by large investors who directly or indirectly acquire the rights to manage forests. Those that acquire the rights to manage land typically appoint a forestry manager to plan and co-ordinate operations using a range of contractors to undertake the work and transport the logs, either to mills for domestic processing or to ports for export.[3] The breakdown of log flow in the New Zealand forestry industry is provided in Figure 5 below.

Figure 5: Log flow in the New Zealand forestry industry (tonnes)



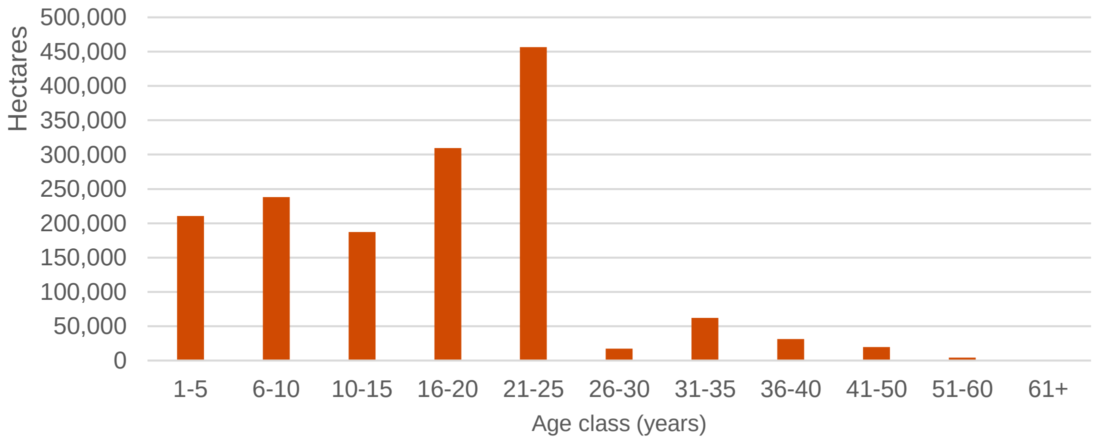
Source: MPI: Log Flow in the New Zealand Forestry Industry (taken from FOA Facts and Figures 2018/19)

[3] Westpac. (2018). *Industry Insight: Forestry and wood processing.*

In 2018 approximately 60 percent of logs harvested in New Zealand were exported (NZ$3.3 billion in export receipts). The majority of logs are exported to China (NZ$2.9 billion, or approximately 80 percent), driven by the rapid pace of urbanisation and growth in disposable income levels in China. A key feature of the New Zealand forestry sector is that it exports a large proportion of production. This is particularly true for low-value products such as logs, but less so for higher-value processed wood products, such as timber, wood panels and paper products. The opposite tends to be true for the world's largest forestry product producers, which produce far larger volumes than New Zealand, but tend to have a higher export propensity for value-added products.[4]

Softwood plantation forests, where most commercial forest activity takes place, cover about 1.7 million hectares of New Zealand. *Pinus radiata* accounts for just over 1.5 million hectares of softwood plantations. Because of its climate and soil conditions, New Zealand is able to grow *pinus radiata* faster than most other countries. *Douglas fir* is the second most common tree species grown commercially in New Zealand, covering about 100,000 hectares of plantation forests. Cypress and other exotic softwoods, such as Redwoods, Larch and Cryptomeria, account for a further 33,000 hectares. Hardwoods, mostly eucalypts, make up a small proportion of commercially grown forests in New Zealand, accounting for approximately 35,000 hectares. As of 1 April 2019, the average age of trees in commercial plantation forests in New Zealand, weighted by area of coverage, was 17.9 years. As shown in Figure 6, about 92 per cent are less than 30 years of age.

Figure 6: Net stocked planted production forest area (2019)



Source: Te Uru Rākau (2019). National Exotic Forest Description.

Beef and sheep farming

Today sheep and beef cattle production is the dominant land-use in New Zealand, utilising 7.5 million hectares of land.[5] For the year ending June 2018, the value of exports was NZ$3.3 billion for beef cattle farming, NZ$3.8 billion for lamb and mutton farming, and NZ$0.7 billion for wool products.

The New Zealand climate is suitable for pasture growth, and it is the key to sheep and beef cattle production as pasture provides over 95 per cent of the diet of sheep and cattle.[6] Production systems range from intensive sheep and beef cattle farms to extensive high country farms with mainly sheep. New Zealand grasslands can be divided into three broad farming groups: high, hill, and flat rolling country. Each varies in the quantity of pasture produced and the number and type of animals carried. High country is characterised by hilly terrain and low pasture production, especially during the cold winter months, and it is used predominantly for sheep farming based on fine wool production. Flat-to-rolling country has good all-year-round pasture production and supports almost all of New Zealand dairy cattle in addition to large numbers of sheep and beef cattle.[7]

[4] Westpac. (2018). *Industry Insight: Forestry and wood processing*.
[5] Ministry for Primary Industries. (2012). *Pastoral input trend in New Zealand: A snapshot*.
[6] Hodgson, J., Cameron, K., Clark, D., Condron, L., Fraser, T., Hedley, M., Holmes, C., Kemp, P., Lucas, R., Moot, D., Morris, S., Nicholas, P., Shadbolt, N., Sheath, G., Valentine, I., Waghorn, G., & Woodfield, D. (2005). *New Zealand's pastoral industries: Efficient use of grassland resources*. In: Reynolds, S.G., & Frame J. eds. *Grasslands, developments, opportunities, perspectives.* New Hampshire, USA, Science Publication. Pp 181-205.
[7] Morris, S.T. *Sheep and Beef Cattle Production Systems*. Institute Veterinary, Animal and Biomedical Sciences, Massey University

New Zealand sheep and beef farms tend to have a mix of animals and age classes. A farmer having sheep and beef cattle on the same farm increases management flexibility through the ability to preferentially feed some livestock while maintaining high levels of grazing pressure with other livestock classes. The role of cattle is important in the sustainability of hill country farms where the contour requires that pasture control is primarily a function of livestock pressure and grazing management. This requires that beef cattle graze with sheep and this is seldom to the short-term benefit of the cattle, but often improves the performance of sheep and the pasture.[8] It is relatively easy for producers to alter their mix of sheep and cattle to suit current economic conditions and preferences. The driving force behind this substitution is the relative profitability between sheep and cattle.

Carbon Farming

The ETS is becoming a significant factor in deciding between agriculture or forestry for rural land-use. Historically, greenhouse gases emitted by organisations have been treated as externalities because emissions have not been taken into account in their decision-making. The ETS is intended to address this by creating a market for emissions and internalising the cost of emitting greenhouse gases. The emitters have a legal obligation to offset the amount they emit each year, called unit liabilities. Removers can record the amount they remove each year and convert this to emission units which they can then sell on the open market. The primary mechanism emitters use to offset emissions is to purchase units from removers.

Currently, the ETS is a domestic-only market. From 2008 to mid-2015, the ETS used the international Kyoto market, rather than government auctioning, to help supply units and set the domestic price. Since de-linking in mid-2015, only NZUs (New Zealand Units) have been eligible for surrender.

As a result of the global oversupply of Kyoto units, which was exacerbated by the global financial crisis and withdrawal of the US and Canada from the Kyoto Protocol, the prices of international Kyoto units declined from mid-2011 and NZU prices followed suit.[9] However, since de-linking was signaled in 2012, domestic prices have risen independently of trends in international unit prices. In addition to open market transactions, the ETS operates with a price ceiling mechanism. Participants can purchase unlimited NZUs from the government for immediate surrender at a fixed price of NZ$25 per NZU. From 2018 the market price has varied between NZ$20 and NZ$25.[10]

One development arising from the ETS is the introduction of carbon farming – growing trees purely to absorb carbon, monetised through the ETS.

[8] Morris, S.T. (2007). *Pastures and Supplements in beef and production systems*. In: Rattray, P.V., Brookes, I.M., & Nicol, A.M. eds. *Pasture and supplements for grazing animals*. Occasional Publication 14. New Zealand Society of Animal Production. Pp 243-254.

[9] UNFCCC. (1997). Kyoto Protocol to the United Nations Framework Convention on Climate Change adopted at COP3 in Tokyo, Japan, on 11 December 1997.

[10] Motu Economic and Public Policy Research. (2018). *A Guide to the New Zealand Emissions Trading Scheme*.

National Analysis

Approach

This analysis estimates the economic impact of the forestry and sheep and beef value chains at a national level. The key metrics are value-add and full-time equivalent (FTE) employment.

The modelling approach follows three-steps. First, the production value (sales or revenues) for each industry sector was modelled. This analysis used publicly available production data from Statistics NZ, Beef + Lamb New Zealand and Forest Owners Association to estimate the sales or revenues for each sector. Second, the relevant economic multipliers were applied to the production value to estimate the value-add and FTE impacts. The economic data used in the analysis included the National Accounts Input-Output tables from Statistics NZ. Finally, the economic impacts are scaled to a per 1,000 hectare basis to enable a comparison of economic impacts for forestry and sheep and beef farming at a national level. As we are using national-level averages, these figures are not intended to reflect the impacts from any particular 1,000 hectares.

We recognise that there are different methodological choices for the calculations in this report. We report our full process in order to have transparency in this analysis. Future work could investigate the impacts of alternative choices on the results and analysis.

Input-Output Framework

The underlying framework of the analysis is Input-Output analysis. An Input-Output analysis captures the dependencies across industrial sectors that are a key feature of a modern economy. The pulp, paper and converted paper product manufacturing sector, for example, depends on a number of sectors that supply it with the materials and services it needs, and in turn it supplies a number of sectors. The supplying sectors are called 'upstream' sectors, and the sectors supplied are 'downstream' sectors. An Input-Output table captures all the linkages in a single, static picture of the economy. In general, it tends to produce higher estimates of economic impacts than other approaches.

Key terms used in Input-Output analysis are:

- **Output / gross output** – output is the gross revenue or sales figure for a sector. It is the sum of all the intermediate inputs supplied by upstream sectors and the value-add of the sector and represents the cost of the sector's outputs for downstream sectors.
- **Value-add / GDP** – value-add is the amount of value that a sector adds to the intermediate inputs it uses. It can be calculated as the compensation to employees and the profits the sector earns, or as the gross output less the intermediate inputs. Value-add is equivalent to the gross domestic product (GDP) of the contribution of the sector.
- **Intermediate inputs** – intermediate inputs are the costs of inputs or supplies that a sector uses to produce its output and are also the payments that a sector makes to its suppliers or upstream sectors.
- **Employment** – employment is expressed as full-time equivalents (FTEs), and is calculated as a fixed ratio to value-add for a sector. The FTE multipliers are adjusted for inflation to 2018Q2 figures, the period for which we have most recent figures. Seasonal or part-time work, which is present in forestry and in sheep and beef farming, will mean that employee headcount will be greater than FTEs.

There are generally three types of impacts, depending on how far the analysis extends.[11]

[11] Layman, B. (2002). *The use and abuse of Input-Output multipliers*. Department of Treasury and Finance, Government of Western Australia.

- **Direct effect** – measures the output, value-add or employment from the sector being studied;
- **Indirect effect** – estimates the contribution from the sectors that supply intermediate goods and continues the upstream analysis of backward linkages to include all the supporting sectors and their supporting sectors; and
- **Induced effect** – takes into account the impacts of the sector's income on the whole economy. A sector pays wages to employees and profits to business owners, and they in turn buy consumption goods from the economy.

The different effects are summarised as multipliers. The direct multiplier is the initial impact on a sector of increasing its output (so the output multiplier of any sector is, by definition, 1.00, while the value-add multiplier is usually less). The indirect multiplier takes into account all the upstream supplying industries to calculate the total supply impact of growth in a sector. Finally, the induced effect multiplier takes into account the direct and indirect effects plus the consumption impact of incomes from the sector.

For illustrative purposes, Table 5 shows what type of jobs would be included in the FTE figure for each type of impact. This is a top-down approach to estimating FTE figures and it is not intended to be an exhaustive list.

Table 5: Illustrative examples of types of jobs potentially included in FTE figures by type of impact

Industry	Direct	Indirect	Induced
Forestry and logging	Forestry and logging workers Forest managers	Forestry consultants Port service workers	Chefs of restaurants in rural forestry hubs
Processed wood product manufacturing	Wood processing workers	Builders Carpenters Truck drivers	Retail assistants in shops in rural centres
Pulp, paper, and converted paper product manufacturing	Pulp and papermill operators	Port service workers Truck drivers	Checkout operators in supermarkets in rural centres
Meat and meat product manufacturing	Farmers Shepherds Abattoir workers	Veterinary workers Agricultural scientist Agricultural consultants Shearers	Baristas at the local café

Input-Output Analysis Limitations

Input-Output tables and multipliers are modelling tools. Like any model, they can be useful but also have shortcomings.[12] Most of these criticisms relate to using multipliers to estimate the economic impact of growth, as opposed to using Input-Output tables to describe a current level of production.

- **Unlimited supply** – multipliers assume that the resources (including labour and land) and industrial capacity exist to produce any increases in output, whereas economies are often constrained in some way.
- **Fixed prices** – multipliers also assume that prices in the supply chain are fixed, so that suppliers will not put up prices in response to increased demand or capacity constraints.
- **Static technology** – Input-Output tables are a snapshot in time of the industrial structure of the economy, so they represent the mix of technology that existed at that time.
- **Fixed consumption shares** – Input-Output tables work on fixed averages of consumption, so any changes in consumption do not take into account how consumers would adjust their consumption as a result of having a little more or a little less income.

These issues with multipliers become more serious if an analysis includes a long time period, consists of a large change to a sector or to consumption or relies on government subsidies to achieve its result.

[12] Schulze, H., Cox, M., & Dixon, H. (2014). Economic impact assessment of the proposed Wellington Film Museum. BERL; Layman, B. (2002). *The use and abuse of Input-Output multipliers*. Department of Treasury and Finance, Government of Western Australia.

Forestry Analysis

To estimate the economic impact of forestry at a national level, the forestry value chain is disaggregated into the different types of final products categories given by the Input-Output industry classifications. These three industries are:

- Forestry and logging – which produces raw logs;
- Pulp, paper, and converted paper product manufacturing; and
- Processed wood product manufacturing.

The average export prices of each type of wood product are multiplied by the quantity produced to estimate the total production value for each industry. The multipliers are applied to the respective industries. For instance, the forestry and logging multipliers are applied to the production value of logs. Summing the impacts of each industry estimates the total economic impact of the forestry value chain to the national economy. Figure 7 illustrates this simplified approach of the modelling for forestry.

Forestry – Volumes

Forestry volume data matters in this analysis, as it is used to generate estimates of domestic use of wood products. There is a variety of data available to describe volumes of forestry product, none of which align clearly with each other. Harvest volumes for the year to June 2018 vary between 30.3 million m^3 (Stats NZ) and 35.8 million tonnes (Forestry Owners Association). Stats NZ's estimates of roundwood consumption in the NZ economy provide a figure of 33.1 million m^3 roundwood equivalent produced.

In this analysis, we have used a total volume figure of 33.8 million m^3. This is derived from Stats NZ's export data for logs and woodchips (21.1 million m^3 roundwood equivalent), and Stats NZ's estimates of volumes of New Zealand forest wood used in New Zealand wood processing industries (12.8 million m^3), as this aligns most neatly to the value chains split out in the economic impact analysis. In all cases, we use the:

- difference between total processing volumes and the export volumes to estimate domestic consumption;
- export prices as proxy for domestic prices; and
- export price for intermediate products (logs) in the processing value chain, to estimate the share of value add generated by the primary industry.

Carbon Units

The ETS distributes carbon units to those that sequester carbon (one 'NZ unit' per tonne of CO_2).[13] Carbon units are intended to internalise into economic transactions the externality of carbon pollution. As such, carbon units could be argued to be another product – sold by forestry owners, and purchased by polluters – which should be included in an analysis of the economic impact of forestry. Equally, on a national basis, carbon units could be considered a transfer between sectors that does not add economic value on a net basis: benefits accrue to forestry, costs to other sectors, with no net change to GDP.

In this national level analysis, we have chosen to treat carbon units as a transfer. This approach produces results consistent with typical economic multiplier analysis. Further, the extent to which the impact of carbon credits is reflected in current multipliers is not clear.

Sheep and Beef Analysis

We estimate the primary production values from farm gate volumes and average prices, and apply farm multipliers to these. For the processing industries, we apply average export values to the total volume of production, to generate the total production value of beef, lamb, mutton and wool products. As for the forestry analysis, domestic prices are assumed to be equal to export prices. Figure 8 illustrates the approach.

[13] Ministry for Primary Industries. (2017). *A guide to Carbon Look-up Tables for Forestry in the Emissions Trading Scheme*. Retrieved from https://www.mpi.govt.nz/dmsdocument/31695/send.

Figure 7: Simplified forestry value chain analysis

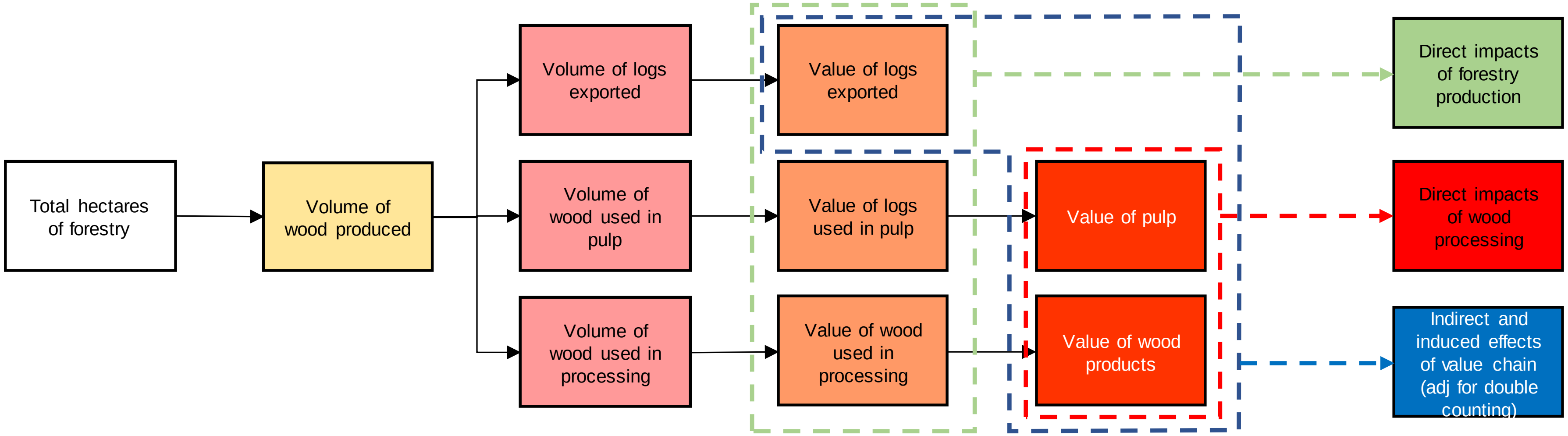
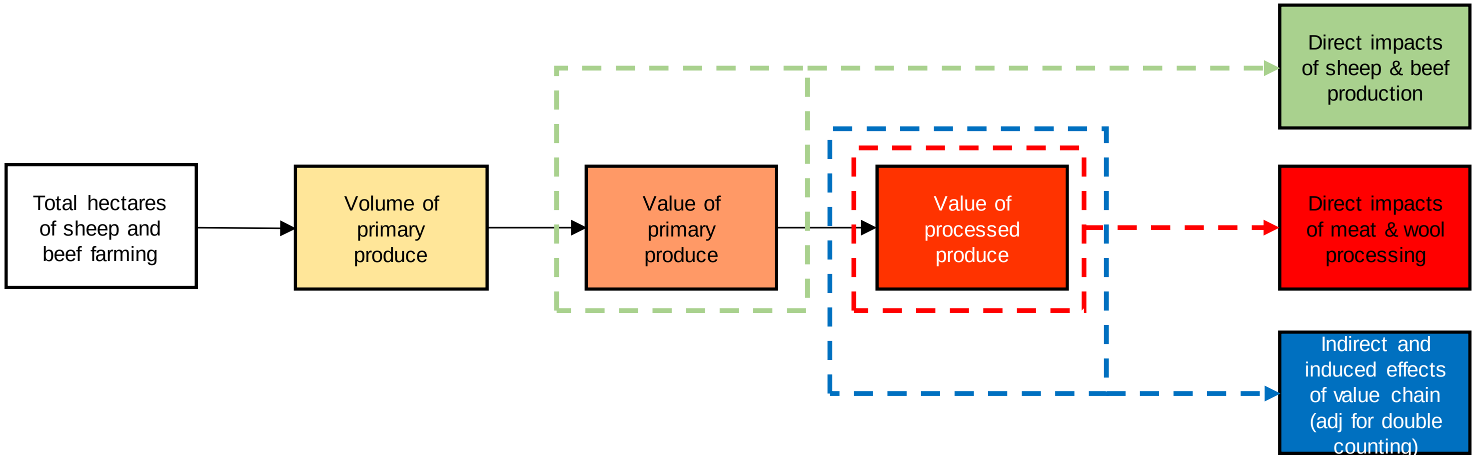


Figure 8: Simplified sheep and beef value chain analysis



National Analysis - Results

Table 6 provides figures for the value-add and FTE impacts for forestry and sheep and beef value chains in New Zealand.

Table 6: Annual economic impacts – forestry and sheep and beef value chains

	Direct effect	Indirect effect	Induced effect	Total
Forestry value chain				
Value-add ($m)	2,877	3,107	1,941	7,926
FTEs	18,460	30,629	15,800	64,889
Sheep and beef value chain				
Value-add ($m)	4,908	4,395	3,475	12,777
FTEs	55,187	41,223	28,142	124,551

Note: There may be small discrepancies due to rounding

FTE figures estimate how many FTEs are supported by the forestry and sheep and beef value chains and supporting sectors. These figures may deviate from headcount in those industries.

The aggregate economic impacts in the sheep and beef value chain are greater than in the forestry value chain, but these are from significantly different land areas, shown in Table 7 below.

Table 7: Hectares of land used in the forestry and sheep and beef value chains

	Forestry	Sheep and beef farming and processing
Hectares of land (millions)	1.7	7.5

Table 8 provides figures for the value-add and FTE impacts for forestry and sheep and beef value chains in New Zealand per 1,000 hectares. These are national-level averages, not intended to reflect the specific impacts of any particular 1,000 hectares.

Table 8: Annual economic impacts – forestry and sheep and beef value chain per 1,000 hectares

	Direct	Indirect	Induced	Total
Forestry value chain				
Value-add ($m)	1.7	1.8	1.1	4.6
FTEs	11	18	9	38
Sheep and beef value chain				
Value-add ($m)	0.7	0.6	0.5	1.7
FTEs	7	6	4	17

Note: There may be small discrepancies due to rounding

Some caution needs to be exercised in comparing the two sectors on a per hectare basis. The comparison by land area only considers one input to the production value chain – it does not consider relative capital intensity, particularly in the downstream industries. There are also a wide variety of land types – particularly for sheep and beef – included in the total hectarage, with different levels of productivity.

When considering the direct employment impacts, the tables above show FTEs employed directly in the primary industry, and in the processing chain. The Input-Output tables do not distinguish between land-based and non-land-based jobs, and the pattern of employment and where workers live can be expected to be different, particularly comparing forestry workers with owner-operator farmers living on their farms. The 1,000 Hectare analysis also should not be taken as a given for 1,000 Hectares in any particular region, as the location of households and processing facilities are not likely to correspond directly to the national average.

Carbon Units and Permanent Carbon Forestry

We define permanent carbon forestry to be a new forest planted with the intention to generate carbon credits under the ETS without being harvested. We note that most forests registered in the ETS are plantation forests that are harvested that also receive carbon units.

As a relatively new option for land-use, there is comparatively less research and modelling on the economic impacts of permanent carbon forestry. Permanent carbon forestry is assumed to have minimal production effects in the economy; there is no harvesting, and no wood is sold into the production value chains noted in the national analysis. We have not considered impacts such as the costs of meeting New Zealand's near-term climate change commitments, the impact on environmental factors, nor a comparison of its social impacts compared to a larger area of plantation forestry with an equivalent carbon benefit.

Approach

The approach is similar to the national analysis, in that it uses a multiplier analysis, but where the national analysis was based on empirical production information, this analysis is more assumption driven. The analysis also needs to accommodate two further complications.

Time Period for Analysis

The national analysis estimated actual economic activity generated by the forestry industry. Implicit in such an analysis is that there is a substantial hectarage across the country, with a mix of forestry at all stages of a 28-year production cycle: in any given twelve-month period, there is economic activity through forestry being planted, thinned and harvested. This presents two issues for the analysis:

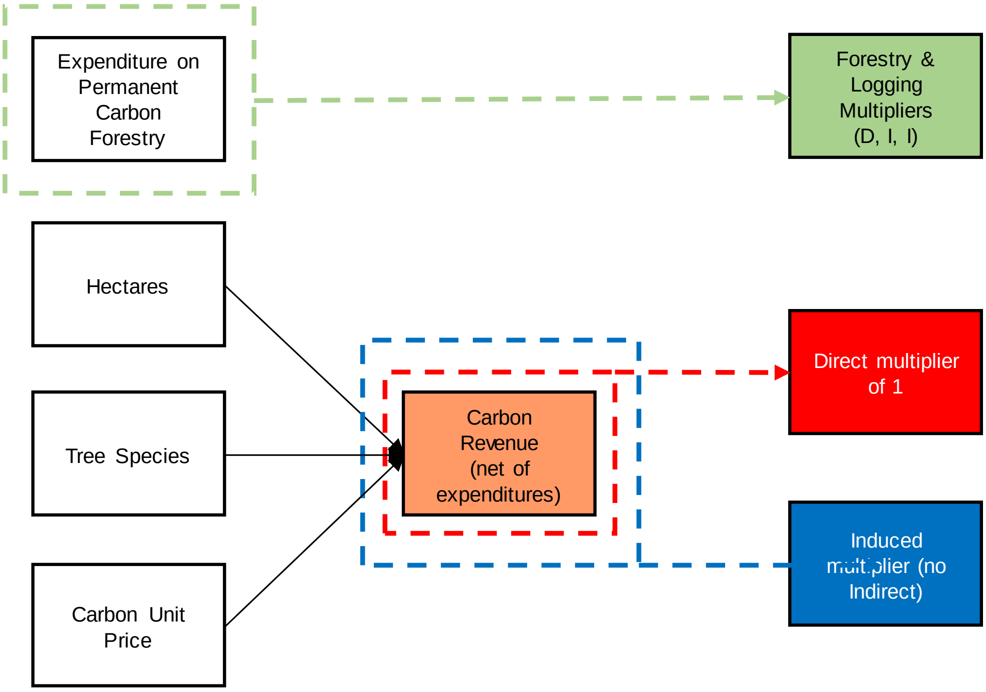
- Permanent carbon forestry only generates material economic activity in the year of planting, with de minimis levels thereafter. An assessment of these impacts is therefore only meaningful for the year of planting.
- The rate at which carbon units are earned changes substantially over time.

In this analysis, for simplicity, we show the multiplier results for the year of planting, standardised ongoing costs as representative of a typical year, and carbon units averaged over a 50-year period.

Multipliers and Carbon Units

We treat the expected expenditure on plantation forestry (planting, rates etc. sourced from BakerAg) as forestry expenditure, subject to the forestry and logging multipliers. In order to recognise some impact from the sale of carbon units, we assume that this revenue is subject to induced multipliers. There is no specific multiplier, so we have assumed that the owner is a private party and have used a simple average of the *Forestry and logging* and *Sheep, beef cattle and grain farming* induced multipliers (ie 50:50 weighting). This is illustrated in Figure 9.

Figure 9: Simplified permanent carbon forestry analysis



One area for further research is the impact of different carbon unit prices. The Government has proposed removing the Fixed Price Option (current price ceiling) after 2021.[14] It will use a price floor and auctioning units into the market (a 'cost containment reserve' or CCR) to maintain a 'floating price' between a price floor and a CCR.[15] This is likely to see prices rise above the current NZ$25. An increasing carbon unit price, all other things being equal, can be expected to improve the attractiveness of forestry, and particularly permanent carbon forestry, relative to other land uses.

Comparison to Plantation Forestry

We have provided a comparator of plantation forestry with carbon unit revenue. In this case, the carbon unit revenues have simply been treated as additional revenues within the existing national multiplier analysis. This reflects the mix of forest ages, corresponding different levels of activity, and an expectation that the carbon unit revenue would be treated as another return that would pay for costs being incurred, or paid to owners. The carbon unit revenue is assumed to only be received in relation to forests in the eligible age range.

Key Assumptions

This analysis uses the following key assumptions.

- All forests are post-1989 forests.
- The price of carbon credits is NZ$25, the current ceiling price.
- Permanent carbon forestry is modelled at a national level only. To estimate the national-level impacts of permanent carbon forestry, a weighted average by hectarage carbon credit index is used. For non-*pinus radiata* forestry, lookup values are national values.
- The permanent carbon forest is not harvested, with the carbon lookup age of 50 years.
- Costs associated with permanent carbon forestry are assumed to be constant by region and tree species, and are assumed to be those identified in BakerAg (2019).[16]
- The expenditure of carbon revenues is annualised.

[14] New Zealand Government. (2019). *Latest Emissions Trading Scheme reforms target transparency and compliance*.
[15] Ministry for the Environment. (2018). *Improvements to the New Zealand Emissions Trading Scheme: Consultation document.* Wellington: Ministry for the Environment.
[16] BakerAg. Harrison, E., & Bruce, H. (2019). Socio-economic impacts of large-scale afforestation on rural communities in the Wairoa District.

Results

The tables below provide the results of the analysis.

Table 9: Annual permanent carbon forestry value add impacts per 1,000 hectares – by component

Value-add ($m)	Direct	Indirect	Induced	Total
Year 1 - Costs of planting	0.2	0.2	0.1	0.5
Years 2 – 50 - Ongoing costs (rates, R&M admin, insurance)	<0.1	<0.1	<0.1	<0.1
Years 2 – 50 - Spending of carbon units	0.6	0.0	0.1	0.7
Total 50-year average	**0.6**	**<0.1**	**0.1**	**0.8**

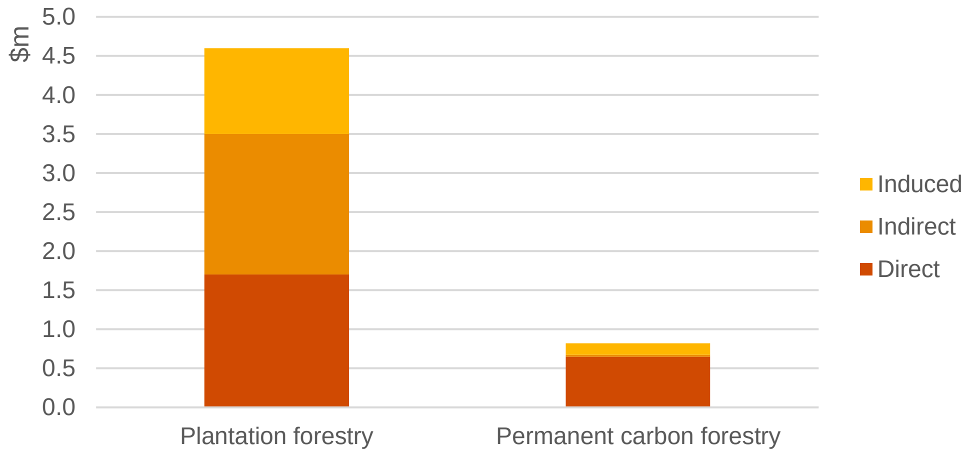
Note: There may be small discrepancies due to rounding

Table 10: Annual permanent carbon forestry employment impacts per 1,000 hectares – by component

FTE	Direct	Indirect	Induced	Total
Year 1 - Costs of planting	1	2	1	4
Years 2 – 50 - Ongoing costs (rates, R&M admin, insurance)	>0	>0	>0	<1
Years 2 – 50 - Spending of carbon units	>0	>0	1	1
50-Year Average	**0**	**0**	**1**	**1**

Note: There may be small discrepancies due to rounding

Figure 10: Comparison of permanent carbon forestry and plantation forestry value chains



The low figures for economic impact, compared to plantation forest, should not be surprising. Permanent carbon forestry requires minimal purchases from the rest of the economy, and does not generate materials or goods for use in the economy. In particular, reflecting the lack of production and low level of input costs, permanent carbon forestry has very low impacts on employment – essentially, negligible.

Variation by Tree Species

The number of carbon units received, and therefore carbon revenue, varies by tree species, as given by the carbon lookup tables published by MPI.17 For this analysis, we have used the total carbon units set out below in Table 11 and Figure 11 below.

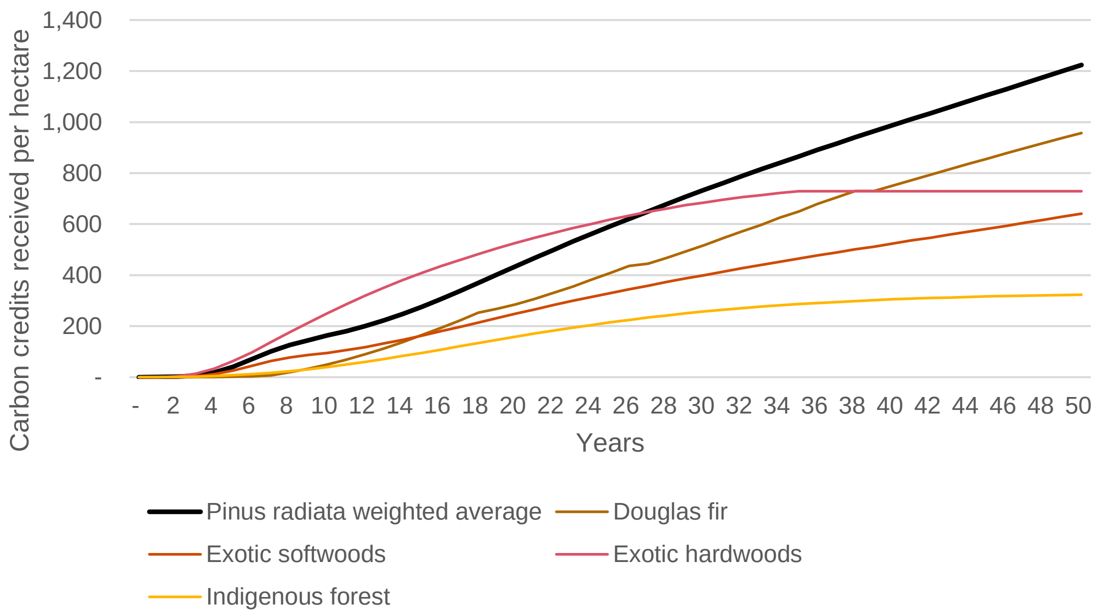
Table 11: Total carbon units by tree species, over 50 years

Value-add ($m)	Pinus Radiata	Exotic Hardwoods	Indigenous Forest
Carbon Credits	1,226*	744**	324

** Note: this figure is from the synthetic national-level carbon index*

*** Note: this represents the amount eligible at year 35, the last year of carbon units available for Exotic Hardwoods.*

Figure 11: Carbon credits for post-1989 forest – by tree species

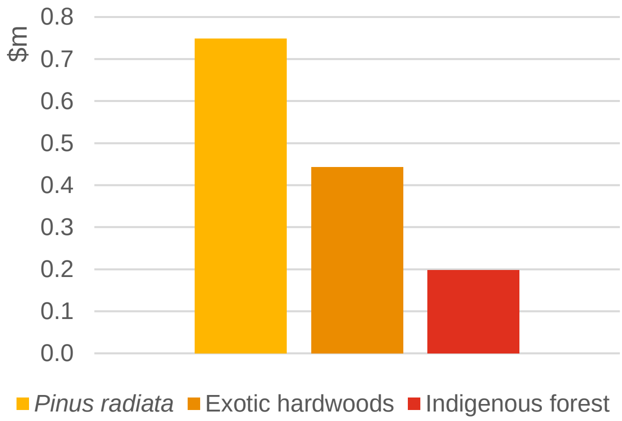


Source: MPI

The economic impact of new permanent carbon forestry by tree species is shown in Figure 12. Exotic hardwoods are included as they are a likely alternative to *pinus radiata* for permanent carbon forestry. The full results of this analysis can be found in Appendix B.

[17] Ministry for Primary Industries. (2017). *A guide to Carbon Look-up Tables for Forestry in the Emissions Trading Scheme.*

Figure 12: Average annual value-add impact ($m) per 1,000 hectares – permanent carbon forestry by tree species, averaged over 50 years



Source: PwC New Zealand

As would be expected, the impacts move proportional to the volume of carbon units.

Forestry integrated into sheep and beef farming

Sheep and beef farming integrated with forestry is based on the key assumption that a sheep and beef farm choosing to integrate forestry is likely to have an area of lower productivity land in mind. In this scenario we assume changing the land-use of the least productive 10 per cent of sheep and beef farmland to forestry will not reduce the overall sheep and beef production. The reasons for this assumption are:

1. Some classes of land on hill country farms in some parts of the country may be better suited to forestry than meat production. This may be due to the low productivity of these classes of land for sheep and beef farming and the challenges of maintaining pasture and production.
2. Focusing on more productive areas of the land may improve the productivity of the remaining area used for sheep and beef farming.
3. Integrated plantings, particularly in more exposed locations, may improve animal survival and welfare.

Other considerations not captured in this analysis that present further avenues for research to refine the assumptions include:

1. The geography of any particular farm – the reasons an area may not be productive for sheep and beef may also mean it may not be productive for forestry. For instance, these could include limited accessibility for logging or whether the less productive land is interspersed or consolidated.
2. The broader impact of diversification to forestry on income, quality-of-life and environmental measures.

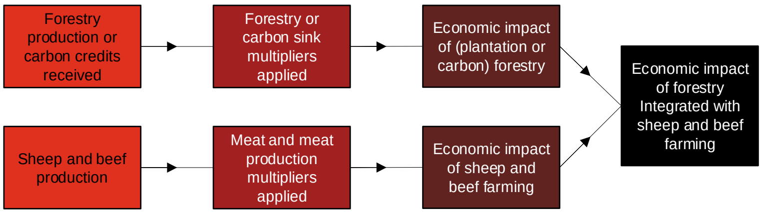
Approach

The analysis combines the approaches taken in the previous two sections (forestry impacts and plantation impacts), to produce results for:

- Sheep and beef farming integrated with plantation forestry; and
- Sheep and beef farming integrated with pinus radiata permanent carbon forestry.

Figure 13 illustrates the simplified approach of the modelling for sheep and beef farms integrated with forestry. Integrated forestry systems are modelled with 10 percent of land-use changed to either plantation forestry or permanent carbon forestry.

Figure 13: Simplified integrated forestry system analysis



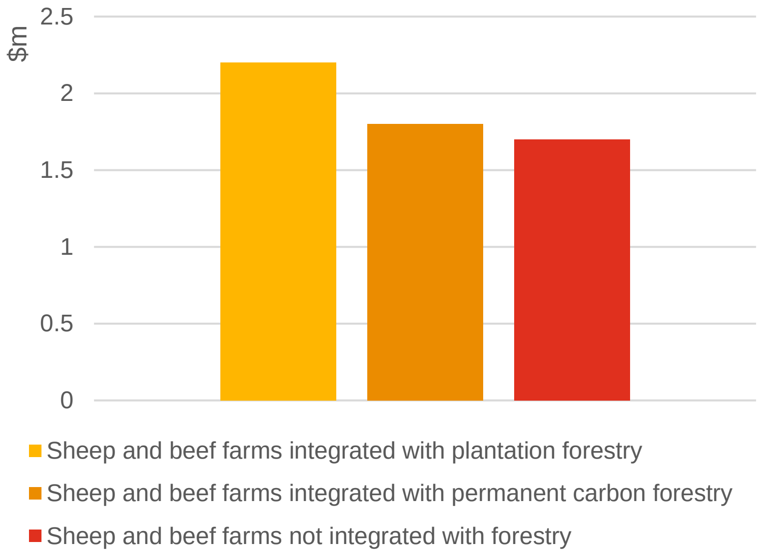
The analysis is presented on a per 1,000 hectares basis. It is important to note that this does not represent a farm of 1,000 hectares. Rather, it should be viewed as a generic 1,000 hectares, used to represent the integrated approach in a form that is comparable to the other analysis presented in this report.

Key Assumptions:

- The composition of forestry and sheep and beef value chains is equal to that of the national level (i.e. wood harvested is split in the same proportion as the national analysis for log exporting, pulp manufacturing and processed wood product manufacturing); and
- For the permanent carbon forestry analysis, the new forest is assumed to be permanent carbon forestry with *pinus radiata* with the carbon revenue allocation simplified to be on a straight-line average over 50 years.

The assumptions used in modelling the economic impact of plantation and permanent carbon forestry portions are also applied here. We also note that a farm integrated with forestry is also likely to have costs that are more variable as the forests are smaller and often on steeper, less accessible areas of the farm.

Figure 14: Annual total value-add impact ($m) per 1,000 hectares - forestry integrated into sheep and beef farming – by type



Source: PwC New Zealand

Table 12: Annual total economic impacts per 1,000 hectares – sheep and beef farming integrated with forestry by type

	Sheep and beef farming integrated with plantation forestry	Sheep and beef farming integrated with permanent carbon forestry	Sheep and beef farming not with integrated forestry
Value-add ($m)	2.2	1.8	1.7

The full results of this analysis can be found in Appendix B.

Comparison of Net Present Values

One of the challenges of analysing the relative economic impacts of forestry (both plantation and permanent carbon) and sheep and beef farming is that the two industries operate on radically different production cycles: annual in the case of sheep and beef, and decades-long in the case of forestry (and no production cycle for permanent carbon forestry). The analysis presented above shows the current national impacts of the two industries, and the subsequent analysis of permanent carbon forestry and forestry integrated into sheep and beef farming, attempts to show a steady state comparison of the various situations.

This approach, however, does not expose the differences in cash flows between the two production cycles, which would be expected to have a significant impact on the relative attractiveness of the two as investments, or on the nature of a transition from one to the other. This section addresses this issue, albeit at a very high level, through a discounted cashflow analysis. We have modelled three scenarios:

1. Two cycles of plantation forestry with carbon units earned from years 0-to-17 with an average harvest age of 28 years.[18]
2. Permanent carbon forestry with carbon credits up to 50 years with no harvest.
3. Sheep and beef farming for the equivalent period as two cycles of plantation forestry.

Key Assumptions

Key assumptions used in the analysis are:

- The operating expenditures for forestry (plantation and permanent) are those identified by BakerAg;
- The cost of purchase of the land is not included;
- The revenue from forestry harvest is equivalent to the quantity harvested per hectare multiplied by the assumed price of logs of $130 per cubic metre (this is around the 2018-average on the PF Olsen Log Price Index and reflects favourable conditions for log prices[19]);
- The pre-tax real discount rate is assumed to be 7 per cent[20] (this is the same for both forestry and sheep and beef farming to keep the analysis equivalent);
- Carbon unit revenues are received on a five-yearly basis;
- The NPV per hectare for sheep and beef farming is calculated using an estimated representative free cashflow from B+LNZ data (farm profit before interest and tax (EBIT) per hectare plus the depreciation per hectare as a proxy for ongoing capital expenditure); and
- The benchmark figures used for sheep and beef farming are the provisional 2018-19 figures for Class 3 land for Gisborne, Hawke's Bay and Wairarapa (North Island Hard Hill Country East Coast) based on the 2017-18 survey (i.e. relatively low productivity sheep and beef farm class and an area likely to see afforestation in the future).

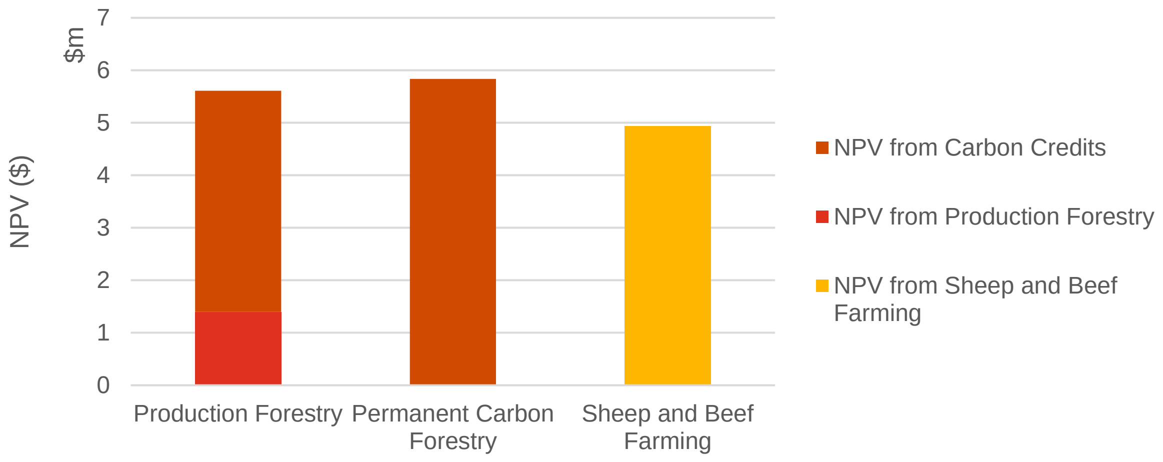
This analysis evaluates the NPV for a general hectare of land. The actual NPV for any specific hectare will depend on the unique characteristics of that land, as well as the economies of scale for each land-use. For instance, the NPV for forestry may be less due to difficult terrain or location, and whether the land is of sufficient scale to be worth doing.

[18] Ministry for Primary Industries. (2017). *A guide to Carbon Look-up Tables for Forestry in the Emissions Trading Scheme.*
[19] Downs, S. (2020). *Log Market – February*. PF Olsen.
[20] Crighton Anderson. (2014). *Forestry Valuation Quarterly – July*.

Results

The results of the analysis are presented in Figure 15 below.

Figure 15: Net present value ($) per hectare – different land-uses



In line with the economic analysis presented above, forestry shows significantly higher returns over sheep and beef farming, over the life of the investment. Permanent carbon forestry is relatively more attractive than plantation forestry due to a combination of significantly lower up-front costs and a longer period of carbon revenues.

This does not however reflect the change in annual cashflows. Sheep and beef farming should produce annual returns, whereas returns to forestry are not received until the first payment of carbon revenue in year 5. In the case of a sheep and beef owner-operator, the removal of annual cash flow (whether technically received as investment returns or as a salary) can make forestry unattractive. In this respect, conversion from sheep and beef to forestry may well occur with change in ownership. The cash flow profiles of plantation and permanent carbon forestry are attached in Appendix D.

Key Conclusions

The results presented here are dependent on the data and assumptions used. Any real-life comparisons of alternative uses for a specific piece of land can be expected to be different, reflecting the productivity derived from actual circumstances. From the modelling, we conclude that, on average, the forestry value chain has a larger economic impact per hectare than the sheep and beef value chain.

A very simple financial comparison of the relative attractiveness of plantation forestry, permanent carbon forestry and sheep and beef farming suggests that for some land types (in this case hard hill country), forestry generally offers greater returns when enhanced by carbon unit revenue. Within this analysis, plantation forestry and permanent carbon forestry offer comparable returns over the long term, but significantly different economic impacts, with permanent carbon forestry having comparatively low impacts, compared to sheep and beef farming and plantation forestry. The split of the value between returns to capital and returns to labour is also shifted almost completely in favour of capital: almost no employment impacts are generated from permanent carbon forestry, by comparison to sheep and beef and plantation forestry.

Overall, this analysis suggests that, with carbon unit prices at or in the range of NZ$25, permanent carbon forestry can offer comparable returns to plantation forestry, and both can offer superior returns to sheep and beef. The GDP impacts, however, are materially different. A move from plantation to permanent carbon forestry significantly reduces the GDP impacts, and reduces employment impacts to negligible. This is the natural effect of converting land to a use that is not economically productive.

Appendix A – Data sources and assumptions

Table 13: Data used and comparable sources – Base case

	Input	Units	Value	Year ended	Author	Source
Logging	Total hectares of plantation forestry	ha	1,725,476	01/04/2018	Forest Owners Association	Facts and Figures 2018-2019
	Cubic metres of exported logs	m^3	21,096,760	03/06/2018	Statistics NZ	Jun Years Exports by Product Forestry product
	Value of exported logs	$	3,394,702,696	03/06/2018	Statistics NZ	Jun Years Exports by Product Forestry product
Wood pulp	Tonnes of wood pulp produced	t	1,430,392	31/03/2018	Statistics NZ	Production of Pulp in New Zealand
	Tonnes of exported wood pulp	t	930,604	30/06/2018	Statistics NZ	Jun Years Exports by Product Forestry product
	Value of exported wood pulp	$	827,624,000	30/06/2018	Statistics NZ	Jun Years Exports by Product Forestry product
	Total harvested tonnes of wood (used to convert tonnes of wood pulp into m^3)	t	35,779,000	31/12/2018	Forest Owners Association	Facts and Figures 2018-2019
Processed wood products	Cubic metres of processed wood (including wood pulp)	m^3	12,813,000	31/03/2018	Statistics NZ	Estimated processing of roundwood from NZ forest by wood supply region
Beef cattle farming	Total number of beef cattle	#	3,616,000	30/06/2018	Beef + Lamb New Zealand	Compendium of New Zealand Farm Facts 2019 (43rd edition)
	Beef cattle processed	#	2,600,000	30/06/2018	Beef + Lamb New Zealand	Compendium of New Zealand Farm Facts 2019 (43rd edition)
	Farm-gate price per head of beef	$	1,245	30/06/2018	Beef + Lamb New Zealand	Compendium of New Zealand Farm Facts 2019 (43rd edition)
	Steer weight per cattle	kg	312	30/06/2018	Beef + Lamb New Zealand	Compendium of New Zealand Farm Facts 2019 (43rd edition)

	Tonnes of exported beef	t	452,920	30/06/2018	Statistics NZ	Quantity of principal exports (excl re-exports) – SH (Annual - Jun)
	Value of exported beef	$	3,324,100,000	30/06/2018	Statistics NZ	Value of principal exports (excl re-exports) – SH (Annual-Jun)
Lamb and mutton farming	Total number of sheep	#	26,527,000	30/06/2018	Beef + Lamb New Zealand	Compendium of New Zealand Farm Facts 2019 (43rd edition)
	Lambs processed	#	20,100,000	30/06/2018	Beef + Lamb New Zealand	Compendium of New Zealand Farm Facts 2019 (43rd edition)
	Farm-gate price per head – lamb	$	134	30/06/2018	Beef + Lamb New Zealand	Compendium of New Zealand Farm Facts 2019 (43rd edition)
	Lamb weight per lamb	kg	18.6	30/06/2018	Beef + Lamb New Zealand	Compendium of New Zealand Farm Facts 2019 (43rd edition)
	Mutton processed	#	4,100,000	30/06/2018	Beef + Lamb New Zealand	Compendium of New Zealand Farm Facts 2019 (43rd edition)
	Farm-gate price per head – mutton	#	108	30/06/2018	Beef + Lamb New Zealand	Compendium of New Zealand Farm Facts 2019 (43rd edition)
	Mutton weight per sheep	kg	26	30/06/2018	Beef + Lamb New Zealand	Compendium of New Zealand Farm Facts 2019 (43rd edition)
	Exported lamb and mutton	t	399,304	30/06/2018	Statistics NZ	Quantity of principal exports (excl re-exports) – SH (Annual - Jun)
	Value of exported lamb and mutton	$	3,802,787,000	30/06/2018	Statistics NZ	Value of principal exports (excl re-exports) – SH (Annual-Jun)
Wool farming	Wool weight per sheep per year	kg	5.2	30/06/2018	Beef + Lamb New Zealand	Compendium of New Zealand Farm Facts 2019 (43rd edition)
	Total wool production (greasy)	t	139,200	30/06/2018	Beef + Lamb New Zealand	Compendium of New Zealand Farm Facts 2019 (43rd edition)
	Wool (greasy) price	$/t	4,120	30/06/2018	Beef + Lamb New Zealand	Compendium of New Zealand Farm Facts 2019 (43rd edition)
	Wool produced	t	105,000	30/06/2018	Beef + Lamb New Zealand	Compendium of New Zealand Farm Facts 2019 (43rd edition)
	Value of all exported wool products	$	687,500,000	30/06/2018	Beef + Lamb New Zealand	Compendium of New Zealand Farm Facts 2019 (43rd edition)

Table 14: Data used and comparable sources – Permanent carbon forestry

	Input	Units	Value	Year ended	Author	Source
Permanent carbon forestry	Price per NZU	$	25	-	Ministry for Primary Industries	Improvements to the New Zealand Emissions Trading Scheme: Consultation document

Table 15: National weighted average carbon index

	Auckland	Waikato/Taupo	Bay of Plenty	Gisborne	Hawke's Bay/ Southern North Island	Nelson/ Marlborough	Canterbury/West Cost	Otago	Southland	Weighted average by region hectares
Weights	6.7%	12.2%	4.4%	3.4%	20.6%	6.6%	22.7%	11.8%	11.6%	**100%**
Years										
1	0.5	0.4	0.4	0.6	0.5	0.2	0.2	0.3	0.2	**0**
2	3	3	2	4	3	1	1	2	1	**2**
3	8	7	6	10	9	3	2	5	3	**5**
4	29	25	24	37	34	12	5	9	14	**19**
5	59	50	51	77	71	28	15	26	35	**42**
6	98	84	84	121	113	48	31	49	65	**71**
7	131	111	118	162	155	73	53	72	99	**102**
8	153	130	143	190	185	100	76	94	134	**127**
9	166	142	155	201	197	117	101	124	160	**147**
10	188	163	169	219	210	132	125	141	174	**165**

11	217	188	188	242	233	144	139	146	181	**181**
12	249	218	212	270	260	161	150	156	198	**201**
13	283	249	239	302	291	182	158	172	219	**224**
14	320	283	269	336	325	206	170	192	244	**249**
15	357	318	300	372	361	232	186	214	272	**277**
16	396	354	333	410	398	260	205	240	302	**307**
17	435	391	367	447	436	290	226	268	334	**339**
18	473	428	401	485	473	322	249	298	367	**371**
19	511	464	435	522	510	353	274	329	401	**404**
20	549	500	468	558	547	386	300	361	435	**437**
21	585	536	501	594	582	418	326	394	470	**469**
22	620	570	533	628	617	450	353	426	504	**502**
23	653	603	564	661	650	482	380	458	538	**533**
24	685	636	593	692	681	513	408	490	571	**564**
25	715	666	622	722	712	543	435	521	604	**594**
26	745	696	650	751	741	573	461	552	635	**623**
27	773	726	677	779	769	603	488	583	667	**652**
28	801	755	704	807	797	632	515	613	698	**680**
29	828	783	730	834	825	661	542	644	729	**709**

30	855	811	755	861	852	690	569	674	760	**737**
31	880	838	780	886	878	718	595	703	790	**764**
32	905	865	804	912	903	745	621	732	820	**790**
33	930	891	828	937	929	772	647	761	849	**817**
34	954	916	851	961	953	799	672	789	878	**842**
35	977	941	873	985	978	825	697	817	906	**868**
36	1,000	965	896	1,009	1,002	850	722	845	934	**893**
37	1,022	990	917	1,032	1,026	875	746	872	962	**918**
38	1,044	1,013	938	1,055	1,050	900	770	899	989	**942**
39	1,066	1,037	959	1,079	1,073	924	793	925	1,016	**966**
40	1,088	1,060	980	1,102	1,097	947	816	951	1,043	**990**
41	1,110	1,083	1,001	1,125	1,121	971	839	978	1,070	**1,014**
42	1,132	1,106	1,021	1,148	1,144	994	861	1,003	1,097	**1,037**
43	1,154	1,130	1,042	1,172	1,168	1,016	883	1,029	1,123	**1,061**
44	1,176	1,153	1,062	1,196	1,192	1,039	905	1,054	1,149	**1,084**
45	1,198	1,176	1,082	1,220	1,217	1,061	926	1,080	1,176	**1,108**
46	1,220	1,199	1,103	1,244	1,242	1,083	947	1,105	1,202	**1,131**
47	1,243	1,223	1,123	1,269	1,267	1,105	967	1,130	1,229	**1,154**
48	1,266	1,247	1,144	1,295	1,292	1,126	988	1,155	1,255	**1,178**

49	1,289	1,272	1,165	1,321	1,319	1,148	1,008	1,181	1,282	**1,202**
50	1,313	1,296	1,187	1,347	1,345	1,170	1,028	1,206	1,309	**1,226**

Note: weights are the proportion of land classified under the Land Use Classification (LUC) system of each region by the total

Table 16: Data used and sources – NPV

	Input	Units	Value	Year ended	Author	Source
Discount rate	Discount rate	%	7	-	Crighton Anderson	July (2014). Forestry Valuation Quarterly
Production forestry	Total hectares of forestry felled	ha	51,609	As at 1 April 2019	Ministry for Primary Industries	National Exotic Forest Description: as at 1 April 2019
	Total harvested cubic metres of wood	m^3	36,404,000	31 March 2019	Ministry for Primary Industries	National Exotic Forest Description: as at 1 April 2019
	Maximum years of carbon credits eligible for first rotation	#	17	-	Ministry for Primary Industries	Potential impacts of NZ ETS accounting rule changes for forestry – averaging and harvested wood products.
	All costs	-	-	-	BakerAg. Harrison E., & Bruce, H.	Socio-economic impacts of large-scale afforestation on rural communities in the Wairoa District. Table 16.
Permanent carbon forestry	National carbon credit eligibility by year	-	-	-		Weighted average national carbon index
	Frequency of carbon credit allocations	Years	5	-	Ministry for Primary Industries	By agreement with MPI.
	All costs	-	-	-	BakerAg. Harrison E., & Bruce, H.	Socio-economic impacts of large-scale afforestation on rural communities in the Wairoa District. Table 17.
Sheep and beef farming	Free cash flow per hectare	$	329	31/03/2018	Beef + Lamb New Zealand	Provisional figure for 2018-19 for Class 3 land in Gisborne, Hawke's Bay and Wairarapa.

Appendix B – Scenario results

Permanent Carbon Forestry by Tree Species

Table 17: Annual economic impacts per 1,000 hectares of permanent carbon forestry compared to sheep and beef farming – *pinus radiata*

	Direct	Indirect	Induced	Total
Pinus radiata				
Value-add ($m)	0.6	<0.1	0.1	0.8
FTEs	0	0	1	2

Note: There may be small discrepancies due to rounding

Table 18: Annual economic impacts per 1,000 hectares of permanent carbon forestry compared to sheep and beef farming – exotic hardwoods

	Direct	Indirect	Induced	Total
Exotic hardwoods				
Value-add ($m)	0.3	<0.1	0.1	0.4
FTEs	0	0	1	1

Note: There may be small discrepancies due to rounding

Table 19: Annual economic impacts per 1,000 hectares of permanent carbon forestry compared to sheep and beef farming – indigenous forest

	Direct	Indirect	Induced	Total
Indigenous forest				
Value-add ($m)	0.1	0.0	<0.1	0.2
FTEs	0	0	0	1

Note: There may be small discrepancies due to rounding

Forestry Integrated into Sheep and Beef

Plantation forestry integrated with sheep and beef farms

Table 20: Annual value chain economic impacts – plantation forestry integrated with sheep and beef farming

	Direct	Indirect	Induced	Total
Forestry portion				
Value-add ($m)	0.2	0.2	0.1	0.5
FTEs	1	2	1	4
Sheep and beef portion				
Value-add ($m)	0.7	0.6	0.5	1.7
FTEs	7	6	4	17
Total				
Value-add ($m)	0.8	0.8	0.6	2.2
FTEs	8	7	5	20

Note: There may be small discrepancies due to rounding

Sheep and beef farms integrated with permanent carbon forestry

Table 21: Annual economic impacts – permanent carbon forestry integrated with sheep and beef farming

	Direct	Indirect	Induced	Total
Permanent carbon forestry portion				
Value-add ($m)	0.1	0.0	0.0	0.1
FTEs	0	0	0	1
Sheep and beef portion				
Value-add ($m)	0.3	1.0	0.4	1.7
FTEs	4	9	4	17
Total				
Value-add ($m)	0.7	0.6	0.5	1.8
FTEs	7	6	4	17

Note: There may be small discrepancies due to rounding

Appendix C – National multipliers

Note: FTE multipliers are as of Q2 2018.

Table 22: National multipliers

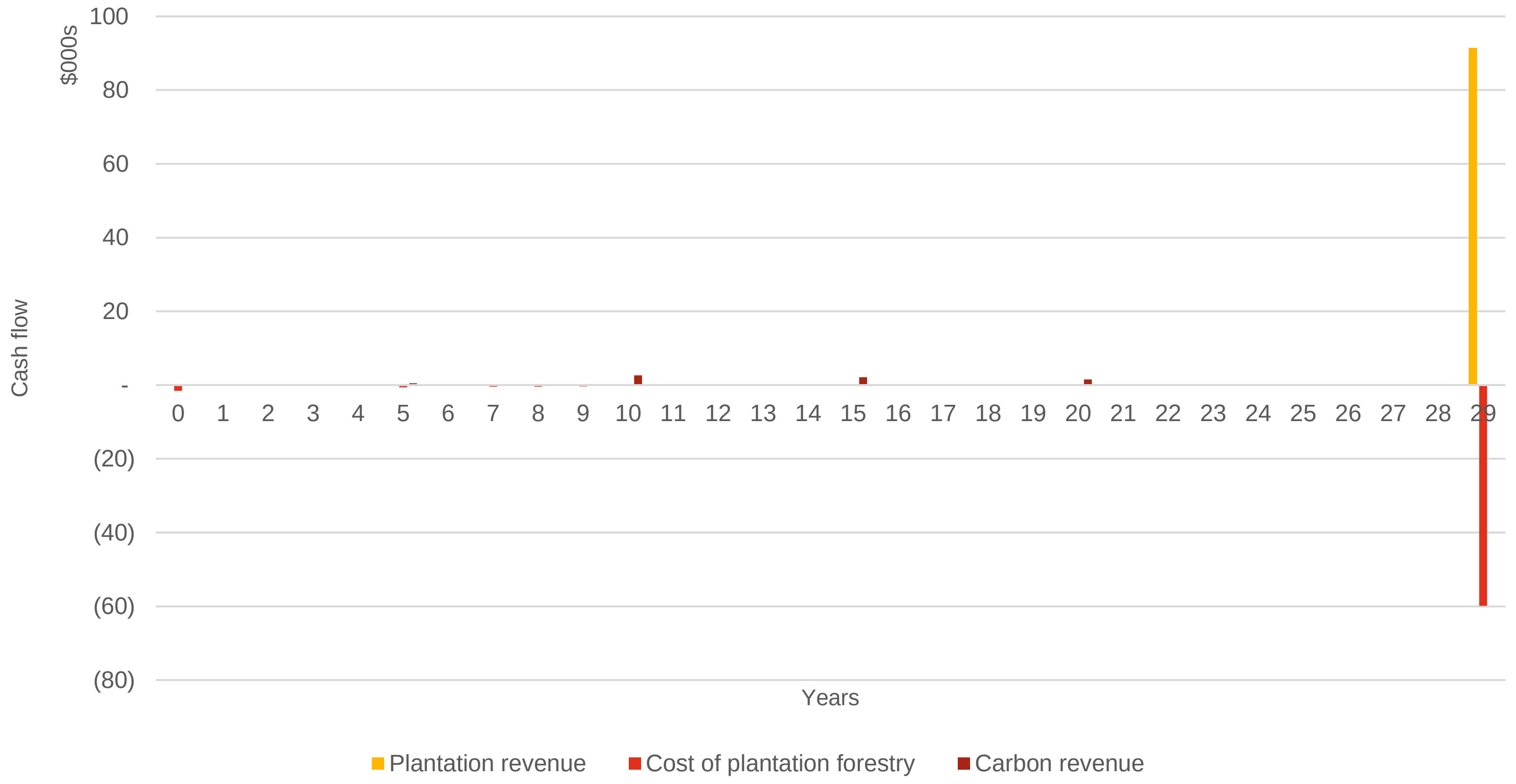
Output multipliers	Direct	First Round	Industrial support	Indirect	Induced	Direct and Indirect	Direct, Indirect and Induced	TYPE I	TYPE II
Forestry and logging	1.00	0.63	0.56	1.19	0.42	2.19	2.61	2.19	2.61
Meat and meat product manufacturing	1.00	0.77	0.71	1.48	0.59	2.48	3.07	2.48	3.07
Wood product manufacturing	1.00	0.63	0.66	1.29	0.62	2.29	2.92	2.29	2.92
Pulp, paper, and converted paper product manufacturing	1.00	0.69	0.78	1.47	0.55	2.47	3.02	2.47	3.02

FTE multipliers	Direct	First Round	Industrial support	Indirect	Induced	Direct and Indirect	Direct, Indirect and Induced	TYPE I	TYPE II
Forestry and logging	1.43	2.41	2.33	4.74	1.80	6.17	7.98	4.11	5.31
Meat and meat product manufacturing	2.37	3.32	2.91	6.23	2.51	8.60	11.11	3.47	4.48
Wood product manufacturing	3.54	2.24	2.48	4.73	2.67	8.28	10.94	2.23	2.95
Pulp, paper, and converted paper product manufacturing	1.40	1.92	2.55	4.47	2.35	5.87	8.22	3.99	5.59

Value-added multipliers	Direct	First Round	Industrial support	Indirect	Induced	Direct and Indirect	Direct, Indirect and Induced	TYPE I	TYPE II
Forestry and logging	0.35	0.27	0.25	0.52	0.22	0.87	1.09	2.49	3.11
Meat and meat product manufacturing	0.19	0.32	0.32	0.64	0.31	0.83	1.13	4.39	6.02
Wood product manufacturing	0.28	0.24	0.29	0.53	0.33	0.81	1.13	2.86	4.01
Pulp, paper, and converted paper product manufacturing	0.21	0.25	0.33	0.58	0.29	0.78	1.07	3.79	5.19

Appendix D – Estimated Cashflows

Figure 16: Estimated cashflows ($000s) per hectare – average new pinus radiata plantation forestry harvested at age 28 with carbon credits



Note: the first 17 years of carbon revenues are eligible for plantation forestry under carbon averaging with the last payment assumed to be paid in year 20.

Figure 17: Estimated cashflows ($000s) per hectare – average new pinus radiata plantation forestry harvested at age 28 without carbon credits

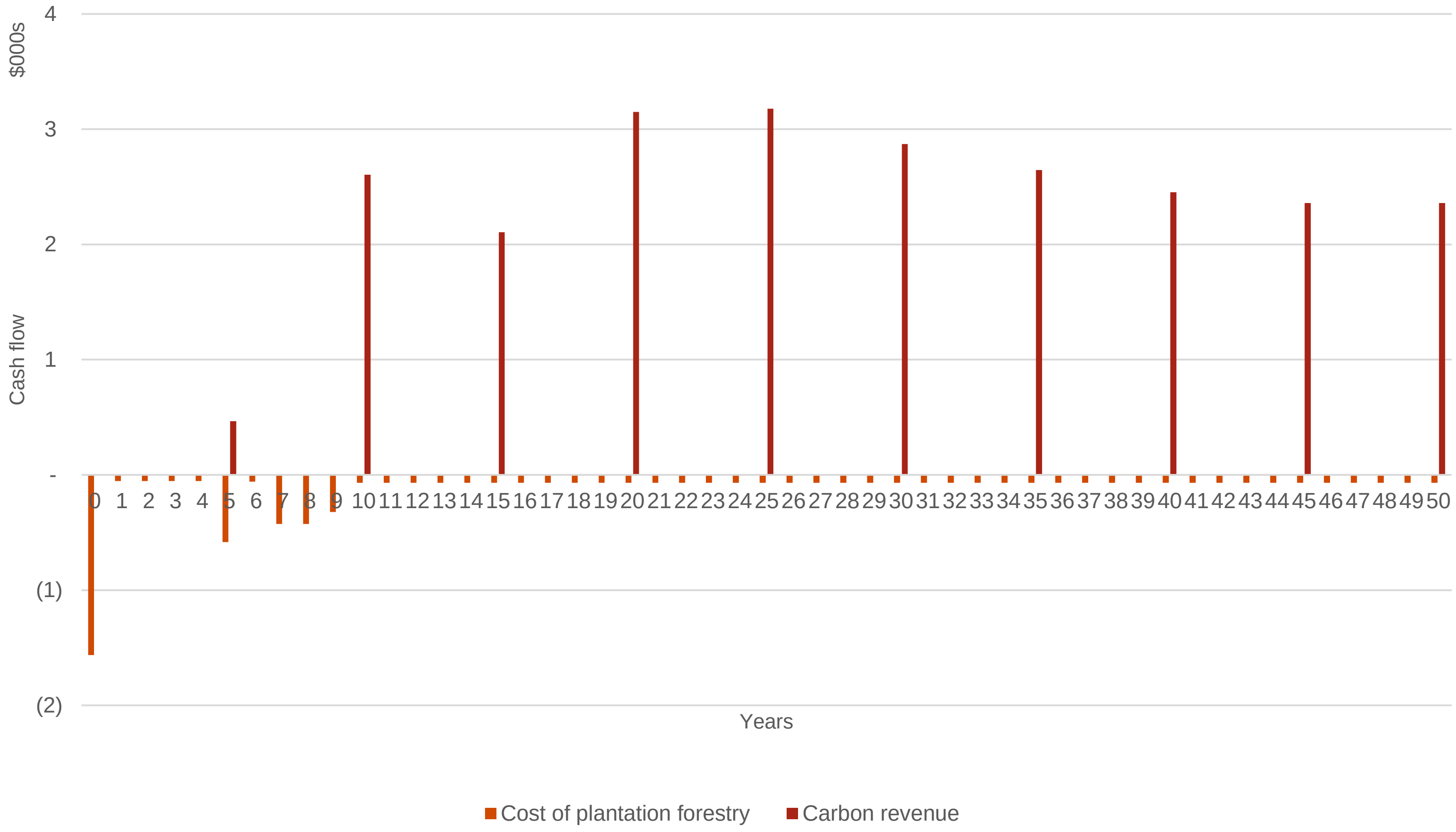
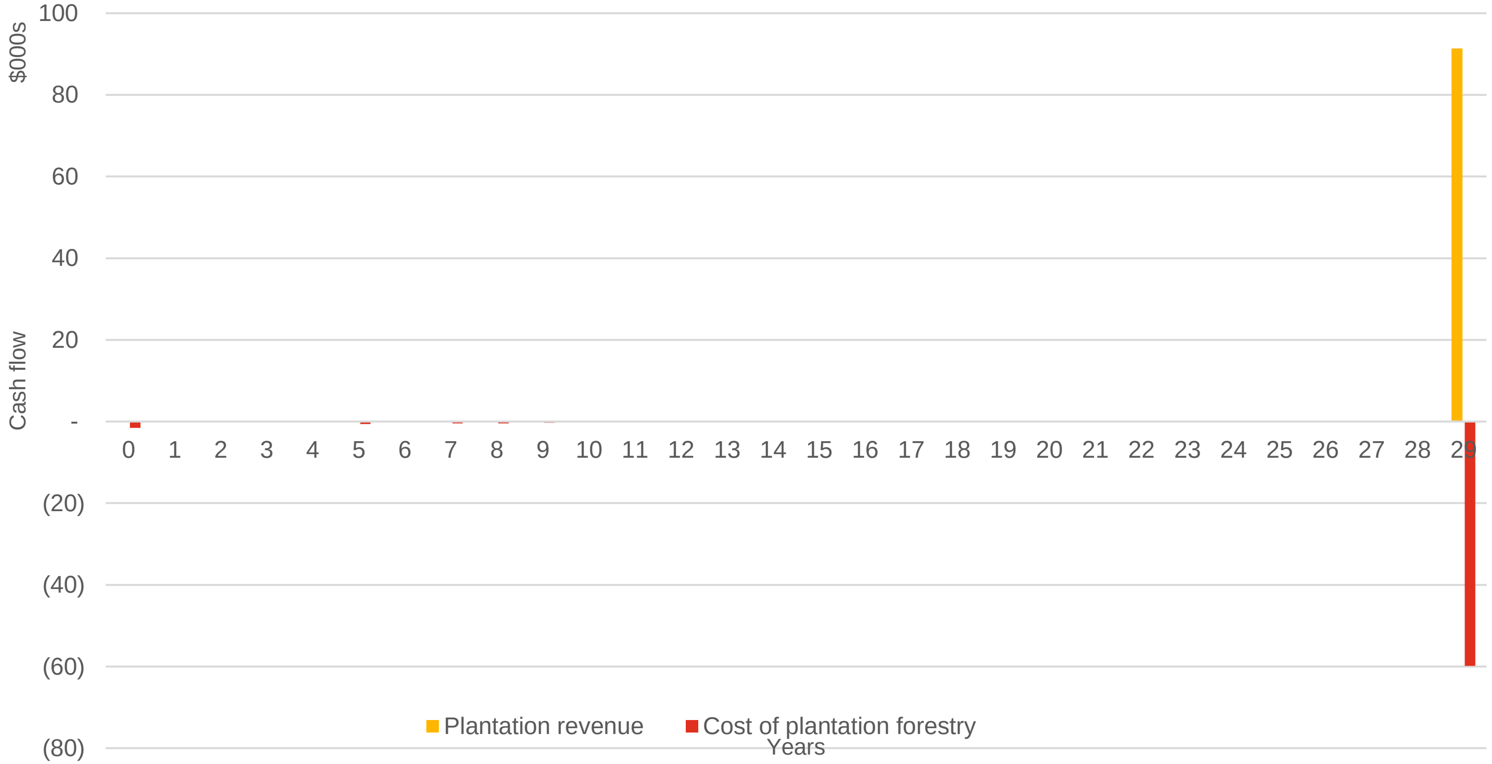


Figure 18: Estimated cashflows ($000s) per hectare – average new pinus radiata permanent carbon forestry



Appendix E – Bibliography

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Appendix F – Disclaimer and restrictions

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This report is issued pursuant to the terms and conditions set out in our contract dated 20 August 2019.