The financial implications of different afforestation regimes in the Hawke's Bay

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Mānuka flower, *Leptospermum scoparium*

Abstract

It is a significant challenge to encourage large-scale afforestation whilst ensuring the right tree is planted in the right place for the right purpose. It is recommended that interventions such as targeted financial assistance, industry and infrastructure support are implemented to minimise unintended consequences and achieve financial, community and ecosystem service benefits.

The financial success of afforestation on a given site is determined by species and regime selection, by the scale of afforestation, and by site-specific factors such as terrain, access to mills and ports, plantable area and accessibility. Eligibility for One Billion Trees Programme (1BT) funding has a significant effect on reducing establishment costs and increasing revenues for non-radiata pine options. Eligibility for carbon credits in the Emissions Trading Scheme (ETS) will vary from site-to-site and is a key economic contributor to returns and provides a major economic incentive for planting trees.

In most situations in the Hawke's Bay, radiata pine provides the highest returns. Other species, however, have inherent benefits that will improve their relative value on specific sites and that can be an attractive option when combined with incentives. An afforestation feasibility assessment can be conducted to compare returns and other benefits for a range of forest systems on a specific site. The level of incentive to encourage alternative exotic or native species can also be determined.

Individual landowners need to find the financial case for afforestation compelling. Achieving specific regional outcomes is likely to require targeted investment incentives to support landowners and communities.

Introduction

The Hawke's Bay Regional Investment Company (HBRIC) and Hawke's Bay Regional Council (HBRC) seek to understand opportunities to engage in afforestation investments to reduce soil erosion. Around 150,000 ha of land has been identified as being highly susceptible to erosion and a potential priority for afforestation within the right tree, right place for the right purpose framework.

The HBRIC/HBRC needs to understand how to drive and influence landowner behaviour to achieve its desired outcomes of developing an economically self-sustaining regional afforestation strategy, which also delivers ecosystem benefits such as avoided erosion and carbon sequestration. It is likely that customised solutions will be required for individual landowners and the argument for afforestation needs to be compelling and, in most cases, provide financial benefits that allow existing lifestyles to continue.

The afforestation options available include choosing from a range of different species and forestry regimes. Radiata pine dominates the plantation forestry landscape in New Zealand. A key contributing factor for the lack of alternative commercial species is the lack of scale and dependable volumes for market or processing development. The HBRC/HBRIC has an opportunity to promote a focused approach to invest in a select group of alternative species (i.e. picking winners) best suited to Hawke's Bay. For each species different forestry regimes are possible:

- Pruned vs unpruned
- Timber or production crop vs permanent planting for carbon, or
- Retiring land and allowing it to revert to indigenous cover naturally.

Here an economic analysis of a representative group of forestry systems has been carried out to understand how forestry regimes and site variables such as terrain, accessibility, distance to processing, forest size can affect returns. Results are presented in a form that enables comparison with agricultural land use. Different forest systems have been compared to understand how targeted investment strategies could be used to achieve a desirable species mix (i.e. ensure native or alternative species are equally attractive to radiata pine for a landowner).

Approaching the problem

Forestry options

This project analyses a representative group of forestry systems that include several commercial alternatives to radiata pine. It is important to note that this project is not specifically advocating for any of these species at this stage, and other species may emerge as viable options over time and in future stages.

The forestry options listed in Table 1 represent a selection of species and forestry regimes with the potential to provide the desired outcomes for erosion control, financial returns and ecosystem benefits.

Table 1: Species and forestry regimes considered in this work

Species group	Regime options
Radiata pine	Pruned with carbon, 28–30 yr rotation
	Framing with carbon, 25–28 yr rotation
	Permanent carbon, manage as per framing regime
Douglas-fir	Timber crop with carbon, 35–50 yr rotation
	Permanent carbon, manage as per timber crop
Dryland *Eucalyptus*	Hardwood timber crop with carbon, 20–30 yr rotation
	Permanent carbon
Cypresses	Pruned timber crop with carbon, 30–50 yr rotation
	Permanent carbon
Coast redwood	Timber with premium for pruned and heartwood with carbon
	Permanent carbon – long-lived species
Indigenous	Podocarps for timber (rimu, tōtara, kauri) with carbon
	Permanent carbon
	Reversion – retirement, or minimal canopy planting, carbon
Mānuka	Honey production

Modelling

A financial model was developed in Excel to generate cashflows and financial outputs of potential species and regimes for afforestation in the Hawke's Bay. A key attribute of the model design was to allow a variety of afforestation scenarios (varying systems and scale) to be compared financially. The analysis was conducted at the macro level, primarily for comparative purposes and educational benefit, and as such is not directly relevant to any specific site. Scenarios such as 100,000 ha of indigenous can be compared to 100,000 ha of radiata pine, or 10,000 ha each of 10 different forestry systems. The output can also be used to show the potential opportunity cost of choosing a particular species at the per hectare level.

Regimes were developed for each forest system with associated average afforestation costs, yields, harvest related costs and log prices. Costs and log prices were expressed in current real New Zealand dollars as at 30

June 2019. It is assumed that future costs and log prices will increase at the same relative rate. The model includes returns from harvesting and participation in the ETS.

Assumptions that vary by species have been made, including:

- A flat carbon price of $25 per unit; costs and revenues are based on the MPI look-up tables, assuming individual participants with less than 100 ha registered in the ETS
- Land value or cost is a model input, but was assumed at zero in the default analysis
- Future log prices are based on CPI-adjusted three-year pricing to July 2019 for species where this information is available
- Where the Forecaster forestry simulation tool has been used to estimate future yields, a reduction to recoverable volume was applied that varied with species
- Cost assumptions were derived from either PF Olsen's actual averaged costs for species where there was sufficient evidential scale or, where this was not available, using expert industry knowledge.

Potential financial returns were calculated using a nominated discount rate of 6% and multiple measures are reported, including:

- Net present value (NPV) to represent the current value of a single rotation
- Land expectation value (LEV) to represent the current value of multiple rotations in perpetuity
- Equivalent annual annuity to represent an average annual return from afforestation for the purpose of direct comparison to agriculture, which is generally represented by annualised earnings.

Results

Effect of species and regimes on potential returns

The financial outputs modelled for the species and regimes listed above (Table 1) are shown in Table 2. The output is expressed per hectare and applies to a typical 'Hawke's Bay' site. Actual financial metrics will vary significantly between specific sites, and forestry regimes will vary in sensitivity to different variables. For example, returns for a permanent carbon regime for any species will not be sensitive to distance from processing facilities and markets, whereas this could have a significant impact on a commercial harvest regime. With the exception of carbon, variables (such as log prices, yield, growing and harvesting costs etc) were altered to simulate low, medium and high scenarios to demonstrate the variation between species.

As discussed earlier, due to the high-level nature of the analysis, specific results reported here can be misleading. For example, the permanent carbon regimes have a relatively narrow variance from low to high

Mature pruned radiata pine stand

Pruned cypress stand

Table 2: Financial assessment of the various species and regimes modelled for 1 ha

Species group	Regime options	Low LEV (ha⁻¹)	Med LEV (ha⁻¹)	High LEV (ha⁻¹)	Low annuity ($ha⁻¹yr⁻¹)	Med annuity ($ha⁻¹yr⁻¹)	High annuity ($ha⁻¹yr⁻¹)
Radiata pine	Pruned, carbon, 28–30 yr rotation	–1,730	5,000	8,650	–100	300	520
	Framing, carbon, 25–28 yr rotation	590	6,320	10,300	40	380	620
	Permanent carbon, manage as per framing regime	4,980	5,740	5,740	300	340	340
Douglas-fir	Timber crop, carbon, 35–50 yr rotation	–640	1,000	2,140	–40	60	130
	Permanent carbon, manage as per timber crop	1,690	2,540	2,540	100	150	150
Dryland *Eucalyptus*	Hardwood timber crop, carbon, 20–30 yr rotation	400	4,370	8,840	20	260	530
	Permanent carbon	4,070	4,830	4,830	240	290	290
Cypresses	Pruned timber crop, carbon, 30–50 yr rotation	–2,360	2,310	5,360	–140	140	320
	Permanent carbon	230	1,040	1,040	10	60	60
Coast redwood	Timber, premium for pruned and heartwood, carbon	–810	3,710	6,300	–50	220	380
	Permanent carbon – long-lived species	440	1,450	1,450	30	90	90
Indigenous	Podocarps for timber (rimu, tōtara, kauri), carbon	230	1,040	2,500	10	60	150
	Permanent carbon	–6,220	1,760	1,760	–370	110	110
	Reversion – retirement, or minimal canopy planting, carbon	2,010	2,450	2,450	120	150	150
Mānuka	Honey production	1,760	4,050	5,400	110	240	330

scenarios, whereas in reality they have the potential to vary significantly (depending on the future price of carbon or the longevity of a radiata pine crop on erodible soils), which are important areas for further research.

Strategic investment decisions

Targeted grants could be a mechanism for achieving a desired mix of forest species if the potential differences in NPVs between forestry systems is a barrier that discourages landowners from choosing alternative exotics or native species. The choice of an alternative species over the highest returning option could be encouraged if a grant matched the variance. Figure 1 shows an estimate of the incentives required to ensure the choice of system by the landowner is financially neutral.

Economic impact of terrain and market distance

Potential returns from afforestation will vary significantly from site-to-site within a specific species and regime, depending on location. Variables such as steepness of the terrain to be harvested and distance to ports or sawmills can influence costs and returns. The impact of these factors can be estimated through modelling. Table 3 shows how hauler terrain and distance to market affect NPVs, both with carbon revenues (which will generate early cashflow for a first rotation forest) and without carbon revenues (as would be the case in subsequent rotations).

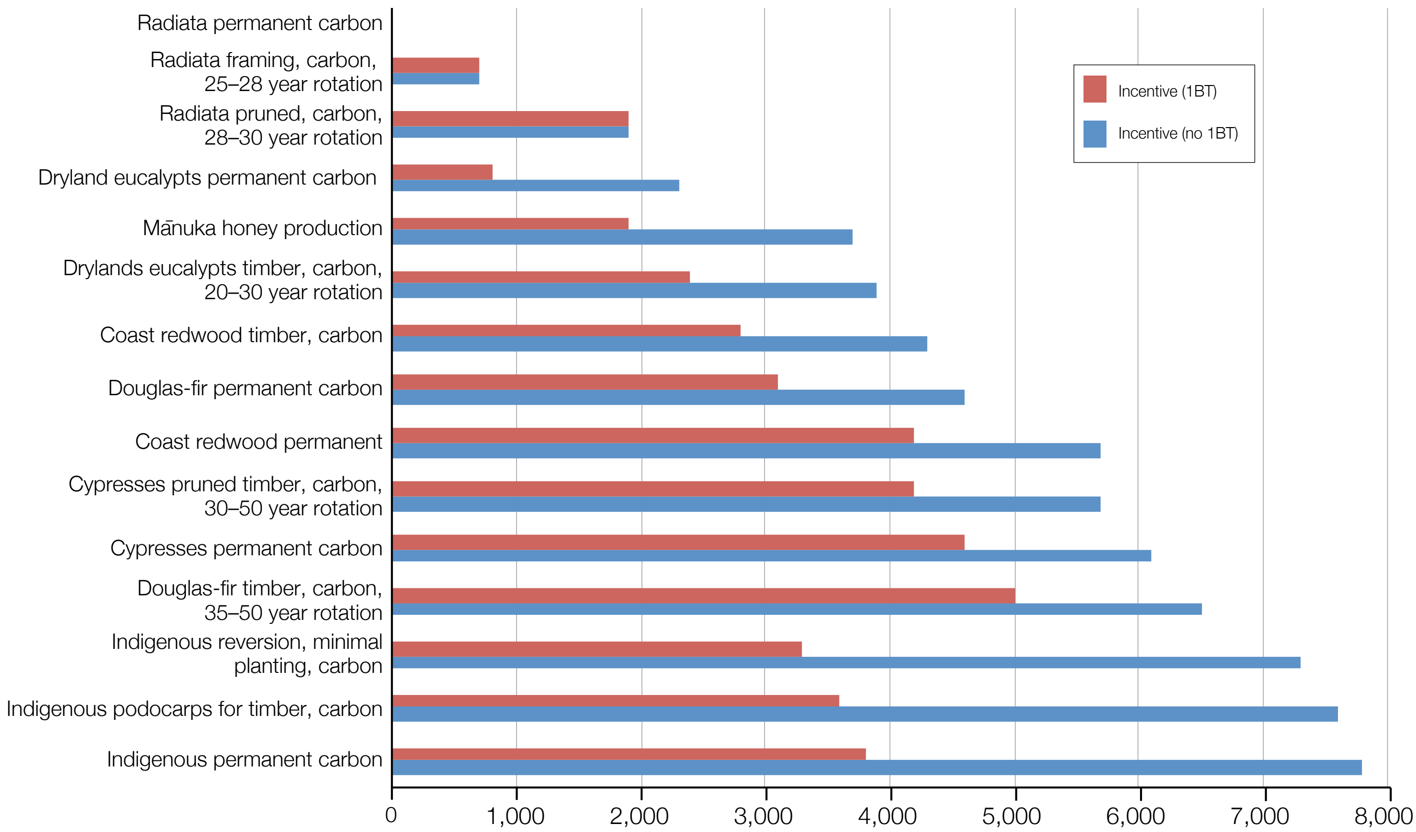

Figure 1: The approximate incentive required to ensure the choice of forestry regime by the landowner is financially neutral (variance per hectare)

Table 3: Impact of terrain and distance to port and terrain on NPV/ha for radiata pine with and without carbon (6% discount rate)

Market distance (km)	Hauler terrain (%)		
	0%	50%	100%
	$	$	$
Radiata pine with carbon			
25	8,900	8,200	6,900
50	8,000	7,400	6,000
75	7,200	6,500	5,200
100	6,300	5,700	4,300
Radiata pine timber only			
25	3,500	2,900	1,500
50	2,700	2,000	700
75	1,800	1,200	−200
100	1,000	300	−1,000

Economic impact of road access and forest scale

Further site-specific factors that can have a major effect on returns are forest scale and the accessibility of the tree crop. Table 4 shows that returns from small forests are highly sensitive to the amount of roading required to access the timber at harvest, whereas a larger forest can absorb this fixed cost.

Table 4: NPV/ha of a radiata framing stand at various scales with varying roading access requirements (6% discount rate)

Scale (ha)	Roading access required (km)		
	0.1	1	2
	$	$	$
1	5,100	−12,600	−32,200
10	7,000	5,100	3,100
100	7,100	7,000	6,800
1,000	7,200	7,200	7,100

Discussion

Species suitability

Radiata pine is a fast-growing and proven species with well-understood economics and associated risks. However, adding to the existing radiata pine resource does not fit with one of the targeted outcomes of the project to establish a more diverse forestry landscape and economic base.

Alternative tree species for planting, and their site suitability, has been explored by Palmer et al. (2020). For example, tōtara is a versatile species and likely to grow at least moderately well on about 75% of land most vulnerable to erosion. Coast redwood and cypress species are more suited to lower elevations, with redwoods more suited to the southern regions of Hawke's Bay. Neither species were suited to coastal regions due to intolerance to sea spray. *Eucalyptus* and mānuka shared similar environmental envelopes and site characteristics. In terms of local processing, some *Eucalyptus* species and coast redwood show positive returns. Cypresses from some stands are not attractive for processing, largely due to the comparatively low recovery rates of quality lumber that sometimes occur (Hall & Harnett, 2020). In general, Douglas-fir is not currently recommended due to its propensity to create wildings.

An indicative species rating for desirable attributes is given in Table 5. It is not possible to claim that one forest species is better than another. Each site is unique and landowner requirements will vary. The important consideration is optimally matching each site and landowner to a forest system or systems. Note: This work does not include ecosystem services values, which are an important consideration, especially on highly vulnerable sites.

Carbon considerations

Post-1989, ETS eligibility is a variable that will vary from site-to-site and is a key economic contributor to returns. On any given potential afforestation site with post-1989 eligible land, a landowner will typically have the option of either rotational forestry with timber and carbon (averaging) or a permanent regime with no harvest. A third option gaining some recent attention is some form of selective logging providing continuous cover. The merits of each option are site-dependent and will be driven primarily by variables such as distance to markets, access, soils and topography. Some other key considerations for carbon include:

- Carbon provides a huge economic incentive for planting trees, but participating in carbon trading (selling units) negates any official carbon neutral benefits (i.e. carbon neutrality)
- It is recommended that in most circumstances a permanent carbon regime should be managed similarly to a timber crop. This has forest health benefits and may allow for alternative income streams if there is a very different future environment (i.e. new harvesting techniques, collapse of NZU price and/or very high fibre or timber prices)
- Land value for a cutover forest where the carbon has been traded is likely to be significantly lower than bare land
- Participating in carbon trading under current circumstances will effectively lock that land into forestry in perpetuity. Therefore, considering legacy impacts is an important factor in decision-making
- The long-term performance of some species, including radiata pine, grown in a permanent carbon regime is not well established, particularly on highly-erodible land.

Targeted interventions

The regional scale of this project means that total costs and revenues from implementation are major. Afforestation of 100,000+ ha would generate billions of dollars of future revenue from timber and carbon. As the costs and returns associated with each forest system vary significantly, it is important to understand the potential financial implications at this scale when developing a strategy. For example, the projected NPVs (6% discount rate) and establishment costs (total expenditure in first five years) for 100,000 ha of radiata pine and a 100,000 ha mix of species (50,000 ha of native species, 20,000 ha of radiata pine and 10,000 ha each of *Eucalyptus*, coast redwood and mānuka for honey) are $512 million and $223 million compared with negative $271 million and $468 million, respectively. This excludes the One Billion Trees Programme (1BT) funding, as the funding

Table 5: Indicative species ratings for desirable attributes

Species	Market certainty	Site suitability	Erosion control	Financial certainty
Radiata pine	high	high	medium	high
Douglas-fir	high	low	medium	high
Dryland *Eucalyptus*	medium	low	medium	medium
Cypresses	medium	medium	medium	medium
Coast redwood	medium	high	high	medium
Mānuka (honey)	high	medium	high	medium
Mānuka (permanent)	not applicable	high	high	not applicable
Indigenous podocarps for timber (e.g. tōtara)	high	high	medium	medium
Indigenous (permanent)	not applicable	high	high	not applicable

not applicable   low   medium   high

timeframe is finite and it is uncertain what central government funding will be available in the future. The revenue includes the sale of carbon credits received through the ETS, assuming 85% of the area is post-1989 eligible in the ETS.

A generic afforestation solution relying too heavily on market forces is likely to lead to unintended consequences such as radiata monoculture or afforestation on stable and productive land. Achieving a desirable species mix at a desirable scale with a focus on planting highly-erodible land, and local, tailored site suitable forestry systems, is likely to require targeted investment strategies including:

- Direct assistance such as grants, loans, rates reduction and so on, targeted to ensure desired outcomes, including erosion control, species mix, integrated catchments, non-market benefits etc
- Supporting industry and infrastructure development from nurseries to wood processing and marketing for selected alternative and native species to develop scale
- Partnership arrangements with the HBRC or external investors (e.g. rentals, stumpage shares, carbon to ensure future returns) to build a reticulating fund
- Developing internal expertise by establishing pilot farms, holding workshops etc.

Table 6 illustrates how varying the species mix could be affected using targeted grants to influence species selection. A key assumption here is that if the returns from radiata pine are attractive enough for under-performing agricultural land, it would be the species of choice for planting without requiring additional grants.

Table 6: Effect of targeted grants on species selection

Species	Scenario 1		Scenario 2	
	Area (ha)	Grant total ($ million)	Area (ha)	Grant total ($ million)
Radiata	20,000	0	50,000	0
Mānuka	10,000	30	10,000	30
Eucalypts	10,000	32	10,000	32
Redwood	10,000	36	10,000	36
Reversion	0	0	10,000	0
Native timber	50,000	345	10,000	69
Total	100,000	443	100,000	167

From a strategic viewpoint, the HBRIC and HBRC may develop a preferred species and regime mix. Targeted interventions will be required to encourage this. However, actual outcomes will ultimately depend on landowners' collective decisions and various market forces potentially requiring a dynamic strategy to achieve desired outcomes.

Conclusion

A financial model has been developed to generate cashflows and financial outputs of potential forestry species and regimes for afforestation in the Hawke's Bay, to assist with future decision-making to make sure financial considerations are included in ensuring the right tree is planted in the right place for the right purpose.

Development costs and potential returns (timber and carbon) vary between forest systems and site variables will affect returns and influence planting decisions. Incentives are likely to be needed to drive the desired species mix to ensure the choice of system by the landowner is financially neutral. As returns and relative differences between the systems will vary significantly from site-to-site, landowners will need customised advice. The HBRIC and HBRC have an opportunity to promote a focused approach to invest in a select group of alternative species (i.e. picking winners) best suited to the Hawke's Bay. Targeted incentives or regulations may be required to ensure that planting native or alternative species are as equally attractive as radiata pine to a landowner.

This project is potentially transformational, as it brings together a range of regime possibilities with associated returns and required incentives or support to develop a regional portfolio mix of forest plantings that does not rely solely on market returns. Using this approach, it will be possible to achieve positive outcomes for the environment, the economy and communities, not just in the Hawke's Bay but in all of New Zealand.

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