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Pine forestry in the Marlborough Sounds

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Front cover photo: Complementary land uses on-farm in mid-Canterbury. Photo courtesy of Scion

Back cover photo: Coastal redwood from Knapdale in Poverty Bay, 20-year-old stand. Photo courtesy of Trevor Best

The view from the boundary

Trevor Best

Last week I had the good fortune to visit various forests in Te Tai Rawhiti. To a forester, a visit to the forestry conurbation that is Tauwhareparae, inland from Tolaga Bay, is to pay witness to a marvel. The natural productivity of the landscape has produced radiata pine forests that have good form and high volumes. A small army of people travel up the road each day to do the work that will provide for their families and put money in their communities (Gisborne and Tolaga Bay). The engineering systems used to harvest wood from these long, steep, broken slopes are way beyond what was originally envisaged when the forests were planted. Eastland Port is now the second largest log exporter in the country, with capacity for three million tonnes per year and an intention to grow that to five million. What has happened within the forest boundary stands as a testament to the skill and capability of generations of kiwi foresters and engineers. The act of faith represented by greenfields afforestation in the 1960s and 1970s has been largely confirmed and rewarded.

However, when driving up State Highway 2 to Tolaga Bay, and then into Tauwhareparae via the road with the same name, you could be forgiven for not having got that part of the story. As you dodge the many logging trucks going up the road, you will see (amongst the pastured roadsides and gamboling peacocks) billboards proclaiming the idea that rural landscapes are for kiwi's, people and birds, not wall-to-wall wood, as if the two are somehow opposite and mutually exclusive within the landscape. If for some reason you decide to do that drive at 2.30 am in the morning, you will not only be dodging logging trucks heading off for their first load, you will be amongst the loader operators driving up from Gisborne to get there before them. The further along the Tauwhareparae Road you travel the greater the consequence to the road itself. Bridges are damaged, some parts are difficult to traverse due to slips, and council roading crews are doing major repairs and maintenance. If you live and farm alongside those roads some of the values that drew you there may well be lost. The vendor at the recently sold Mangaheia Station, located alongside Tauwhareparae, cited trucks and community loss as a reason not to sell the 2,400 ha to forestry interests. The community expressed their gratitude and relief. Few forces are as virulent as shared grief. Empathy provides a pathway that triggers fear in those who could be similarly affected, more so if the view you used to enjoy over the beach is periodically covered in slash.

Despite all the political rhetoric surrounding the issue, this seems to me to be what the current forestry vs farming stoush is about. The costs being borne outside the forest boundary are socialised, while the benefits are largely returned to those invested in what goes on within the boundary. Everyone's perspective is dictated by where they sit in the landscape relative to that forest boundary. It is a reminder that landscapes are imbued with meaning by those who go about their life's work of building their identity in that place. People are at the heart of a landscape, and if foresters want forests to be part of that landscape we must find a way to engage with those people. If we cannot find a way to engage with the community then regulators stand ready to act.

With this very public fight going on around the profession at the moment, it is a good time to continue our review of the work Scion has been doing by using data-driven evidence as the basis for a sustainable afforestation strategy for the Hawke's Bay Regional Investment Company and the Hawke's Bay Regional Council. That strategy is aimed at using the potential of the land to produce a commercial forestry return, while reducing soil erosion alongside a range of other environmental benefits. Improving the community's social, environmental and economic well-being is the outcome sought by the stakeholders. In the last edition of this Journal, the subject matter was focused on the potential sites, species and non-wood benefits and the biomass and processing opportunities. In this edition, the papers focus on what it will take to convince existing landowners to convert part of their land to plantation forests.

We are also fortunate to have contributions from other authors that fit with the theme of right tree, right place, for the right purpose. Steve Urlich provides a review of the impacts of harvesting operations in another challenging landscape, the Marlborough Sounds and the Pelorus Catchment. Ian Page has completed an interesting case study of his own experience logging small-scale forest blocks. Chris Perley finishes things off with The Last Word on a more integrated approach to development within landscapes. I hope you find something in the edition that is both enjoyable and thought provoking.

The role of data, models and tools in support of afforestation

David Palmer and Michelle Harnett

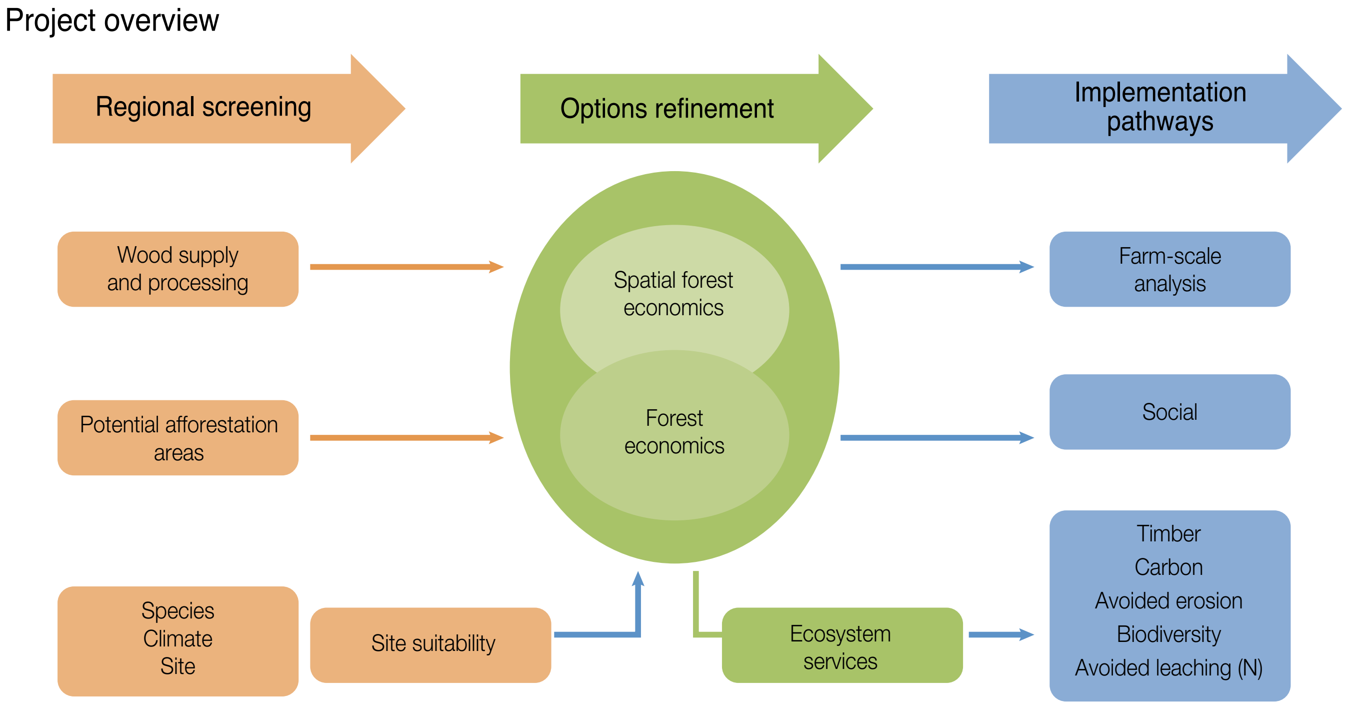

Figure 1: An overview of the 'Planting Eroding Hill Country in the Hawke's Bay Region: Right Tree, Right Place, Right Purpose' project

Abstract

In the Hawke's Bay region erosion and sediment loss is a major environmental issue. A recent project looking at the potential for afforestation to control erosion has identified a range of tree species, forestry regimes, the potential economic and environmental returns of afforestation across the region, as well as comparing the economics of afforestation with agriculture. The regional resources developed as part of the project will enable objective discussions and decision-making in what is becoming an emotive and subjective social arena. Data and modelling tools and software were fundamental to the success of the project. Advances in data technology will allow even better afforestation potential analysis at much finer scale. These new technologies and ways to monitor the land and its productivity are increasingly making sustainable, complementary land management (which unites farming, plantation forestry, permanent forests and other land uses) a reality.

Introduction

Researchers from Scion (along with forestry and agricultural consultants and funding from Te Uru Rākau) have used broad-scale spatial information across a range of tree species and forest systems, as well as forest economics and social analysis, to explore planting the right tree in the right place and for the right purpose across the Hawke's Bay landscape. In this case, the primary purpose of afforestation is to reduce or mitigate erosion. Around 12% of the Hawke's Bay region has a high susceptibility to erosion. The Hawke's Bay Regional Investment Company (HBRIC) and the Hawke's Bay Regional Council (HBRC) want to explore opportunities for using afforestation to reduce erosion and provide both economic and environmental land-use solutions. See inset about the HBRC's work in this area (written by Chief Executive James Palmer) at the end of this paper on page 8.

The structure of the project was designed to provide a sound platform for future decision-making. Regional screening (Figure 1) investigates the possible (practical) options for afforestation and was reported in the May 2020 issue of the *New Zealand Journal of Forestry*.

Implementation pathways

Human and social aspects are important considerations when trying to encourage forestry options. Indeed, for the establishment of forests across landscapes identified as the most vulnerable to erosion to occur, landowners need to be convinced of the economic, environmental and social benefits that afforestation will bring. Forestry consultants, PF Olsen, have modelled the financial implications of afforestation using different tree species and alternative forestry management regimes for the Hawke's Bay. Agricultural consultants, AgFirst Hawke's Bay, have demonstrated a tipping point between forestry and pastoral land use where forestry options can make better financial sense under the right conditions.

Detailed assessments at the farm level need to take place if a complementary approach between forestry and farming is to be considered. The approach could be where less-productive land is assessed for afforestation, while higher quality land is managed more intensively, together increasing overall returns. Landowner attitudes towards afforestation have been explored by business consultants, Fresh Perspective Insight. They believe that every landowner's situation is unique and needs careful consideration to address and encourage the drivers to afforestation and overcome barriers such as lack of experience and uncertainty around financial risk.

The work has also shown that the HBRC and HBRIC and landowners need more information and knowledge to support their decisions around afforestation. This is information that can be used to compare agricultural and forestry outcomes, to support landowners considering afforestation, and to provide incentives. This can be achieved in part by empowering landowners with the tools to help with decisions, but also through educating and employing rural professionals to work through details with landowners on the hows (where and what to plant) and whys (range of benefits) of forestry.

Data key to supporting individual solutions

The information that individual landowners and regional bodies need to make decisions often depends on software and tools for modelling available data. The models and software used are continually being refined and the amount of data related to terrain, land use, tree species and genetics, for example, is growing rapidly. Combined, improved models and data will contribute to better decision-making and improved economic, environmental and social outcomes.

A wealth of spatial data is available for modelling forests, many of which are in the public domain, but also some that are privately owned. Table 1 lists the spatial layers that are frequently used in the modelling and mapping of land uses including forestry.

Table 1: Selected spatial layers frequently used in the modelling and mapping of forestry and afforestation

Spatial layers	Units	Abbreviation	Reference
Climate			
Air temperature (mean annual)	°C	T_{mean}	Wratt et al. (2006)
Air temperature (Dec & Jan)	°C	T_{DecJan}	Wratt et al. (2006)
Degree ground frost (Oct)	days	DGF	Leathwick et al. (1998)
Rainfall (total annual)	mm	Rain	Wratt et al. (2006)
Rainfall days (Dec & Jan)	days year^{-1}	Rain days	Wratt et al. (2006)
Landscape and topographic			
Aspect	°	Asp	Palmer et al. (2009)
Distance from coast	km	CoastDist	Palmer et al. (2020)
Distance from mills	km	MillDist	Yao et al. (2016)
Distance from ports	km	PortDist	Yao et al. (2016)
Elevation	m	Elev	Barringer et al. (2002)
Hauler and ground-based	–	HaulGround	Yao et al. (2016)
Impedance	$	Imp	Yao et al. (2016)
Land Cover Database	–	LCDB	MfE (2020)
Land Use Capability	–	LUC	Lynn et al. (2009)
LUCAS	–	LUCAS	MfE (2020)
Roads	–	Roads	LINZ
SedNetNZ	t km^{-2} yr^{-1}	SedNetNZ	Dymond et al. (2010)
Slope	°	Slope	Palmer et al. (2009)
Wind effect (SAGA)	–	Wind exposure	SAGA-GIS.org
Productivity			
300 Index	m^3 ha^{-1} yr^{-1}	300Index	Palmer et al. (2009a)
Soil water			
Profile available water content	mm	PAW	Newsome et al. (2008)

Models and tools

Making use of these data required integrated modelling systems and tools. In this project we used a number of them to undertake the regional analysis and finer scale case study analysis at the property level.

Forest productivity and economic modelling requires forest regime and productivity data, and also costs and revenues to enable economic analysis. Radiata pine has the best supporting data and tools such as Forecaster are normally used for regime analysis. In the case of this project, where much less information and data was available for species other than radiata, Excel-based models were developed.

The Forest Investment Framework (FIF) integrates data from many sources to quantify the broader value of planted forests. FIF was used in the Hawke's Bay right tree, right place, right purpose project by Yao and Palmer (2020) to estimate the non-market value of benefits such as avoided erosion and reduced nutrient leaching. Being able to account for the multiple values of an ecosystem that are realised not only by landowners and/or managers, but also by the general public, helps bodies such as the HBRC with decision-making. They are now armed with the information and understanding to formulate and support programmes that promote economically viable, ecologically sound and socially just initiatives as part of sustainable land management.

WoodScape, a techno-economic model, was used to assess wood-processing capabilities in the Hawke's Bay (Hall & Harnett, 2020). They found there was scope for increasing processing, leading to employment creation and an increased gross domestic product (GDP). Techno-economic modelling can be taken further by looking at how a whole value chain might be optimised. Scion used this approach in their Biofuels Roadmap study (Scion, 2018) considering variables such as land use capability, where biomass could be grown, the siting of existing and new forests, feedstock transportation and technologies to produce biofuels. A process of mixing, matching and analysing then modelled various scenarios to find optimised combinations.

Farmax (www.farmax.co.nz) is a decision support tool for farmers that allows them to create a farm system model and test different scenarios to see how changes to the farm will affect biological and financial feasibility. In this project we used it to develop on-farm case studies and explore the opportunities for trees, and the tipping point between pastoral systems and production or retirement forestry, by linking to separate forestry models.

A taste of the data-rich future

Perhaps most exciting and interesting to farmers and foresters is the new data being collected remotely by laser scanners, still and video cameras, and spectral sensors mounted on unmanned aerial vehicles (UAVs), aircraft or even satellites. With decreasing cost, improving resolution and more frequent scanning, obtaining the data for precision land management is becoming a reality.

The highly detailed terrain maps that can be created using laser scanning will allow landowners to identify smaller, more vulnerable areas that need to be managed closely, and assist in decision-making around permanent (riparian) plantings, for example, or plantation forestry, or a combination. Identifying the right place to plant trees to prevent vulnerable land from further degradation is at the heart of the Hawke's Bay afforestation on erodible landscapes project.

Forest owners and managers are also taking advantage of this technology. Not only can remote laser scanning be used to create digital terrain maps of forested landscape, individual trees can also be picked out and characterised. This opens up the possibility of using a tree's appearance (phenotype), which is influenced by both its genes and its growing environment, to identify trees with optimal genetics for different niches in the landscape. For example, while most trees will grow well on warm fertile sites, being able to select trees that thrive despite a southerly aspect or being planted in a damp gully or on a dry, cold site, can speed up genetic improvement programmes and increase overall forest productivity by ensuring the right genetics are planted at the right micro-site (Dungey et al., 2018). Figure 2 shows a tree that has been laser-scanned from above, then below. Each image is missing detail, but by combining the two the full tree can be visualised.

Remotely-sensed measurements collected at mid- and end-of-rotation can be used to construct 3D representations of forests to accurately predict key variables such as top height, stem density, basal area and total stem volume (Puliti et al., 2020). Having an accurate inventory of both tree volumes and tree

Figure 2: Laser scanning results for an individual tree. (Left) scanned from above; (middle) scanned from below; (right) composite image

grades allows forest owners and managers to value their forests, and decide prior to harvesting which products (end use) the trees may be most suited for.

The technology can go further. Laser scanning below the canopy can also allow the vertical structure of a forest to be represented and characteristics such as internode distances and tree sweep can be estimated (Figure 3). This technology has the potential to provide processors with an exact tree stem shape and form before milling, allowing optimisation of milling operations. Overall, trees can be harvested, processed and marketed to reduce waste and maximise returns.

Discussion and conclusion

Reliable and detailed data, and tools to translate the data into information, are essential to support the landowners who will be planting trees on vulnerable landscapes with the goal of reducing erosion. Each landowner's situation is unique in terms of their financial situation, land use capability classes, and their aspirations and attitudes. However, the majority want to protect their land for future generations and make their operations more resilient and sustainable. To do this they need to assess the performance of their land to within-paddock detail and consider other land-use options such as forestry that could, for example, complement pastoral farming and increase overall returns. They also need to recognise that afforestation can provide wider environmental and social benefits, as well as economic.

More data is also needed on tree species. Radiata pine dominates plantation forestry in New Zealand, and it is the current focus of increasing forest productivity. While other species can compete favourably, their performance is not always consistent. However, applying new data collection and analysis technology to these species will also lead to improved productivity though better site selection and genetic improvement. Targeting selected alternative species will also allow effort to be focused on market development, collaboration, and developing scale and infrastructure.

Other benefits of afforestation are often ignored when making decisions about what to plant and where. The economic tool FIF can be used to better account for the full value of planted forests in land-use policy. Being able to put a value on benefits that do not have market values, such as avoided erosion or water quality, helps stakeholders understand and compare the true costs of different land uses and move towards sustainable land management practices.

The HBRC and HBRIC have an opportunity to support and leverage existing industry and infrastructure. This includes using specific interventions and investment strategies to influence landowners' decisions

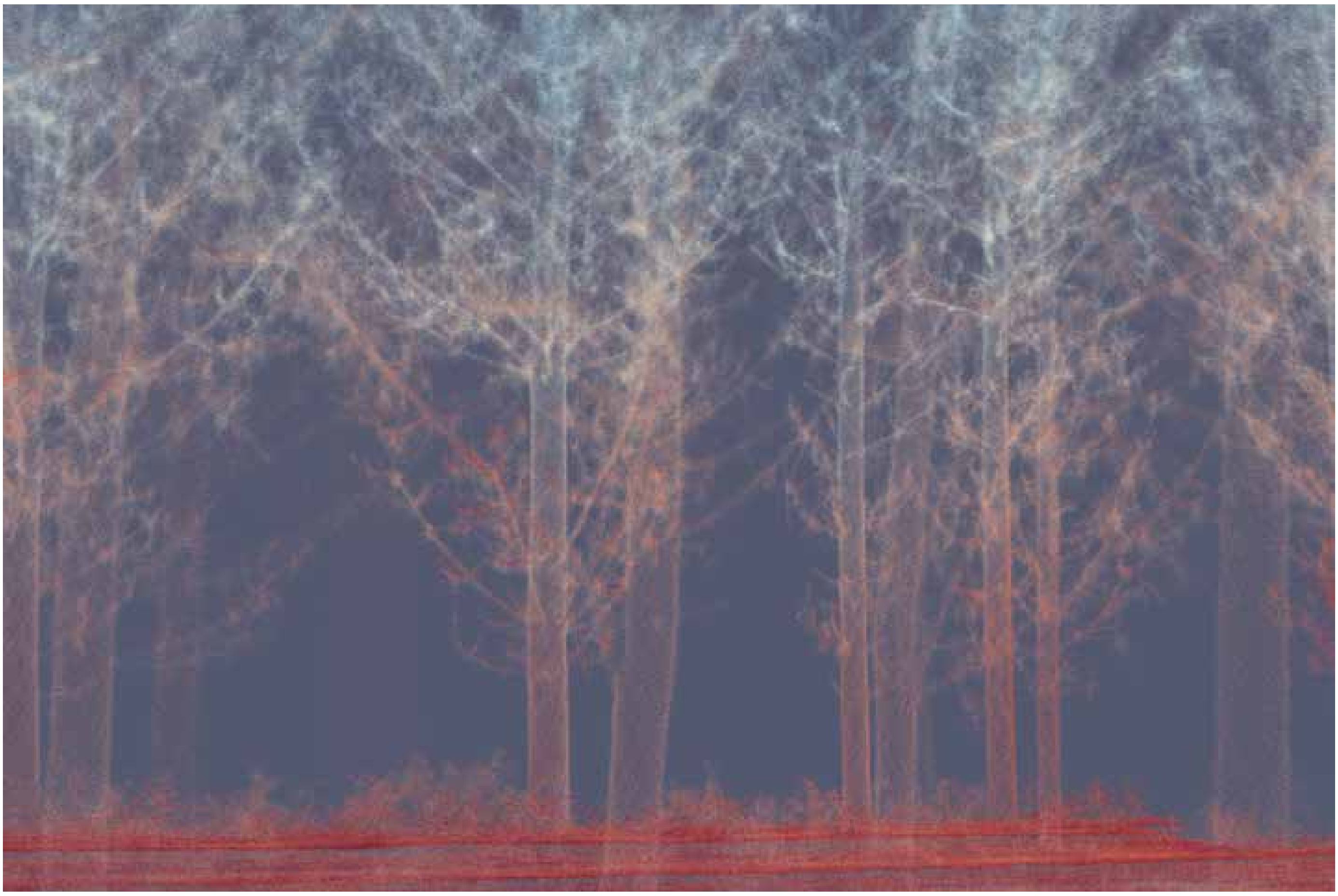

Figure 3: 3D representation of radiata pine trees obtained by below-canopy laser scanning

to choose native as well as exotic forest species to deliver environmental benefits and satisfy landowners' preferences. Another possible role for regional bodies is developing internal forestry expertise and resources for landowners unsure of how to get into forestry.

Data collection and analysis has underpinned this entire project, and some of the new data science and technologies that have been described here are already helping foresters increase the productivity of their forests. The ability to get remotely-sensed data that is frequently updated, detailed and accurate from remote, hard to access country, is cheaper and safer than having boots on the ground. Foresters will be able to monitor forest health and growth rates, for example, and make early interventions to boost productivity. Accurate pre-harvest inventories of volume and form will also boost productivity by enabling optimised processing and waste reduction.

The HBRIC and HBRC and landowners can now identify areas that are vulnerable to erosion, which forestry species and regimes could be appropriate, the economic (timber and carbon) value of afforestation plus the value of preventing erosion and other environmental benefits, and how the wood could be processed to increase returns and jobs. New technologies and ways to monitor the land and its productivity are increasingly making sustainable, complementary land management (which unites farming, plantation forestry, permanent forests and other land uses) a reality. The result will be a robust and resilient landscape increasing the wellbeing of all New Zealanders.

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HBRC pulling all the levers to reverse catastrophic erosion damage

Hawke's Bay is at a critical turning point where we must act with urgency and plant trees on such a scale so as to reverse the catastrophic damage to our environment over the past 100 years. Our landscapes are barren – the casualty of mass clearing by pioneering settlers to create farms, who could not have foreseen the full environmental implications of their actions. You don't need to go very far down a rural road in this region before seeing gaping, scarred and eroded hills.

We estimate around 12% (or 250–380,000 ha) of our region is highly vulnerable to soil erosion. Every year, thousands of tonnes worth of potentially productive soil dislodge and fall into our waterways, threatening our ecologically important estuarine and coastal habitats. On a stormy day, you can see the pervasive sedimentation of our waterways, from our streams and rivers to the coast, where our seas turn brown.

The story of how we got here is similar to other regions, and rural areas around the world, marked by deforestation, the development of pastoral farming and loss of biodiversity. In 1938, a storm hammered the East Coast, which resulted in massive sediment loss from the hills north-west of Napier, drowning the valley floors and burying homes in silt to the rooftops. This resulted in the 1941 Soil Conservation and Rivers Control Act, which started the soil conversation programme and established catchment boards – the early genesis of our regional councils.

Following that event, the Hawke's Bay Catchment Board (now the Hawke's Bay Regional Council) established the Tangoio soil conservation reserve and reduced soil erosion in one of the most affected parts of the region. Fast-forward to today, and despite 80 years of valiant soil conservation work the region still faces wide-scale erosion damage. Given climate change is coming at us like a freight train, we need to act with urgency.

We know planting trees is the single most effective short-term action to restore erosion-prone areas, slow climate change, and the most cost-effective mechanism to improve water quality and biodiversity. We want to develop our existing partnerships with landowners to plant trees, and accelerate this planting programme at sufficient pace and scale to meet freshwater quality objectives and ensure climate resilient landscapes.

The quality and quantity of our soil is critical to the overall health of our land and wider environment, storing water, carbon and nutrients, growing food, breaking down contaminants and hosting species. The data-driven Right Tree, Right Place (RTRP) programme project reinforced that owners of the land need to see the social, environmental and financial benefits of afforestation and how it might impact local communities. It provided context on regional afforestation options in Hawke's Bay. The project showed us a detailed technical and spatial analysis of what tree species might be planted where, wood processing opportunities, an assessment of ecosystem services, farmer perspectives on afforestation and farm case studies.

We will use the insights gained from the RTRP project to partner with landowners to optimise the mix between permanent forest and tree crops and pastoral farming, to knit together a more diverse patchwork of land use with greater resilience and ecological integrity and function.

The regional council recognises the sediment and water quality challenges associated with plantation forestry as well, and that binary choices between landscape-scale pastoral farming and plantation forestry are an impediment to optimised land use. Most of all, the project reinforced for us the importance of partnership with our farming community.

While there may be broad themes applicable across farms with similar characteristics and soil types, each farm is unique. Each farmer has their own vision and aspirations for their land.

The RTRP programme needs to be co-designed with farmers as early as possible. The most likely area for a co-design trial for large-scale implementation would be in the Wairoa area. Catchment management advisors will be key to that, as they hold the relationships with farmers and local knowledge.

Our strategic goal is that all highly erodible land in the region is under tree cover by 2050, through acceleration of riparian planting and fencing in priority catchments and financial incentivisation of the treatment of erosion-prone land.

We are exploring funding mechanisms and landowner engagement programmes to bring the environmental and economic issues, and subsequent options, to landowners. In partnership with our community, we can ensure the right tree is placed in the right place for the right purpose. In doing so we can dramatically improve water quality and biodiversity, farm system resilience and diversification of income, and make a tangible difference to climate change adaptation and mitigation. Eighty-two years on from that storm in Northern Hawke's Bay the imperative to act is greater than ever before.

James Palmer

Chief Executive of HBRC
Member of Forestry Ministerial Advisory Group

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

Andrew Clarke

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 ($ha^{-1}yr^{-1})	Med annuity ($ha^{-1}yr^{-1})	High annuity ($ha^{-1}yr^{-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).

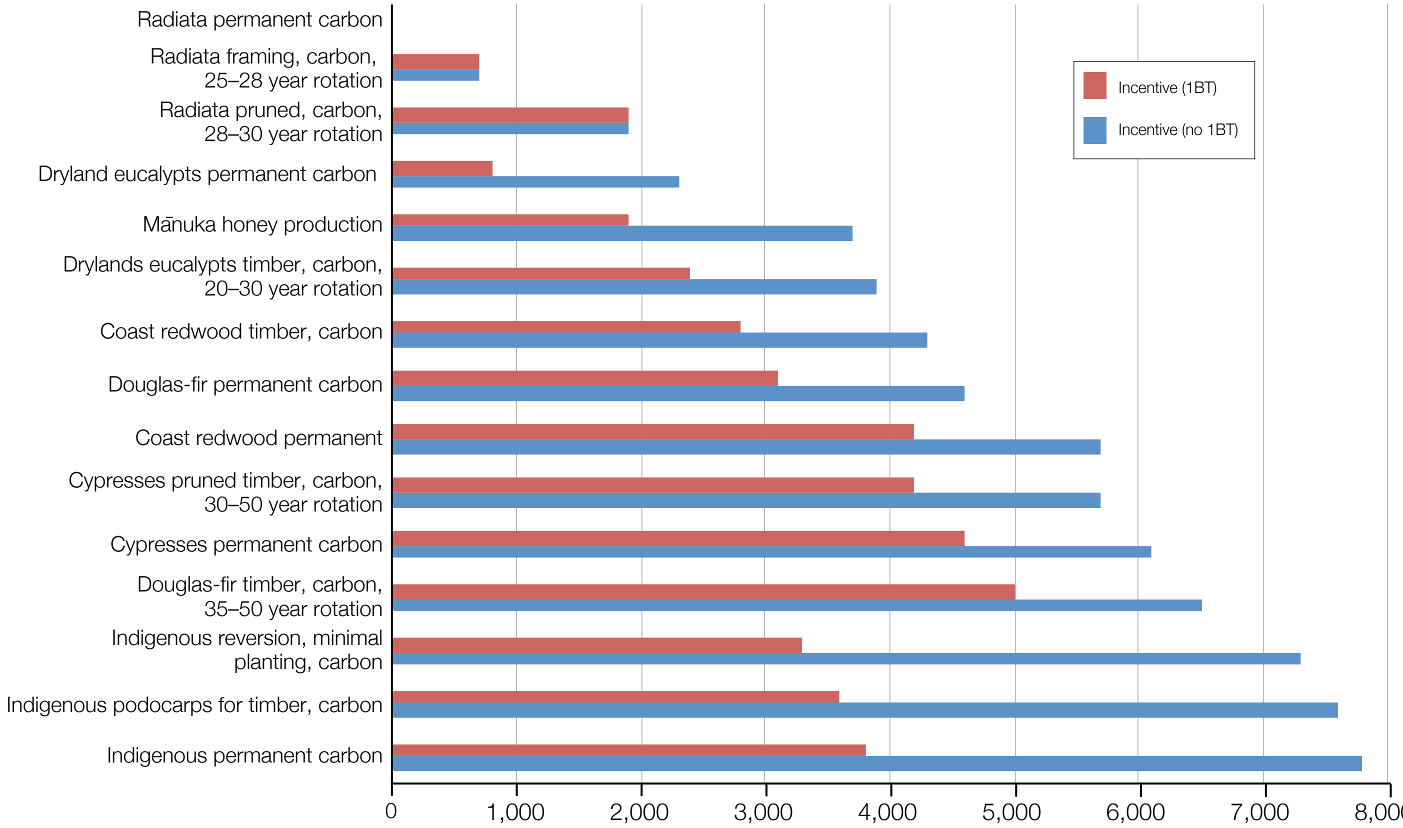

Figure 1: The approximate incentive required to ensure the choice of forestry regime by the landowner is financially neutral (variance per hectare)

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.

Acknowledgements

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Endless shades of green – calculating the economic thresholds between farming and forestry

Lochie MacGillivray and Phil Tither

Abstract

Land use options have been evaluated to explore at which point it become economically worthwhile to plant pastoral land in trees by considering the relative returns between production forestry and pastoral options in the Hawke's Bay. The work indicates that land carrying less than 6.5 stock units/ha (su ha^{-1}) would produce higher returns in production forestry. If carbon is included at \$25 t^{-1} then the breakeven is closer to 13 su ha^{-1} for the first rotation. This would mean that Land Use Capability (LUC) class VI and the better class VII is more viable in the long term for pastoral production than for production forestry. A high-resolution land inventory with an updated legend, reflecting more modern livestock (and possibly forestry) stocking and production systems, would assist land managers allocating land between the farming, forestry (and even permanent planting) as they seek to maximise their earnings before interest and tax (EBIT).

Introduction

AgFirst were asked to provide a view on the place of forestry on pastoral land and an overview of the economic advantages of planting production forestry on behalf of the Hawke's Bay Regional Investment Company. We analysed a series of farm case studies in the Hawke's Bay region focusing on the relationships between land quality, forage type and financial returns from pastoral farming and forestry. In particular, we have broadly classified land more suited to forestry rather than remaining in pastoral production systems.

Case studies

Case Study 1 considered the impact of land and forage type on production levels presented as kilograms of meat and wool per hectare. Case Study 2 focused on the relationship between land quality and returns from pastoral farming compared with forestry. In Case Study 3, the learnings from the first two studies are applied in a practical demonstration. The last study is a desktop analysis looking at the possible effects of retiring land on farm revenues. The work was carried out in July/August 2019 using Farmax software (www.farmax.co.nz).

Sheep graze intensively farmed flats

Case Study 1: Impact of land and forage type

The case study farm was divided into three land classes based on slope (steep hill, easy hill and flats) and two additional areas on flats planted in specialist legume forage (lucerne and plantain/clover). By considering the effect of land class and forage type feed supply, an estimate of their impact on meat and wool production levels could be obtained (Figure 1).

On this farm, steep hill comprised 30% of the land area, easy hill 48% and flats 22%. While the steep hill units made up 30% of the land area, they only provided about 17% of the feed supply and 12% of the meat and wool production, reflecting the lower quality of this land class. By contrast the easy hill units provided nearly a proportionate amount of feed supply (48%) to land area, but a lower level of meat and wool (43%). The flats and legumes by comparison demonstrated their higher quality by providing higher feed supply (32%) and meat and wool (46%) compared to the percentage of land area (22%).

Converting this to earnings before income and tax (EBIT) shows that better quality land gives significantly higher farming returns (Figure 2). The flats return ~\$1,000 ha^{-1} yr^{-1} more than the steep hill and ~\$650 ha^{-1} yr- more than the easy hills.

Higher quality land not only produces more dry matter and is able to carry more stock units, but typically produces feed of a higher quality.

Higher feed quality enables more profitable livestock enterprises to be employed, such as finishing stock versus breeding stock. Increasing the metabolisable energy of feed by utilising enhanced pasture mixes, such as lucerne and plantain/clover, will improve livestock feed conversion efficiency and livestock business returns.

Currently, simple dry matter production, or stocking rate, is generally used as a guideline for land use decisions. However, whole-farm modelling that includes the response in animal performance to the land types/feed type will provide more accurate guidance.

Case Study 2: Impact of land quality on stocking rates

This case study focuses on the relationship between land quality and comparing financial returns from sheep and beef, and from forestry. Stocking rate is used as a proxy for land quality.

The forestry scenario used here assumes a pruned production forestry regime with a net stumpage of \$35,000/ha converted to an annuity. Two options for carbon were considered:

- No carbon
- Including carbon credits at a value of \$25/tonne, selling the first 17 years of carbon during the first rotation.

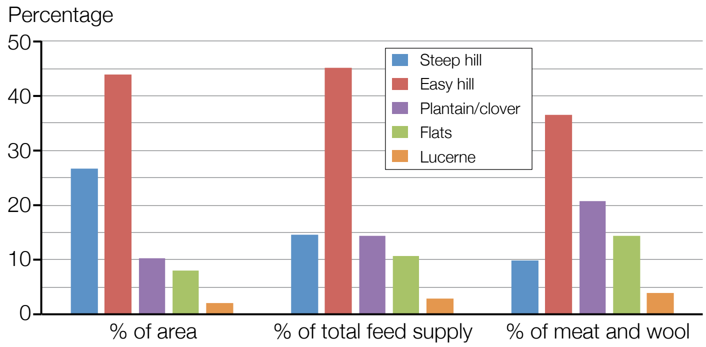

Figure 1: Contribution of land class and forage type to feed supply and meat and wool production

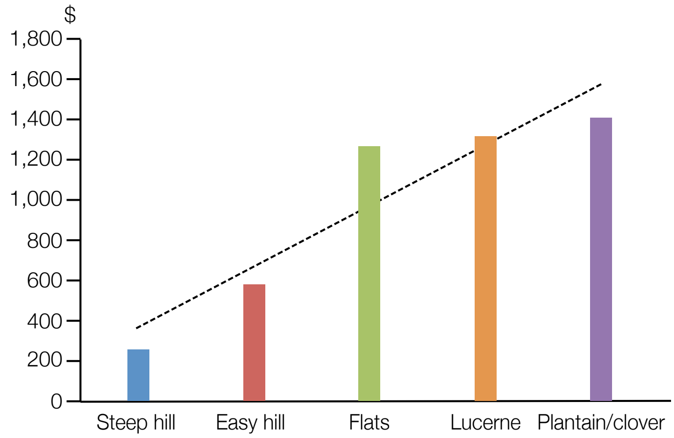

Figure 2: EBIT for pastoral farming as income \$/ha/yr

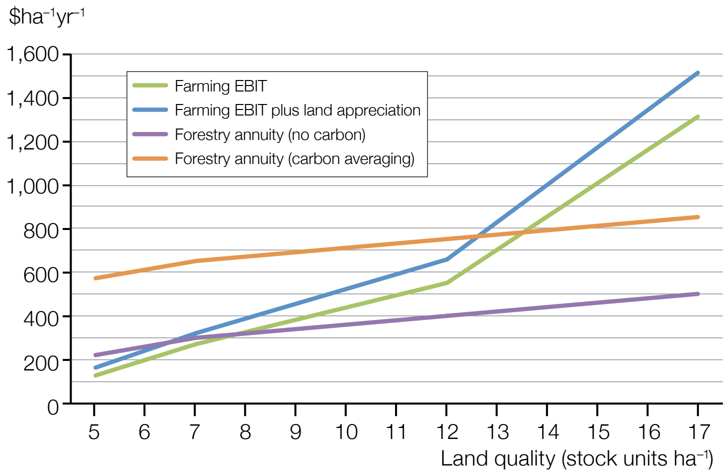

Figure 3: Farming EBIT compared with predicted forestry annuity with changes in land quality

The calculations of the forestry economics accounted for a reduction in the value of greenfields land to cutover forest ready for the second rotation. The market for cutover forest is relatively moderate with a range of \$2,000 to \$3,000/ha, and reflects the significant carbon revenue that can be earnt on the first rotation but not on subsequent rotations.

The expected earnings for land quality (as su/ha) are shown in Figure 3, along with forestry options with and without carbon. The breakeven point where forestry without carbon becomes financially viable is around 7.5 su ha^{-1} or a return of $300/ha.

The impact of adding land appreciation at 1% per year is shown by the blue line in Figure 3. Historically, clear pastoral land has increased in value at a rate greater than inflation. Often that rate of gain has averaged 2-3% p.a. There is a general expectation that the rate of real appreciation of land is likely to be slower in the future. However, the analysis has allowed for some land appreciation to be considered as a sensitivity around the option of retaining land in farming. Including land appreciation reduces the breakeven point for forestry without carbon from 7.5 su ha^{-1} to 6.5 su ha^{-1}.

When carbon is included in the first forestry rotation, the annual income breakeven point for livestock increases to around $750/ha or 12 su ha^{-1}. In this example, if stocking potential of the land is greater than 12 su ha^{-1} it should remain in pastoral farming, even accounting for the one-off benefits of carbon. (A key assumption was that whilst easier contour land would increase the forestry stumpage, the forestry returns are not as sensitive to this land quality as the livestock returns are.)

Case Study 3: A practical demonstration

A 2,100 ha coastal property with 1,250 ha currently in pastoral farming was reviewed. The farmed portion was estimated to be producing an average EBIT of around $300/ha. This was determined using a combination of benchmarking and farm simulation modelling, assuming current performance levels and expected medium-term prices. The property owners were advised that if forestry returns were presented as a discounted annual cash flow, then $300/ha would be the expected forestry income. Based on averages, the net farm revenue from pastoral land use and forestry appeared to be very similar.

Very simply, the most difficult half of the property in pastoral farming could be considered for forestry or, potentially, land retirement. This assumes that forestry returns are less sensitive to land quality, and that livestock returns could not be improved.

Alternatively, AgFirst believed that implementing farm management strategies that increased productivity on the cultivatable parts of the farm, along with a targeted livestock policy, had the potential to increase the EBIT to $538,000/year, or $430/ha. However, moving beyond looking at averages and identifying the profit contribution of the most difficult land, it was discovered that (even with improved policies) approximately 500 ha of land would still return an EBIT below $300/ha. Removing this land from pastoral use and focusing on the best 750 ha could increase the EBIT of the now smaller pastoral farm to $395,000/year, or just over $525/ha (see Table 1).

Table 1: EBIT summary

	Ha in pasture	EBIT per ha	Total EBIT
Current farm area & performance	1,250	$300	$375,000
All pasture – best practice performance	1,250	$430	$537,500
Best 750 ha @ improved performance	750	$525	$393,750

Identifying the profit contribution of different land classes

The farm had kept records of pasture covers, livestock tallies and performance within the Farmax system. Using this, it was possible to determine that potential pasture growth rates on this farm averaged 6.5 tDM/ha/yr. The farm had also been mapped into four farm production classes with further overlays of steepness and environmental risk, giving us seven land groupings. We allocated potential pasture production to ensure that the seven land class units produced the same weighted average as the total that has been recorded.

The most difficult land class was steep and erosion-prone and accounted for 132 ha. It was assumed that this block of land had the potential to produce four tonnes of low-value dry matter per hectare annually and that this would be utilised by breeding ewes and beef breeding cows. AgFirst modelled the farm as it is today and then again with the reduced land area. As well as scaling back livestock numbers, we also modelled changes to livestock policy and per head performance.

A summary of the modelled results for the steep and erosion-prone land is outlined in Table 2. The results suggest that, due to the low carrying capacity combined with the impact on animal performance, this land is generating a gross income less than $400/ha.

Even with optimistic product prices, this land class is not going to bridge the gap in returns between a net profit of $87/ha for livestock and the assumed $300/ha for forestry.

The second most difficult land class consisted of 368 ha of land and was estimated to have a potential pasture production of 5.35 tDM/ha/yr capable of carrying stock unit equivalents of 7.3/ha and generating an EBIT of $352/ha. The potential financial effects of retiring this land from grazing is shown in Table 3.

The forecast net profit for this 368 ha is estimated at $294/ha after allowance for interest on livestock capital. This is very close to the guideline breakeven figure of $300/ha for forestry. A decision on whether to retire this land class from grazing or not should be made on the basis of other factors relating to the objectives of the business. These might include:

- Environmental concerns
- Carbon capture and storage

- Ability to attract premiums in the marketplace
- Viability of scale of the residual operation
- Impact on staff
- Impact on land asset value
- Expectations of future demands for products

Whole-farm modelling approach

A whole-farm modelling approach is more sensitive to the impacts of feed quality on animal performance than simply trying to create a partial budget for the land being considered for land use change. This method also makes it possible to take into account grazing that is assumed to be available under pine trees that are three to 10 years old.

Overall, this farm would be able to generate a very similar EBIT from concentrating on the most productive 750 ha compared to the currently more extensively farmed 1,250 ha. The additional 500 ha in forestry would produce significant carbon income and eventually timber returns. Also, total nitrogen loss was expected to be reduced by 8% and phosphate loss was modelled to be reduced by 43% over the total property.

It must be noted that some of the strategies used to increase productivity would be expected to result in an increased nitrogen loss per hectare on some of the cultivated land and the use of high legume content pastures. However, the net benefits from improving the good land and allocating more difficult pastoral land to forestry would result in both financial and environmental benefits overall.

This case study identifies the opportunity to maintain cash flow income through a focus on applying more productive/profitable systems on the better land and freeing up more difficult land that can be allocated to longer-term forestry investment. The environmental benefits of such an approach can be significant, and the recommended methodology for analysis is to carry out whole-farm modelling with and without the land in question and compare the difference between the two models.

Table 2: Financial summary of the effect of retiring the most difficult land class from grazing

Financial summary: Retiring land from grazing				
Area retired from grazing (ha)		132		
Stock unit reduction			723	
Stock units per ha			5.5	
	Total	**$/ha**	**$/SU**	**c/kgDM eaten**
Income reduction ($)	51,680	392	71.48	13.0
Farm working expenses ($)	34,044	258	47.09	
EBIT ($)	17,636	134	24.39	
Interest on livestock capital ($)	6,099	46	8.44	
Net Profit ($)	**11,537**	**87**	**15.96**	**2.9**

Farm working expenses are estimated at $47/su or $258/ha

Table 3: Financial summary of the effect of retiring the second most difficult land class land from grazing

Financial summary: Retiring land from grazing				
Area retired from grazing (ha)		368		
Stock unit reduction			2,686	
Stock units per ha			7.3	
	Total	**$/ha**	**$/SU**	**c/kgDM eaten**
Income reduction ($)	255,216	694	95.02	17.3
Farm working expenses ($)	125,531	341	46.74	
EBIT ($)	129,685	352	48.28	
Interest on livestock capital ($)	21,483	58	8.00	
Net Profit ($)	**108,202**	**294**	**40.28**	**7.3**

Farm working expenses are estimated at $47/su or $258/ha

We believe that to fully assess the benefits or otherwise of a forestry investment, a whole-farm approach to the economic returns is necessary rather than using a gross margin approach. The whole-farm approach recognises the different land inventories that exist on a farm and how their dynamic interaction affects the production system choice and consequently the farm outputs.

Case Study 4: Remaining primarily a pastoral farm

Not every landowner wishes to branch out into forestry, but this should not preclude retiring land for ecosystem benefits. A desktop study was done on a 1,245 ha property in a northern Hawke's Bay sub-catchment that the owners wanted to remain primarily pastoral. This property has a mix of LUC class VII e9 (525 ha) and VI e11 (720 ha) and is carrying 11,200 su (9.0 su ha^{-1}). Across the whole farm, an average of 6,300 kgDM/ha/yr was grown. By retiring 310 ha of steep land with an annual dry matter growth of 3,850 kg/ha^{-1}/yr^{-1} (supporting 5.5 su ha^{-1}), the remaining land could theoretically grow 7,100 kg/ha^{-1}/yr^{-1} of dry matter with a stocking rate of 10.1 su ha^{-1}.

A 9% increase in gross return per stocking unit would be necessary to obtain the same Gross Farm Income (GFI) from the reduced area. This is considered feasible given the landowners would be farming only the more productive country. If the farm operating expenses were held at the current level, then the resulting surplus remains the same. It would be expected that there would be some reductions in working expenses that would be related to pastoral activities. The retired 310 ha would, on the basis of a study carried out for Beef+ Lamb NZ (Harrison & Bruce, 2019), return an NPV of between $2,600,000 to $2,900,000 under the carbon forestry regime. No calculations were made in this exercise on the resulting reduction in sediment losses from such a land use change.

Conclusions

As a broad guideline, we suggest that land on the East Coast of the North Island that has a carrying capability of less than 7.0 su/ha may be considered as potentially attractive for forestry. Farms, or parts of farms, that can produce EBIT levels greater than $300/ha should probably mostly remain in livestock production. By balancing farming and forestry, overall business viability is significantly improved.

Farms earning less than $300/ha, but with a desire to stay fundamentally in pastoral farming (such as in the northern Hawke's Bay case study), have the capacity to maintain current farm financial returns and have a forestry programme running concurrently, adding to the whole-farm long-term environmental and financial viability.

Classifying land at a farm paddock scale using LUC classification systems that take into account base soil structure, soil classification, slope, erosion risk and climate (plus other limiting factors) helps landowners identify the scale and location of poor and high-performing land. The current LUC regional scale of 1:50,000 gives an overall district picture, but the resolution is not high enough for practical farm use. A high-resolution land inventory with an updated legend reflecting more modern livestock (and possibly forestry) stocking and production systems would be a major leap forward in best land use identification, and would assist land managers in their decision-making in identifying those parcels of land where the EBIT justifies the land use decisions made.

Landowners and managers in the case studies commented on how having a forestry rotation in their farming business augmented cashflow, helping through the lean pastoral years (either caused by drought or fluctuating prices), and strengthens farm viability. They also commented that it removed some stress by not having to continually rely on the sale of protein as the major source of business income.

The whole-farm sustainability discussion must also take into consideration the increase in ecosystems and better management of land resources, to which the 'right tree in the right place' is the logical solution.

We believe that regional councils have a key role in assisting farmers to make the best long-term land use decisions for their farming businesses. Integrating land best suited to forestry and land best suited to pastoral systems at an individual on-farm scale will lead to more sustainable and resilient farming businesses and rural communities.

Reference

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Landowner attitudes to afforestation in the Hawke's Bay region of New Zealand

Simon Taylor and Michelle Harnett

Complementary land uses on-farm in mid-Canterbury. Photo courtesy of Scion

Abstract

The decisions made by landowners about tree planting or any other strategic land-level decisions are influenced by a range of factors, drivers and barriers that make every situation unique. Developing an understanding of core drivers and barriers affecting New Zealand landowners' views on afforestation, and addressing these, may increase the likelihood of them planting the right tree in the right place to ensure both individual landowner and community expectations are met.

Interviews with landowners and rural professionals established that a range of potential benefits can be achieved through purposeful tree planting, and that perceived risks were often a barrier. Alongside this, a clear gap (and opportunity) was identified for a central support and guidance system to work alongside landowners to understand their objectives and constraints and to develop long-term plans that fit with their needs and expectations.

There is an opportunity for regional bodies to influence and drive tree-planting behaviour, but this needs to be focused on the needs of individual farms and be supported by a community dynamic that encourages responsible planting. It is possible to drive behaviour change, but it will require conversations around the dining table, not pre-packaged solutions.

Introduction

Afforestation is being promoted worldwide for the benefits provided by trees, such as reduced erosion, improved water quality, habitat provision, carbon sequestration, and mitigation and adaptation to climate change (e.g. Basher, 2013). The One Billion Trees programme has been set up at the New Zealand central government level to get one billion trees in the ground by 2028. The Government has budgeted $120 million to support landowners, particularly farmers, who wish to plant on their land (MPI, 2019). The programme has the potential to create employment, optimise land use, mitigate climate change, support Māori values and aspirations, protect the environment, and support New Zealand's transition to a low emissions bio-economy.

There is a fear that indiscriminate tree planting will lead to productive land being blanket planted in *Pinus radiata* (the dominant planted tree species in New Zealand). However, both the One Billion Trees programme and those cautious about planting agree that the country does need to plant trees, that we need to ensure the right tree is in the right place, for the right purpose, and that there are multiple ways to achieve this.

The Hawke's Bay Regional Investment Company (HBRIC) and Hawke's Bay Regional Council (HBRC) wanted to explore the potential of afforestation to control erosion and other ecosystem and economic benefits. The region has some areas that are highly susceptible to erosion, with around 150,000 ha (or 12% of the region) losing more than 1,000 tonnes of sediment per square kilometre a year. The region is also exposed to extreme weather events that have historically caused significant erosion, flooding and infrastructure damage, and which are expected to increase in frequency with climate change. With 'right tree is in the right place, for the right purpose' in mind, the HBRC wanted to explore options that include commercial plantations of radiata pine, redwood, cypress, *Eucalyptus*, tōtara and mānuka, as well as permanent native forests to achieve positive outcomes for the environment, the economy and communities.

Resistance to the afforestation of productive land is not unique to New Zealand. Conflict over the perceived environmental, economic and social impacts of planted forests has been reported around the world, including Australia (Schirmer, 2007; Schirmer & Bull, 2014; Williams, 2014), Ireland (Schirmer, 2007), Scotland (Hopkins et al., 2017) and the US (Claytor et al., 2018). Objections often centre around perceived losses of food-producing land, jobs, community and a way of life, with the profits flowing elsewhere.

Developing an understanding of New Zealand landowners' views on afforestation to ensure individual landowner and community expectations are met is essential to the success of the right tree, right place initiative. Beyond spatial and financial considerations, it is human factors that will support success. At its heart, this is a behavioural change process (encouraging and supporting landowners to do something). Therefore, it is crucial that the success factors, drivers and barriers are understood and included in planning.

Here we explore the behaviours, attitudes and perceptions of landowners in Hawke's Bay, as well as those who work with or potentially influence them, to understand and document the key factors required to engage with and encourage/support landowners to plant trees on their land, by:

- Exploring and understanding the common 'success' elements among landowners who have engaged in commercial tree planting
- Investigating barriers that have driven landowners from engaging in tree-planting initiatives and factors that could make involvement more likely
- Exploring which aspects of the process were missing from a landowner perspective
- Identifying key parts of this process in terms of the parties involved, the information or support required, and the practicalities of implementation
- Understanding the elements of successful council engagement with landowners undertaking commercial tree-planting activity.

Methods

Qualitative research was conducted by independent agency Fresh Perspective Insight using in-depth interviews (face-to-face and telephone) to understand behaviours, attitudes, perceptions and the past experiences of participants. Fifteen participants were recruited via the HBRC database and existing contacts, according to agreed criteria. Participants included those with previous experience and success in commercial on-farm planting operations, those in early stage engagement with commercial tree planting, and those with roles in farm forestry/farm consultancy/land management. Interviews were structured around an interview guide specifically designed to address the objectives outlined previously and signed-off by the client.

The interviews started with considering overall farm operations in general before focusing on tree planting, to ensure participants were not directed down a particular tree-planting or forestry path. Responses were analysed using a three-stage process of coding, categorising and theme identification using the project objectives as the analysis framework.

Results

Landowner perspectives

Looking at tree planting, there are baseline levels of awareness and engagement with activities such as pole planting and waterway initiatives, but very mixed awareness and comfort levels beyond this into larger scale or commercial tree-planting activity. There is a recognised gap in knowledge (and therefore comfort) about the realities and practicalities of tree planting among those who have not been exposed to it. As a result, there has been an obvious learning curve for those who have engaged or are more advanced in their tree-planting activity.

At a broader level, there is emerging disillusion with some aspects of tree planting in the region. This is largely based on negative perceptions around 'blanket planting' behaviour and the absence of long-term and land optimisation thinking.

It is important to remember that, in most cases, tree-planting behaviour and decision-making will be based on factors unique to the specific individual/operation. Tree planting is seen as a strategic-level decision and several elements are considered in this paper, including (but not limited to):

- Succession planning and the most appropriate structures/approaches to this
- Short, medium and long-term financial risk and potential benefit
- Integration of tree planting with other land-use activities
- Workload and cashflow impacts in comparison to other strategic options
- Emotional factors, including landowners' relationship with the property and wider ecosystem.

Success factors

A number of important factors underpin the decision-making and behaviour of landowners who have achieved a degree of success in their tree-planting initiatives.

An integrated land management mindset

Successful outcomes and decision-making were attributed to thinking about the property or farm as an overall resource to be optimised through the use of a range of integrated activities. This mindset not only influenced tree-planting behaviour, but also farming practices more generally.

For these farmers, planting trees increased the overall productivity (and profitability) of their operation rather than decreased it, and tree planting was seen to be the best use of particular blocks based on land type, access and so on. As a result, the current and planned tree-planting initiatives on these properties were viewed as 'good farming practice' as opposed to something distinct or separate from their 'core' activity.

'You have to have a mindset of what land is or could be in terms of what you do with it.'

'Farmers that keep their farms will be the ones that have planted trees.'

'It doesn't mean you have to reduce stocking levels.'

A clear role for trees

As an extension of this 'resource optimisation' thinking, it was evident that each landowner had identified a very clear role for trees within their overall operation. These roles included one or more of: erosion control, land management, diversification, cashflow, succession planning, workload reduction and long-term investment. As with most farm decisions, each landowner viewed their operation (and the role of trees within this) as the result of several factors unique to them and their land.

'It's not as simple as saying "here is some money, plant some trees", there is more to it than that.'

'You need to think in terms of gross margin of each block. You plant on those blocks with a negative gross margin.'

Focus on a range of benefits

Benefits were thought about in multiple terms rather than in isolation when landowners spoke about tree planting. The benefits broadly fell into primary, top-of-mind benefits and secondary, supporting benefits. Top-of-mind were benefits based around the core pillars of their operation – financial (cashflow and long-term investment) and land use optimisation – the primary reasons that tree planting was undertaken in the first place. Secondary benefits are those that enhanced the overall operation. In many cases, these benefits were only discovered after initial planting had taken place. They include elements such as animal welfare (shade, shelter and feed), aesthetics, social licence and improved mental health. Also, a benefit of increased productivity (or at the very least no discernible decrease) was reported by most.

'It can be cash-flow, help with stock capacity, provide shade.'

'The commercial side of it is the icing on the cake. The most important thing is protecting the land.'

'It really can be a win, win, win. Money potential, animal welfare, climate change, social impacts, biodiversity.'

Willingness to learn and adapt

All landowners accepted that they had learnt a lot through the course of their tree-planting activities. This learning centred around the key themes of species suitability, planting and initiation, access and extraction practicalities, and financial structures/approaches. The learning process largely takes the form of trial and error, or access to a specific individual or group with expertise and experience relevant to the landowners' situation.

'I've got a whole lot of tricks to make it work that I have learnt along the way.'

A degree of help in getting started

Almost all landowners identified the importance of grants or incentive schemes to help with the upfront cost of initial planting/fencing etc. In many cases, this was initiated or facilitated via the regional council or specific public sector forestry initiatives at the time.

'In the early days I needed an incentive to get started.'

'Grants or help with the upfront cost is important to get people underway.'

A range of factors are needed to support success from an individual perspective. Due to the unique nature of each operation, the weighting applied to these factors differs and can only be determined by looking at the operation as a whole. Within this, there is also a very clear direction in terms of how tree planting is perceived by farmers that may differ from others in the industry. That is, it is complementary and integrated within their overall farm/business as opposed to operating in isolation.

The success factors identified here are similar to those identified by research focusing on Australian, Scottish and American landowners (Williams, 2014; Hopkins et al., 2017; Claytor et al., 2018). Successful farm foresters tended to have diversified income streams and recognised that tree planting provided a range of socio-economic benefits beyond the provision of income. Personal experience or knowing those interested in forestry was also mentioned as having the potential to influence attitudes.

Barriers

Barriers to tree planting based on personal experience and current situations, as well as watching others, were considered. At their heart, these come down to perceived risk relating to three key factors.

Financial risk

There is a perceived financial risk in tree planting for many landowners, both in the short and longer term. In the short term, this relates to set-up costs and the stress or pressure this can place on the economic sustainability of the overall operation. These costs extend well beyond the provision of trees and into fencing, pest control, early stage maintenance, labour costs etc. Alongside this short-term cost there is also the perceived loss of productivity from converting land to trees. For some, this can be a double hit.

'A key barrier is the initial capital outlay.'

'Sometimes the focus is on the upfront cost (like fencing) rather than the end benefit.'

From a longer-term perspective, the financial risk relates to the timeframe of potential returns and the volatility this brings to the overall equation. For a lot of farmers, this becomes a strategy of 'hope' regarding returns rather than a robust and certain investment return strategy. Added to this long timeframe can be a lack of familiarity with the financial workings and implications of forestry operations and low awareness of the different financial approaches and mechanisms. This heightens the perceived risk, particularly when it is compared to other farm activities with more certain or familiar financial models.

'There is fear of locking it away for 20 or 30 years.'

'There is fear of the unknown.'

'I am hoping I can drive an income stream from it in terms of carbon credits, but we are still nailing down what will qualify.'

Implementation risk

Operational risk, or the practical considerations that come with tree planting, is another major risk factor that inhibits tree-planting activity. This is driven by a lack of knowledge or expertise and therefore the potential for implementation to fail due to poor decision-making or execution. This largely applies to selecting site locations and suitable species, the timing of planting etc. Once again, when other potential farm activities have a much more certain outcome then tree planting may be superseded. This can often be expressed in a desire to 'stick to my knitting' or focus on 'growing grass, not trees'.

'People need help with what to plant and where to plant it.'

Also, there can be a risk or barrier around the practical side or physical planting of trees or extraction. This can prove a key barrier, especially when knowledge or awareness of different options is lacking, or when labour resources are particularly tight.

'The country I would like to commercially plant is too remote.'

Reputational risk

Reputational or social risk can also be a real barrier; this is the risk of going outside 'traditional' farming. It is made worse by the permanent and very visible nature of tree planting, as well as the longevity of horror stories or well-known 'failures'. In 2019, this risk was heightened due to the ongoing community narrative around tree planting, which is bringing with it a large amount of negative sentiment, and in some cases positioning tree planting as 'anti-farming' when done at scale.

'I am nervous about any change that is permanent and irreversible.'

'If you sit down and talk logically to most farmers, they will have blocks of land suitable for planting. But on the other hand, there will be push back because of the risk and worry.'

Barriers to planting, either perceived or real, need to be acknowledged, accepted and understood as part of the engagement with landowners. Given the time, resource and financial pressures most landowners are under, it is very easy for them to de-prioritise tree-planting activity in favour of the status quo. Combined with knowledge gaps and lack of clarity around end benefits, this can result in failing to implement something that makes sense at a logical level.

International research also reports similar barriers to afforestation. Financial risk can weigh heavily. Work looking at the success of Australia's Strategic Tree Farming project suggests that engaging farmers was difficult, partly because they had to wait for 15 years for any financial returns. In contrast, plantation models that provide yearly payments are more readily adopted (Williams, 2014).

Landowners are also concerned about loss of land management flexibility, and feel they lack knowledge and experience. Reputational risk features very strongly. Being seen as a good farmer is very important, and how landowners believe others in the community view afforestation influences their views about the social acceptability of afforestation.

Cattle grazing under *Eucalyptus regnans* at Wiltsdown (near Tokoroa). Photo courtesy of Scion

Participants' views on potential roles for regional policy-makers

Participants were clear on the potential role(s) for regional policy-makers in supporting tree-planting behaviour in response to the current context and the drivers/barriers to behaviour identified above. It was felt there was a role as a Facilitator, and potentially as an Enabler, to support individual landowners and communities in navigating the tree-planting journey.

The facilitation requirement comes from the need (and current gap) for a body or party able to understand the needs, objectives and constraints of the landowner and then guide them through a process to tree planting. This includes introductions to other parties who can support and help deliver to the objectives of the landowner when the need falls outside of what can reasonably be expected or delivered by the regional council or others.

Facilitation and support are also needed in this space. This is because the barriers and current context means that purely addressing one element of the activity (e.g. finance), or leaping too far down the decision-making path at an early stage, does not adequately address the complex nature of farm operations and the decisions to be made and will not lead to longstanding and mutually beneficial relationships.

The Enabler role is very much around providing the required ingredients for success. For landowners, this primarily relates to financial and expertise needs. When specifically looking at regional bodies, this means that their role is entirely dependent on the needs and situation of the landowner. Landowners are open to a range of solutions or approaches when it comes to the commercial side of their activity (such as joint ventures, grants), as long as it fits with their objectives and appetite.

'Forestry consultants don't understand farming and farm consultants don't understand forestry.'

'They have to know their stuff otherwise they are no good to me.'

'It is a bit of a leap of faith, so some people will need more help than others.'

'4 or 5 hectares can be too small sometimes. They could help to make small blocks more attractive.'

'They need to have a one stop shop to make it easier for people like me. Otherwise we won't get onto it.'

'It's like the Smart Energy guys who just show up and take care of it all. Insulate, apply for funds, and do the job.'

Influencing the wider narrative

There is a social gap in terms of perceptions and attitudes that needs to be addressed alongside the gaps at an individual level. This is needed to create fertile ground for messages and initiatives to drive behaviour and normalise tree-planting activity. While much of the focus was on the individual success factors and barriers to tree planting among landowners, many participants also saw a role for the HBRC and others to influence the narrative around the place of tree planting and trees in responsible and sustainable land use.

It was felt that greater coverage and messaging was needed around:

- Promoting tree planting as an appropriate land use in conjunction with other farming practices
- Showcasing the success stories and different approaches in the wider community
- Illustrating the full range of potential benefits of tree planting (beyond financial benefits), including the role of different species in creating a more resilient region
- Signposting the regional council's commitment to long-term decision-making and support in this area, with real examples of the council ensuring the right type of activity takes place across the region.

'They have to influence the wider community around trees as well. It has to come from all sides.'

'At the moment I think we are too Carbon Credit driven.'

Consistent messaging is necessary to maintain a supporting narrative. It will be essential that communication from the HBRC, councillors or staff in the public domain support the intent and purpose of the initiative and comes from an informed and constructive viewpoint.

The wider research on the social acceptability of afforestation provides information that can both support and add depth to any messaging. Generally, the establishment of small-scale farm forests by local landowners, planted on marginal areas of a property rather than a whole property, is more acceptable than the establishment of large-scale plantations by non-farmers (Schirmer, 2007). In other words, planting trees is part of good farming practice.

Plantations need to be seen to provide positive outcomes for the environment and the broader community. For example, Australian communities generally prioritised public good outcomes over individual gains. In particular, plantations become more acceptable in areas with local processing facilities providing jobs as opposed to where chips or logs were exported (Williams, 2014).

It is also important to reiterate the message that the regional council and others are committed for the long term. Australia's Strategic Tree Farming project faltered when government funds were withdrawn and landowners started to worry that plantations could become 'stranded assets' with no clear market or processing infrastructure (Williams, 2014).

Rules of engagement

Working closely with landowners and facilitating their journey is likely to be the most effective approach to encourage afforestation of land vulnerable to erosion. However, this needs to be done in a way that fits with the overall intent and develops and maintains trust and cooperation. Some key rules of engagement are needed to shape any engagement strategy or design to ensure this relationship works from a landowner's perspective.

- It is the landowner's plan and their objectives and constraints are the starting point
- The focus has to be on individual and local solutions, not a *'one size fits all'* approach
- Implementation has to take place at the speed the landowner is comfortable with (*'Don't tell me how to run my farm'*)
- Genuinely use the *'right tree, right place'* principle and explore different options rather than jumping to commercial radiata pine
- Focus on selective land optimisation and not blanket tree planting (*'It has to be right tree, right place. Not any tree everywhere'*, *'We have to move past being purely focused on Pinus Radiata'*, *'They (the Council) can't have a purely production focus. That isn't right'*)
- Focus on building relationships and trust rather than taking a transactional view
- Bring people and communities together to build relationships and work together. Introduce people who can help or who have *'been there, done that'*
- Be in it for the long haul (*'This is about making good, long-term, thoughtful decisions. You have to make sure money doesn't drive short term decision-making'*, *'I think at the moment the driver is just to plant pine trees, not on right tree, right place. I question the motives of some people involved'*).

Conclusions

Deciding to plant trees is a complex process for many landowners. Encouraging a landowner to change current farming practices on an erodible landscape to forestry will require a range of tools and support from specialist consultants and industry experts, as well as including community engagement. There is an opportunity for regional bodies to influence and drive tree-planting behaviour by working alongside landowners to understand their objectives and constraints and to develop long-term plans that fit their needs and expectations. This will entail building awareness and knowledge of the many different tree-planting options, the range of environmental and social benefits, and how this is compatible with landholder and community beliefs about the appropriate use of agricultural land to ensure the right tree is planted in the right place for the right purpose.

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Opportunities to manage sediment from forestry more effectively in the Marlborough Sounds and contributing catchments

Stephen C. Urlich

Abstract

Soil disturbance associated with earthworks and harvesting of radiata pine *(Pinus radiata)* has caused erosion and run-off into the coastal waters of the Marlborough Sounds (the Sounds) and resulted in excessive deposition of fine sediment onto estuarine and subtidal benthic habitats. Ecological consequences have included habitat damage and species loss, alteration of ecological interaction networks and associated biogeochemical processes, and loss of resilience from ongoing disturbance. The causes and consequences of forestry's contribution to excessive sedimentation in the Sounds' coastal ecosystems are reviewed in this paper.

Despite awareness of these issues, the regulatory response over the last 45 years has been largely ineffectual. This now includes the Proposed Marlborough Environment Plan 2020 (PMEP, 2020) where greater stringency available under the National Environmental Standards for Plantation Forestry (NES-PF) has been exercised. However, this focused on the management of diffuse sources from surface processes through the provision of coastal setback controls of greater distance than required by the NES-PF. Greater stringency has not been applied to the major sources of sediment delivery, which are mass failures generated by erosion-prone gullies, gully-heads and steep side-slopes. Stricter harvesting controls and the requirement for replanting management plans that retire these source areas would significantly reduce sediment production and promote sediment retention. An update of the NZ Land Resources Inventory is also needed to improve the NES-PF Erosion Susceptibility Classification (ESC), as the predominant High ESC designation in the Sounds does not reflect the likely widespread occurrence of Very High ESC landforms.

Introduction

Ecologically healthy estuaries and inshore environments provide multiple ecosystem benefits to nature, as well as cultural, recreational, economic and social value to humans (Thrush et al., 2013). Excessive sedimentation into estuaries, harbours and nearshore areas from accelerated erosion caused by land use is a serious threat to benthic intertidal and subtidal habitats, including shellfish beds, seagrass meadows and kelp forest (Thrush et al., 2004; MacDiarmid et al., 2012). Habitats can be smothered, resulting in damage and alteration of ecological functioning, which leads to reduced ecosystem resilience to disturbance (Thrush et al., 2004).

Other adverse effects from sedimentation include:

- Increased turbidity and reduced light transmission, which affects primary productivity in the water column
- Altered biogeochemical gradients, such as inhibited nutrient cycling and reduced photosynthesis of benthic microalgae
- Clogged fish gills and the feeding parts of sediment-dwelling filter-feeders
- Chronic effects on macrofauna physiological condition and behaviour (Thrush et al., 2004).

The sheltered waters and estuaries of the Marlborough Sounds (the Sounds) are particularly vulnerable to excessive sediment deposition due to low current speeds (Johnson et al., 1981; Hadfield, 2015). For example, in slower-flowing side bays and inlets, the bottom stress from tidal current action can often be below a typical resuspension threshold of 0.1 Newton m^{-2} for clay-rich sediments resulting in settlement onto the seabed (Hadfield, 2015). Settlement can occur rapidly as clay-rich particles flocculate on contact with seawater (Thrush et al., 2004).

In the Sounds and its contributing catchments, the adverse effects of excessive fine clay-based sediment derived from extensive land clearance and disturbance have resulted in the smothering and ecological degradation of estuarine and subtidal communities over the last 160 years (e.g. Stevens & Robertson, 2014; Handley et al., 2017).

Figure 1: Relatively common issues from forestry earthworks and harvesting in the Marlborough Sounds: (a) Log-scoured runnels by inadequate lift from a cable hauler cable on a ridge top and pulling across slopes, Port Underwood, 2016; (b) Batter slump, and fill failure from logging road into Pelorus Sound, 2012; (c) Debris flow post-harvest, Pelorus Sound, 2011; (d) Post-harvest slope failure and top of debris flow, which smothered an estuary, 2015; (e) Bulldozer mishap above the shoreline Tory Channel – note sediment discoloured waters close to shore; (f) Harvesting to the shoreline, vulnerable to sediment run-off, Tory Channel, 2016; (g) Landing failure from inadequate water controls and poor construction resulted in debris flow down a forested creek, with sediment discharge into Pelorus Sound, 2017; (h) Debris flow with logs and soil after Cyclone Gita, Port Underwood, 2018. Photos: MDC – except (e) courtesy of Peter Beech

Since the 1970s, radiata pine forestry ('forestry') earthworks and harvesting have been shown to cause high sedimentation rates and ecological damage to coastal ecosystems in the Sounds (Johnston et al., 1981; Fahey & Coker, 1992; Philips et al., 1996; Urlich, 2015). Log-laden debris flows, landing and batter failures, slope runnels from insufficient deflection, and diffuse run-off from roads and harvested areas are relatively frequent occurrences (Figure 1). Many events are rapidly deposited into the Sounds due to the steep topography and short distances to the coast (Phillips et al., 1996; Urlich, 2015). Despite regulators attempting to respond to these factors over the last 45 years or so, ecological damage is continuing (Field, 1976; Planning Tribunal, 1979; Marlborough District Council (MDC), 1992; Urlich, 2015).

This paper provides an overview of the causes and consequences of excessive fine sediment deposition in the Sounds, drawn from Urlich (2015) and Marden and Phillips (2015). The objective is to examine whether the National Environmental Standards for Plantation Forestry (NES-PF) (NZ Government, 2017) and the Proposed Marlborough Environment Plan (PMEP, 2020) are likely to be effective in addressing these issues. Practical solutions to mitigate sediment deposition are outlined, with the aim of reversing ecological decline. This is critical to maintaining biodiversity and its associated ecological functioning, thereby safeguarding ecosystem life-supporting capacity. The outcome may also serve to help stem the erosion of the social licence of forestry to operate in steeplands (c.f. Raymond, 2015).

Methods

The technical library of journal articles and scientific reports held by the MDC (around 1,500 items) was searched for forestry references, which had also informed an earlier MDC review (Urlich, 2015). Additional referenced articles were identified following further reading. A Google Scholar search (20 web pages) was also undertaken on 9 June 2020 using the search term 'forestry Marlborough Sounds' to ensure all the relevant literature was identified. The MDC and Te Uru Rākau websites were also examined for relevant regulatory measures.

Results and discussion

Soils and erodibility

In 2018/19, forestry (predominantly radiata pine) covered about 12,311 ha in the Sounds – Queen Charlotte/Tōtaranui, Pelorus/Te Hoiere and Port Underwood (Urlich & Handley, forthcoming), and about 14,109 ha of the Pelorus/Te Hoiere, Kaituna and Cullens Creek catchments, which are coupled to Pelorus Sound (hereinafter the 'key catchments').

Most forestry is situated on land primarily zoned orange (high risk) for erosion susceptibility in the NES-PF (NZ Government, 2017). This is mostly designated as Land Use Capability (LUC) Class 7e steeplands (Urlich & Handley, forthcoming). The predominantly steepland soils are prone to slips, and sheet and rill erosion once the vegetation cover is removed (Johnson et al., 1981; Laffan & Daly, 1985). These soils are mostly derived from Greywacke and schist and are silt and silty-clay loams with up to approximately 45% clay, formed by weathering of the parent material and some loessial deposition (Laffan & Daly, 1985).

In the Sounds, soils between the shoreline and 200 m elevation are generally clay-rich, highly weathered, and therefore prone to erosion (Laffan et al., 1985). Soil mantles are thicker at these lower altitudes, and likely to yield more fine sediment than less weathered and thinner soils at altitudes above 200 m (Laffan et al., 1985; Fahey & Coker, 1992). Geomorphological advice to the MDC in 1992 to inform the development of the regional coastal plan stated (Sutherland et al., 1992, p.17):

> *The landscape below the 200 m contour [in the Sounds] is regarded as being more unstable due to the presence of deep weathering profiles, higher clay contents [with relatively low aggregate stability], colluvial deposits and re-worked loess.*

This also applies to the key catchments given shared geology, soils, topography and strong coupling of steeplands to the river network with rapid delivery to Pelorus Sound.

Under high rainfall intensity, considerable run-off into coastal waters occurs from erosion and landsliding where hillslopes are directly coupled to the coast (Johnson et al., 1981; Sutherland et al., 1992; Phillips et al., 1996). For example, Phillips et al. (1996) identified eight landslides in a recently harvested forest above Tory Channel/Kura Te Au after a storm in 1994. All landslides were below 200 m elevation in gully depressions on steep slopes (often over 30°).

Soil erosion also occurs at higher elevations under heavy rainfall. The shallow soil mantle sits over weakly weathered rocks, which can slip under high rainfall due to relatively shallow shear planes between the thin soil and bedrock (Laffan & Daly, 1985). There is increased susceptibility to erosion in recently harvested areas and risk of delivery to waterways. In the Sounds and key catchments the 'window of vulnerability' is always open somewhere, as extensive harvesting occurs across the landscape at any time (Urlich & Handley, forthcoming).

High rainfall events are relatively frequent in the Sounds and its contributing catchments. For example, in three sub-catchments of the Pelorus River, the minimum return period for the top 20 rainfall events over the last 20 years is about a one-in-two-year annual return interval (ARI) for all sub-catchments (Figure 2). The maximum ARI was a one-in-65-year event or greater in July 1998. This coincided with floodwater flows exceeding 2,000 cumecs calculated at Dalton's Bridge for the Pelorus River, upstream of the Whakamarino confluence. Other floods over the last 20 years that exceeded 2,000 cumecs occurred in 2008, 2010 and 2012 (Figure 2).

Environmental consequences of erosion

The MDC (1992, p.3) recorded long-term community concern about forest development in the Sounds and excessive sedimentation:

> *Land preparation clearance for planting in the early 1970s using line dozing and root raking techniques on steep hill country resulted in damaging on-site and off-site effects including increased and [sic] silt-laden run-off, soil erosion and marine sedimentation.*

Community concern was heightened by the 'unfortunate environmental spectacle [of] severe land

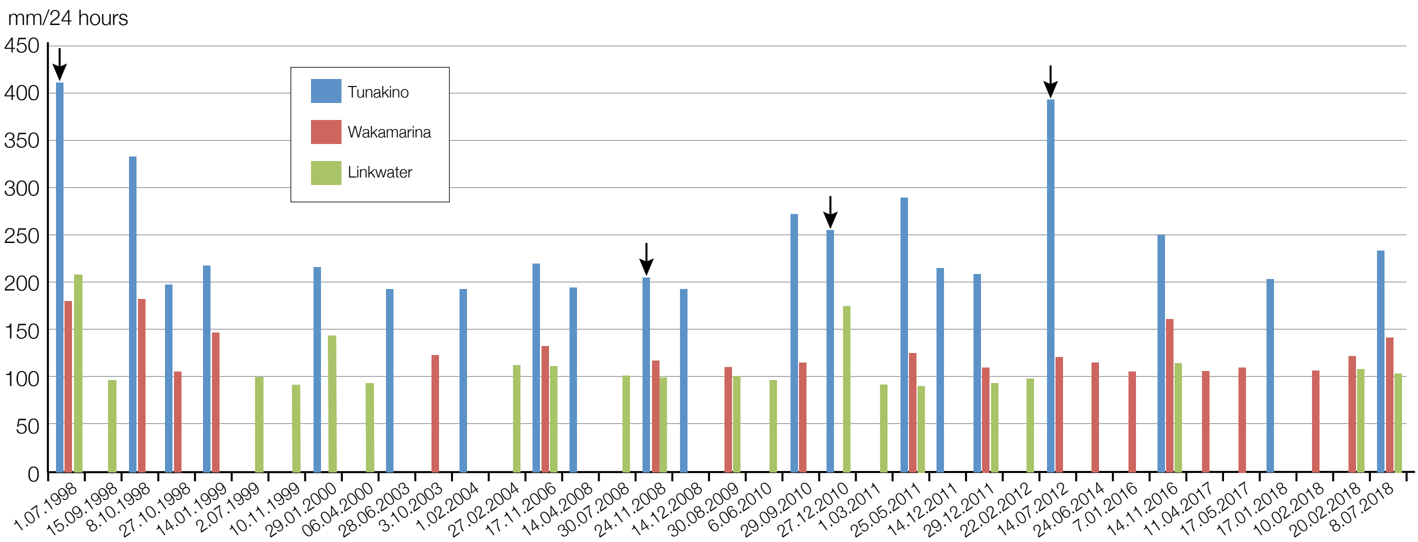

Figure 2: Twenty largest rainfall events 1998-2018 in three Pelorus/Te Hoiere sub-catchments. Arrows denote flood volumes of the Pelorus/Te Hoiere River that exceeded 2,000 cumecs, as calculated at Dalton's Bridge upstream of the Whakamarino River confluence. Data courtesy of Val Wadsworth, MDC

instability and sedimentation problems' at Farnham Forest, Queen Charlotte in the mid-late 1970s (MDC, 1992, p.4). Field (1976) refers to a complaint to the Marlborough County Council and the Minister for the Environment by the Nature Conservation Council in March 1974 about suspended sediment discolouring coastal waters.

Run-off after heavy rain also resulted in damage to the seafloor close to Farnham Forest (Johnston et al., 1981). There were few species within the fine-textured muddy sediments, which instead contained buried radiata pine bark and detritus. In contrast, in nearby seabeds unaffected by sediment run-off, coarser textured sandy sediments hosted a biodiverse array of shellfish, urchins, anemones, starfish and tubeworm colonies. There was also greater fish abundance in unaffected areas (Johnston et al., 1981).

In the late 1970s, the Marlborough Catchment and Regional Water Board considered the effects on the Brown River and the Havelock estuary from the impending pine harvest of the Rai State Forest (Bargh, 1977). Increased stream turbidity and possible effects on recreation, wildlife and commercial wet fish catches were identified. Adverse effects of fine sediment on mussel spat were inferred, with reference made to a 'massive sedimentation' event in 1976 suggested as affecting spat production (Clarke, 1977 cited in Bargh, 1977).

Bargh (1977) commented that sedimentation was a natural process, but acknowledged that how much sediment was too much was unknown. It was accepted then that: 'Sediment loads increase significantly in all streams draining logged catchments' (Bargh, 1977, p.3). The Catchment Board were also clear that: 'Sediment originating from forest harvesting operations needs to be strictly controlled … as they may cause detrimental changes to life in the river system or in Pelorus Sound' (Bargh, 1977, pp.4–5).

There are currently multiple adverse effects from forestry in the Marlborough Sounds and the key catchments (Figure 1). The consequences of mass failures associated with harvesting and earthworks, and ongoing diffuse flow from clearfell areas and roads, include the smothering of habitats assessed as ecologically sustainable under Section 6c of the Resource Management Act (RMA) 1991, such as shellfish beds and seagrass meadows in estuarine and shallow subtidal areas (Urlich, 2015 and references therein).

Estuaries in the inner Pelorus Sound are now amongst the muddiest in the country (Stevens & Robertson, 2014), with seagrass reduced in extent and in some areas observed with fine sediment coating on the leaves. Handley et al. (2017) identified that sediment accumulation rates are elevated five to 20 times above pre-European levels in Pelorus Sound. Sediment derived from forestry is disproportionately represented in the top 2 cm of seabed samples within Pelorus Sound, including near the entrance about 40-50 km from Havelock (Handley et al., 2017).

Regulatory responses over time

In 1975, forestry was notified as a conditional use for soil conservation reasons in the Marlborough County Council District Planning Scheme under the Town and Country Planning Act (Field, 1976). The District Scheme reserved control to the County Council due to the recognition that environmental and landscape effects of forestry had the potential to conflict with other uses of the Sounds. Field (1976) noted that this arose from a multi-agency meeting, which included environmental groups, following public concern in 1974 at run-off discolouring coastal waters caused by forestry earthworks and harvesting at Farnham Forest.

The District Scheme drew its own adverse reaction from forestry interests and hastened, according to Field, the formation of the Marlborough Forest Owners Association (MFOA). Thus began the often fraught relationship between the industry and local authority regulators. At its heart is an ongoing tension between different ideas about the use of the commons that is the Sounds, with its myriad waterways, diverse ecology and scenic values.

This has played out in different ways within succeeding planning instruments over the last 45 years and has included other activities, such as marine farming and fast-ferry operations. These conflicts were compounded by a general lack of ecological understanding of the nature and seriousness of effects within both the planning and land use communities. More latterly, as the effects on ecological functioning and seabed health are becoming more widely known, the debate is starting to shift to the proportional contribution by forestry of sediment into Sounds waterways compared with other land uses. An industry representative has publicly expressed that they share the public's concern about sedimentation in the Sounds (Vern Harris, Marlborough Forestry Industry Association, Stuff Business website, 27 December 2017).

The MFOA objected to the conditional use in the District Scheme as 'bad stewardship' (Field, 1976). They argued forestry could provide the economic base to support communities in the Sounds, as the pastoral sector was struggling, and tourism and recreation were too small. The NZ Forest Service also argued for forestry to be a predominant (permitted) use. Their vision was for tourism and recreation around the coastal margins and forestry on the hills above. There was also an existing public investment in forestry encouragement loans (Field, 1976).

The Planning Tribunal heard a series of appeals to the District Scheme in 1979. The Scheme allowed forestry in two rural zones, with the Marlborough Sounds zone (Zone B) proposed to restrict forestry to a conditional use, and only farming and passive recreation as permitted uses 'to preserve the unique Marlborough Sounds Coastal environment and to protect it from unnecessary subdivision and development' (Planning Tribunal, 1979, p.170). The MFOA wanted Zone B abolished or, failing that, forestry to be recognised as a permitted use.

The Tribunal considered the appeals to be of '… considerable significance to the future development of the Marlborough Sounds in particular' [para 1.2]. At that time, 6,146 ha of radiata pine was established within the Marlborough Sounds. In considering the environmental effects of enabling forestry to expand under controls in the Marlborough Sounds, the Planning Tribunal heard evidence from Dr Colin O'Loughlin, a Senior Scientist with the Forest Research Institute. Despite forestry activities causing increased turbidity near the shoreline, he assessed that the seawater was able to:

> *… clear itself quite quickly after contamination … He concluded that there was no reason why forestry cannot be practised without adverse consequences to the marine environment. In the past, some practices with regard to these matters have been unsatisfactory. He considered, however, with changing technology and proper practices, such problems could be overcome. He thought the land was stable; there was unlikely to be much problem from landslides; and that overall, taking into account the fact that the whole forestry cycle is something like 25 to 30 years, the cumulative sedimentary effect on the sea bottoms would be less than for other land uses. [at 5.1]*

Subsequent research on landsliding and debris flows has run counter to the idea that the land is stable (e.g. Phillips et al., 1996). Adverse consequences have also occurred, and continue to occur, to the marine environment from forestry (Figure 1), and there has been a demonstrable cumulative sedimentary effect on the seabed (Johnson et al., 1981; Handley et al., 2017).

The Tribunal did not hear evidence from a marine biologist, nor from iwi. Rather, in contrast to the evidence called in support of the appellants, which placed faith in technological developments to minimise run-off, the Nature Conservation Council witness urged that thought be given to avoiding future issues before trees were planted [at 5.16].

The Tribunal dismissed the MFOA appeals due to the need 'to protect the unique Coastal environment' as a matter of national importance (p.183). However, it also rebuffed conservationists who were opposed to an expansion of forestry and had argued that significant regeneration of native bush within the Sounds should continue to expand. The Tribunal placed production ahead of natural values '... in the interests of the national economy, we think there needs to be a balance' (p.183). This overall balancing approach or 'broad judgment' presumption has carried through to the Resource Management Act 1991 (RMA), but the Supreme Court in 2014 determined that to be incorrect (SC82/2013 [2014] NZSC 38). The court found that there are environmental bottom-lines around the need to protect certain values, which had been articulated within the New Zealand Coastal Policy Statement (NZCPS, 2010).

The 1990s saw an increase in public concern at the environmental effects of forestry as harvesting got underway above Tory Channel. A number of studies on environmental effects resulted (reviewed in Urlich, 2015). In 1995, the Marlborough Regional Policy Statement required under the RMA was made operative.

Example along the lines of what a replanting management plan aims to achieve. Note the retention of mature indigenous forest in steep erosion-prone gullies and faces and careful placement of roads and landings, Havelock, 2016. This operation had issues with woody debris left in a waterway out of view

This identified that forestry run-off was an adverse threat to coastal marine and freshwater ecosystems. The maintenance of marine water quality was a specific objective, given its acknowledged importance to the health of the marine ecosystem.

The method was to put controls into resource management plans to avoid, remedy or mitigate sediment entering coastal waters from land, and educate those undertaking land use practices. The Marlborough Sounds Resource Management Plan came into full effect in 2011. It stated:

> *Rigid controls are necessary in the coastal marine area as this is the 'environmental sink' where the effects of all coastal and land-based activities impact. Coastal marine ecosystems depend on uncontaminated seawater, undisturbed seabed or foreshore and healthy land and freshwater ecosystems adjacent to the coast. Environmental effects in the coastal marine area are felt in essentially two ways: Degradation of coastal water quality; and alteration to the foreshore or seabed. (Volume 1, 9-8A & 9)*

Resource consent was required for land disturbance associated with forestry earthworks, but not harvesting or for replanting to retire erosion-prone areas. From personal observation between 2011 and 2018, replanting was prohibited within 30 m of the coastal marine area but was not actively monitored for compliance. The question of whether plan provisions and resource consent conditions were adequate is now moot, given the advent of the NES-PF and PMEP.

The MDC review of environmental effects in 2015 did, however, identify gaps in the regulatory regime and suggest a range of solutions (Table 1). The key recommendation was for a property-specific replanting management plan to control future erosion and sedimentation. This would require the identification of areas for retirement to prevent debris flows, exacerbated by slash left in gully-heads, steep gullies and faces (see example in the photo). Discretion would be reserved to the MDC for replanting approval. Native regeneration under the high rainfall of the Sounds would be swift, but wildings would need management.

These recommendations could have been addressed within the Marlborough Environment Plan notified for public consultation in June 2016. The release of the draft NES-PF for public consultation the previous year meant that the MDC chose not to undertake policy work for the notified plan around greater coastal setbacks or replanting management controls. However, this would have benefited the MDC's Hearings Panel in February 2020 when they were considering greater stringency in the PMEP in response to numerous public submissions. The Panel chose to control replanting between 30–200 m from the shoreline, and reserve restricted discretion over earthworks to require a higher standard of design and implementation (MDC Hearings Panel, 2020). They ignored mass failures which deliver the most sediment to the Sounds (Marden & Phillips, 2015) by being silent on the need to control replanting in erosion-prone steep landforms, except for woodlots on farms.

Opportunities for better management

Replanting in the NES-PF is controlled with reference to the underlying Erosion Susceptibility Classification (ESC) for the Marlborough Sounds and contributing catchments. The ESC oscillated between orange and red in the years leading to the finalisation of the NES-PF (Figure 3), reflecting the coarseness of underlying soil and land use capability mapping, as well as the subjectivity of expert assessment of the potential for soil erosion underpinning the ESC. The MDC's submission on the draft NES-PF said that the ESC did not fairly or accurately represent erosion risk (Figure 3 centre), and expressed concern about potential adverse effects being effectively managed under permitted activity conditions. While initially appearing to address the MDC's concern in the third reiteration of the ESC,

Table 1: Regulatory options from Urlich (2015) after analysis of scientific studies on forestry effects in the Marlborough Sounds, with review by Marden & Phillips (2015)

Regulatory options	NES-PF	PMEP	Comment
Replanting setbacks from shoreline 30 m, 100 m or 200 m	Replanting setback 30 m	30–200 m controlled to manage erosion	PMEP criteria for control not defined. High transaction costs, little certainty, compliance issues. Highest erodible soils from sea-level to 200 m. Also 200 m setback supported by available soils evidence
Replanting setbacks for permanently flowing streams coupled to sea	Replanting within 5 m of perennial rivers <3 m width, 10 m >3 m width	Not applied	NES-PF reflects regulatory option
Replanting control on steep slopes: mandatory replanting management plan to retire erosion-prone slopes	No discretion as all forestry land zoned as orange in ESC	Not applied	Mass failures greatest source of sediment delivery to coast. Replanting plan enables property-specific solution. Discretion to replant over 200 m and ESC revision options needed (see *Opportunities for better management* above)

Note: NES-PF = National Environmental Standards for Plantation Forestry (2017); PMEP = Proposed Marlborough Environment Plan (2020). MEP column is where the MDC applied greater stringency under the NES-PF to address the NZ Coastal Policy Statement (NZCPS, 2010)

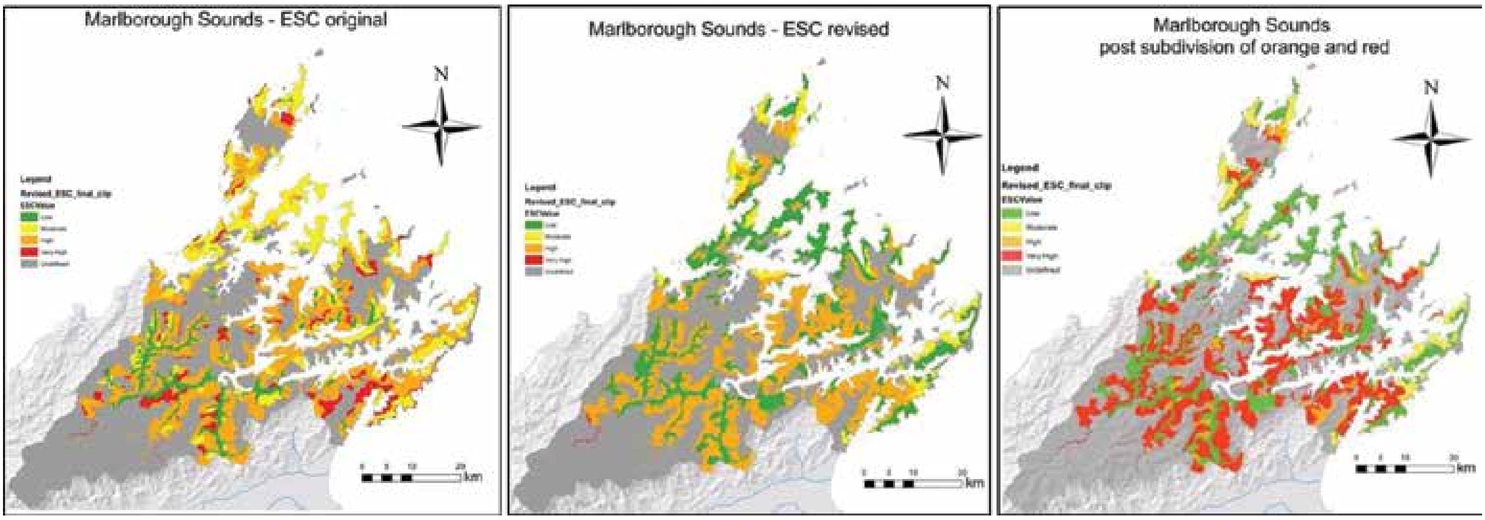

Figure 3: Variations of the ESC for the Marlborough Sounds and contributing catchments, from Basher (2016). Left: Original ESC from Bloomberg et al., 2011. Centre: First revision by Basher et al., 2015 and third (final) revision by Basher & Barringer, 2017. Right: Second revision by Basher et al., 2016. See the NES-PF for full references. The centre image is the current ESC

with large areas becoming red (Figure 3), the ESC reverted back to its second iteration (Figure 3 centre).

The MDC was advised that the NZLRI mapping of the Sounds was too coarse at 1:50,000 scale for the ESC, and remapping should be undertaken to the property scale 1:10,000 (Basher, 2016), but this has not yet occurred. The MDC has commissioned LiDAR across the region, which will be available in 2021. The elevation data can be combined with an analysis of radiometric isotopic data, collected from an aeromagnetic survey flown in 2015/16, to identify areas of mass wasting, erosion pathways and inherent erosion susceptibility on different geologies (Basher, 2016; Clint Rissman, pers. comm.). Along with improved underlying soil mapping, the information may also improve terrain stability zoning at an operational scale to better match harvesting methods with slope stability, hazard and risk management (Phillips et al., 2018).

Any future improvement to the ESC should lead to the identification of areas within different landforms that would meet the NES-PF threshold of Very High ESC (Mark Bloomberg, pers. comm.), triggering resource consents for forestry activities. If harvesting consent conditions are strong enough, landowners may be compelled to replant forests in a way that reflects land use capability, or even let the land revert to native forest or adventive species (Mark Bloomberg, pers. comm.). It could also result in trees within some areas being unharvestable and therefore left standing.

However, these developments may take years to be operationalised, and there are no barriers to practical controls on replanting, which are needed now (see photo). This is the subject of appeal on the PMEP by environmental groups, with community support. Replanting controls will also assist forest owners in the long term to meet the stringent water quality standards set in the NES-PF. In the Sounds and contributing catchments, it would be extremely difficult for clearfell harvesting to meet NES-PF Regulations 26 or 65 to prevent any conspicuous change in colour or visual clarity or any significant adverse effects on aquatic life. The clock is ticking for compliance and enforcement of the PMEP and NES-PF in the Sounds.

New and refined tools are a step in the right direction if they lead back to the salient words of noted explorer and conservationist Sir Holmes Miller, Deputy Chairman of the Nature Conservation Council, before the Planning Tribunal in 1979: '… that the problems be given some thought before trees were planted.' The challenge before the industry is to embrace the need for change and lead on developing replanting guidelines for retiring erosion-prone landforms on steeplands, thereby mitigating the erosion of its social licence (Raymond, 2015).

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Harvesting Tahere Farm Forest – a case study

Ian Page

Abstract

Detailed data are presented from the harvest (over 10 years) of six small plantations on a Northland farm property. These data show that with innovative harvesting techniques, sensibly located small plantations – even on very steep, broken country – can be a profitable investment. Small plantations also present environmental advantages, encourage appropriate land use and lessen the aesthetic impact of logging on the landscape. Spreading planting in time as well as spatially, by lowering annual cash and/or labour requirements, places quite substantial forest estates within reach of many hill country family farms. It is argued that the results support that smaller plantations carefully sited on a large number of rural properties, and established over extended periods, are a valid way to achieve our afforestation goals. They also have additional environmental, land use and scenic advantages that are likely to be increasingly important to our industry's social licence to operate.

Introduction

Much is made of the economies of scale in harvesting plantation forests. The perception has developed that small areas of plantation forest may not be worth the effort. Of course, some unitised fixed harvest costs are going to be higher for small plantations, but they need not be overwhelming. They can be minimised by good planning and may be compensated by other values.

This paper presents a case study of small-scale plantation forestry on a Northland property which is now halfway through its first harvest cycle. The financial results presented here show that small-scale plantation forestry can be a very profitable exercise on the right real estate and given good planning.

Background

The property is 160 ha of mixed topography hill country 15 km east of Whangarei. Primarily yellow-brown earths derived from Greywacke, the soils are highly erodible and skeletal on the steeper slopes. They are considered of poor-to-medium quality for pasture and of medium-to-good suitability for radiata pine. Mean annual increments in excess of 20 m^3/ha/yr can be achieved.

Periods of intense rainfall in the winter and summer droughts are characteristic of the east coast of Northland. Pre-European, the land was little used by Māori. Pakeha use commenced in 1886 and for three generations the Jones family milked 90 cows and ran 300 wethers. The fourth generation were not interested in farming and the farm was put on the market. When we took over in 1978 the farm consisted of:

- Approximately 60 ha of secondary kauri/podocarp/broadleaf forest on the very steep northern part of the farm
- Approximately 100 ha of mixed quality grassland on slopes ranging from flat (10%) to rolling (40%) to steep (40%) to very steep (10%).

A maximum carrying capacity of around 1,000 stock units was insufficient to support a heavily mortgaged family and, even if it had been, a couple of dry summers in a row soon convinced us that maintaining this maximum was very high risk financially and environmentally. As a result, off-farm work was necessary.

Approximately 40 ha in small blocks scattered across the farm were identified as being more suited to plantation forestry than to pastoral farming. These blocks were steep and erosion-prone. What little grass did manage to grow in the winter often turned to 'cornflakes' during summer. Pasture weeds, both exotic (such as gorse and blackberry) and native (such as mānuka and kanuka) were invading and hard to control on the steep terrain. We did not expect that taking these areas out of the pasture rotation would significantly reduce the carrying capacity of the farm, and in this we were proved right.

It was never envisaged that the 40 ha would be planted in one year. Radiata pine forestry in New Zealand provides the opportunity to create something approaching a normal forest in far less than a working lifetime. As we were less than 40 years old when we started, we could see a spread of plantation ages providing a relatively steady income supplement as our off-farm earning capacity declined. That was the philosophy. The reality was that, being self-employed both on and off-farm, future income was going to be irregular as would be the necessary surplus cash for plantation establishment and silviculture.

The plantation estate

Planting commenced in 1983. Initially boundary lines were decided on considerations such as steepness, erosion risk, existing fences and ease of moving stock. As planting progressed, a pragmatic harvesting ethic was given increasing weight, primarily in the form of ensuring that each plantation was located adjacent to the main ridge running through the farm that would provide the easiest and cheapest access at harvest.

By 2001, 43 ha had been planted and 38 ha were in radiata pine from an average annual planting programme

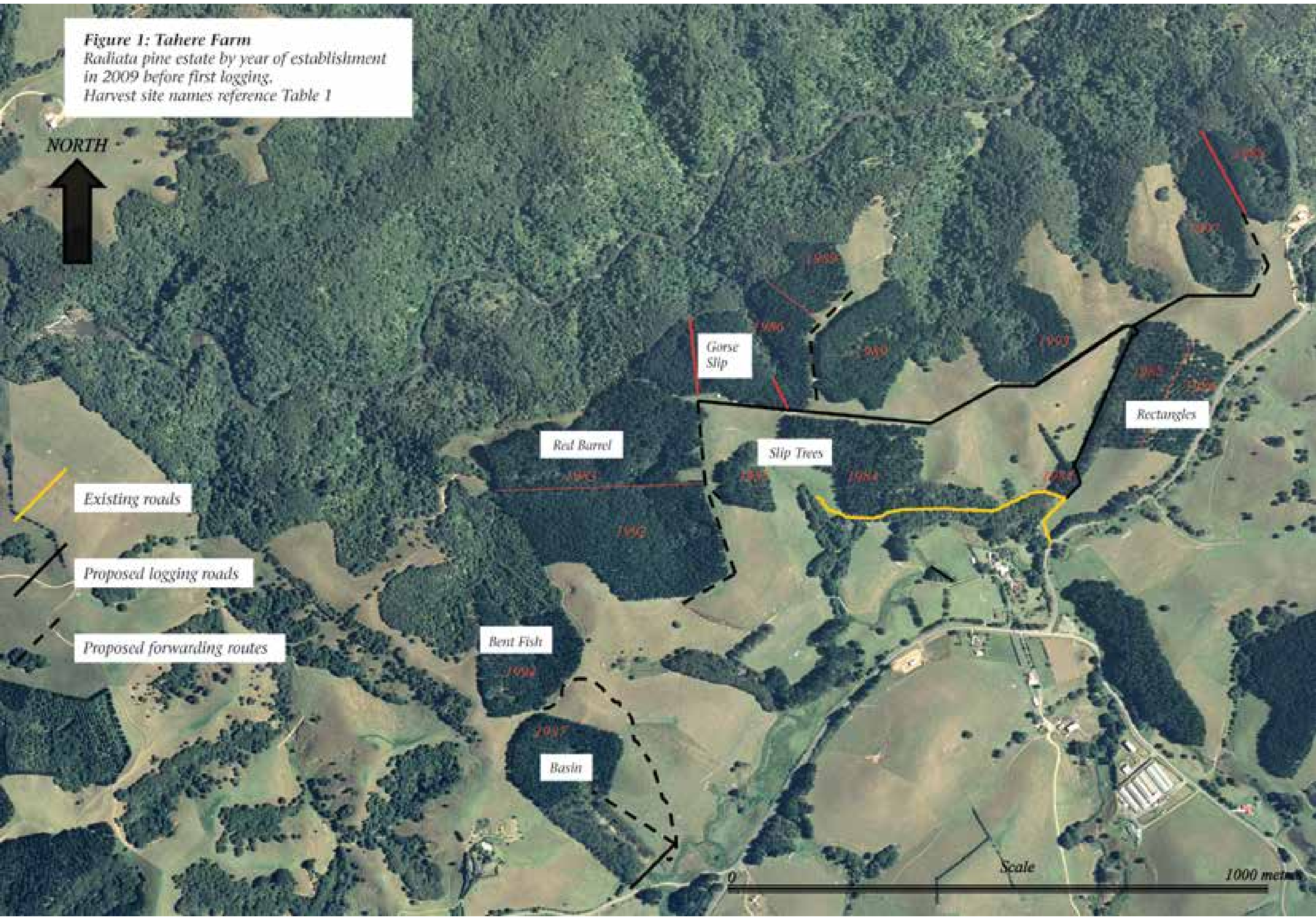

Figure 1: Tahere Farm

of 2.1 ha (range 0 to 7 ha). The small blocks generally allowed planting and subsequent silvicultural operations to be the work of family. In periods when off-farm work was plentiful and family time scarce, the additional income being earned allowed the use of contractors.

Figure 1 shows the pine estate in 2009 (before logging) and the location of planned extraction routes.

Harvest

Harvesting began in 2010, and by 2019 just under half of the pine estate had been logged in six operations carried out over the 10 years, with the oldest stand being 32. Details of this harvest history are set out in Table 1.

Stand details

The average operational area was 3.1 ha, with a range of 1.3 to 5.9 ha. There were several reasons for logging the first two-year areas that were not the oldest in the estate:

- The plantations were agroforestry areas standing at 111 and 200 stems per ha (SPH), respectively. Many of the pruned butts already had a large end diameter in excess of 1 m; leaving them any longer would have made for difficulties in log extraction and processing at local mills
- The stands were located close to the farm's entrance to public roads and required minimal expenditure on roading
- The returns gave us more than enough funds to establish the main harvesting roads to serve the rest of estate
- The returns also allowed a four-year delay before the next harvest which:
  - allowed the newly built roads to consolidate
  - gave a better matching of harvest returns to reducing other incomes as retirement approached
  - enabled us to take advantage of rapid log value accretion as stands aged, but before wind damage became a problem.

Table 1. Tahere Farm case study – harvest running summary (all dollar figures are dollars of the day)

Year of harvest	2010	2011	2015	2018		2019	Totals & means
Stand name	**Rectangles**	**Slip Trees**	**Red Barrel**	**Gorse Slip**	**Basin**	**Bent Fish**	
Stand details							
Area (ha)	3.7	3.1	5.9	1.3	2.3	2.4	**18.7**
Age at harvest (yrs)	24	27	30	32	31	25	Mean = 3.1 ha
Stocking (SPH)	111	200	400	300+	237	450	
Yields (tonnes)							
Total recovered (tonnes)	1,454	1,941	4,124	828	1,461	1,512	**11,319**
Total recovered per ha (tonnes)	393	626	699	637	635	630	Mean = 1,886t
Pruned %	42%	20%	16%	21%	33%	6%	
A grade %	12%	23%	37%	59%	47%	57%	
KI grade %	30%	40%	20%	8%	14%	19%	
Pulp %	17%	17%	12%	12%	7%	19%	
Average JAS conversion (JAS/tonne)	0.80	0.84	0.93	0.98	0.99	0.99	
Market indicators							
Average A grade price received ($/t)	$81	$118	$105	$140	$157	$144	
Average Pruned price received ($/t)	$120	$121	$167	$185	$195	$188	
Gross financial yields							
Gross $ per ha	$33,131	$62,377	$73,782	$95,724	$101,872	$84,237	
Gross $ per tonne	$84.34	$99.61	$105.61	$140.58	$151.35	$133.72	
Costs ($/t)							
Log and load	$34.50	$36.92	$33.95	$43.92	$44.54	$46.02	
Admin. (incl levy, weighbridge, consumables, reporting)	$2.50		$0.70	$5.33	$5.54	$6.73	
Management fee			$3.00				
Transport machinery	$0.39	$0.39	$0.61				
Engineering	$0.00	$0.26	$6.10	$0.19	$0.83	$1.91	Total eng. costs $29,919
Clean-up	$0.69	$0.26	$0.56	$1.45	$0.82	$1.65	
All costs except cartage ($/t)	**$38.08**	**$37.83**	**$44.92**	**$50.89**	**$51.73**	**$56.31**	
Cart logs($/t) (destinations vary between years)	$11.24	$13.77	$13.90	$19.61	$19.73	$15.08	
Total costs for harvest operation ($/t)	**$49.32**	**$51.60**	**$58.82**	**$70.50**	**$71.46**	**$71.39**	
Net returns ($)							
Net return in $/t	$35.02	$48.01	$46.79	$70.08	$79.89	$62.33	Mean = $57.02
Net return in $/ha	$13,763	$30,054	$32,706	$44,641	$50,730	$39,268	Mean = $35,193
Total net return ($)	$50,923	$93,168	$192,967	$58,033	$116,679	$94,243	**$606,013**
Return on investment	N/A	11%	9.1%	N/A	9.5%	N/A	

The last area logged in 2019 (Bent Fish) was also felled young (age 25) because it was suffering ongoing attrition from wind following serious damage in the 2007 storms.

Yields

The average recovered yield by block was 1,886 tonnes with a range of 828 to 4,124 tonnes. The log grade recoveries reflected the wide-ranging silvicultural histories of the stands. At one end of the scale were the agroforestry stands harvested in 2010. Low stocking (111 SPH) and felling age (24 years) gave low total yields (393 tonne/ha) but high pruned percentage (42%). This was countered by the low quality logs above the pruned butts. At the other end of the scale was the Basin harvested in 2018. This stand, grown from GF25 cuttings, was ultra-high pruned to between 6 m and 10 m and held at 237 SPH before harvest at age 31 years. Log grade outturn was excellent, with 33% pruned and 47% Export A grade.

Such variation in stand quality is common in smaller family-owned estates. It reflects, over time, the owner's financial position and their attitudes to plantations – thankfully, our preference for agroforestry was very short-lived.

An interesting part of the yields section (see Table 1) is the JAS (Japanese Agricultural Standard) conversions for each stand. There are explanations for the rather dramatic shift from the start of logging (0.80) to the conversions achieved in the later harvest (0.99).

The stand logged in 2010 (Rectangles) was an agroforestry stand. The enormous pruned butts were sold on the domestic market at a price per tonne so no JAS measurements were taken. The export logs taken from the cabbage-like upper part of the trees had large taper and consequently low JAS conversions. The next two stands – Slip Trees and Red Barrel – were established with seedling stock, with the Red Barrel's greater age and stocking giving the better conversion. The last three stands logged were all established with cuttings and all had noticeably less taper and consequently better conversions. All the pruned butts from the 31-year-old Basin plantation had conversions exceeding 1.00, with the largest achieving 1.08. This had the effect of turning a $185/m JAS export price that year into a return of $201/tonne. Offering those logs to local mills for the equivalent export price per tonne produced some interesting responses!

Market indicators

This section is included to place each year's harvest returns in the context of the market that year (note the range in prices over the decade). Except for the pruned logs in 2010, all logs were exported and sold at wharf gate Marsden Point. The prices quoted for Export A grade and pruned are the average of those prices received for the mix of subgrades produced converted from dollars/m^3 JAS to dollars/tonne. Prices are in dollars of the day. (Inflation over the 10 years, as measured by the Consumers Price Index, has been around 14%.)

Costs and changes made

Costs are also quoted in dollars of the day and all have been calculated as dollars/tonne using the total tonnage harvested in each operation. Over the six operations there have been changes in:

- Topography of areas logged
- Logging methods and machinery used
- Approach to management of logging, cartage and marketing.

The first two operations (Rectangles and Slip Trees) were on easy to occasionally difficult tractor terrain close to public roads. Existing farm roads were adequate for logging trucks after only minimal upgrading. Hence, the low unit engineering costs for these two operations – $0/tonne for Rectangles and $0.26/tonne for Slip Trees.

Management of log and load, health and safety, trucking, marketing and documentation was carried out by a local harvesting organisation, with log and load operations sub-contracted to a two-person operation. No internal tracking was required. Felling was manual with whole trees hauled to temporary landings outside the stump line by a rubber-tyred skidder. Log-making was manual with slash and sloven material stacked for burning by the skidder. Loading was by a 20 tonne digger. In both cases log and load costs were $34/tonne, with administration and management at $2.50/tonne. Transport of machinery onto the site was charged separately and was a modest $0.39/tonne for both operations.

The third operation (Red Barrel) was on slightly more difficult country. Management and marketing for this operation was entrusted to a large national forest management company who charged a basic fee of $3/tonne plus at cost charges for various administrative items and transport of machinery onto the site (these are identified in Table 1). Log and load was contracted to a five-person crew equipped with a rubber-tyred skidder, a bulldozer and towed logging arch and a 30 tonne excavator for loading. Felling and log-making were manual with slash and sloven stacked for burning. Log and load costs were again $34/tonne with administration and management at $3.70/tonne.

Transport of machinery onto the site again was charged separately and was substantially higher (more machines) at $0.61/tonne. Substantial upgrading of approximately 1.2 km of farm track was required to give log trucks access to this site and create a landing for log processing and loading. The total cost of this was $25,156, giving a unit engineering cost for this operation of $6.10/tonne. What is important to the case study is that this engineering asset was utilised by the next operation (Gorse Slip) in 2018 and will be used again in the future for at least two more operations. It is also an asset that greatly facilitates other farm operations and provides all-weather access for silvicultural operations in the second rotation stands.

A three-year gap in harvesting followed giving time for a radical rethink of harvesting strategy before we began again in 2018. The factors considered from the property's point of view were:

- The farm was now subject to a QE2 National Trust Open Space Covenant. The small scattered logging operations are acceptable under the covenant, but landscape values and the overall aesthetics of logging have risen in importance
- Because of this, as well as for financial reasons, we did not wish to build any more roads and landings and needed to reduce the amount of earthworks within the cutovers
- We were now going to meet much more difficult terrain. Very steep but short slopes were now going to be prevalent. Just a few years ago the choices would have been skidders/tractors with a large amount of now unacceptable access tracking or haulers demanding massive road upgrades and extensions just to get on-site, with very large landings – both unacceptable and very expensive.

We were very fortunate to find the solution in a local four-person harvesting and marketing operation based around tracked excavators and small 4WD off-road trucks. These stripped down 'baby' trucks function as forwarders, but are fast, cheap and fuel efficient compared to what the industry normally calls a forwarder.

Features of this operation were:

- All machinery was easily transported to the farm gate and could then walk cross country to the logging site
- Felling was mainly by a chainsaw felling head on a 30 tonne excavator able to negotiate much of the steeper country and 'shovel' the logs to a convenient processing site. This machine was fitted with a winch and lightweight, but high-breaking, strain rope which allowed machine assist for manual felling of trees the excavator could not reach. The winch could then be used to haul whole trees to within reach of the grapple for subsequent shovelling. The first photo shows this machine in action.

This year, a ridge top, traction assist winch system (T-winch) has been added to this operation, allowing the excavator to safely access more difficult parts of a logging setting and further reducing the need for manual felling and on-site tracking. Shovel logging left a much more even spread of broken slash over the cutover and very little soil disturbance. A distinct advantage of small blocks is that their short haul distances allow shovel logging.

Log-making was by means of a processing head mounted on another 30 tonne excavator. Because finished logs were continuously moved to loading sites by the off-road trucks (see second photo), processing sites could be very small. They required minimal (if any) earthworks and were easily sited to suit shovelling patterns, clean-up operations such as slash pile burning, and landscape values.

30 tonne excavator fitted with a chainsaw felling head and winch. The trees are felled manually with winch assist and are pulled up the hill and picked up by a grapple. The Taheke Scenic Reserve (DOC) is in the background

Off-road truck heading up to load out site

Load out sites too could be smaller and, in the absence of slash and slovens, kept very clean and safe. They are quickly prepared by a small excavator. If topsoil has to be moved it can be stockpiled and easily replaced and re-grassed and the area left as useful grazing until needed again (see third and fourth photos).

The fifth, sixth and seventh photos illustrate the set up at three different locations.

As can be seen in Table 1, the costs of marketing, management and administration and transport of machinery to the site were incorporated into a single charge per tonne negotiated and agreed before start up. No nasty surprises and responsibilities placed where they ought to be. With tracked excavators on-site, investment in an hour or two of machine time before they leave allows immediate tidy up of the site, including clearing lines for replacement fences and consolidation of waste piles in safe locations for subsequent disposal by burning (see eighth photo).

Net returns

Net returns in Table 1 are expressed in dollars/tonne, dollars/ha, and annual and overall totals. As can be expected from a wide variety of stand qualities and a fluctuating log market they are variable year to year. We were fortunate that our best stand (the Basin) was harvested at a time when the market was buoyant. All the pruned logs from that stand returned net values well in excess of $100/tonne.

The mean net return of $35,193/ha translates to more than $1,000/ha/p.a., and that from relatively poor, steep Northland hill country, a wide range of silvicultural treatments and no adjustment for inflation over the 10-year harvest period. Take out the (thankfully) short-lived agroforestry block and the

Load out site on ridge top beside main logging road

The same load out site two years later and ready to be used again to load out mature trees in the background

Bent Fish Gully with the processing machine in the centre. An off-road truck loading machine is temporarily shovelling in the background. The felling machine has been shovelling from the right (out of picture) and is about to load an off-road truck which is reversing into position

At the Basin, a felling machine is in the background and shovelling to feed the processor. A processing machine is in the centre working atop a waste pile. An off-road truck is being loaded in the foreground

Bent Fish Gully site layout. A processing machine, felling machine and one off-road truck can be seem on the ridge (see fourth photo). There is an off-road truck track to the load out site clearly visible. The Basin cutover (see fifth photo) logged one year previously can be seen over the yellow smoko hut. The photo is taken from a public road with a farm gate off to the left

mean net returns are $39,480/ha and $61.42/tonne, respectively. Compare these levels of profitability with the median four-year average of $203/ha/p.a. for sheep and beef farming reported in the June 2019 *ANZ Red Meat Benchmarking Report*. The range in that report was $12 to $451/ha/p.a.

During the development of these plantations, there were times when we meticulously recorded all the costs associated with their establishment and management. We have good data for three of the stands in this case study. To this actual expenditure I have added an annual cost of rates (1.6% of unimproved land value) and an annual cost for use of the land or rent (7% of unimproved land value). Thus, an annual outgoing cashflow is created culminating at harvest in a single net return. From this cashflow can be calculated a percentage return on the monies invested, which is shown in the last line of Table 1. The returns range from 9% to 11%. The analysis is crude, but accurate enough to demonstrate that plantation farm/forestry with small-scale blocks can be a very satisfactory investment. Again, it is salutary to compare these returns on investment with those for sheep and beef farming. The June 2019 *ANZ Red Meat Benchmarking Report* reported a median return on assets of 2.2%, with a range of 0.3% to 4.1%.

Discussion

This case study shows that plantations on farms can be a very good investment even when the average setting size is only 3 ha. With all other factors held constant it is very probable that larger areas would have produced improvements in financial returns, but the difference is much less than is often claimed.

There are many compensating advantages for small blocks:

- Erosion and the risk of downstream damage are much reduced
- Land use can be much better matched to land capability
- Spreading plantings over space and time lowers the annual cash requirements for the establishment and management of plantations and such spending can be better matched to fluctuating incomes from other sources. This is particularly important for those contemplating intensive management such as pruning. Pruning and thinning are expensive, and their timing window is tiny and critical. If sufficient cash (or owner's labour) is not available during that window, the opportunity is lost
- Spreading forest planting on a property over a number of years also makes it easier to spread harvest, which mitigates market risk
- Forest harvest makes a mess – spreading the visual impact over smaller areas and over time can be scenically important.

Gorse harvest complete with fence re-established. Processing waste is accumulated into a safe area for burning

Successful harvesting of the increasingly steep and broken country encountered in this case study was made possible by innovative harvest technology. It would have been physically and financially ridiculous to use haulers on these areas.

As mentioned above, Tahere Farm is now subject to a QE2 National Trust Open Space Covenant. Registered on the title, this covenant is binding on all future owners. With respect to future options for the land, the covenant opens some opportunities and closes others, and the financial implications may be substantial. This case study does demonstrate that the establishment of what is close to a normal forest estate has created for the property a useful income that will be ongoing for as long as there is a forest industry in New Zealand. For instance, my partner Sandy and I now live comfortably on the ongoing harvest of a small plantation estate, universal super and the pastoral farming of beef – in that order of annual value.

The data presented here counters the myth that small-scale forestry is not financially worthwhile. It shows that small scale can be very profitable and has other benefits that are compensatory to any additional costs that do occur. Those compensating benefits are important; they point towards a future for plantation forestry in New Zealand that is coming whether we plan it or not. For instance, I question:

- For how much longer is our society going to tolerate vast areas of rolling hill country logged so that they are reminiscent of World War 1 battlefields?
- For how much longer are we going to be allowed to harvest the protective forest cover from whole catchments with the consequent downstream risks?
- For how much longer are we going to ignore the wide range of site and soil qualities that exist on almost all rural properties and cover the whole lot with a forest of only one species in one year?

Our social licence to operate will be eroded if we carry on this way. All over the developed world the size of logging coupes is shrinking and the pressure will be on to do the same here. Our excuse that we have planted large contiguous areas in the same year – whole properties, whole catchments in one age class – will not cut the mustard with our critics. The pain and technical difficulty of trying to spread over time the harvest of huge even-aged monocultures will be intense. So let's not encourage big investors' plans to plant these suffocating blankets. A billion trees is a great and necessary target, but we should be encouraging their planting over thousands of properties. Let's really put the right trees in the right place.

Ian Page is a retired Registered Forester and a Fellow of the NZIF who has had 50+ years in the forest industry in New Zealand and overseas. Email: ianpage.forester@gmail.com

Shifting the culture of development policy

Chris Perley

Forestry is not about trees, it is about people. And it is about trees only insofar as trees can serve the needs of people.

(Jack Westoby, 1990)

A fellow forester and I were having coffee – which he complained about because it wasn't sourced green from some hillside plot in Uganda or Ethiopia and then mixed and roasted quite to his taste – and discussing the policy framing of what is unfortunately called 'development'. He has worked in Africa and Asia on behalf of mainly European countries and world policy organisations like the World Bank. We were talking about 'the experts' to whom life was simple. You establish something primary, shove it through a linear processing chain, link it to a market, and Bob's your uncle, 'Development!'

I remembered Dennis Richardson (1994), whose prose I miss, referring to failed development. One example he gave was of some brilliant plan devised from afar, involving lots of quanta, wherein a fuelwood 'resource' should be established to provide heating for the tobacco factory. Unfortunately, and predictably, the tobacco plant closed down. And the *Eucalyptus* resource was incompatible with the local culture. Richardson suggested that the planting of something that was far more compatible with the culture of place, and their multiple needs, might have been worth a thought.

My friend laughed and said that they don't work like that anymore. They look to the underlying functions that make up a place, and it isn't simply 'resource' and infrastructure. There is a whole 'political ecology' framing. Look to not just the infrastructure and resource nouns, but the culture, politics, institutions and power relations within a place. The complex.

I was complimentary. Systems thinking. Looking at the broader framework of making life better. He said it was interesting that the systems approach of development was now coming back to us so much more sophisticated 'western' countries.

I cannot help but contrast that approach, broad and connected to a socio-ecological system, with the one we still take to woodland development in New Zealand. The most appalling example was the East Coast Forestry Scheme where the scope of potential of necessary woodlands in the landscape – the scope of all the socio-ecological mutualisms – wasn't considered; wasn't even imagined. Plants lots of trees, geared to scale and corporate agents.

In contrast, the best example from the past was arguably the NZ Forest Service Forestry Encouragement Grants in lieu of tax deductibility. That scheme was not – as some described it – simply a dishing out of cash. They had staff who were connected to the local agricultural culture, as much friends and motivators as instructive. Social, connected and technical. The soft and the hard. Similar to the political ecology framing of modern development work.

I welcome our 'right tree, right place' look at the potential for other than one species in these hill country landscapes. However, we need an appropriate socio-ecological context. These places are not simply socially-divorced 'resources'. And we need to use the appropriate scale that matches potential synergies. A farm-sized 500 ha pixel would be yet another disaster.

The real potential lies in the people and in the synergies of integrated land uses where you can get all of these positive – better economic, social and environmental – outcomes.

Woodlands – and we ought to include wetlands – are 'keystone' features within especially hill country landscapes. They suit the spatial patterns of pastoral costs and returns (often ignored in comparisons), they suit the environmental functions, they suit a varied approach to forestry, and they create mutualisms. But don't evaluate them as two distinct and averaged dichotomies to be compared and contrasted, or added as a 'crop' without reference to spatial patterns and connections (using farm averages is a nonsense), because you won't see the mutualisms that way.

There are so many mutualisms, and yet such strong cultural contrasts. A small proportion of farm forestry enthusiasts (who have retired on their forestry returns from 'useless' pastoral gullies), and a strong adversarial cadre of died-in-the-woodchip blanket pastoralists and foresters, throwing spreadsheet numbers at each other … signifying nothing.

There was nothing 'rational' here. It was deeply cultural. It made me wonder about how completely immersed we are in our worldview. The ontologies of rural land. Blanket land use, socially-divorced, economies of scale not scope, seeing either/or competition rather than and-and mutualisms.

Which comes back to the coffee with my peripatetic friend. New Zealand needs more woodlands. But I think we need to stop thinking industrially, and start to see this land and its people as a complex system. Then, we might be able to achieve something good instead of driving wedges through peoples' hearts.

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