Te Kuiti l Verry Farming Ltd (#6)

Integrating Forestry for Profitable and Sustainable Land Use

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NEW ZEALAND AGRI-BUSINESS ADVISORS

With funding support from
Te Uru Rākau
Forestry New Zealand

Executive Summary

- Wendy and Reon Verry farm four individual hill country land blocks of 1,397 ha located south east of Te Kuiti.

- Integration of 186.6 ha of forestry on steep areas explored opportunities to improve environmental resilience, diversify income and enhance the farm's biodiversity and aesthetics.

- It is important to understand current performance to plan how the business best positions itself to meet present and future environmental challenges and whether current profitability and economies of scale will allow further forestry establishment.

- There is a clear environmental benefit to retiring poor quality land and planting trees. The overall reduction in N and P loss and 11.8% reduction in biological GHG emissions from the forestry scenarios provide significant long term reductions and put the business in a strong position to meet future requirements to manage environmental externalities. The expected trends in carbon prices, currently c. 50% higher than the $25/NZU assumed here, will help prevent any significant erosion in business profit from land use change.

- The importance of long-term thinking around land use decisions and stewardship are highlighted by this case study. Capital costs including on farm infrastructure required and changes to cash flow need to be considered along with personal and environmental factors.

- Planning for right tree, right place and right purpose is fundamental in achieving landowner objectives to support the performance of the existing business, enhance the properties aesthetics and biodiversity, and build environment resilience.

Table 1. Summary of key metrics for the status quo farm system.

	Base system	Scenario 1a / 1b
Effective area (ha)	1256.9	▼ 15%
Drystock production (kg meat & wool/ha)	336	▲ 6%
IRR%	35.7%	▼ 4% / ▼ 3%
Equity at Year 56 (incl. sale of carbon)	54812348	▲ 4% / ▲ 5%
Total N leaching loss (kg N/yr)	27,831	▼ 9%
Biological GHG (t CO2 eq./ha/yr)	4.96	0%

Case Study Overview

This case study illustrates the impact of integrating radiata pine and natives into a pastoral sheep and beef farm business. Options were analysed specific to the Verry's farm and farming aspirations. Financial and environmental analysis demonstrate potential returns, impact on improving the farm's environmental resilience, and total farm business performance. The full case study report with detailed analysis can be found at www.mpi.govt.nz/forestry/ and www.perrinag.net.nz/planting-trees/.

Sections covered in this case study include:

CURRENT FARM BUSINESS

This section presents a snap shot of the businesses background, goals, and current performance. The data from the 2019/20 season is utilised to form the 'status quo system' to provide a base comparison to the planting options analysed.

Read more on page 4-5

RIGHT TREE RIGHT PLACE RIGHT PURPOSE

Understanding a planting site and its effect on tree performance and future harvesting operations/growth potential is essential for selecting the right tree to achieve the desired outcomes. In this section the property is described and the tree options for the different land classes on the Verry's farm are explained.

Read more on page 6-8

WHOLE BUSINESS ANALYSIS – BEST FUTURE LAND USE & FARM SYSTEM

The forestry options at an enterprise (sheep and beef and forestry) and a whole farm business level are analysed to show the performance of each integrated forestry option compared to the status quo and identify which option best supports the attainment of the owners' objectives.

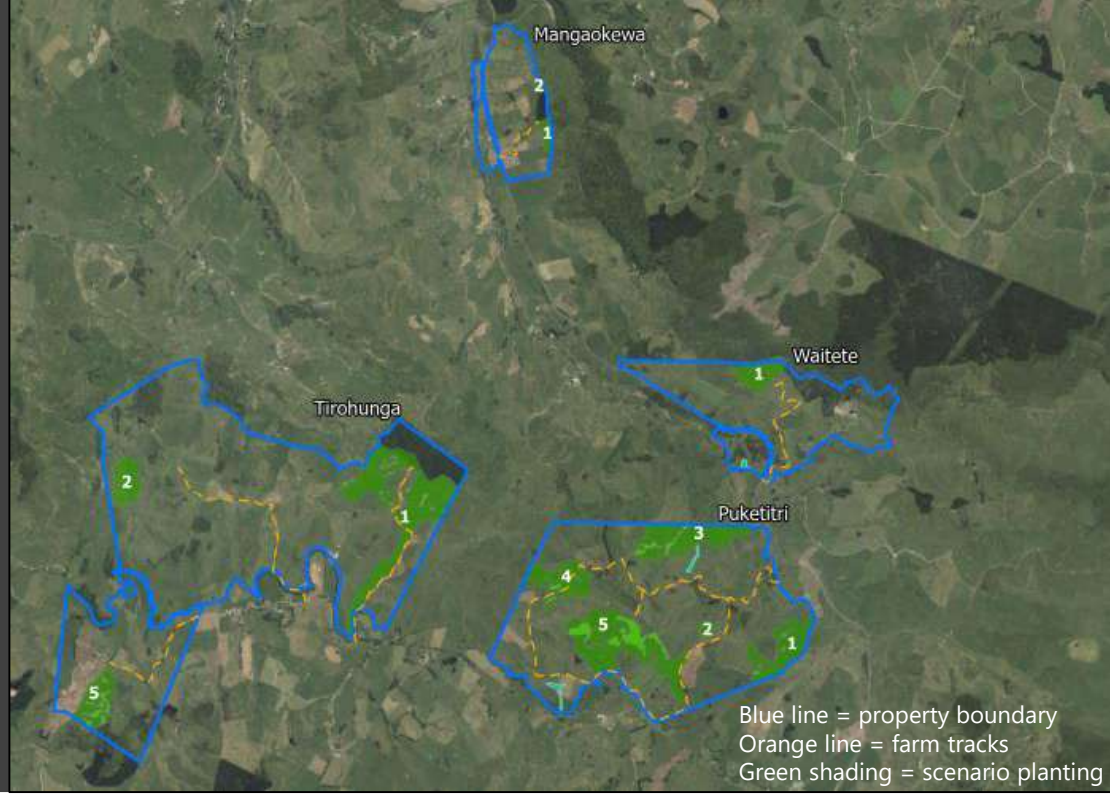
Read more on page 9-13

Farm Overview (Status Quo Farm System)

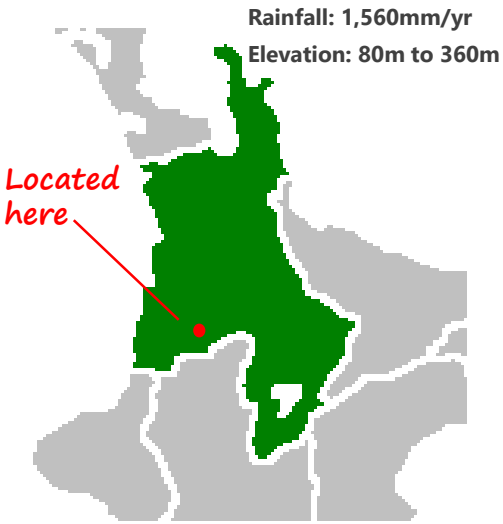
Wendy and Reon Verry farm four individual hill country land blocks with a total area of 1,397 ha located between 3 km and 25 km south east of Te Kuiti. The properties include around 1,257 ha of pastoral area, 60.4 ha of *pinus radiata* and 51.3 ha of existing native and 25.8 ha of non-productive area.

The extensive sheep and cattle breeding enterprise operates on parts of the farm that include areas containing steeper contoured land (26-35°) and browntop dominant pastures. The finishing enterprise is run on the flat to easy hill slopes with improved pasture and soil fertility.

The Verrys are interested in how targeted integration of forestry compares with their livestock enterprises and how it can be used on at risk areas to support their goals including increasing the sustainability of their farm system.



Location



Farm Details

Total farm area (ha)	**1,397**
Effective pasture (ha)	**1,257**
Soil type	**Mairoa ash**
Water course	**Mokau River Mangaokewa stream**
Est. pasture grown (per effective ha/yr)	**7.8 to 11.7 tDM**
Sheep : cattle ratio	**49%:51%**

Livestock Details

Flock size (ewes)	**4,539**
Lambing %	**140%**
Ave lamb ccwt (kg)	**16.7**
Herd size (cows)	**171**
R1 Bulls/R2 bulls	**486/149**
R2 Hfr grazers	**330**

Performance Indicators

Stocking rate (su/ha)	**12.6**
Operating profit ($/ha)	**603**
Return on asset (ROA%)	**2.8%**
N leaching (kg N/ha/yr)	**19**
P loss (kg P/ha/yr)	**1.2**
Biological GHG emissions (t CO_2 eq./ha)	**3.5**

Factors Motivating Tree Planting and Land Use Change

Physical Constraints

- The areas identified for forestry planting comprise 186.6 ha of the 489.5 ha of steep land and gullies across the four properties. Slope varies but is generally steep at 26-35 degrees and for some blocks, particularly Puketitri and TIrohunga, includes areas of very steep land above 35 degrees. Controlling pasture growth on these steep blocks is a challenge and erosion and soil loss can be an issue if heavy stock are grazed.
- Gullies are present throughout the forestry compartments and in some locations, particularly Tirohunga and Puketitri, need to be carefully managed to avoid nutrient and sediment loss where flowpaths are present. These steep slopes and gully areas are less productive than the residual farming area due to lower soil fertility, less topsoil and reduced soil moisture holding capacity. They provide an opportunity to diversify low-producing hill country to alternative land uses that can provide timber and/or carbon returns, biodiversity benefits and environmental protection.

Environmental Constraints

- The Erosion Susceptibility Classification (ESC) database (accessed from the MPI webpage) is a key tool used to identify land susceptible to erosion and set regulatory thresholds under the NES-PF for eight forestry activities. Table 3 classifies each of the compartments proposed for planting. Site visits and mapping at no less than 1:10,000 is required to confirm the ESC and identify additional site information that may impact on the risk rating. This assessment will support operational decisions to achieve acceptable environmental outcomes.

Table 2. Site description of forestry compartments

		1	2	3	4	5
Mangaokewa	Area (ha)	3.0	1.0	n/a		
	Slope (degrees)	26-35	26-35			
	Aspect	North	South			
	Flowpath present	N	N			
Waitete	Area (ha)	10.2	n/a			
	Slope (degrees)	26-35				
	Aspect	North				
	Flowpath present	N				
Puketitri	Area (ha)	18.4	2.1	23.9	16.1	35.3
	Slope (degrees)	>35 / 8-15	26-35 / 4-7	>35 / 26-35	26-35	>35 / 26-35
	Aspect	South	South	South / North	South	South
	Flowpath present	N	N	Y	Y	Y
Tirohunga	Area (ha)	54.8	11.4	n/a		11.4
	Slope (degrees)	26-35 / >35	>35 / 26-35 / 16-20			26-35
	Aspect	South	South / North			North
	Flowpath present	Y	Y			N

Table 3: NES-PF ESC for forestry compartments (1-5).

	1	2	3	4	5
Mangaokewa	Low	Low	n/a		
Waitete	High	n/a			
Puketitiri	Mod.	Low	Low	Mod.	Mod.
Tirohunga	Mod.	Mod.	n/a		Low

Right Tree Right Place Right Purpose

Understanding a planting site and its effect on tree performance and any future harvesting operations is essential for selecting the right tree to achieve the desired outcomes. In this section the tree options for the different land classes on the Verry farms are explained. The Verrys have already undertaken significant plantings across their property and have developed good knowledge of what works and what does not in their environment.

Steep hill slopes

- All of the forestry compartments identified comprise areas of steep land. While log yield on hill slopes is typically less than that grown on flat to rolling country due to poorer soil fertility and moisture holding capacity, log quality can be greater as a result of the slower growth rates (NZFFA, 2005). Where slope is especially steep (e.g. >35°), consideration around erosion control may be required.
- The Verrys also favour planting smaller woodlots into native bush where the economics don't stack up. Planting natives aligns with improving the aesthetics, value of the farm, and being good stewards of the land.

Gullies

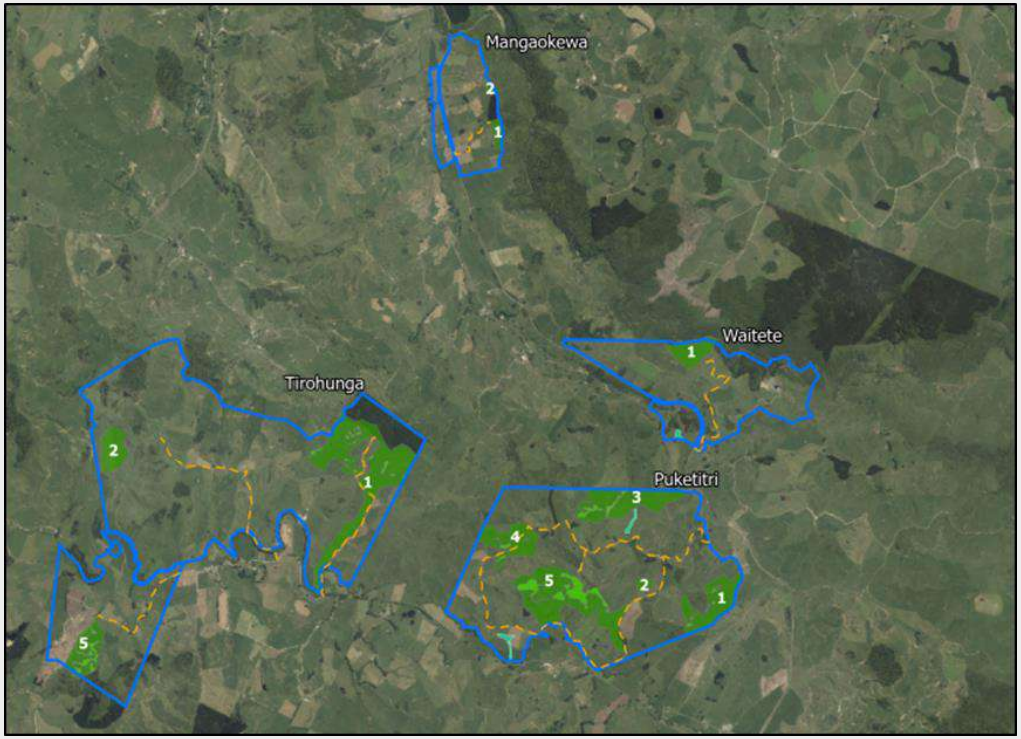
- Gullies are prevalent on Verry Farming and have several zones that should be considered when thinking about species selection. These may include the steep slopes, lower slopes and flat, bottom gully. Where steep slopes require protection from erosion, landowners should consider various tree growth attributes when selecting a species. These include growth rate, permanent canopy, root decay, timber value, carbon value and coppicing.
- Fertility and drainage tend to be unimpeded on lower slopes providing suitable growing conditions for a range of species. In contrast, the falt zones at the bottom of gullies tend to be wet, prone to frost and can be exposed to periodic flooding and wind gusts.

Integrated Forestry Analysis

The Verrys are interested in comparing the profitability of forestry against their existing sheep and beef operation. *Pinus radiata* is the species of choice due to its strong financial returns from timber and carbon relative to other species. Radiata pine provides a resilient species capable of good growth across a wide range of sites. It has well established log markets and supply chains in place to support planting, silviculture, harvesting and sale.

The scenarios modelled evaluate the impact of afforesting 186.6 ha of land in radiata across the four land parcels (Figure 2). Afforestation was classified as either timber woodlot or native. Woodlots were assessed for their economic potential (including carbon), while native plantings were included as costs for establishment plus any carbon revenue that would accrue over time if eligible.

Figure 2: Planting sites on Verry Farming Limited.



Planning Considerations

Planting of steep slopes for timber will require consideration around access and harvesting, particularly if stems need to be extracted uphill. Transporting logs from the harvest site to public roads requires good roading infrastructure and can be a costly exercise if tracks are not up to standard. If large upgrades are required, then landowners should consider increasing the scale of planned woodlots to dilute fixed roading costs (NZFFA, 2005). Similarly, if slope and slope length of hill areas requires tracking for ground harvest or if haulers are required, then harvesting costs will be greater.

Waterways in and around planting sites can also impact on forestry activities. For forestry compartment #1 on Tirohunga, the presence of a stream at the base of the hill slope will either require extraction of stems uphill to a skid site, or construction of a stream crossing in compliance with the NES-PF. In addition, the long narrow arm of the woodlot may require a hauler to be set in several locations to access the entire woodlot and, if required, allow the stems to be pulled to the top of the hill. This will add to the cost of harvesting and should be considered when planning the scale of a woodlot. In challenging situations where slope, access and/or nearby waterways are likely to increase harvesting costs land owners should consider whether the proposed woodlot has the scale and potential timber value necessary to justify extraction.

Where waterways are near a planting site, and have a bankfull channel width of less than three metres, then a five metre setback of forestry planting must be included as part of the NES-PF to mitigate adverse environmental impacts.

The distance to port or processor typically has the largest impact on the profitability of small woodlots due to high associated transport costs. The farm has several processors of radiata within 100 km.

Scenario Design

A total of eleven compartments spread over the four land parcels were considered. Ten of these were selected for evaluation as woodlots planted in either *Pinus radiata or* natives. From this, three scenarios with the same planting areas were tested. Matching planting areas (186.6 ha) meant the net impact on the livestock business was the same. Afforestation was classified as either woodlot or native.

Scenario 1 - Planting 186.6 ha in *Pinus radiata* assuming grants such as those from One Billion Trees or similar are available to assist with upfront costs of planting and establishment.

Scenario 2 – Tests the position if no grants or funding is available to plant the 186.6 ha in *Pinus radiata* and assumes an additional six years of safe carbon to provide additional carbon revenue.

Scenario 3 – Planting 181.6 ha in *Pinus radiata* and 5 ha in native plantings assuming grants available to assist with funding planting and establishment.

Following initial analysis a further option of Scenario 1 was investigated to assess the financial impact of staggered planting over a six year period. The original Scenario 1 was referred to as **Scenario 1a** and the staggered planting option as **Scenario 1b.**

Table 4 indicates the land parcels each woodlot is on and the total NPV and annual annuity. The analysis shows the larger woodlots such as Tirohunga #1 provide the highest NPV and annuities at $5,601/ha and $335/ha/yr, respectively, while the smaller woodlots such as Puketitri #2 provide the lowest at $2,317/ha and $151/ha/yr, respectively. This relates to economies of scale as larger areas can dilute fixed costs and make greater use of investments such as roading and skid sites.

Table 4: Summary of individual woodlot investment performance including sale of logs and carbon.

	Area	Total NPV	NPV/ha	Annual Annuity
Puketitri #1	18.4	98,446	5,350	335
Puketitri #2	2.1	5,077	2,417	151
Puketitri #3	23.9	129,922	5,436	340
Puketitri #4	16.1	85,270	5,296	318
Puketitri #5	35.3	195,233	5,531	346
Waitete #1	10.2	51,462	5,045	316
Mangeokewa #1	3	10,252	3,417	214
Tirohunga #1	54.8	306,909	5,601	350
Tirohunga #2	11.4	58,336	5,117	320
Tirohunga #5	11.4	58,336	5,117	320
Full Area	**186.6**	**1,036,705**	**5,556**	**347**

The Mangaokewa #1 woodlot also has a low NPV and annuity but there is an option that this could be joined to an existing contiguous woodlot that is nearing harvest to provide economies of scale for both areas.

Consideration of natives in the planting regime revolves around factors such as the aesthetic, environmental and biodiversity benefits as these areas are not harvested. Small areas of native bush provide biodiversity corridors allowing fauna to travel from one patch of native bush to another. The areas provide shelter, food and protection from predators by imitating the structure and diversity of larger native bush areas. These benefits align well with the Verrys' value of being good custodians of the land.

Results of Forestry Scenario Analysis

Table 5 summarises the investment outcomes from two full forest rotations (plant, grow, harvest, replant, grow, harvest) excluding and including carbon revenues.

Scenario 1: With the aid of assumed grant funding, the net undiscounted proceeds for S1 for timber only was $47,278/woodlot ha. This includes revenue of $64,722/ha less expenses of $17,345/ha and is equivalent to an annuity of $163/ha in present value. Applying a 6% discount rate provided a positive present value of $2,605/woodlot ha. The IRR was a modest 8% over the 56yr investment period. If the 'safe tradeable carbon' is sold between Year 8 and Year 17, the present value of free cash flow over the whole term increases to $5,556/total planted ha. This provides a healthier IRR of 11.3% and an annuity of $347/ha/yr.

Table 5: Summary of individual investment performance of the forestry investments under each scenario.

Planted Area	Scenario 1 186.6		Scenario 2 186.6		Scenario 3 186.6	
Area in P. radiata	186.6	ha	186.6	ha	181.5	ha
Area in native	-	ha	-	ha	5.1	ha
Area qualitfying for ETS	186.6	ha	186.6	ha	186.6	ha
Returns over two rotations (56 years)	**Total**	**/ woodlot ha**	**Total**	**/ woodlot ha**	**Total**	**/ woodlot ha**
NET PRE-TAX LOGS (undiscounted)	8,822,113	47,278	8,560,512	45,876	8,740,922	46,843
Present Value for whole term (WACC = 6%)	486,145	2,605	230,152	1,233	483,002	2,588
Internal Rate of Return (IRR)	8.0%		6.8%		8.0%	
	Total	**/ planted ha**	**Total**	**/ planted ha**	**Total**	**/ planted ha**
NET PRE-TAX LOGS & CARBON (undiscounted	9,902,687	53,069	9,943,169	53,286	9,839,815	52,732
Present Value of free cashflow (WACC = 6%)	1,036,705	5,230	1,008,902	5,407	1,042,535	5,587
Internal Rate of Return (IRR)	11.3%		10.6%		11.4%	

Scenario 2: If no grant funding is available the net undiscounted proceeds for timber only is **$**45,876/ha. This is equivalent to an annuity of $14,393 or $77/ha/yr. If the safe tradeable carbon is sold at $25/NZU, the net return increases to $71,858/ha. The present value of free cash flow over the whole term increases to $5,407/planted ha and provides a healthier IRR of 10.6% and an equivalent annuity of $338/ha. The lowest returns post sale of carbon (at $25/NZU) were generated in S2 and were insufficient to offset the benefit of receiving the assumed grants early in the investment cycle to pay for the cost of establishment.

Scenario 3: The net undiscounted proceeds for timber only was $46,843/ha. This is equivalent to an annuity of $164/ha at a 6% discount rate. Net proceeds were less than S1 which related to 2.1 and 3.0 ha being planted in native rather than *Pinus radiata*. If planted in radiata, these smaller blocks would return less ($26,659/ha vs $46,843 for the remaining larger woodlots) due to economies of scale and dilution of costs. If the safe tradeable carbon is sold, the net return from S2 increases to $52,732/ha. The present value of free cash flow also increases to $5,651/planted ha and provides the highest IRR of the three scenarios at 11.4% with an equivalent annuity of $353/ha. While the total net return is the lowest of the three scenarios due to the reduced forest area (-5.1 ha), the NPV and IRR were the highest. Planting of the natives was assumed to be cost neutral as assumed grants were sufficient to fully offset them. If these grants were not taken or available at a lesser extent, costs would increase and erode returns. This could result in S3 providing the lowest return of the three scenarios.

Base System: The equivalent annual annuity for the status quo farming operation is $599/ha/yr. The sensitivity analysis indicates that at a $50/NZU carbon price and a 10% higher log price, the forestry scenarios become more profitable than the existing farming operation. Current trends in carbon prices and government policy (already now at $37/NZU) suggest $50/NZU may be achieved in the near term.

Impact on the Farm Enterprise

DRYSTOCK PRODUCTION

The total area retired is 186.6 ha including 183.5 ha from the extensive sheep and cattle zone and 3.1 ha from the intensive cattle zone. This is 14.8% of the operations total pastoral area and represents a high proportion of the steep harder hill country.

Puketitri has the largest area planted in trees with 95.8 ha, followed by Puketitri with 77.6 ha, Waitete with 10.2 ha and Mangaokewa with 3.0 ha.

Retiring a high proportion of steep hill country resulted in the extensive sheep and cattle zone reducing from 63% of the total pastoral area to 57%.

Total stock units reduced by 13.1% to 10,580 SU. Sheep numbers reduced the most (-1,334 SU) while only modest changes occurred to cattle numbers (-262 SU) and is largely a result of reducing the breeding cows. Bull beef numbers were maintained as they were the most profitable livestock enterprise followed by the dairy heifer grazing. With sheep numbers reducing the sheep to cattle ratio changes from 49:51 to 44:56. In practice the owners may prefer to reduce bull numbers as these have higher labour requirements.

Retiring 186.6 ha of largely very steep country resulted in average pasture production increasing by 158 kg DM/ha on the remaining farmed land (1,070 ha). This flowed through into pasture eaten which increased by 126 kg DM/ha. As a result, meat and wool produced increased by 5.7% on a per ha basis (19 kg/ha). A larger portion of the increase in pasture growth is spread over the autumn, winter and early spring periods as the easier contoured land has a less 'peaky' growth distribution through the season.

PROFITABILITY

On a whole farm basis (Table 6), gross farm income reduced by 12% with the reduction in stock numbers. Expenses reduced by 13% for the farming enterprise once the steepest areas were converted into forestry. Gross farm income per kg of meat and wool produced reduced as the ratio of sheep to cattle decreased as sheep provided higher returns per kg of product than cattle. Overall, planting 186.6 ha in forestry reduced gross operating profit by 10.6%.

However, on a per ha basis the income increased by 4% while expenses lifted by 2.6% with overall profit lifting by 4.8% to $632/ha. This was due to farming better quality land allowing a slightly higher overall stocking rate and lifting meat and wool production by 19 kg/ha.

Table 6: Summary of financial performance indicators for the status quo and forestry scenarios

Financial KPIs	Status quo	Forestry Scenarios	Difference
Gross farm income ($)	1,824,089	1,613,229	-210,860
Gross farm income ($/farmed ha)	1,451	1,507	56
Gross farm income ($/kg meat & wool produced)	4.32	4.25	-0.08
Total operating expenses ($)	1,033,071	903,124	-129,947
Operating expenses ($/farmed ha)	822	844	22
Operating expenses ($/kg meat & wool produced)	2.53	2.38	-0.15
Operating expenses (% of GFI)	57%	56%	-0.01
Total operating profit ($)	757,793	676,881	-80,912
Operating profit ($/farmed ha)	603	632	29
Operating profit margin ($/kg meat & wool produced)	1.79	1.87	0
Cash operating surplus ($/farmed ha)	720	757	37
Discrestionary cash ($/farmed ha - after interest and tax)	422	442	20

Environmental Performance

Water Contaminant Losses (Nitrogen and Phosphorus)

On an overall farm basis, N loss to water reduces by 8.8% to 18 kg N/ha as a result of reduced total livestock numbers in each of the forestry scenarios (Table 7). The breeding cows provide a proportionally higher reduction of N loss as cattle, particularly female, have higher N losses relative to sheep. On a per ha basis the N surplus and N leaching increase due to the higher stocking rates.

P loss decreases by 0.1 kg/ha, primarily from reduced P fertiliser use (from the reduction in pastoral area). This OverseerFM calculation excludes any reductions associated with improving land stability and providing contaminant buffers.

Biological Greenhouse Gas (bGHG) Emissions

Total biological greenhouse gas emissions (bGHG) at a whole property level reduced by 734 t CO_2 eq. (-11.8%) and are mainly a result of lower methane emissions (less feed intake), but also less nitrous oxide emissions (Figure 3). This reduces the farms exposure to a potential future liability on biological emissions. Assuming these emissions were similarly priced to carbon NZUs ($25/t CO_2 eq.), this would save the business $18,375 per annum.

The safe carbon claims provide a short-term offset and have a considerable impact on total emissions for the period analysed. The safe carbon claim represents approximately eight years of total farm emissions. Further reductions are achieved by lowering livestock numbers which provides a modest permanent reduction (-734 t CO_2e/yr). For the first rotation this equates to 20,552 t CO_2 eq (28 years x 734 t CO_2e/yr) - approximately 42% of the safe carbon claim of the forestry scenario, and represents a permanent reduction.

The overall reductions presented by the forestry scenarios provide meaningful long-term reductions and would put the business in a strong position to meet potential requirements to manage its GHG emissions and reduce any potential liability that may occur.

Table 7: Summary of environmental indicators compared to the status quo.

Environmental Indicators	Status Quo	Forestry Scenarios
Total N leached (kg N/yr)	27,831	25,374
N leached per hectare (kg N/ha)	19	18
N surplus (kg N/ha/yr)	79	71
N conversion efficiency	12%	12%
Operating Profit/kg N leached	$27.23	$26.68
Meat & wool produced per kg N leached (kg meat & wool/kg N leached)	17.3	20.2
P Loss (kg P/ha/yr)	1.2	1.0
Total farm bGHG emissions (t CO_2 eq.)	6,231	5,497
GHG/eff. ha (t CO_2 eq./farmed ha)	4,957	5,136
GHG/eff. meat & wool (kg CO_2 eq./kg meat & wool)	15	14

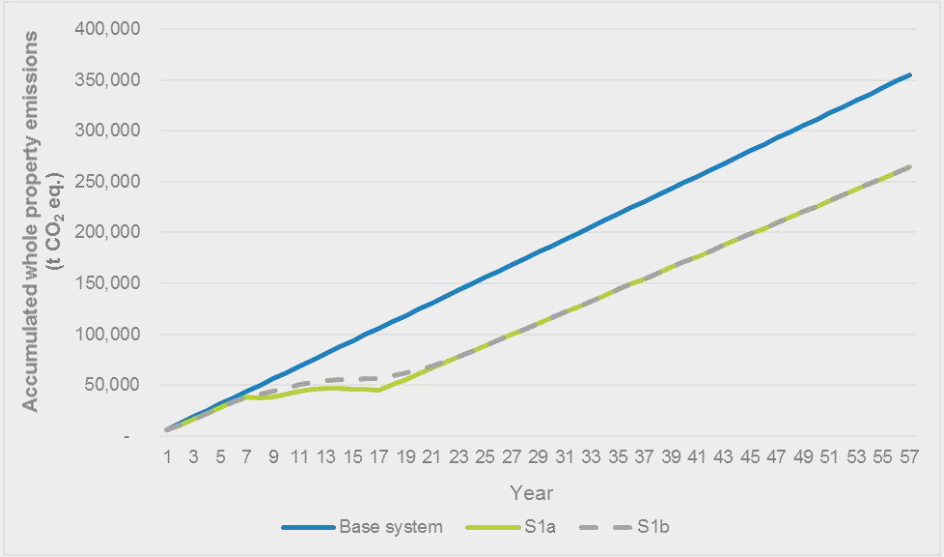


Figure 3: Comparison of accumulated bGHG emissions over time.

Whole Farm Business Analysis

This section evaluates the integrated livestock and forestry scenarios against the status quo system. Instead of comparing the three previous scenarios, the first forestry option (S1) which included planting 186.6 ha of *Pinus radiata* only with the use of assumed landowner grants was selected. Two sub scenarios were established which investigated staggering establishment to lower the initial large capital requirements and reduce disruption to the overall livestock operation. Scenario 1a (S1a) utilises the existing 2-year planting program and single harvest date at Year 27 and again at Year 54 while Scenario 1b (S1b) utilises a longer 6-year establishment period. This scenario is shaped by feedback from the Verrys indicating they would be interested in establishing around 90 ha in year one and 30 ha every two years following. This provided a 6-year planting program (90.0 ha at Year 0, 34.1 ha at Year 2, 34.5 ha at Year 4, and the remaining 27.9 ha in Year 6).

For this case study, the existing farming operation is more profitable than any of the integrated farm and forestry scenarios considered. Total wealth created is higher for the two forestry scenarios (S1a & S1b) having 2.7-3.0% greater projected equity by year 56 without carbon and 4.0-4.4% greater equity with carbon income included (Figure 4). The meat schedule has the largest bearing on IRR varying by 5.8% for each 10% price change from the status quo. Retaining the more productive land in stock production is therefore fundamental to the business. Of note, staggering forestry establishment improved short-term cash flow without compromising long-term returns.

However, the timing of revenue combined with the 6% discount rate results in the existing farming enterprise returning an NPV in the order of 7% higher than the forestry scenarios. Lowering the discount rate would reduce this difference and present the forestry scenarios more favourably. Altering the discount rate is a decision that would need to be evaluated by the Verrys and considered against the business' financial and non-financial goals. The timing of returns also plays a significant role with the farming business providing consistent annual returns and the forestry providing large lump sums.

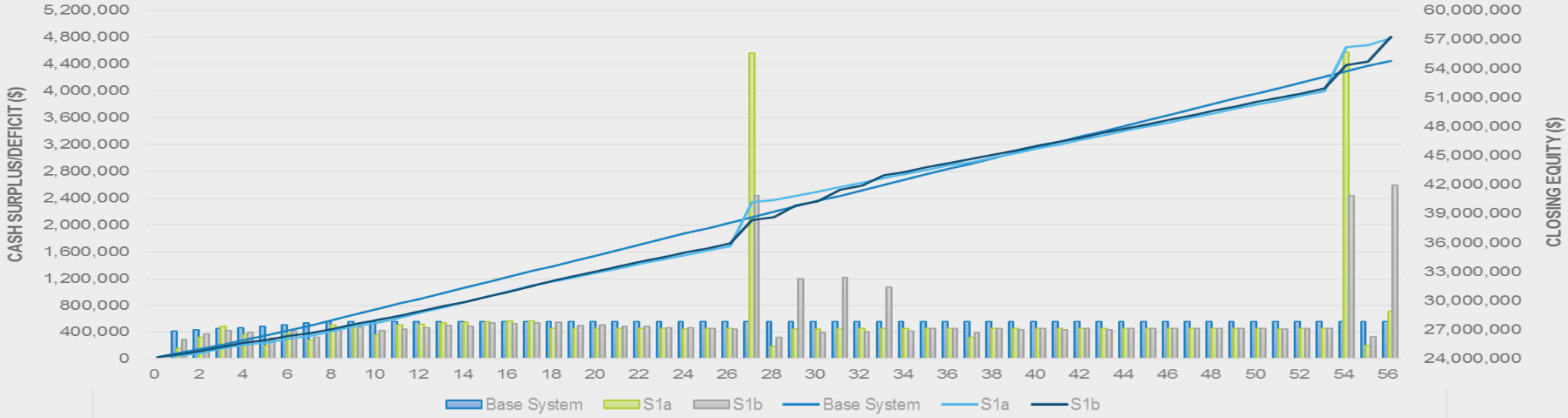


Figure 4: Comparison of total business cash surplus/deficits before principal repayment (LH axis, bars) and closing equity positions (RH axis, line) for S1a and S1b compared to the base system including the sale of carbon.

Summary

- Retiring a high proportion of steep hill country resulted in the extensive sheep and cattle zone reducing from 63% of the pastoral area to 57%. Total stock units for the forestry scenarios decreased by 13.1% which is slightly lower than the 14.8% reduction in farmed area. This was achieved by increasing the stocking rate per hectare (+0.2 SU/ha) due to increased per hectare pasture growth from retiring the most marginal land. Sheep stock units reduced by 22% whereas cattle reduced by only 4% and is reflective of the stock type carried on the steeper contoured land.

- The overall farming operation saw an increase of 19 kg/ha in meat and wool produced on a per ha basis from an additional 158 kg DM/ha grown. Total production however reduced due to the large reduction in stock numbers. This in turn resulted in a 5% lift in profitability per hectare but reduced total profit by 10.6%. The scale and profitability of the overall business is such that even with a reduction in total profit of this magnitude the business is not capital or cash flow constrained regarding decisions to convert land to forestry. However, that not all farmers are likely to be in this situation.

- The overall reductions in N and P loss and 11.8% reduction in biological greenhouse gas emissions presented by the forestry scenarios provide meaningful long-term reductions and would put the business in a strong position to meet potential requirements to manage its GHG emissions and reduce any potential liability that may occur.

- The high initial cash investment of establishment and silviculture and long period before harvest revenue is received has a large impact on the profitability of forestry in present value terms, particularly at a 6% discount rate. Dropping the discount rate to 5% results in the NPV of the forestry scenarios and the status quo farm operation becoming equal and below 5% provides a higher NPV for the forestry scenarios. Considering the existing business has limited debt, the landowners could consider evaluating forest investments using a lower discount rate, particularly if tree planting provides closer alignment with other important values such as reducing environmental impact, supporting ease of management, further diversifying revenue streams, and supporting future succession.

- The importance of long-term thinking around land use decisions and stewardship are highlighted by this case study. This was shown in the analysis of integrating forestry within a pastoral farm business in such a way that may underpin the long-term viability of pastoral land use, but also to protect and grow the asset for future generations.

Definitions

SU/ha	Stock units per ha based on 550 kg DM eaten per year
Pasture eaten (t DM/ha)	Measures how much pasture grown that is being eaten and is measured in kilograms or tonnes of dry matter per hectare, standardised at 11 MJ ME/kg DM
kg DM	Kilograms of dry matter
Kg product sold	Net increase in kilograms of meat (eg beef/lamb/mutton) and wool grown on farm
Nitrogen loss	An estimate of the N that enters the soil beneath the root zone (>60 cm) , expressed as kg N/ha/year
N surplus	The quantity of N supplied that exceed plant requirements
Greenhouse Gas Emissions (GHG)	Green house gases on a whole farm basis expressed as CO_2 equivalents
Biological Greenhouse Gas Emissions (bGHG)	A measure of methane (CH4) and nitrous oxide (N2O)emitted from a farm as CO_2 equivalents. CO_2 from electricity, fuel, and fertilizer manufacturing is excluded because a levy is applied by the supplier and included in the cost of goods
FWE (farm working expenses)	Direct farm working costs including owner operator remuneration before depreciation and financial costs
Operating profit	A measure of farm profitability use for benchmarking comparison between farms. Dairy operating profit is dairy gross farm revenue less dairy operating expenses
Capital expenditure (CapEx)	Funds used by a business to acquire, upgrade, and maintain physical assets such as property, building, plant and equipment
Present value (PV)	Is the current value of a future sum of money or stream of cash flows given a specified rate of return. Future values are discounted at the discount rate, and the higher the discount rate, the lower the present value of the future cash flows
Net present value (NPV)	The different between the present value of cash inflows and the present value of cash outflows over a period of time. NPV is used in capital budgeting and investment planning to analyze the profitability of a projected investment or project
Discount rate	Interest rate used to determine the present value of future cash flows in a discounted cash flow analysis. The weighted average cost of capital (WACC) is commonly used for a businesses discount rate when completing an investment analysis
Weighted average cost of capital (WACC)	Is a calculation of a businesses cost of capital in which each category of capital is proportionately weighted. All sources of capital are included
Internal rate of return (IRR)	Used in capital budgeting to estimate the profitability of potential investments. The IRR is a discount rate that makes the net present value (NPV) of all cash flows from a investment equal to zero

Project Details

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