Integrating dairy and hill country farming with forestry for profitable and sustainable land use

Case Study Summary Report

Report prepared by

Perrin Ag Consultants Ltd

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Executive Summary

- The purpose of this case study research was to increase awareness and understanding of the diverse range of tree planting alternatives and management practices suited to various purposes, their comparability, and the factors that need to be considered when planning tree planting. This project was conducted by Perrin Ag and PF Olsen researchers in collaboration with case study farmers. Funders were: Te Uru Rākau, DairyNZ, Waikato, Bay of Plenty and Horizons Regional Councils, Farmlands Co-operative, Forest Growers Levy Trust and the Living Waters Trust (Fonterra and DOC).
- Six farming case studies in the Waikato and Bay of Plenty, and four in the Rangitikei (Taihape area), representing a diverse range of farm types and attributes, were selected with input from local steering groups. Farms were visited and data collected to model a 'status quo' farm system and identify tree enterprises of interest appropriate to the property. For each case study, two to three forestry scenarios that integrated with the farm business were modelled using Farmax, Overseer and Forestry Forecaster software, and other analysis, with results interpreted and discussed.
- Farmers had multiple reasons for integrating trees into the business, including: income from timber and/or carbon, income diversification, retirement of poor-quality farmland, easier management of hill slopes, environmental reasons (e.g. reduction of nutrients or greenhouse gases, nutrient trading, erosion control, cleaner waterways), biodiversity, restoration of native or natural landscapes (Case Study 10), aesthetics, shade and shelter, fodder, integration with other enterprise (e.g. mānuka for honey or oil), and family or personal reasons (e.g. succession, retirement, future generation benefits).
- Themes included in the case studies were defined by: the purpose of tree planting (e.g. timber, carbon, land retirement, regeneration, erosion control, GHG and nutrient reduction, biodiversity, aesthetics); tree species comparisons (e.g. radiata pine versus alternative timbers, exotics versus natives for timber, high value timber species, space planted poplars); management practices (e.g. staggered planting, scale, clearfell versus continuous harvest, managing environmental impacts of harvesting); and other topics (e.g. wetland and riparian planting, mānuka planting, mixed stands, carbon NZU eligibility, planting and harvesting on steep hill slopes, honey, mānuka oil, grants).
- The financial implications of integrating tree enterprises on farm was of interest to farm owners nine of the ten case studies. Comparative financial investment analysis quantified changes in profitability and equity. Liquidity and cash flow implications were also investigated in some case studies.
- Carbon sequestration and ETS eligibility is relevant to trees planted for timber, farming, land retirement (e.g. natives or mānuka) and erosion control (e.g. poplars) and was of interest in all case studies. Similarly, nutrient (N, P) losses and bGHGs for the Status Quo Farming Scenario and integrated farming and forestry scenario(s) were compared.
- Radiata pine is the most common timber species but is more suited to some regions than others, such as the Bay of Plenty with its suitable climate and ready access to contractors, processors and markets (port). Investment returns, particularly in the first harvest cycle with carbon and subsidies, outperform other exotic and native timber species in all regions. However, farming returns exceeded forestry enterprise returns in the Taihape area case studies and some Waikato case studies. In the Bay of Plenty, radiata pine returns could exceed farming returns on poor quality sheep and beef land.
- Alternative species were preferred in the Taihape area where climate is less suited to radiata pine (snow-prone), and distance from port and smaller tree stands result in lower returns than in the Bay of Plenty or Waikato. Aesthetics, biodiversity, better suitability to the climate, fewer or continuous cover harvests (less erosion and nutrient loss), interest in high-value timbers and an optimistic perspective regarding future markets, and better environmental outcomes were other reasons.

- Biodiversity, environment and aesthetics were important attributes, with all farms having native trees, trees on retired farmland, mānuka planting for regeneration (see Case Study 10), naturally reverting areas, trees for erosion control (Case Study 9) and/or riparian planting. Most case studies incorporated non-timber trees plantings in their scenarios for these reasons.
- Space planting poplars on erosion-prone hill country can underpin the long-term viability of hill country land use for pasture on erosion-prone slopes and earn NZUs. Including ongoing pasture loss due to erosion in the Status Quo Farming scenario, resulted in slightly higher returns for the space planting scenario: with carbon returns, these were even higher. This excludes quantification of long-term, ongoing reductions in erosion, sediment and phosphorous. Results suggest initiatives that support poplar space-planting would result in benefits beyond the farm business. Reducing eligibility for NZUs, as is being considered, will have the opposite effect.
- Forestry for carbon sequestration is being promoted to help meet national GHG reduction targets, particularly permanent afforestation which meets ETS requirements. Biological GHG emissions are reduced if animal numbers decline following land retirement to trees. On-farm GHG reduction tools will be important if pastoral farming is required to account and pay for biological GHG emissions. The price of carbon was a significant contributor to forestry returns from eligible planting. Note current NZU price (May 2020) is now almost 50% higher than the $25/NZU price assumed in the case studies. However, forestry as an offset for GHG is a short-term solution, with NZUs (potential carbon income) in the first harvest cycle only, after which that land use is locked into trees long-term.
- The 'right tree, right place' decision is complex. The first steps in the tree planting decision are to clearly identify the following. (1) Goals and objectives, generally, and with respect to the tree planting under consideration. (2) Property' attributes e.g. farm physical attributes especially for the area targeted for planting, climate, local access to expertise, labour, contractors and markets. (3) Integration of potential tree enterprises with the current farm system and enterprises.
- Suitable alternatives need to be identified and understood, supported with robust analysis. Due to the complexity of the decision, landowners are advised to seek professional or informed (NZFFA, informed locals) advice. The following information is required: species suitability and availability; their relative performance on attributes of interest (production, financial, environmental, cultural, personal); potential markets; tree management to meet end use; harvest impacts; integration with the farm system or other enterprises; implications for future generations e.g. ETS registration; opportunity costs – long-term comparison with current or alternative land use.
- Financial aspects for consideration are: investment returns, capital requirements, cashflow, equity, opportunity costs, appropriate discount rate, and risk and uncertainty with sensitivity analysis where there is considerable uncertainty re costs and returns e.g. alternative species. Whole farm business analysis as well as forestry analysis is required to ensure business viability and ability to repay debt. A strong balance sheet can help fund land use change to forestry. However, this is often a result of a strong farming business which forestry land use alternatives cannot compete with.
- The long-time timeframe over which some plantings are expected to accrue benefits to the farming enterprise can be undervalued by conventional economic analysis with high expected investment returns (high discount rate). Arguably, planting permanent forests for carbon should use a lower discount rate to reflect the value of long-term climate change implications. Other long-term environmental benefits are also ignored in the financial analyses e.g. erosion and nutrient reduction.
- Less common exotic and native timber species with long harvest periods are less profitable than radiata pine at the 6% discount rate, but at lower rates the reverse occurs. Alternative species returns are uncertain suggesting a higher discount rate be used. However, these also provide long-term inter-generational benefits suggesting a lower discount rate is appropriate. Once harvest starts, alternative species timbers can provide a sustainable forest system e.g. regular income with limited harvest environmental impact, which is likely to outperform clearfell radiata pine rotations with no carbon.

CONTENTS

Introduction

The Integrated Farm Forestry Systems research and extension project described in this report is funded by Te Uru Rākau, with co-funding from DairyNZ, Waikato, Bay of Plenty and Horizons Regional Councils, Farmlands Co-operative, the Forest Growers Levy Trust and the Living Waters Trust (Fonterra and DOC). This project was undertaken by Perrin Ag and PF Olsen researchers, in collaboration with farmers (sheep and beef cattle, dairying) and industry groups. The project aims to address key issues associated with the adoption of forestry enterprises in farm businesses so as to provide landowners, iwi and rural professionals with information needed to help landowners make well-informed forestry enterprise decisions and increase their confidence in implementing forestry as a land-use option. Findings will also inform policy makers.

This report summarises the individual case study component of the project, which is the second of the four project phases (literature review and interviews, individual farm case studies, syndicated case studies, extension activities). A diverse range of individual farm case studies, including some iwi-owned properties, were undertaken to illustrate the impact of integrating forestry options into existing pastoral farming systems. This phase followed on from the literature review and farmer interview phase of the project, completed in 2020, which provided insight into farm forestry practices, views and knowledge, and enablers and barriers to integrating forestry into pastoral farming businesses in the regions involved in the project (Dooley et al. 2020).

In this phase, ten case studies, comprising six Waikato and Bay of Plenty farm businesses (Case Studies 1 to 6) and four Rangitikei farm businesses (Case Studies 7 to 10), were selected on their potential to demonstrate the impact of tree enterprises on farm business (e.g. production, financial, personal or organisational goals) and environmental performance, and address some of the knowledge gaps and topics of interest to the farmers identified in the interview phase of the project.

A range of complementary, integrated farming and forestry scenarios were evaluated for the ten different farm businesses. Forestry scenarios explored incorporated: radiata pine (*Pinus radiata* or Monterey pine) for wood fibre or logs, Douglas fir, redwood, eucalypts, rimu and totara for timber and carbon; speciality timbers (black walnut, Tasmanian blackwood, oak, eucalypts) for furniture or flooring; under-planted natives (rimu and totara) for timber into mānuka stands planted for carbon, apiculture, regeneration and biodiversity; retirement of poor farming land into natives and exotics for retirement; management of forest edges; riparian planting; and poplar space-planting for carbon and erosion control. The next phase of the project will be four syndicated case studies.

Case study reports, summaries and videos will be made available on-line. Planned workshops and field days were cancelled due to COVID-19 restrictions and replaced by videos. Findings will be further disseminated to farmers and rural professionals through publications and articles, to raise awareness of forestry options suited to on-farm integration. Two articles have already been published in the NZIPIM Journal (Durie et al. 2020, Parker & Dowling 2020).

This report summarises and discusses the ten individual case studies completed as part of this project. The method is described, followed by an overview of each of the case studies and a discussion section outlining key findings and implications.

CASE STUDY SELECTION

Ten case studies were selected, six in the Waikato and Bay of Plenty and four in Rangitikei. These included a range of sheep and beef farms, dairy farms, and farms with mixed livestock enterprises. The range of case studies selected recognised the importance of having diversity in case studies, both within and between regions (farm geographic area, enterprise type), to capture differences and meet the brief to “provide results relevant to a range of farm situations nationally, with the alternatives contributing in different ways to the various benefits” as stated in the project proposal.

The Waikato and Bay of Plenty case studies were identified through the researcher’s professional networks with potential case study selections discussed with the local project steering group (local industry and farmer members). Potential case study farms were compared and selected against their ability to address the questions and knowledge gaps identified in Phase 1 (Dooley et al. 2020) as well as ensuring farm and sector diversity within the regions. Selected case study farmers were approached to see if they would be willing to participate.

The Rangitikei case study farms were identified by the local project steering group (local regional council member and farmers) working with the researcher. Geographic, topographic and climatic diversity within the area, and diversity in farm situations and farmer objectives were all considered in identifying potential case study farms. The Horizons representative’s knowledge of local farmers interest in initiating or considering tree enterprises was particularly helpful in identifying a diverse selection of case study farms. A shortlist was arrived at that captured a diversity across all factors and was crosschecked with findings of the interviews in Phase 1: the diversity captured in the potential cases selected exceeded the diversity required. Selected case study farmers were approached to see if they would be willing to participate.

DATA COLLECTION

Researchers visited the farms to collect information on farmer interest and preferences for integrating forestry into their existing business, as well as collecting information on their farm business and farm systems. The farms were inspected and information about the exiting farm and forestry activities was captured. Data was collected using a template adapted from the DairyNZ Whole Farm Assessment (DairyNZ 2016) to help guide data collection and ensure consistency between case studies.

All Rangitikei visits were completed before the March 2020 COVID-19 lockdown, with two case studies followed up for more information later. Some Bay of Plenty and Waikato visits were changed to online interviews (e.g. Zoom meetings) due to COVID-19, including Kapenga M Trust (Case Study 3) and Taumata Farming Partnership Ltd (Case Study 2) with information from previous on-farm visits by Perrin Ag Consultants Ltd (Perrin Ag) used to reinforce and help validate interview information. The remaining Bay of Plenty and Waikato farms were visited after lockdown.

CASE STUDY ANALYSIS

The farm property was mapped and analysed in ARC GIS software to identify the geo-physical variation across the property to ascertain the impact on aggregated pasture production of changing land use. Aerial maps were sourced for 1990 and 2008, if required, to estimate the area eligible for carbon (NZU) sequestration under the emissions trading scheme (ETS).

Financial and physical data from the current and preceding years was analysed to develop a feasible status quo model ("base scenario") of the business. This data covered between one and three previous years depending on data availability and requirements for modelling. The farms production and finances were modelled in Farmax (www.farmax.co.nz.) for a base status quo situation to ensure feasibility and generate budgets. OverseerFM software (www.overseer.org.nz/overseerfm) was used to estimate the nitrogen (N) and phosphorus (P) losses to water and biological greenhouse gas emissions (bGHGs) from the current land use activities. Modelling assumptions can be found in the Appendix.

Once a suitable status quo farm model was developed, the afforestation enterprises for integration with the farm's existing activities were developed in association with the owner, ensuring scenarios aligned with their objectives and tree species of interest to them. These scenarios were then analysed for projected expenses, revenues (timber, carbon, honey, subsidies) and carbon sequestration over a 56-year timeframe, essentially two full 28-year cycles of planting, growing, harvesting of radiata pine: this timeframe was used for consistency with other case studies. Forestry Forecaster software v2.2.1.1553 (West et. al. 2013) was used to model the production forestry enterprises. Where applicable, the impact of accessing regional or national grant schemes available at the time of analysis was included. Modelling assumptions are in the Appendix.

The farm system was then re-modelled in Farmax and OVERSEER for each scenario to account for the impact of afforestation on the farm system and the reduction in farmed area, with resulting financial and physical outputs recorded. The production, financial and environmental performances of the integrated whole farm business scenarios (combined farm and forestry enterprises) were then evaluated against the Status Quo Farming Scenario using investment analysis tools, primarily discounted cash flow analysis, enabling regular, annual cashflow from farming to be compared with the irregular cashflows from forestry. The scenarios were also analysed for their aggregate impacts on the property's environmental footprint using OVERSEER.

The Ngāti Awa Case Study (Case Study 5) did not include financial investment or environmental analyses. The theme for this case study was the decision-making process and outcome from an afforestation decision. Hence, a financial investment analysis was outside the scope of this high-level case study. Potential implications regarding ETS legislation were also discussed, and some scenarios tested on their eligibility for ETS and funding grant schemes.

Case Study Summaries

The 'right tree, right place' decision is complex requiring consideration of multiple factors. These include the attributes of the property (e.g. slope, aspect, climate, soil type, locality, access to labour and markets), the ability to integrate with current enterprises and the farm system, and the goals and objectives of the owner(s) which can be multiple, requiring trade-offs in reaching a final decision. Furthermore, having decided where to plant, and selected a species that is suited to the location, fits well within the farm system, and meets most farmer objectives, further decisions may need to be made regarding management regimes which can impact on production performance. Hence, defining the attributes for comparison in a case study was not straightforward, and case studies sometimes combined a number of comparisons encompassing a combination of tree types/uses, species, management practices and other attributes of interest.

The selection of a diverse range of case studies in terms of property attributes, farm systems and owners' goals enabled a wide range of themes to be explored in these case studies. These themes aligned with the knowledge gaps and interests identified in the interview phase of the project (Dooley et al. 2020), and with the locality-specific areas of relevance and interest identified by local steering groups to ensure the cases were applicable to their region or similar regions.

Financial and carbon sequestration aspects were of interest in all case studies, however, the context in which these were explored varied, reflecting the diversity of the case study farm businesses. In all cases, except Ngāti Awa (Case Study 5), the financial implications of integrating tree enterprises on farm, comparative financial investment analysis was undertaken to quantify profitability for nine of the ten cases and impacts on equity were described. Liquidity and cashflow implications were investigated in some of the case studies.

Carbon sequestration and eligibility for ETS carbon credits is relevant to trees for timber, farming land retirement (e.g. natives or mānuka) and erosion control (e.g. poplars). This was of interest to all case study farmers and included in all case study analyses. Similarly, an environmental comparison comparing nutrient (N, P) losses and bGHGs from the base Status Quo Farming Scenario and the scenario(s) integrating the tree enterprise was done for all case studies.

Integrating trees into the business to improve business efficiency and sustainability, diversify income, improve environmental resilience and compliance (N, P, bGHG) and reduce erosion impacts, and enhance biodiversity and aesthetics were common themes across the case studies, although the scenarios for each case study focussed largely on those aspects most relevant to that particular scenario.

This case study summary section presents the following.

- The case study themes with the case studies that explored that theme identified.
- A table with information on region, farm enterprise type, and the scenarios modelled for each of the ten case studies (Table 1).
- A one-page summary for each case study with a farm description, scenario description and a brief overview of results.

These descriptions can be used to help readers identify those case studies of most interest or relevance to them. Full reports and on-line summaries for each of the case studies are available if further information is required. The reports are listed in the Case Study Report References section.

CASE STUDY THEMES

Themes explored in the case studies are shown below to help readers identify those they are interested in. Case studies relevant to the themes are in shown brackets, with the number in bold where that factor was a key theme for that case. If a theme was only of minor significance to a particular case study, the case study may not be noted for that theme. However, that does not necessarily mean that theme is unimportant to the decision maker: it simply means it was not important to the decision explored in that case study.

PURPOSE OF TREE PLANTING

- Timber (**1,2,3,4**,**6**,**7**,**8,**10)
- Carbon sequestration (10)
- Carbon sequestration – shown with, and without, carbon returns (1,2,3,4,5,6,7,**8**,**9**)
- Retire marginal land from farming – best land use (1,3,4,6,**7**,**8**,**10**)
- Regeneration of natives (**3**,5,8,**10**)
- Erosion control - prevent loss of pasture (**9**)
- Nutrient or GHG reduction, possibly with nutrient trading in BOP (1,2,3,4,8)
- Biodiversity (**10**)
- Aesthetics (1,2,7,8,9,10)
- Shade and shelter for stock (1,9)

TREE SPECIES COMPARISONS

- Radiata pine versus alternative timber species (1,**2**,**8**)
- Non-radiata exotics versus natives for timber (**8**)
- Timber species for high value logs (**7**,**8**)
- Natives for timber under-planted into mānuka for regeneration (8,10)
- Narrow crowned poplars versus fastigate poplars - carbon eligibility implications (**9**)

MANAGEMENT PRACTICES

- Single year versus staggered planting (**3**,**6**)
- Clearfell harvest versus continuous cover (**8**)
- Managing the edges of radiata pine plantings (**4**)
- Impacts of scale (block size) in planting (**1**,6)
- Measurement versus estimation of tree growth (3,5)
- Managing environmental impacts of harvesting (2)
- Trees within the pastoral area (**9)**

OTHER

- Wetland restoration (**3**)
- Riparian planting (5)
- Mixed species timber stands (**9**)
- Assessing eligibility for carbon NZUs under the ETS (**5,8,9**)
- Access to forest stands and log markets (see 4 versus 8)
- Honey returns (8,**10**)
- Mānuka for oil production (**5)**
- Managing the harvest process (4)
- Harvestability of steep hill slopes (6)
- Considerations for planting steep hill slopes (2,7)
- Grant use and availability for riparian planting (**5,6,**10)

CASE STUDY DESCRIPTIONS

Table 1: Description of the case studies by farm enterprise type, region and scenarios.

Case Study		Region	Farm Type	Case Study Scenarios
1	Holdem Farm (2017) Ltd	BOP	Dairy farm	Scenario 1 was radiata planting on a marginal pasture area. Scale (larger tree blocks, some on better quality land), and inclusions of alternative species (redwood), were explored in Scenarios 2 and 3, respectively.
2	Taumata Farming Partnership Ltd	Waikato	Mixed dairy and sheep and beef farm	Two scenarios, both with radiata plantings, were analysed with and without carbon. In Scenario 2, a eucalypt woodlot for pulp and improved aesthetics replaced some radiata. Both scenarios planted natives in gullies and difficult topography areas.
3	Kapenga M Trust	Waikato	Dairy and drystock farm	Staggered (Scenario 1) and single year (Scenario 2) radiata and mānuka plantings to spread cashflow and risk, were evaluated, with and without carbon, using on-farm tree growth projections. Scenario 3 used Forestry Forecaster growth projections. Wetland restoration was also evaluated (financial, cultural, environmental impacts).
4	MK & FW Linton	BOP	Dairy and Kiwifruit	The theme was management of radiata forest edges. In Scenario 1, edges were managed similarly to the rest of the planting. In Scenario 2, extra edge management was included. Scenario 3, narrow forest sections had natives planted at the edge. Harvest processes and best practice harvest management practices were described.
5	Ngāti Awa Farms Ltd	BOP	Two dairy units, and a sheep and beef farm	Three scenarios demonstrated farm afforestation decision processes and outcomes: (1) replanting radiata with native and exotics; (2) planting mānuka for oil production; (3) eligibility of riparian planting for grants and ETS.
6	Verry Farming Ltd	Waikato	Sheep and beef farm	Species and funding grants were explored. Scenario 1 was 186.6 ha (10 woodlots - 2.1 ha to 54.8 ha from 4 hill country blocks) planted in radiata with grants available. Scenario 2 had no grants but years 1 to 6 safe carbon. Scenario 3 replaced 5 ha of radiata with natives, grants available. Scenarios modelled with, and without, carbon. Staggered planting and harvest for better cashflow was evaluated: Scenario 1A equated to Scenario 1, and Scenario 1B staggered planting and harvest over 6 years. Harvestability of steep slopes and factors affecting this were discussed.

7	Mangaweka Asparagus	Rangitikei	Asparagus farm with carry-over cow grazing	Scenario 1 was 22.6 ha structural timber (Douglas fir, larch, fir) on steep slopes, with 6.9 ha low-productivity specialty timber (black walnut, Tasmanian blackwood, oak) on river flats, both harvested at 55 years. In Scenario 2, the speciality timber was a higher-productivity timber species (*Eucalyptus fastigata*) harvested at 35 years.
8	Lazy G Ranch	Rangitikei	Sheep and beef farm	Alternatives for a steep, reverting, poorly accessible block with questionable ETS eligibility were explored. Scenarios 1 and 2 were radiata pine (clearfell), and redwood (continuous cover), respectively. Scenario 3 was mānuka (for carbon, honey while possible, regeneration) interplanted with rimu for timber (continuous cover).
9	Pa-iti	Rangitikei	Sheep and beef farm	Space planting poplars on erodible farm areas to prevent slips was compared with doing nothing (pasture loss). 29.6 ha and 38.5 ha were planted for Scenarios 1 and 2, respectively, with current carbon NZUs, and 25% of current NZUs, able to be claimed. Scenario 3 planted a fastigate poplar variety that took longer to sequester carbon.
10	Makokomiko	Rangitikei	Sheep and beef farm	Incorporating carbon sequestration and/or honey production on a transitioning mānuka block planted for regeneration. 1A sharefarms with a beekeeper and claims carbon NZUs, 1B only claims carbon. 2A and 2B own the hives and collect honey for 30 and 50 years, respectively, as well as claiming carbon. Scenario 3 is the same as 1A but also interplants with totara for timber.

CASE STUDY 1 - HOLDEM FARM (2017) LTD (BAY OF PLENTY)

FARM DESCRIPTION

The Holdem farm is 308 ha family-owned and operated dairy farm business on the Mamaku plateau, North-West of Rotorua, of which 276 are effective pasture. It is mostly flat to rolling with some steep gullies and Rhyolite mounds. There are 27 hectares of native bush, 1.4 hectares of new riparian planting as well as newly planted shelter belts. Soils are deep and well drained. Annual rainfall is high. The property is in the Lake Rotorua catchment and is subject to decreasing nitrogen limits, requiring cow numbers to be reduced from 700 to 600 by 2032. The farm has recently undergone development and is now focussed on increasing operational efficiency.

The owners are interested in integrating forestry into the business for timber and carbon, particularly on poorer producing areas, to increase business efficiency, resilience, and income diversification, as well as for environmental protection and N leaching reduction. These plantings are complemented by native and riparian plantings for aesthetics, environment, compliance, biodiversity and shade and shelter for stock. They want the business to be sufficiently viable to support family and doing this in an environmentally responsible manner. They are interested in tree options to increase farm efficiency, build environmental resilience, diversify income, enhance property biodiversity and aesthetics, and provide shade and shelter for the stock.

SCENARIO DESCRIPTION

The first two forestry scenarios were all radiata pine based, while the third scenario incorporated redwood to provide a species comparison.

1. Planting 17.7 ha of steeper, lower producing pasture areas considered marginal for dairy farming in radiata pine, with 7 ha of native planting and 3 ha of riparian planting.
2. Planting 49.3 ha of radiata pine woodlots on better quality land to evaluate the impact of greater forestry scale. This scenario included 5.3 ha of riparian planting and 5.1 ha of native plantings.
3. As for Scenario 2 but replacing 29 ha of the 49.3 ha radiata pine planting with Redwoods (Sequoia sempervirens) to assess whether their greater carbon sequestration makes them a viable alternative to the timber and carbon revenues from a conventionally managed radiata pine woodlot. This included the 5.3 ha of riparian and 5.1 ha of native plantings in Scenario 2.

RESULTS

Scenario 1 provided the closest alignment with owner objectives, having the highest IRR and equity growth with minimal impact to cash flow. Whole farm business (aggregate of the forestry and farming enterprises) IRR was 15.6%, which was 0.4% higher than the base farming scenario. Total equity was also expected to be $625,000 higher than the base farming scenario by the end of the first forestry rotation. This was because forestry provided similar returns to dairying on the poorer quality land, and reduced N losses so additional rights to pollute or a more costly system change to lower annual N losses would not be necessary.

Timber and carbon revenues from Scenarios 2 and 3 were insufficient to offset lost dairy farm profits from either scenario. N loss to water decreased by 4% in Scenario 1 and 16% in Scenarios 2 and 3. GHG emissions decreased in all scenarios (-4% in Scenario 1, -16% in Scenarios 2 and 3), highlighting the potential of trees as a tool to support domestic and international emissions GHG reduction targets.

CASE STUDY 2 - TAUMATA FARMING PARTNERSHIP LTD (WAIKATO)

FARM DESCRIPTION

Taumata Farming Partnership Ltd is a 309 ha (263 ha effective), family-owned business located in Pukeatua in the Waikato region. The farm business comprises a 157.5 ha dairy and 105.4 ha drystock unit. The dairy unit comprises high quality flat to rolling land, whereas the drystock unit is mix of easy hill and steep land. There is also 10.3 ha of native and riparian plantings and 7.0 ha of radiata pine woodlots, all of which are on the drystock unit. Recently, there has been significant riparian planting, retirement of sidelings, creation of wetland catchments, upgrades to farm races and increased buffer strips around riparian zones following approval of their resource consent for land use change. A key consent condition is the farm must comply with a nitrogen leaching loss rate estimated by OverseerFM from inputs in the farm's environment plan.

The owners are interested in understanding how further integration of trees on farm can support their continued environmental work and increase farm performance and operational efficiency. The aim is to optimise land use on marginal areas while meeting environmental obligations, reducing total contaminant loss and developing the farm for future generations.

SCENARIO DESCRIPTION

Two scenarios were considered, both of which were analysed with, and without, carbon revenue.

1. Planting 20.5 ha of radiata pine timber woodlots, and 7.4 ha of natives. The natives are planted predominantly in gullies and areas of challenging topography where timber harvesting is considered prohibitive.
2. Planting of two timber species comprising a 15.1 ha radiata pine woodlot, and a 5.4 ha eucalypt woodlot for improved aesthetic appeal. Native planting area and location remain the same as for Scenario 1.

RESULTS

The high level of pasture grown on Taumata meant that neither forestry scenario could outcompete the base system with IRR and equity at year 56 reduced for both scenarios. Compared to the base farm scenario, farm enterprise productivity per hectare and IRR on the residual farming land increases for both scenarios after converting the most marginal land to forestry and native, however, whole farm business profitability (farming and forestry) reduces compared to the base system, whether carbon is included or not.

Including carbon sales improves the equity position after the first rotation for both scenarios, and for Scenario 1 generates a 5% growth in equity compared to growing trees for timber only. However, by Year 56 (two rotations) total equity is reduced for both scenarios (6% in Scenario 1 and 11% in Scenario 2) compared to the base farming system. With carbon included Scenarios 1 and 2 generate an net present value (NPV) 3% lower than the existing farm enterprise. The IRR from both scenarios was also 1.1% - 1.2% less than the base system.

Incorporating trees created greater flexibility within the farm's N loss limit to increase production on the remaining farm. Nitrogen loss to water was reduced by 5% with the afforestation modelled in Scenarios 1 and 2. Biological GHG emissions reduced under both scenarios by 6% compared to the base scenario. However, these reductions need to be weighed against economic outcomes from this land use change.

CASE STUDY 3 - KAPENGA M TRUST (WAIKATO)

FARM DESCRIPTION

Kapenga M Trust's farming business comprises 1,165 effective hectares including 339 ha of dairy, 191 ha of deer and 635 ha of sheep and beef land in the Waikite Valley, 15 kilometres south of Rotorua in the Waikato. Each unit has a mix of land classes with high-producing flat-rolling blocks and lower-producing hills. The dairy, and sheep and beef, units have areas of especially poor, low-quality steep land. In addition to pastoral land, there is 266 ha of forestry, 189 ha of native bush and scrub, and 168 ha of wetland ('Kapenga Swamp'). The Trust have been de-intensifying the farm system, returning some land to its original state, and restoring the wetland to provide a regenerative, natural resource.

Kapenga M (Ahu Whenua Trust) is interested in trees to provide the maximum benefit to beneficiaries while preserving the land as a taonga for future generations. They want to diversify income, build environmental resilience, enhance biodiversity and aesthetics and support the farm operation.

SCENARIO DESCRIPTION

Multiple woodlots were planted on 155 hectares of slopes across both dairy and drystock units, consisting of 144 ha radiata pine and 11 ha mānuka. Scenarios assumed the same planting but were differentiated by management. All three scenarios were modelled with, and without, carbon.

1. A staggered planting approach over four years with tree growth projections based on measured data from existing forests on Kapenga.
2. A single year planting with tree growth projections based on measured data from existing forests on Kapenga.
3. A single year planting with tree growth projections estimated by the well-recognised Forestry Forecaster software program. This scenario was discounted early on and results focused on the other two scenarios.

RESULTS

Integration of forestry and mānuka plantings on Kapenga improved profitability with a 9% increase compared to the current operation over two forestry rotations for both Scenario 1 and Scenario 2. This difference increased to 32% when carbon is sold in both Scenarios 1 and 2. With carbon included, the IRR was 0.5% greater than the base system, and total equity after the first rotation was projected to be $1.8 million higher. These figures reflect the greater productivity of trees on marginal land for farming.

Scenarios 1 and 2 provided the greatest wealth creation over the first rotation, with closing equity at Year 31 of $37.4 million (without carbon) and $38.1 million (with carbon), compared to $28.3 million at the start. This is 5% ahead of the base system which had closing equity at Year 31 of $36.3 million. Although the final equity position was similar between scenarios, the cashflow for Scenario 2 was much lumpier than the staggered planting in Scenario 1, especially during key events such as planting and pruning.

Planting more trees on farm supported the Trust's goal of improved environmental sustainability with N and P loss reduced by 9% and 22%, respectively. Biological emissions also reduced by 11%.

Restoration of the Kapenga wetland was analysed in a standalone section. This included native regeneration (11.8 ha) as well as new native plantings (5.4 ha) at a net cost of $2,000/ha and $61,475/ha, respectively after funding grants. Good advice and understanding the key constraints limiting wetland function is critical to ensuring successful restoration.

CASE STUDY 4 – MW & FK LINTON (BAY OF PLENTY)

FARM DESCRIPTION

MW & FK Linton have a family-owned farm business in Te Ranga, 17 km south of Te Puke, consisting of 423 hectares of mixed contour land. Enterprises include a 172 ha dairy platform, 59 ha for grazing young stock replacements, 3.6 ha of kiwifruit, 38.8 ha of plantation woodlots (*Pinus radiata* and *Cupressus lusitanica*) with the balance in native bush. The property's ready access to wood processors and location close to the Port of Tauranga for log transport to market makes forestry for timber an attractive option.

The owners are interested in opportunities to convert marginal land that is difficult to graze to productive plantation woodlots. This integration of trees will support their goals for a more environmentally-and financially robust business. Key opportunities from retiring low quality land into a low nitrogen land use include mitigating environmental externalities, providing shade and shelter for stock, enhancing biodiversity, and providing income from log sales and carbon sequestration over time.

SCENARIO DESCRIPTION

The scenarios evaluate the impact of planting 36.6 hectares of sidelings and gullies in radiata pine due to its strong economic performance which aligns with the landowners' priorities. Scenarios differed in the management of considerable area of forest edges which can be costly to manage.

1. Forestry edges were not managed any differently from the rest of the forestry.
2. Forestry edges within 10m of the forest edge incurred higher spraying, pruning and thinning costs.
3. Scenario 3 is similar to Scenario 2, with 1.3 ha of narrow sections planted in native to reduce the total length of forest edges. Forest area was reduced to 35.3 ha.

RESULTS

The existing farming operation is more profitable (higher NPV) than any of the forestry scenarios considered. Improved productivity per hectare for the farming enterprise after removing the most marginal land did not result in an improved IRR since the business lost economies of scale. 'Sticky costs' present challenges for small operations, such as MW & FK Linton, since the operating structure still needs to be maintained regardless of minor changes in livestock numbers.

Options to manage forest edging to minimise damage to fences, improve aesthetics, or enhance biodiversity had a minor impact on profitability. This small difference suggests landowners can select the option that best meets their preference and achieve similar financial outcomes.

The ability to sell "safe" carbon has a significant impact on the relative profitability of forestry as a land use. Net equity gain after 28 years, including the sale of carbon, this was slightly above or similar to the pastoral enterprise. Scenario 1 had a $37,489 increase (0.4%), Scenario 2 increased by $18,177 (0.2%), whereas Scenario 3 had similar results to the base system. However, the poor liquidity of the forestry scenarios meant the NPV for the scenarios was $102,000 to $117,000 less with carbon, and $197,000 to $209,000 less without carbon, over a 56-year period, highlighting weaker liquidity and lower net returns in the second rotation which has no grants available or sale of safe carbon. For smaller business's, debt levels would need to be lower in the second rotation to ensure the business maintains adequate liquidity to pay debt and remain sufficiently viable to achieve the landowner's objectives.

CASE STUDY 5 - NGĀTI AWA FARMS LTD (BAY OF PLENTY)

FARM DESCRIPTION

Te Rūnanga o Ngāti Awa's farming company, Ngāti Awa Farms Ltd, own an 1,117 ha drystock hill country sheep and beef breeding and finishing unit surrounding the Whakatāne Township in the Bay of Plenty. They are also majority shareholders in a partnership with other hapū trusts in a 204 ha, 600 cow dairy unit near Te Teko on the Rangitāiki plains and a 340 ha, 900 cow dairy unit near Rotomā.

Ngāti Awa want to reduce the environmental footprint of their farming operations and farm sustainably. They are interested in options for retiring land that enhance their properties from an environmental, financial, aesthetic and cultural viewpoint. Traditional Māori values of mana, mauri, whakapapa and tapu are integral to their relationship with the natural environment and interconnect with the iwi's other social and cultural values. These values form the decision-making framework for business strategy and policy decisions. They are interested in planting trees to build environmental resilience, diversify income, enhance biodiversity and aesthetics and protect vulnerable areas.

SCENARIO DESCRIPTION

This case study focussed on high level analysis of the process and outcomes of decision-making with respect to afforestation, so did not include financial analysis. ETS legislation implications were discussed, with some scenarios tested for ETS and funding grant schemes eligibility. Eleven potential planting sites across the three farms were identified with sites grouped into three different scenarios.

1. Replanting radiata pine stands with native and exotic species.
2. Planting mānuka for oil production on a 5.2 ha stopbank alongside the Rangitāiki River.
3. Eligibility of riparian planting for grants and ETS eligibility.

RESULTS

Scenario 1 highlighted that replanting radiata pine with alternative species affects carbon liability and future carbon earning potential depending on the forest's age, species and definition within the Emissions Trading Scheme (ETS) framework. There was a clear advantage for native forests using the Field Measurement Approach (FMA) to measure carbon stock compared to the MPI lookup tables. The potential of a premium for carbon credits from native forests was discussed, as was the alternative income streams from honey and the medicinal value of mānuka and kawakawa if grown as cover crops.

Scenario 2 found that despite meeting most of the grant funding and ETS criteria, mānuka planting for oil production was not eligible for inclusion in the ETS since mānuka harvesting of foliage would limit forest height and canopy cover. However, there is potential to replace the barberry hedgerows on the Ngakauroa Dairy unit with mānuka, with harvesting foliage for oil production reducing height enabling the centre pivot irrigator to pass. Mānuka trees would provide stock shelter and an aesthetic value.

Scenario 3 examined potential riparian planting sites. Two drystock property examples showed that riparian planting for landscape enhancement and sustainability, if planned correctly, can meet the objectives for both grant funding and the ETS.

CASE STUDY 6 - VERRY FARMING LTD (WAIKATO)

FARM DESCRIPTION

Wendy and Reon Verry own a family sheep and beef farm consisting of four individual hill country blocks located 5 km to 9 km south-east of Te Kuiti. Total area is 1,397 ha, including 1,257 ha effective farm area, 60 ha radiata pine and 51 ha of existing native.

The Verrys are interested in planting trees on at-risk, steep (over 26 degree) slopes across all blocks to improve environmental resilience, diversify income, and enhance the property's biodiversity and aesthetics while supporting the sheep and beef operation.

SCENARIO DESCRIPTION

Scenarios investigated species and funding grant availability. A total of 186.6 ha (10 woodlots, 2.1 ha to 54.8 ha across the 4 hill country blocks) were planted in either radiata pine or natives. Planting was over 2 years, with harvests in years 27 and 54. Scenarios were modelled with, and without, carbon.

1. Planting 186.6 ha in radiata pine, with grants (1BT assumed) available for establishment costs.
2. Planting 186.6 ha in radiata pine, no grants available but safe carbon for first 6 years received.
3. Planting 181.6 ha in radiata pine and 5 ha (small 2.1 ha and 3 ha woodlots) in native plantings, with grants available for establishment.
4. A fourth scenario evaluated staggered planting and harvest: 1A was the same as Scenario 1, and 1B assumed planting and harvest were staggered over 6 years for better cashflow.
5. Harvestability of steep slope and factors affecting this is discussed.

RESULTS

Scenario 1 had the highest *forestry returns* without carbon. NPVs were $486,145 ($2,605/ha), $230,152 ($1,233/ha) and $483,002 ($2,588/ ha) for Scenarios 1, 2 and 3, respectively, over 56 years. IRRs were 8%, 6.8% and 8.0%. With safe tradeable carbon ($25/NZU) sold between year 8 to year 17 (when half the final forest carbon has been sequestered), the NPVs increased to $1,036,705 ($5,556/ha), $1,008,902 ($5,407/ha) and $1,042,535 ($5,587/ha), respectively for Scenarios 1, 2 and 3. IRRs increased to 11.3%, 10.6% and 11.4%. Scenario 2 had the lowest returns, with extra carbon being insufficient to offset the benefit of grants received early in the investment cycle. Scenario 3 had the highest returns, slightly ahead of Scenario1. Revenue in Scenario 3 was lower, but costs were also lower. Planting costs for natives were assumed to be fully offset by historic One Billion Tree and Regional Council grants. If these grants were lower or unavailable, native planting costs would erode forestry returns. However, these small bush areas also provide un-costed aesthetic, environmental, and biodiversity benefits (shelter, food, protection, biodiversity corridors for native species). Farming outperforms forestry: forestry scenarios become more profitable than farming at a 10% higher log price and $50/NZU carbon price (discounted over the 55-year period at the 6% discount rate).

In the staggered planting scenario, *whole farm business returns* (integrated farming and forestry over the 1317.3 ha total area) without carbon were $9,141/ha for farming, $8,508/ha for Scenario 1 (1A), and $8,482/ha for Scenario 1B. With carbon, Scenario 1A was $8,925/ha and 1B was $8,993/ha. Aggregated IRRS were 35.7% for farming, and 31.8% and 32.2% for Scenarios 1A and 1B (31.1% and 31.8% without carbon). Farming outperformed forestry with differences between forestry scenarios small. Cashflow remains manageable even with planting over two years. The comparatively small forestry to farming area meant the impact of forestry on the whole farm business was small. The business remains viable with a smaller farming area. At year 58, equity was slightly higher with forestry.

CASE STUDY 7 - MANGAWEKA ASPARAGUS (RANGITIKEI)

FARM DESCRIPTION

Mangaweka Asparagus is a 164.9 ha property located in the Kawhatau Valley, 10 km east of Mangaweka. The farm is owned by the Turney family and managed by Sam Rainey. Two distinct enterprises operate on the property: asparagus growing on 101 ha of the flat cropping land, and carryover dairy cows grazed on 47 ha of steep slopes (36 ha) and river flats next to the Kawhatau river.

The business is interested in alternative (i.e. non-radiata) timber species to: protect the river by removing cattle to prevent stock occasionally breaching fences and gaining access, deliver environmental benefits through reduced contaminant loss and improved soil stability, provide biodiversity and aesthetics, diversify income streams (timber and carbon), and improve business enterprise integration by reducing workload at times of peak labour demand on the asparagus farm.

SCENARIO DESCRIPTION

The scenarios combined a lower-maintenance, structural timber system (e.g. Douglas fir, larch, fir) on 22.6 ha of the steeper slopes alongside the river, with 6.9 ha of pruned, speciality timbers on the flatter areas by the river for easy pruning and harvesting of small numbers of trees as required.

1. 22.6 ha of structural timber, with 6.9 ha low-productivity speciality timber (black walnut, Tasmanian blackwood, oak for furniture or flooring). Harvest period is 55 years for both.
2. Scenario 2 is the same as Scenario 1, except the 6.9 ha trees were replaced by *Eucalyptus fastigata* which is a higher-productivity speciality timber that can be harvested at 35 years.

RESULTS

Since scenarios did not affect the size or performance of the asparagus block, financial analyses compared tree planting returns with cattle grazing returns from the area replaced by trees. Neither scenario could compete with the cattle grazing operation, with or without carbon. High upfront establishment costs of the forest scenario's (S1 = $10,850/ha; S2 = $9,237/ha) combined with the long-term investment of the slower-rotation timber species (35 to 55 years) resulted in both scenarios generating negative NPVs (6% discount rate). In contrast, the current cattle enterprise is highly profitable (NPV $8,037/ha given the high revenue received and small cash investment. While forestry returns were less than the current system at the assumed log and carbon prices, trees integrated better with cropping and eliminated stock access to the river. They diversified income, contributed to biodiversity and aesthetics, and resulted in improvements in environmental performance. Nitrogen, phosphorus and biological greenhouse gas emissions reduced by 40%, 57% and 77%, respectively.

Generic cashflows for the forestry systems were used because data for alternative species is limited or unavailable. Prices received at harvest for alternative speciality timbers can be greater than for radiata given the superior timber properties, but time to harvest is much longer which impacts on investment returns. The development of specialty sawmilling and timber supply chains and future demand will have a significant bearing on future profitability. Sensitivity analyses should be used by landowners to investigate the implications for financial returns, particularly when considering investment in risky and uncertain markets. One of the key constraints to growing alternative species is that information for growers is limited. A good source of information is local farm foresters and the New Zealand Farm Forestry Association (https://www.nzffa.org.nz/).

CASE STUDY 8 - LAZY G RANCH (RANGITIKEI)

FARM DESCRIPTION

Lazy G Ranch is a 445 ha hill country farm (375 effective with 4 ha woodlot, 7 ha indigenous bush and the rest scrub), 2 km south-west of Taihape. The farm is 21% flat to rolling, 22% easy hill, and 58% steep or very steep. The property runs a breeding ewe flock of 2,250 mixed age and two-tooth ewes and 70 cows. The low input system and high performing sheep flock underpin farm business profitability. The owner's priorities are ensuring the happiness and welfare of family and livestock on the property, and farming sustainability to care for the environment, and he has developed his farm system accordingly.

The owner is interested in options for a steep, poorly accessible, block reverting to mānuka and scrub. Eligibility of this block for carbon credits is questionable. His tree planting objectives are to generate timber and carbon returns equivalent to or better than farming, identify carbon eligibility, and limit or reduce erosion impacts. He prefers non-radiata or native timber species, considering radiata pine to be not aesthetically pleasing, vulnerable to snow damage, and detrimental to the soils and environment.

SCENARIO DESCRIPTION

Scenarios for a 25.8 ha tree block (at 100%, and the more likely 50%, eligible carbon) were evaluated.

1. Radiata pine for carbon and timber (as a comparative benchmark since it is not a preferred species) with clearfell harvest every 28 years.
2. Redwoods for carbon and timber, continuous cover with harvest after 55 years.
3. Mānuka for carbon, interplanted with rimu for timber. Mānuka honey revenue is received before the mānuka matures and regenerates. Continous harvest after 80 to 100 years.

RESULTS

Farming returns in this area can be relatively high, so forestry returns need to be high to compete. Taking the tree block out reduced farmed area by 6.2%, farm operating profit by 10.3% and cash surplus after interest and tax by 13.6%. Most forestry NPVs were negative at the 6% discount rate.

Radiata returns were higher than redwood and rimu. Factors affecting species differences were: earlier, less discounted radiata returns (years 28 and 55); higher redwood and rimu costs in earlier, less discounted years, whereas their log income (year 55 harvest for valuation) was highly discounted; most redwood income was received late (year 55), whereas rimu received a higher subsidy and honey income in the less discounted earlier years. However, redwood had a higher IRR than rimu because redwood costs were lower and later than rimu, and redwood income was very high. Potential rimu and redwood log returns were uncertain since markets are currently undeveloped and sales in the distant future unpredictable. Some people may be willing to take the risk anticipating higher future returns.

Since only a small proportion of the farm was in trees, cashflow and farming returns, although reduced, could be sufficient for the farm to be viable and sustainable, should the forestry scenarios be preferred for other reasons. This could include aesthetics, environment, land retirement, biodiversity, benefit to family e.g. long-term species on intergenerational farms.

Comparative NPV and IRR performance varies with discount rate, and both should be considered. Enterprises, such as continuous cover rimu and redwood, which primarily benefit future generations economically, and benefit environment and biodiversity, could be compared at lower rates. Businesses with long-term perspectives may be willing to trade-off earlier returns for the next generation's benefit.

CASE STUDY 9 - PA-ITI (RANGITIKEI)

FARM DESCRIPTION

Pa-iti is a 361.7 ha hill country property located 11 km west of Taihape, in the Upper Turakina catchment. Pa-iti comprises 306 ha of effective pasture and 55.7 ha of existing retired farmland and commercial woodlots. The farm is considered winter wet and historically "summer safe", with annual rainfall of 1,020 mm per annum. Heavy soils and winter rainfall make the easier contoured parts of the farm prone to pugging risk, and the steeper parts of the property with good topsoil are prone to erosion when saturated. In total, 39.5% of the farm comprises land between 20°-35° slope which is highly erodible as a result of soil type, and a further 28% of steep land is >35° in slope. Some of the latter is already retired from grazing, but the easier country most at risk from shallow landslides (slips) forms the majority of the farming operation.

The owners of Pa-iti have a strong focus on intergenerational land management and are motivated to make decisions that will have longer benefits to the business and Pa-iti, beyond their tenure as owners and managers of the property. Generations of family have planted trees including various exotic timber species, landscape trees, riparian planting. One option the owner is interested in is space-planted poplars on some erodible areas of the property, with grazing underneath and carbon NZUs if possible.

SCENARIO DESCRIPTION

Space planting poplars on highly erodible land (slope 20°to 35°) to prevent slips was evaluated, as was the alternative of doing nothing and accepting continual productivity loss on erodible parts of the farm.

1. Planting poplar poles on 29.6 ha. 1A assumed currently available NZUs can be claimed through the ETS. 1B assumed only 25% of NZUs can be claimed due to a recalibration of CO_2 sequestered in space-planted poplar stands.
2. Scenario 2 is the same as Scenario 1 but with 38.5 ha of poplar plantings. It is also split into 2A and 2B, as for Scenario 1.
3. Scenario 3 replicates Scenario 1 except Scenario 3 uses fastigiate ("Lombardy"-type) poplars instead of narrow-crowned cultivars. In addition, it is assumed fastigiate form clones will take an additional 20 years to sequester the same amount of carbon as Scenario1.

RESULTS

In all the analysed space-planting scenarios for Pa-iti, the present value to the whole business of the space-planting was higher than not taking steps to protect the farm from slip damage. Hence, equity from operating cash flows after 28 years was estimated to be higher under all scenarios than the alternative of taking no action. Equity increased 8.2% with 29.7ha of space-planted poplars, and 9.4% with 38.6 ha planted. The lift in equity was only 3.5% and 3.3% if it was assumed carbon could only be included at 25% of the ETS tables.

Total N loss to water is expected to marginally decline over time under any of the scenarios as a result of the reducing carrying capacity. N loss reduction ranges from 12.9 kg N/ha to 12.5 kg N/ha for the current state if no planting occurs is the only substantive change. Modelled P loss at 0.4 kg P/ha remains unchanged across scenarios. However, as P loss is strongly correlated to soil loss, space planting poplars which protect soils from overland soil flow would also help reduce P loss. With bGHG emissions strongly linked to dry matter intake and livestock numbers, the reduced carrying capacity expected to occur over time at Pa-iti leads to a decline in bGHG emissions of 11% under the Status Quo Farming Scenario, while only a 2% to 4% decline occurs for the space-planting scenarios.

CASE STUDY 10 - MAKOKOMIKO (RANGITIKEI)

FARM DESCRIPTION

The Maata Kotahi Partnership Trust own and operate Makokomiko Station, a 2,283 ha hill country property near Pukeokahu, 20 km north east of Taihape, in the in the Middle Rangitikei and Lower Moawhango catchments. In 2019, Makokomiko Station comprised 1,998 effective ha and 285 ha of existing native bush, commercial woodlots and recently re-established mānuka plantings.

The Trust are focussed on ensuring their whenua is looked after, that the owners can be proud of how the business performs and that the legacy of their tūpuna is honoured and built upon. The trustees and management team have a strong belief in ongoing development of the business' core assets for long-term benefits for people, livestock, environment, financial and the community. The Trust has invested in planting steep, summer dry slopes in mānuka (local eco-sourced varieties where available) for native bush regeneration.

SCENARIO DESCRIPTION

The scenarios explore the potential for honey production as a transition enterprise in a 60 ha mānuka plantation for eventual regeneration to natives. A third scenario also includes totara for timber. It is assumed mānuka is eligible for NZUs through the ETS from years 5 to 50.

1. Scenario 1A assumes the mānuka block is sharefarmed with a beekeeper for honey production with the landowner receiving 25% of honey returns. Scenario 1B assumes the mānuka block only generates carbon revenue (current Status Quo Scenario).
2. Scenario 2A is the same as 1A, but instead of sharefarming, the hives are owned by Makokomiko for the 50-year lifespan of the mānuka. Scenario 2B is the same as scenario 2A, with hives owned by Makokomiko for 30 years after which honey quality drops and costs exceed income.
3. Scenario 3 is identical to Scenario1A, except that at year 5, totara trees are planted within the mānuka to accelerate the establishment of long-lived podocarps, to enable selective harvesting of these trees for high value timber after a minimum period of 100 years.

RESULTS

In all mānuka scenarios analysed, the present value to the whole business was lower than continuing to farm the entire property, despite the low productivity of the land retired. This is due to the several year lag in honey and carbon revenues following planting, and the gradual decline in both these revenue streams over time. This impact was exacerbated when totara was also co-established, with revenue increases being highly discounted and insufficient to compensate for increased costs. The base farming IRR was 12.2%. This decreased to 11.9% for all scenarios, except Scenario 3 which decreased to 11%.

However, the opportunities provided by mānuka honey and the monetisation of carbon sequestration provide a financially viable pathway for land use to transition from pastoral agriculture to indigenous forest. Having only one or the other income stream available would significantly impact business returns from land use change, but together they would be a potential game changer for hard hill country land use.

With the property's bGHG emissions strongly linked to dry matter intake and livestock numbers, the reduced carrying capacity from the 60 ha of mānuka planting suggests bGHG emissions will decline under the three forestry scenarios. In this example, a 3% reduction in pastoral area resulted in a 2% reduction in methane and nitrous oxide emissions

Summary and Discussion

The purpose of this case study research was to increase awareness and understanding of the diverse range of tree planting alternatives and management practices suited to various purposes and their comparability, and the factors that need to be considered when planning tree planting. This Discussion section summarises some of the key concepts explored by the case studies.

THE TREE PLANTING DECISION

GOALS AND ASPIRATIONS OF THE OWNERS.

Motives for tree planting are multiple, and can include income from timber and/or carbon, retirement of poor-quality farmland, environmental reasons (e.g. reduction of nutrients or greenhouse gases, erosion control, cleaner, healthier waterways), biodiversity, restoration of native or natural landscapes (Case Study 10), aesthetics, shade and shelter, fodder, integration with other enterprise (e.g. mānuka for honey or oil), easier management of hill slopes, and family reasons (succession, retirement, future generation benefits).

Financial (timber, carbon) and environmental reasons, which are often linked to retirement of marginal land and aesthetics, were cited as being reasons for planting trees in all, or most, of the case studies. Investment returns, primarily from timber or carbon, are obviously important for timber species. However, financial aspects such as capital requirements, establishment and maintenance costs, other income sources available (e.g. carbon, subsidies), and cashflow are relevant to all tree planting enterprises. Often, non-financial factors are more important drivers for change than financial benefits.

Planting trees on marginal farmland and riparian areas including for regeneration of natives (e.g. Case Study 10), planting trees on high productivity land (Case Study 2), and planting timber species trees with long harvest periods (with early costs far exceeding early returns) where the current generation is unlikely to benefit (Case studies 7 and 8), are all largely driven by non-financial aspirations such as improved environmental performance, biodiversity value, aesthetic appeal, easier land management, and future benefits to family or future generations.

While long-term net financial benefits may not be realised or may accrue to future generations, those planting trees will more immediately benefit from non-financial benefits such as more pleasing aesthetics, greater biodiversity, improved environmental performance, easier management, shade and shelter for stock, and a sense of stewardship and satisfaction having left the property in a better state for the next generation and for the environment.

DECISION-MAKING AND PLANNING

Tree planting is expensive and is often a once in a lifetime decision, particularly for non-timber plantings or timber species with long harvest periods, and an ill-informed decision can result in poor or unforeseen outcomes. As the case studies reviewed in this report demonstrate, like many farm system decisions, the 'right tree, right place' decision is complex. The process used in these case studies to identify possible tree planting alternatives followed that described in this section.

The first steps in the tree planting decision are to identify and understand the following.

- The multiple and diverse goals and objectives of the owner(s), both generally, and with respect to the specific tree planting objectives under consideration.
- The property's physical attributes (e.g. aspect, slope, soil type) especially for the areas of interest for tree planting, location affecting climate, and local access to labour, contractors and markets.
- Potential for tree enterprises to integrate with the current farm system and farming enterprises. Positive benefits from integration can include aesthetics, shade and shelter, fodder, retirement of areas difficult to manage from a farming or environmental perspective, easier stock management, and weed suppression. Similarly, negative impacts can result from planting 'wrong tree, wrong place'.

To identify the right tree for the right place to meet landowner objectives and optimise land use, suitable tree planting alternatives need to be identified and understood, and decisions need to be supported with robust analysis to help identify the most promising options.

The most appropriate afforestation plan will depend on whether the landowner is prioritising timber, carbon, biodiversity, aesthetics, shade, shelter, fodder, nutrient or carbon reduction and/or erosion control. Due to the complexity of the decision, landowners are advised to seek professional or informed (NZFFA, informed locals) advice and information when making planting decisions to support high quality tree planting outcomes and avoid potentially significant negative impacts.

Information and analyses on the following is required.

- Suitable tree species for the purpose in mind, and their selection and availability. The selection of a species not suited to planting site can severely diminish forestry returns. Site assessment requires experts visiting the areas under consideration to evaluate suitability. Slope evaluation, soil testing and structure (digging holes) may be required to help identify species suited to the area, particularly with alternative, high-value timbers.
- Management requirements and markets. Markets can determine tree management i.e. managing trees for higher value markets can be more costly, but can also be a risk management strategy where the future is uncertain, enabling trees to be sold for more than one land use. Different management regimes will affect performance on the attributes of interest e.g. pruning, thinning, scale, staggered planting, harvest regime.
- The likely performance of the various species and their management on attributes of interest, including production, financial, environmental and cultural or personal attributes, including identification of any potential negative impacts e.g. harvesting implications, risk and uncertainties.
- Farm system considerations e.g. avoiding key areas for stock movement in deciding planting sites. This can also include potential negative impacts on aspects other than the attributes of interest.
- Implications for future generations: decisions will influence what future generations can do with the trees and their potential income. Poor tree management can affect future opportunities and challenges e.g. suitability of trees for market, trees unsuited to an area that need to be managed or removed later. Future land use can be affected, especially if land is registered in the ETS.
- Sensitivity analyses should be used to investigate the implications for financial returns, particularly when considering investment in risky and uncertain markets e.g. alternative timber species.
- The opportunity cost of tree planting i.e. financial and environmental performance in the current system, or an alternative system to the tree planting option being evaluated.

The following sections will discuss some of the considerations identified in this section.

TREE SPECIES SELECTION AND MANAGEMENT

TIMBER SPECIES COMPARISONS

Investment return is a primary objective for timber species. In general, forestry returns from timber will depend on climate suitability and growth rates of the selected species, on-farm location and accessibility (tracks), access to labour and forestry contractors, distance to port, and the market for the type of timber all of which are location-specific. Forestry for timber (excluding carbon returns) can be profitable where it is planted on low productivity land and/or in locations where the species grows well and is located close to ports.

Radiata pine is the most recognised timber species, with species consistency (clones) and availability, established markets and expertise available, and considerable data to support decisions. Consequently, this can end up being a 'default' timber species, perhaps due to limited information on other species, or advisor preferences often with a financial bias. However, the case studies showed radiata pine may not necessarily better farming returns or perform well on other objectives.

Typically, in the Bay of Plenty/Waikato, with a climate suited to radiata pine and ready access to ports and markets radiata pine financially outperforms some hill country sheep and beef farm returns at the assumed $25/NZU carbon price). It was less likely to be as profitable on dairying land, except on low productivity areas within a farm where changing land use has little effect of dairy production levels (Case Studies 1, 2, 6). In contrast, in the Taihape area, radiata pine was unable to better sheep and beef farming returns under the base assumptions used (Case Study 8) although it performed better financially compared to other timber species particularly in the first cycle.

Location was a major factor contributing to this difference e.g. climate, market access, contractors. In the Taihape area, radiata pine was negatively affected by climate (slower growing, snow damage), was more than 100 km from ports and processors, and access to contractors was limited compared to Bay of Plenty/Waikato. Small stands and poor on-farm access in this area can also contribute to high harvesting costs. In this area, farmer interviews (Dooley et al. 2020) and case study data collection interviews with farmers found that there tends to be a dislike of radiata pine with aesthetics, snow damage impact and management, and negative impact on the environment all stated as reasons: the case studies in this area were not interested in planting radiata pine. In contrast, radiata pine is suited to the Bay of Plenty/Waikato region where this species is prevalent and grown at scale.

This suggests the view, sometimes expressed, that sheep and beef farms would be better in forestry than farming is incorrect. In fact, in the more remote sheep and beef farming area in this study, farming far outperformed forestry. In contrast, forestry, particularly on poorer areas on sheep and beef farms, in the more populated regions (Bay of Plenty, Waikato) was able to financially outperform farming. This demonstrates that forestry on marginal land on farms in locations suited to plantation forestry, can provide diversification opportunities and positive financial returns. However, flow on effects on communities and the broader economy can be impacted when land use is changed across whole farms and regions, which was a concern in the more isolated Taihape area. Pursuing this aspect further was beyond the scope of these case studies.

Alternative tree species are available, both exotic and native, suited to a range of purposes including timber. One of the big challenges made apparent in the case study analyses is the inability of non-radiata pine species to be able to provide comparable financial returns. However, there are more than just financial reasons considered when comparing species options. As a result, any investment analysis must also take into consideration other inherent benefits (including environmental, biodiversity, cultural, landscape enhancement, inter-generational) when comparing these species with radiata pine.

Alternative timber species to radiata pine have slower growth rates and longer harvest rotations (35 for eucalypts, 55 to over 100 years for other species, compared to 28 for radiata pine). Markets for many of these alternative species are poorly established or do not yet exist, although there are initiatives underway now to establish markets for non-radiata species, especially for high-value timbers. Income returns were based on projected estimates of future log prices which are uncertain, particularly for non-radiata pine species. This creates considerable uncertainty for alternative (non-radiata) species. Sensitivity analyses should be undertaken to understand the relative implications to financial returns if this a primary objective, particularly when considering investment in such risky and uncertain markets.

Given the prevalence of radiata pine in New Zealand forestry, there is also considerably more knowledge and expertise for radiata pine in relation to growing, harvesting and financial costs and benefits. However, there is limited information available on alternative species, how to access and grow these, and their relative performance and suitability for different purposes. This lack of information for growers is one of the key constraints to the consideration of alternative species. A useful source of information is the New Zealand Farm Forestry Association (https://www.nzffa.org.nz/). Local farmers with expertise in tree growing are also an excellent source of information and advice on forestry, especially with alternative species. They can advise on species suited to the area, and sourcing the best trees, which given the genetic diversity in non-radiata, may be by collecting seed from good trees and getting the trees grown so a two-year lead in time may be needed prior to planting.

Some case studies included timber species comparisons. Case studies 1, and 8 compared redwood with radiata pine. In both case studies, radiata returns exceeded those of redwood. Redwood production exceeded radiata pine, but the higher redwood costs, and long harvest period (2+ radiata harvests to 1 redwood) with highly discounted returns contributed to this. Case Study 8 also included rimu for timber under-planted into mānuka for carbon. This option had the highest costs with most costs occurring in early years, and lower timber growth and the longest harvest period so rimu returns were comparatively low, despite receiving a higher subsidy and some honey income in the earlier, less discounted years. Radiata pine received carbon income early but only up to year 17, whereas redwood and rimu, as permanent forests (continuous cover harvest regimes), continued to receive carbon income up to year 50, with the heavier, faster growing rimu receiving more income. Radiata pine returns drop after the first harvest cycle (28 years) with no further carbon or subsidy income.

Case Studies 8 and 10 investigated mānuka plantations for regeneration to full indigenous reversion, with under-planting for rimu and totara, respectively, to create a sustainable timber resource 100 years or more in the future. However, the cost of timber species establishment and post-establishment silviculture is high, and this combined with significantly slower timber growth compared to conventional exotics, and an illiquid and speculative market which was conventionally assessed (financial returns only), resulted in low investment returns. However, planting these species for timber may be justified where it is integrated into tree planting for other reasons (reversion to natives long-term) and it aligns with other long-term goals and aspirations of the owners. The current generation will not benefit, but for those with an inter-generational perspective these plantings could establish an ongoing, continuous cover harvest system to advantage future generations, particularly if high value markets for the timber can be established in future.

Case Study 7 also evaluated alternative, non-radiata species for high value timber (furniture, flooring) with structural timer species on the steep hills (less management required). Case Study 2 also included eucalypts with pine for aesthetic reasons. Future demand and development of specialty sawmilling and timber supply chains will have a significant bearing on future profitability. The current cattle grazing enterprise in this case study provided higher returns than the tree enterprises. However, trees had a better fit with current farm operations, the area of trees was relatively small compared to farm size, and environmental nutrient losses and biological greenhouse gas emissions were reduced with trees.

The importance of long-term thinking around land use decisions and stewardship is highlighted by Case Study 9, in the Taihape area, where two generations of the family have invested extensively in the integration of forestry in their pastoral landscape for timber, erosion control, aesthetics, and more recently riparian planting, despite a lack of overt short-term financial incentive to do so, so as to protect and preserve their asset for future generations. The majority of tree species planted are non-radiata species suited to the area, although he has a radiate pine stand (however would not plant this species again). A description of how they have incorporated mixed timber species stands 'right tree, right place' tree planting is included in this case study. Locals involved in farm forestry and NZFFA can provide informed advice on alternative species suited to a locality.

Space planting poplars has the potential to underpin the long-term viability of hill country land use for pasture on erosion-prone slopes and earn NZUs in the process. Planting poplars on erosion-prone land country is common on hill country farms and supported by regional councils. Case Study 9 demonstrated the integration of space planted poplars on erosion-prone hill country pasture to prevent pasture loss due to erosion, with trees planted at a density to allow carbon sequestration and NZU eligibility and income. Carbon eligibility was compared at two levels of eligibility because of uncertainties regarding poplar eligibility for carbon in future. Excluding carbon income, tree returns were just higher than the Status Quo Farming Scenario because of ongoing erosion and pasture loss in this scenario. With carbon returns, poplars outperformed the Status Quo Farming Scenario. Narrow crowned and fastigate poplar species were compared, with the latter assumed to take as much as an extra 20 years to sequester the same carbon amount.

MANAGEMENT PRACTICES

Having decided where to plant, selected a species suited to the location which fits well with the farm system and meets owners' objectives, further decisions may be required on management regimes which can impact on production performance. A number of the case studies, combined comparisons on tree types/uses, species, management practices and other attributes of interest, with non-timber comparisons fitting into this theme. These are identified in the Case Study Themes section.

Some of these themes were relevant to timber plantings, particularly regarding planting and harvest practices and management.

- Single year planting, and staggered planting to improve cashflow Case Studies 2 and 6).
- Planting at scale did not offer advantages in the example (Case Study 1) because this was achieved by some planting on better land suited to dairying, and forestry could not offset lost dairy returns.
- Managing forest edges, with management practices providing different advantages (Case Study 4).
- Continuous harvest for redwood and rimu (Case Study 8) in the long term will benefit the generations who harvest these higher value trees, and put in place a system with regular, ongoing net tree returns, and reduced environmental impacts from harvesting compared to clearfell radiata pine.
- Harvestability of hill slopes and managing the harvest process (Case Studies 4 and 6).

Themes with respect to carbon included measurement versus estimation of tree growth (measurement preferred) and assessing eligibility of NZUs. Environmental themes explored were wetland restoration, riparian planting, and considerations for planting steep hill slopes. Alternative returns from forestry investigated were subsidies, honey from mānuka, and mānuka oil.

FINANCIAL CONSIDERATIONS

Long-term, investment opportunities which are difficult or impossible to reverse, such as forestry, require careful planning and long-term intergenerational thinking. Landowners contemplating forestry investments need to consider the financial impacts including: cashflow, the upfront capital required to establish and manage the forests, the length of the investment period, changes to potential returns and equity over the investment lifecycle, anticipated market accessibility and returns, and impacts on the current farm system including farming returns, and future implications associated with the forestry enterprise such as obligations to continue to have to retain the land in trees and impacts on land values. Environmental implications, ease of business integration and non-financial and personal goals considerations are also key considerations.

All but one case study included a financial analysis comparing the differences in investment returns and/or costs, and equity, between different tree enterprises or management practices, with some case studies discussing cashflow and liquidity considerations. This section will summarise some of the financial aspects of forestry investment, and investment analysis approaches e.g. use of discount rates.

INCOME SOURCES

Receiving multiple revenue streams from a forest enterprise not only increases enterprise investment returns but can also help with cashflow early on in a timber enterprise. Most case studies compared timber enterprises, so included timber returns. These have already been discussed in the Timber Species Comparisons section.

All case studies were interested in the potential for carbon sequestration, and eligibility for NZUs which can be sold for carbon returns. Most case studies also included grants in the early years and three cases studies included other income. The carbon returns for the various species depends on how they are included in the ETS, and the level of carbon able to be claimed for that tree type in the MPI carbon look-up tables (MPI 2017). Case Studies 3 and 5 looking at carbon using measured rather than estimated tree growth which allows for greater accuracy (useful with greater than average growth rates) and is necessary for large tree stands. The price of carbon was, unsurprisingly, a significant factor in forestry returns from eligible planting. We also note that the current price of NZUs at the time of writing this report is now almost 50% higher than the base $25/NZU assumption in the case studies.

Timing and rate of carbon income varied considerably between species. Radiata pine (clearfell), which is fast growing, can accrue a reasonable amount of net carbon up to about year 17, and this income source does make a difference in income in the first harvest cycle, compared to subsequent cycles where it cannot be claimed. In contrast, species planted for permanent forest cover or continuous cover harvesting accrue carbon up to 50 years receiving NZUs on a considerably greater level of production, although most of this is discounted more heavily than radiata pine carbon income. The carbon income assumed in the cashflow analyses also implies NZUs are sold as they are earned: NZUs earned will still add to equity and investment returns whether they are not sold or not.

Case Study 5 explored a decision to replant radiata pine forest with alternative species (natives and exotics), identifying implications around carbon liability and future carbon earning potential depending on how the pine forest is defined within the ETS, the subsequent forest species rotation and the methodology used to measure carbon stock.

Case Study 9 (poplar space planting) was interested in the likelihood and level of carbon income returns possible. Poplars are planted for erosion control, which is largely a cost to the business with no anticipated income other than regional council subsidies to help with costs sometimes. To be eligible for carbon NZUs, the space planting was at a higher density than usual to ensure sufficient canopy cover for NZU eligibility, and even then, there are still questions about eligibility for poplars because of their growth form, although it is argued they accumulate similar carbon above ground with greater leaf cover up the trunk compared to other species across the canopy. A lower carbon eligibility rate was also evaluated because of the likelihood that the assumed rate of carbon sequestration in poplars for NZU calculations might be reduced. Any carbon units earned are added income, since tree returns without carbon are similar to the Status Quo Farming scenario with loss of pasture from erosion. Allowing space planted poplars for erosion control on hills to be carbon eligible, could provide an incentive for farmers to consider this option to generate income, as well as providing ongoing, long-term benefits for both the farm enterprise and the environment.

Funding grants can provide a mechanism to help offset the initial capital cost of afforestation and, as in Case Studies 6 and 10, potentially be a significant factor in the overall investment return. However, it is important to understand the funding criteria to ensure these expectations fit with a landowner's objectives and long-term intentions. Grant funding can impose long-term requirements on a forest, which may create liabilities for landowners in the future. In addition, some funding sources might 'lock-in' land uses and limit a landowner's future options e.g. ETS funding from sale of carbon credits.

Incorporating a mānuka honey venture (Case Studies 8 and 10) in a mānuka stand planted for regeneration can be a win-win situation for a landowner and a beekeeper, with about 11 years of high-quality honey possible before the mānuka becomes too mature. Honey operations require specialised skills and equipment, and the most profitable option was to sharefarm with a beekeeper rather than the landowner managing the operation (Case Study 10).

Mānuka oil from specialised mānuka plantings or mānuka stands was described in Case Study 5, as another potential source of income from mānuka. There is increasing interest in income opportunities like this, with three companies offering to purchase mānuka from landowners. A drawback of mānuka harvested for oil is the stand is unable to reach canopy cover height to be eligible for carbon.

PROFITABILITY AND INVESTMENT RETURNS

As discussed previously, timber returns are affected by tree species and growth rates, establishment and maintenance costs and their timing, timber prices and markets, time to harvest, and risk. The Timber Species Comparisons section discussed some of these factors and comparative returns.

Investment returns from timber in the Taihape area, even with carbon income (at $25/NZU), were in most cases lower than the discount rate (6%) used, and well below sheep and beef farming returns. The preference in this area was for alternative (non-radiata) species which had lower returns than radiata pine, but growers were optimistic about the potential for the growth of value-added timber markets and preferred non-radiata species for other reasons e.g. aesthetics, environmental, biodiversity, suitability for the environment. Hence, the difference between timber returns for radiata pine and alternative species was unlikely to be the deciding factor in the decision.

However, radiata pine plantations, particularly on poorer areas on sheep and beef farms, in the Bay of Plenty and Waikato regions were able to financially outperform farming, demonstrating that forestry on marginal pastures or steep slopes and gullies on farms in locations suited to plantation forestry can provide diversification opportunities and positive financial returns. The comparative results in this research highlight the importance of investment analysis on a case-by-case basis to inform decisions.

Discounting advantaged radiata pine over longer harvest period species, with the first radiata pine cycle including carbon and subsidies contributing to this advantage: in the first 28 years other species tended to have very high costs and comparatively lower carbon income, with no timber income for 55 years or longer (35 for eucalypts) or longer. Early subsidy and honey income were comparatively low.

OPPORTUNITY COSTS

The opportunity cost of pasture production on farmland prior to afforestation will impact the likelihood of an increase in potential returns. Areas of lower pasture production (marginal land) are more likely to result in an increase in financial returns when planted in trees (making trees the preferred alternative), than areas with better pasture production and thus higher returns from farming, as was demonstrated in Case Study 1. Any decision to plant trees on high productivity land is likely to be driven, or influenced by, non-financial aspirations such as improved environmental performance, biodiversity value, aesthetic appeal and ongoing ease of management of hill slopes.

Two case studies demonstrate the need to consider opportunity costs and potential changes over time in making comparisons. The majority of the case studies assumed a status quo farming situation that did not include changes in farm production over time, although given the time frame, some small incremental increase in production due to technology might be expected which would need to be included the farm scenarios with and without trees and would likely have had only small impact on the results. However, in the poplar space planting scenario, the expectation was there would be a change over time due to erosion and pasture loss without tree planting, and this was reflected in the Status Quo Farming Scenario in the modelling. Had it been assumed that there was no change over time (all years were the same as the base year), then it is unlikely that the forestry scenarios, without carbon, would have been better than, or similar to, the Status Quo Farming Scenario. This demonstrates the importance of considering whether what is being compared fairly reflects what is likely.

Case Study 8 considered the establishment of a tree enterprise on a poorly accessible block on the farm which is not well integrated into the farming enterprise. As in other case studies, a status quo farming situation that did not include changes in farm production over time was assumed: this Status Quo Farming Scenario far outperformed all the forestry scenarios. In reality, the alternative was to invest in fencing, fertiliser and improved pasture and better integrate parts of this block into the farming enterprise, leaving the rest to revert. Long-term, this Status Quo Farming Scenario may well have had higher returns and probably poorer environmental performance (higher stock numbers) than the current status quo situation. However, this analysis was not within the brief for this project and is unlikely to have changed the general finding given the high farming returns in this farm business.

Nevertheless, as identified in Case Study 6, while high farming returns can present a high opportunity cost for afforestation, they can also provide farmers with the financial capacity to make decisions about afforestation to reduce their environmental footprint, improve biodiversity, offset biological greenhouse gas emissions or to meet other longer-term non-financial goals.

Planting trees is an intergenerational decision and decisions being made now will influence what future generations can do with the land, particularly where land is registered in ETS. In the short-term, any NZUs for tree planting, which can be retained or sold, will accrue to the current generation in the first harvest cycle. This effectively restricts the opportunities available to the next generation, and potentially reduces land values due to loss of optionality on that land after harvest (costly to repay any NZUs, with replanting trees the only other option). Even if NZUs are surrendered, the cost to revert forestry land back to pasture or other alternative enterprises can be expensive.

CAPITAL REQUIREMENTS

Investment in forestry has high capital requirements for tree establishment and maintenance, with decades to wait before any timber income is realised. The more leveraged a farm business is the more it may struggle to implement investments such as forestry which require significant upfront capital investment and foregone short-term farming income traded off for a future lump sum return. While funding grants help to alleviate cash flow constraints, a strong balance sheet is still required to enable farms to meet debt requirements and provide sufficient reserves for the owners to draw from. However, a strong balance sheet is often a result of a long-term profitable business, such as those in Case Studies 6 and 8, which can present a high financial threshold to any decision around the integration of forestry in those farming systems.

Limited capital to invest in the establishment of tree planting can restrict New Zealand farmers from planting trees to the extent they would like. Any financial support, or advice on species and management practices, that can assist with helping select the best option to meet farmer objectives while keeping costs down or helping manage establishment costs or cashflow implications will help facilitate or incentivise tree planting on farms.

LIQUIDITY AND CASHFLOW MANAGEMENT

A key challenge when integrating forestry into farming enterprises can be the impact on the cashflow. If the area being planted in trees reduces the area in pasture, cashflow from farming will be reduced, and consequently the amount available for debt repayment and capital expenses. At the same time, the forestry enterprise will require high establishment and maintenance costs (lumpy costs), mostly over the first ten years or so. These will need to be funded by capital, cashflow or debt. Anyone considering on-farm tree enterprises should ensure the size of the area planted does not result in the business becoming unviable long-term from a profit or cashflow perspective because of early, high tree planting, pruning and thinning costs, or a farming to forestry balance which does not sustain regular returns.

Carbon sales (selling NZUs under the ETS) could help offset losses from removing pasture from the system or provide cashflow to help with pruning or thinning costs in the short term, aiding in the transition from pasture to forestry. However, carbon NZUs are only received from timber woodlots in the first rotation under the averaging accounting scheme. Hence, forestry investments that rely on carbon sales for cashflow and profitability may struggle to have sufficient cashflow and profitability in future rotations unless timber returns improve substantially. There is also the risk that selling carbon could generate a carbon liability if the forest is removed and not replanted e.g. through fire or future land use change. If the NZUs have been sold, the option to surrender these is lost.

Revenue options such as honey could help provide a financially viable pathway for transitioning land use from pastoral agriculture to indigenous forest i.e. help with costs. However, the whole farm business needs to be sustainable long term without carbon or honey income.

Staggered planting (Case Studies 2 and 6) can be a way to stagger the upfront capital investment required to meet cashflow requirements, as well as staggering future lump sum returns. However, this system can be complex to manage in terms of both planting and harvest.

RISK AND DISCOUNTING

For this analysis, a uniform discount rate of 6% was used for both the forestry and farming aspects of farm business model, and incorporated returns from timber, subsidies, carbon (ETS), nitrogen where this could be traded, and honey. A consistent discount rate was a necessary practical assumption when presenting the NPV between scenarios but may not truly reflect preferences where landowners favour one revenue source over another.

While 6% is a common agricultural discount rate, 8% is a more common forestry discount rate. Other conventions can differ between standard practices for agricultural and forestry economic evaluation, such as the treatment of land opportunity costs and the length of time considered which interact with the choice of discount rate. Land value was also excluded in the analysis on the basis that land was a sunk investment for all of the scenarios considered in the case studies. A consistent discount rate was a necessary practical assumption when presenting the NPVs between scenarios.

There is considerable debate over appropriate discount rates for the different outcomes wanted, and the appropriate rate can depend on what is being analysed. The higher the discount rate, the lower the value that is placed on future costs and benefits. Conversely, the lower the discount rate, the more value that is placed upon future costs and benefits. Generally, higher discount rates are used for risky investments where there is considerable uncertainty. Lower discount rates are used where there are long-term benefits and benefits to future generations. For example, low discount rates are used for social discount analysis reflecting the long-term, inter-generational benefits that can accrue widely e.g. public benefits, environmental benefits. While differing discount rates for different benefits and their costs can be useful to account for differences in risk profiles and other aspects of the revenue streams included, that additional level of analysis was considered out of scope for the case studies.

The long-time frame over which some plantings are expected to accrue benefits to the farming enterprise can be undervalued by conventional economic analysis, particularly when higher rates of investment return (i.e. high discount rate) are required. For example, while it is useful to treat uncertain revenue streams such as the sale of carbon credits with a higher discount rate, emerging schools of thought would argue that planting permanent forests for carbon should use a lower discount rate to reflect the value of the long-term climate change implications.

Often, reasons for selecting an alternative are more than financial, and these are not captured in the discounted investment analysis. Hence, an analysis of the options also needs to take into consideration these inherent benefits e.g. cultural, biodiversity and landscape enhancement benefits. Externalities (e.g. erosion reduction, phosphorus or sediment loss, N loss in some case studies) were not monetised in the analysis. In personal situations, such as landowners considering options for their own property, these trade-offs can be made intuitively. However, these trade-offs on a national or regional basis, for policy planning, do need to employ approaches to which include these trade-offs in a transparent manner. These were not required for this case study.

Space planting (Case Study 9) provided a positive financial return on investment compared to the alternative of no investment in poplar planting with continued erosion. However, in this analysis, retained pasture from the reduction in erosion were accrued over a long-time frame, with the greater benefits in the more distant future where they were more heavily discounted. Hence these benefits to the farming enterprise from poplar planting can be undervalued by conventional economic analysis, particularly when higher rates of return (expressed by the choice of discount rate) are used. Furthermore, reductions in externalities such as phosphorus or sediment loss were not included in the discounted investment analysis. A more holistic approach could be used in policy consideration of potentially valuable land use decisions. For example, although carbon sequestration of poplars may be less than other species below ground, the long-term advantages of poplar planting in reducing erosion, sediment and phosphorous loss from farmland could be recognised by accepting the standard assumptions on canopy closure and sequestration rates poplars in the ETS to support poplar planting.

There is considerable uncertainty around forestry investments where fundamental shifts in pricing, can occur, for both input costs such as harvesting and for product prices, by the time the investment is realised. This uncertainty is higher in products where there is a long-term investment (such as hardwoods) and in products that are more uncertain or volatile already e.g. those with smaller niche markets. Non-radiata timber species are a case in point. These species, particularly those planted for potentially high-value timber markets, have a long harvest period and markets for these timbers are not yet well developed. This situation may change in the future with work underway to develop markets for these products. Certainly, there is no question the world will be a different place in 100 years-time when timber from some of these planting becomes available, both in market demand, potential timber use, and harvest and processing technologies.

Many of those planting these alternative timber trees now, will be doing so without the expectation of harvesting. Some of these people have positive expectations for the future of these timbers, so analyses using current costs and returns will differ from what they anticipate. Sensitivity analysis with discount rates that reflect their views and preferences should be used in analyses targeted to them. Others will have an inter-generational perspective, with a view to putting an enterprise in place that in the long-term will result in a forestry enterprise that will benefit future generations. For example, an analysis of an *established* continuous cover forest of high-value timber would probably be preferred over a clearfell radiata harvest, and over time the value of the continuous harvest forest planted now is likely to increase in a non-linear manner as this gets closer to harvest. Yet at this planting stage, clearfell radiata returns exceed that of continuous harvest forest e.g. redwood or rimu in Case Study 8. However, at low discount rates (under 6%), the redwood and rimu options exceed the radiata pine. Hence, it can be argued that for some people or some circumstances, a lower discount rate will be acceptable for evaluating some enterprises.

In comparing options, it is important to consider both NPV and IRR values. Alternatives have a single, break-even IRR value, but NPV rankings change with discount rate, often considerably e.g. redwood in Case Study 8. These comparative differences in NPVs could influence a decision, particularly where a slightly lower discount rate could be an acceptable trade-off with alternative criterion i.e. trees with long-term environmental benefits or intergenerational benefits could be acceptable even if they do well at a slightly lower discount rate. For example, in Case Study 8, tree and farm enterprise NPV rankings reversed between a 0% and 10% discount rate, from redwood, rimu, radiata and farming (best to worst NPV order) to farming, radiata, rimu and redwood. For the whole farm analysis, this was redwood, farming, rimu and radiata, to farming, radiata, rimu and redwood.

The scenarios that were preferable at the lower discount rates were permanent (continuous cover harvest regime), had environmental advantages (less erosion and P loss, no clearfell harvest impacts, greater carbon capture ultimately), and intergenerational benefits with the establishment of a continuous harvest forest which would be sustainable and result in more even cashflow from the forest operation once harvest starts. This suggests that for alternatives such as these, lower discount rates may be acceptable, and in some circumstances, preferred to shorter term investments with a higher rate of return.

Long-term cashflows are sometimes considered using an annuity (an annual cashflow value that would deliver the same NPV over the lifetime of the investment at the assumed discount rate as the investment itself) to compare forestry investments with alternative land uses i.e. farming with its regular cashflows. However, this this approach does not consider how the actual cashflows would be phased for the farm business, and as such, can mask financial distribution impacts for a business. NPV values for the enterprises expressed on a per hectare basis provide better comparability when comparing different sized enterprises, with these per hectare forestry NPVs reflecting the impact of revenue and cost distribution on the investment return. However, it should be noted that if these relative enterprises sizes change, fixed costs would be redistributed or would change, altering the investment returns and the NPV/ha values.

The case studies provided examples of forestry enterprises integrated into farm businesses, with all analyses specific to the context for that farm. This resulted in varied case study outcomes e.g. sometimes the farming enterprise returns exceeded trees enterprise returns, and in other cases studies the reverse occurred. Forestry scenario returns that are low in some areas in New Zealand, may be more comparable with farming returns in other areas. Every case differs. Hence, anyone considering tree enterprises should have an investment analysis done which is specific to their property.

ENVIRONMENTAL CONSIDERATIONS

Forestry enterprises can provide a range of benefits as described in Goals and Aspirations section, and it is important to be clear on the objectives for tree planting when determining the tree enterprise to select. Afforesting some areas can provide opportunities for farms to meet environmental regulations while maintaining greater flexibility on the remaining pastoral land and/or at a lower cost than alternative mitigation measures.

Areas targeted for tree planting are primarily the poorer quality, often steep, low producing areas of the farm where tree planting can be a better land use option than farming from an environmental, and often financial, perspective. Tree planting on these areas can reduce nitrogen, phosphorous and erosion, replacing high nutrient loss land use with low nutrient loss land use. This is becoming increasingly important with water quality concerns and the increasing regulation and 'licence to operate' restrictions associated with nutrient loss, including nutrient trading in some particularly sensitive areas. Tree planting can also provide benefits for wetlands and waterways (water quality) when used for riparian management (Case Study 1), which stock increasingly need to be excluded from.

Forestry can reduce nutrient loss and provide erosion control; however, harvesting can impact the potential sediment and phosphorus benefits, particularly if managed poorly. With trees grown for timber, tree harvesting, particularly under clearfell harvest regimes, can result in sediment and phosphorous loss with associated impacts on waterways. An alternative to clearfell harvest is selective tree harvesting under continuous cover harvest regimes, or phasing planting to ensure staggered harvest windows in sensitive landscapes. The former is more likely to be used with non-radiata timber species for high value timbers.

Some tree planting alternatives integrate well with the farm enterprise with benefits from both the business aspects and environmental benefits. The poplar space-planting case study (Case Study 9) which has been previously discussed is a case in point, providing harder to quantify environmental benefits through soil stabilisation, and minimising phosphorous and sediment losses, with the resulting pasture stabilisation providing financial benefits. Trees planted for shade and shelter also integrate well with the farming enterprise.

Biodiversity came through as being intrinsically important for the case study farmers: this also came through as being important in the survey (Dooley et al. 2020). The case study farms had all preserved native bush and/or planted areas in natives or riparian plants for land retirement and/or regeneration, with one of the objectives in doing so being to encourage biodiversity. Tree planting alternatives which would contribute to biodiversity were explicitly included most case studies, in at least one of their scenarios. In particular, biodiversity was an important objective in Case Study 10, where steep slopes were being planted in mānuka to establish planting to initiate regeneration of native plants indigenous to the area. About a third of the mānuka plants had been sourced from local varieties and grown out for planting, and it was hoped birds would disperse seed from one of the last remnants of original native bush nearby into the mānuka area. Already, small native plants were starting to grow in the mānuka already planted.

Planting forestry is a farm level option which is being widely promoted to help meet national GHG reduction targets. Planting trees provides GHG benefits though carbon sequestration, particularly if the forest is permanent afforestation and meets the ETS requirements. There is also a reduction in biological GHG emissions if animals are removed from the farm following land retirement to forestry. These on-farm GHG reduction tools become more important if pastoral agriculture is required to account for, and pay for, biological GHG emissions. However, using plantation forestry as an offset for GHG is a short-term solution only.

Landowners need to be aware of the long-term implications of their planting decisions when using plantation forestry for GHG mitigation. Carbon from forestry to assist with GHG reductions is only a short-term solution. Under the Averaging Accounting scheme, carbon can only be sold from the first rotation and only up to the average age of the rotation for trees that will be clearfell harvested (approx. year 17 for radiata pine grown for timber). Furthermore, from a farm perspective, on-farm forestry will reduce optionality for future generations because the land will need to be replanted in forestry, which is likely to result in a negative impact on land value. Furthermore, landowners will need to plant a new area (not necessarily on the same land area or even farm) of approximately the same size every 16-18 years (assuming radiata pine as the plantation species) to continue to offset annual GHG emissions from pastoral farming and then replant each block at the end of each rotation to lock in the average amount of carbon sequestered in that woodlot, unless other on-farm mitigations are made.

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Case Study Report References

Reports are listed in case study order.

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Appendix: Method Assumptions

Each case study report described the specific farm modelling assumptions relevant to that case study, and these can be found in the relevant case study reports. However, there were some common assumptions across all case studies which are detailed below.

The relative financial performance of the both the individual forestry, and aggregate land use, enterprises in each scenario is measured by both net present value (NPV) and internal rate of return (IRR). This approach is useful in helping quantify the relative annual average profitability of forestry with land uses that generate revenue every year. However, the timing of cash flows is not directly apparent from this measure so this needs to be considered in conjunction with time series cash flow analysis.

A uniform discount rate of 6% has been used in analysing across both the forestry and farming aspects of the business model, including returns from ecosystems services such as nitrogen and carbon. A consistent discount rate is necessary when presenting NPVs to compare between scenarios but may not be appropriate where landowners prefer one revenue source over another. The use of a consistent discount rate here was a necessary practical assumption.

In this analysis, investment in the land is deliberately excluded, and case study results only reflect the investment in livestock, plant and machinery and any additional rights to discharge nutrients to water for farming scenarios, and tree stock in the forestry scenarios. This assumption is made on the basis that the investment in the land is not discretionary between scenarios, but the choice of land use is.

Medium term product prices have been used for meat, wool and milk. Input expense data and product pricing were based on each case study farm's annual accounts adjusted to reflect normalised (non-capital) expenditure each year or sourced from the FARMAX farm expense schedule. Where necessary, an adjustment for wages of management was included to account for the owner's time contributions, negating the requirement to include drawings, thus providing comparative data with similar farm businesses.

Annual cash operating surplus (before tax, interest, capital costs) was used to calculate NPV and IRR. Discounted annuity values for forestry scenarios were calculated for some case studies.

To ensure confidentiality and make the analysis comparable with industry averages, debt and debt servicing levels were assumed based on industry averages for the relevant farm types. These values were used in the calculation of annual cash surpluses or deficits, and accrued cash.

To provide a "like with like" analysis, the farming assets (excluding land) were purchased and sold at the start and end, with full conversion costs for forestry replanting included at the end of the second rotation (year 56) in the cash flow analysis. Where applicable, changes in the value of livestock on hand flowed through to the equity calculation at the end of the 56 years (effectively offsetting the cash flow implication of these transactions) e.g. Pa-iti Case Study.

Rates of carbon sequestration from ETS eligible forests are referenced against the MPI lookup tables (MPI 2017). A carbon price of $25 per New Zealand Unit (NZU) was assumed for the timber and native stands, unless stated otherwise.

Only ‘safe’ carbon was considered tradeable. Under changes to the ETS, forestry planted from 2019 is able to earn NZUs up to the forest’s “average age”. The “average age” for a forest is the age at which it reaches the average level of carbon it is expected to store over the long-term (several rotations). The “average age” is based on the typical age at which the forest is commercially harvested (MPI 2020). Where native plantings were considered permanent in the case studies, all carbon sequestered up to 50 years (the extent of the lookup tables) was considered ‘safe’.

Investment periods were based on two plantation forestry rotations, generally this was 56 years, unless specified otherwise in the specific case studies due to longer rotation species.

The sources for growth rates of tree species in each case study are detailed in the case study assumptions, as are the log prices. Forest industry representative values were used for seedlings and associated royalties, fencing, track upgrades and maintenance, and annual costs such as operations management, property maintenance and public liability insurance. The method for calibrating average forest productivity for the site is described in Palmer et al. (2010).

To evaluate the impact of slope and aspect on pasture production and feed quality for the farm analyses, assumptions were formed using principles drawn from journal articles, discussions with the case study farmers, and observations made by Perrin Ag Consultants during farm visits. The assumptions were subjective but provide an approximation for the analysis. The relative pasture production was then able to be estimated based on validation from whole farm Farmax modelling and the empirical relationships known to exist between aspect, slope and fertility and inherent pasture production potential based on Radcliffe (1982), Gillingham (1973) and Morton and Roberts (2016).