Impact of possible environmental policy interventions on case study farms

VOLUME 1 OF 2: MAIN REPORT

MRB final report to the Ministry for the Environment

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About Macfarlane Rural Business Ltd

Origin

Macfarlane Rural Business Ltd (MRB) is a farm management consultancy based in Ashburton, servicing clients throughout New Zealand, with a primary focus in the South Island. Established in 1997 by Andy and Tricia Macfarlane, the team now includes seven consultants plus administration staff.

Philosophy

We are strong believers in the management skill of integrating many disciplines into a farming system. Rural businesses of tomorrow cannot be solely focused on food and energy production. They must also be focused on environmental issues, resource use, social issues including public relations, risk management, marketing and business development.

Objective

To assist our clients manage their business growth by utilising our experience, knowledge, vision and networks to package advice to match personal objectives. Our challenge is to become the most credible group of farm management consultants in New Zealand. We believe agriculture faces its most exciting period in several generations. Our excitement is tempered with the need for good risk management in a volatile global environment. We enjoy working with the farming families and businesses who will take agriculture forward as the powerhouse of the New Zealand economy.

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1. Executive summary

1.1. The Government's Essential Freshwater programme contains proposed measures for reducing contaminant discharges to water from farming activities and managing intensification of rural land use. The *potential* policy response to achieve this includes a proposal for a new National Environmental Standards (NES) for Freshwater Management.

1.2. The purpose of this report is to examine how potential policies in an NES will impact the agricultural sector regarding farm economics, and nitrogen and phosphorus discharges to water. Rule changes require analysis to assess the impact of the proposed policies.

1.3. A team of Farm Management Consultants from Macfarlane Rural Business Ltd (MRB) used their areas of specialist expertise to model case study farms and independently analyse a range of Ministry for the Environment (MfE) supplied 'Scenarios'. These Scenarios should not be construed as the preferred policy proposals. Metric impacts of the possible MfE policy interventions were examined regarding farm management, environmental and farm financials.

1.4. Four anonymous case study farms were the basis for impact testing of the scenarios. Four types of farm included: a red meat hill country farm; a dairy farm; a dairy support farm; and an arable mixed cropping farm. All farms are Canterbury situated, chosen due to them being fairly representative of each farm system, and having watercourses on the property.

1.5. The farms were co-modelled using: the Farmax biophysical model, Overseer nutrient budget model, and an MRB farm financial budget spreadsheet model. Information to establish the Status Quo models was derived from physical farm data and historical financial records of the properties.

1.6. The farms were modelled as a Status Quo baseline. Models were then rerun to analyse the MfE supplied Scenarios; Nitrogen Loss Cap, Livestock Exclusion, and Land Intensification.

Nitrogen Loss Cap involved restricting the nitrate discharge to water to 60 kilograms of nitrogen per hectare within Overseer, while co-modelling the farm system changes in Farmax and the MRB financial model.

Livestock Exclusion involved a five metre fencing setback from the banks of permanent and intermittent (not ephemeral) waterways and wetlands.

Land Intensification modelled a range of scenarios for the different farm types, that increased/maintained production, while trying to decrease/maintain nitrogen and phosphate losses.

1.7. The farm systems, farm financials and models incorporate many assumptions. The modelled farms were selected as they reflected typified farm type, system and management throughout Canterbury. While the modelled farms do represent the sectors in broader Canterbury, we respect that they will not reflect all farm systems and management, for similar types of properties within Canterbury, nor boarder New Zealand.

1.8 Key results are summarised visually in Table 1 and should be further examined in the Results and Discussion section of this report. For each farm type four key indicators are presented, with quick-reference to the direction and amplitude of the trend, for each Scenario tested.

Table 1. Case study farm scenario testing key summary results / trends.

Key Indicator	Status Quo	Scenario 1 Nitrogen Loss Cap	Scenario 2 Stock Exclusion	Scenario 3/3.1 Land Intensification	Scenario 3.2 Land Intensification
Red Meat/ Hill Country					
Disposable surplus	$15,182	-	↓↓↓↓↓	↓	-
kg N / ha discharge	19	-	↓	↔	-
kg P / ha discharge	0.4	-	↓	↔	-
kg GHG / ha emissions	4193	-	↔	↑	-
Dairy					
Disposable surplus	$204,803	↓	↓	↑	↑
kg N / ha discharge	66	↓	↓	↓	↓
kg P / ha discharge	1.5	↓	↓	↔	↔
kg GHG / ha emissions	17,351	↓	↓	↑	↑
Dairy Support					
Disposable surplus	$38,763	↓	↓	↓↓↓	↑↑↑
kg N / ha discharge	68	↓	↓	↓	↓
kg P / ha discharge	0.2	↔	↔	↔	↑
kg GHG / ha emissions	9752	↓	↓	↑	↑
Arable mixed cropping					
Disposable surplus	$20,257	-	↓	↑↑↑↑↑	-
kg N / ha discharge	24	-	↔	↓	-
kg P / ha discharge	0.5	-	↔	↑	-
kg GHG / ha emissions	6084	-	↓	↑↑	-

Key:

↔	no significant change
↓	positive decrease
↓	negative decrease
↓↓↓	more than threefold negative decrease
↓↓↓↓↓	more than fivefold negative decrease
↑	positive increase
↑↑↑	more than threefold positive increase
↑↑↑↑↑	more than fivefold positive increase
↑	negative increase
↑↑	more than twofold negative increase

1.9. Farm financial budgets are prepared in steady-state mode, meaning that set farm management cycled continuously year-on-year. Therefore, as soon as the Disposable Surplus is negative, the financial viability of the business is unsustainable.

1.10. It is crucial to note that no mortgage debt is repaid in the financial budgets, as a default. The reader should be mindful that Disposable Surplus, if any, is the maximum available for debt repayment. Financial institutions (influenced by the Reserve Bank of New Zealand) are now expecting all agricultural businesses to be able to repay all debt over a defined period of time of 20 to 30 years depending on the particular institution. Note that the debt repayment period for all four of the Status Quo model farms is well beyond 30 years to begin with.

1.11. Farm financial budgets assumed: efficient management for Status Quo, operating at or near to Good Management Practice (GMP); fair medium-term costs and commodity prices; local Canterbury conditions (e.g. contracts for arable crops, dairy grazing rates, value of trading livestock etc).

1.12. The proposed policies may affect land asset values, however this has not been factored in the analysis.

1.13. Typical indebtedness was assumed for each farm type, on a Canterbury centric basis. Discussions (*pers. comm.*) with four (mainstream) bank local branches and one local farm accountancy firm (during early May 2019), combined with MRB experience of client situations, led the project team to set the Status Quo model debt levels at: Red Meat / Hill Country $200 per stock unit ($1185 per hectare), Dairy $33,667 per hectare including Fonterra shares ($23 per kilogram milksolids), Dairy Support $10,825 per hectare and Arable Mixed Cropping at $13,500 per hectare, on an effective hectare basis. Farms with greater than these typical debt levels would have less resilience to significant government policy change, or indeed other significant events.

1.14. The Nitrogen Loss Cap scenario testing was very linear. The outcomes only represented the four farms at those 4 locations - they are very soil type specific and annual rainfall specific.

1.15. The analysis within this report has been undertaken by utilising modelling software (Farmax) to calculate theoretical system feasibility, and to estimate greenhouse gas emissions, nitrogen losses and phosphorus losses (Overseer). It is important to consider that many linear assumptions are made in models and as a consequence modelled outcomes should be read whilst considering a margin of error.

While Farmax is considered to be reasonably accurate for outdoor, pastoral modelling, it has limitations in terms of modelling feed pad or housed systems with the same level of accuracy.

Like Farmax, Overseer is a mathematical model of biological systems in a dynamic environment, and as such makes many assumptions to predict nutrient losses. Being a model, it is only as accurate as the trial date calibrations allow. There is an abundance of drainage trial data for nitrogen on pastoral systems and some arable crops, but there is considerably less data to validate the nitrogen sub-models for forage and specialist seed crops. The phosphorus losses must also be carefully considered. The AgResearch report "Review of the phosphorus loss sub-model in OVERSEER" (2016) gives detail of the limitations of the phosphorus sub-model. The report describes the pastoral model, as generally robust, but outlines difficulties associated with validating arable crop blocks, forage crop blocks, and other farm sources sub-models, citing limited scientific data to validate the model assumptions.

1.16. Unexpected outcomes during the modelling were encountered during the Land Intensification Scenario.

For the Dairy Level 1 and 2 scenarios, the modelling showed increased milk production, while reducing nitrogen loss at both Levels, reducing phosphate loss at Level 1, although an increased phosphate loss at Level 2.

For the Arable land conversion to dairy Scenario, nitrogen discharge decreased from 24 to 20 kilograms of nitrogen per hectare per annum.

While nitrogen loss *decreases* were unexpected, it reflects that dairy systems are becoming much more efficient and considered regarding nitrogen losses to the environment.

2. Introduction

2.1. Purpose

The Ministry for the Environment (MfE) have commissioned this impact assessment work to help determine the:

- economic impacts of the potential rules in the National Environmental Standards (NES) on a small sub-sample the agriculture sector,
- effects of the potential rules in the NES on nitrogen and phosphorus discharges to water; and
- effects of the potential rules in the NES on wider environmental, social and cultural system.

National direction under the Resource Management Act 1991 (RMA) requires a Regulatory Impact Statement (RIS) and section 32 report. This includes completing a cost-benefit analysis to assess the impact of the proposed policies.

This analysis models the impacts of potential NES regulations on farm. Anonymous case study farms were chosen to represent a typical example of a Canterbury farm. The farms vary in topography/slope and include watercourses. Four farm types are examined including: one red meat hill country, one dairy (milking platform), one dairy support and one arable mixed cropping farm. The case study farms are based on actual commercial operations in the Canterbury / South Canterbury provinces.

2.2. Context

The Government's Essential Freshwater programme contains proposed measures for improving farming practices and managing intensification of rural land use, in order to reduce contaminant discharges to water from farming activities. The *potential* policy response to achieve this includes a proposal for a new NES for Freshwater Management, including national regulations *potentially* prescribing:

- mandatory Farm Environment Plans, to promote good management practices and practices that will support the implementation of regulatory requirements, that reduce the impact of rural land-use on water quality;
- requirements to setback livestock from waterways;
- restrictions on high-risk activities (such as intensive grazing on forage crops, hill country cropping and feedlots/feedpads/sacrifice paddocks) to reduce the effects of these activities on water quality;
- constraints on farm intensification in specific areas, to prevent further degradation of water quality caused by land-use changes or increasing farm inputs; and
- a nitrogen loss cap.

2.3. Choice of farms

Four anonymous case study farms were chosen for modelling. Four farm types were represented: a red meat hill country farm; a dairy farm; a dairy support farm; and an arable mixed cropping farm. All farms are Canterbury situated, chosen due to them being representative of each farm system, and having watercourses on the property.

Red Meat / Hill Country - Due to the steep contour of 70 per cent of this hill country case study farm, the proportion of waterways can be considered particularly typical of Canterbury hill country.

Dairy - The farm has one minor and two major streams / waterways with a combined total length of 5,103 metres, running through the dairy platform.

Dairy Support - This case study farm is predominantly flat, with relatively few waterways at only 1750 meters of streams. MRB decided to scale up the length of waterways on the modelled farm so that livestock exclusion area was at least one per cent of the farm area. An exclusion of 5390 lineal metres of streams was modelled. It is likely that other properties with more undulating terrain in different localities will have a greater proportion of waterways to exclude livestock from. Note that on properties where steeper topography or meandering streams are present, the stock exclusion area will be larger than ten metres as it is difficult and expensive to get the fence uniformly five metres from the stream.

Arable - This farm was chosen, due to the significant number of waterways on the property, albeit certainly not unrepresentative. All paddocks have at least one fenceline adjacent to a waterway. Whilst this coastal property does have a high proportion of *natural* waterways relative to a typical mid-Plains Canterbury arable farm (whom tend to have *man-made* waterways), many coastal Canterbury properties do have comparable proportions of (different types) of waterways. When this arable farm was Status Quo modelled it was realised that whilst it had a good EBITD per hectare, at only 231 hectare effective, it did not have enough economy-of-scale to be financially sustainable. MRB made the decision to scale up the effective area (and consequent income and expense items) by 40 per cent therefore to 335 hectares, which is in fact more aligned to a typical Canterbury mixed cropping farm. The proportion of waterways was scaled up also, which is fair, due to the farm being typical the surrounding district.

The farms were chosen such that they provided ample scope for modelling of Scenarios as requested.

3. Objectives

Macfarlane Rural Business Ltd (MRB) has analysed metric impacts of potential policy interventions. Effects on farm management, environmental and farm financials have been examined.

4. Methodology

MRB received the project scope from MfE.

The Status Quo management/biological/environmental/financial metrics of each farm are represented using Farmax and Overseer models, and an MRB in-house farm financial spreadsheet. Brief descriptions of the modelled farms are presented in Chapter 5.

Scenarios provided by MfE were co-modelled using the tools mentioned above. The Scenarios were developed early in the policy process and should not be interpreted as preferred policy proposals to be consulted on.

Brief descriptions of the analysis are presented in the following chapters. Detailed modelling analysis is presented in the Appendices of this report.

5. Results and Discussion – Status Quo Case Study Farms

The case study farms were first described using 'Status Quo' current management and production to give a baseline for comparisons of the Scenario modelling.

5.1. Red Meat / Hill Country – Status Quo

5.1.1. Farm description

5.1.1.1. General farm

The 598 ha "Red Meat" hill country farm is intended to represent properties that farm sheep, beef and deer enterprises across a combination of physical land resources, utilising a range of crops and farming techniques. This particular property was selected as representative of the sheep, beef and deer sectors as it contains:

- A combination of hill country tussock, developed rolling downs and developed irrigated flats (approximately 13 per cent of total farm area).
- Both sheep and beef breeding and finishing enterprises. While this Red Meat property does not farm deer, there are a number of properties similar to this that do also farm deer, the deer typically displace sheep.
- Two types of irrigation being sprinklers and centre pivots.
- A combination of soil types including Lismore (lighter in texture and more free draining) and Claremont (heavier and deeper soils that are imperfectly drained).
- Summer forage crops, winter forage crops and conserves pasture and silage for meeting expected and unexpected feed deficits throughout the season.

The modelled property focuses on finishing (animals sold to meat processors) all of the progeny it produces. Within the range of Red Meat farms in the South Island of New Zealand, the focus of individual operations can range from breeding only (animals on-sold to other farmers to be finished), to finishing only, or a combination of the breeding and finishing and can include other enterprises such as dairy support or arable crops. Dairy support and arable enterprises are analysed by other models in other parts of this report.

5.1.1.2. Land

598 ha effective area

- 420 ha tussock hill (steep)
- 70 ha developed downs (Figure 1)

    6 ha forage rape (winter)

    6 ha forage leafy turnip (summer)

    58 ha pasture

- 108 ha easy to flat paddocks
    - 28 ha dryland
        - 4 ha lucerne
        - 24 ha pasture
    - 30 ha sprinkler irrigation (Figure 2)
        - 6 ha forage rape (multi-graze summer/winter)
        - 6 ha forage rape (winter)
        - 6 ha annual ryegrass
        - 18 ha pasture
    - 50 ha centre pivot irrigation (Figure 3)
        - 7 ha forage oats and grass (winter)
        - 7 ha fodder beet
        - 7 ha forage rape (summer)
        - 36 ha pasture

5.1.1.3. Crop rotations

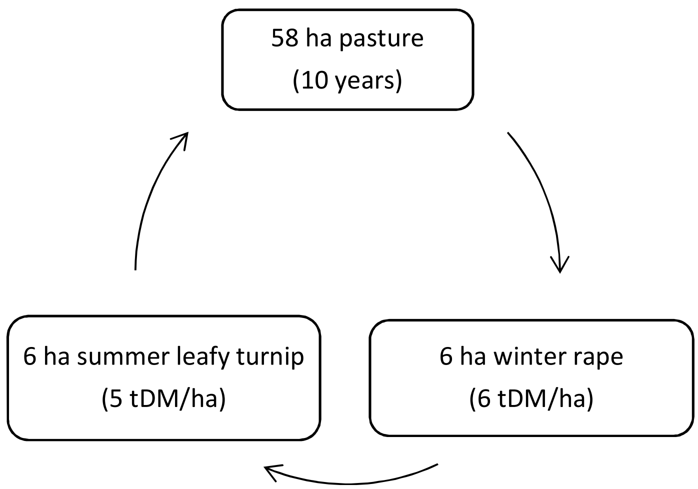


Figure 1: Red Meat / Hill Country: Status Quo - developed downs crop rotation.

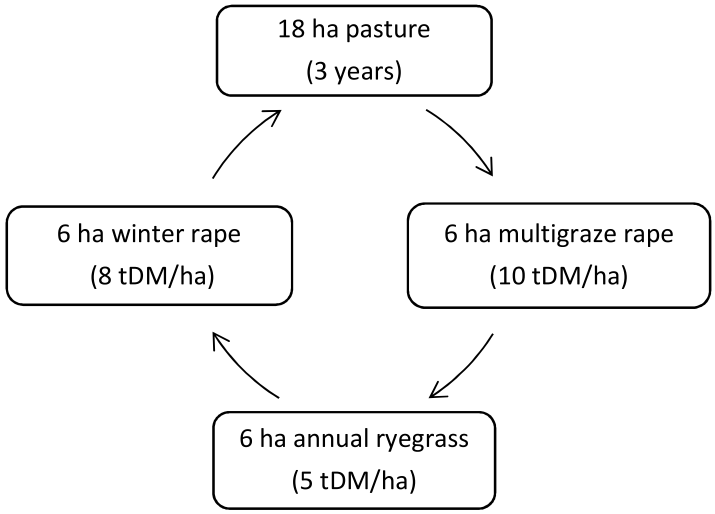


Figure 2: Red Meat / Hill Country: Status Quo - Sprinkler paddocks crop rotation.

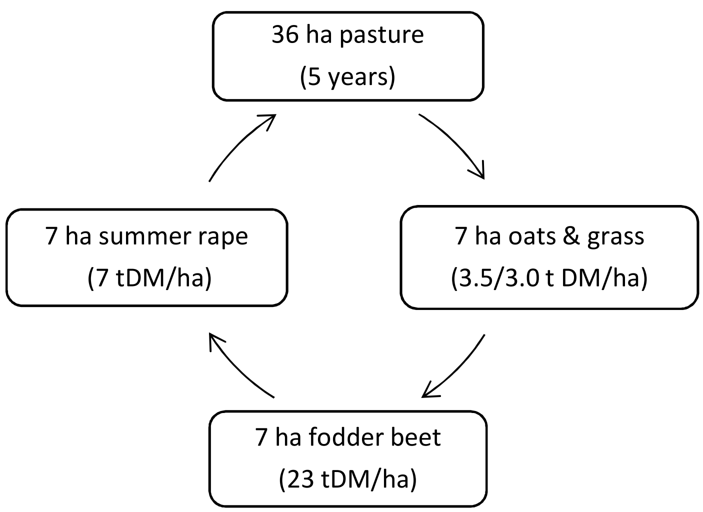


Figure 3: Red Meat / Hill Country: Status Quo - Centre pivot paddocks crop rotation.

5.1.1.4. Stock numbers and performance

Cattle

- 160 cows Including first calvers (calving 1 August at 94%, finishing progeny).
- 30 R2 heifers mated.
- 45 R2 heifers sold (30 sold store in October at 315 kg liveweight; 15 sold in March at 266 kg carcass weight).
- 75 R1 heifers weaned and wintered.
- 75 R1 bulls weaned and wintered.

- 75 R2 bulls sold (30 sold in October for breeding; 45 sold in March to June at 285 kg carcass weight)
- 5 breeding bulls.

Sheep

- 1100 ewes (lambing 5 September at 150%, 13% weaning draft to works, remainder finished to 18.5 kg carcass weight February to May).
- 300 ewe lambs kept as replacements (lambing 10 September at 71%, lambs finished to 18.5 kg carcass February to May).
- 350 trading lambs bought-in and finished.
- 15 rams.

5.1.1.5. Supplements

- 25 tonnes drymatter pasture and lucerne silage made and fed on crops over winter

5.1.2. Modelling outputs

5.1.2.1. Financial budget summary

Table 2: Budget summary: Red Meat / Hill Country - Status Quo.

	Status Quo
Nett Farm Income	$380,922
less Farm Working Expenses	$274,065
gives Earnings Before Interest and Tax	$107,031
less Capital Replacement / Depreciation	$37,750
less Interest (on original term debt)	$43,578
less Interest (marginal per scenario)	-
less Interest (on working capital)	$4,015
gives Taxable Surplus	$21,688
less Tax Provision (at 30%)	$6,506
gives* Disposable Surplus	**$15,182**

*Note: No debt/principal repayments are made in these models.

5.1.2.2. Emission results

Table 3: Emission summary: Red Meat / Hill Country - Status Quo.

	Status Quo
Nitrogen	
Total kg	11,588
kg/ha	19
Phosphorus	
Total kg	260
kg/ha	0.4
Greenhouse gases (CO2 equivalent)	
Total kg	2,507,414
kg/ha	4,193

5.1.3. Discussion

Nett Farm Income (NFI) generated is $118 per stock unit, and Farm Working Expenses (FWE) are $85 per stock unit. 81 per cent of the $33 per stock unit Earnings Before Interest Tax and Depreciation (EBITD) is used to pay interest, depreciation and tax.

Traditionally Red Meat properties operated a cost structure at approximately 60 per cent of gross farm income, however over time as inflation of inputs costs and have exceeded that of output quantities and commodity returns, the cost structure has increased. The modelled farm spends 72 per cent of the generated nett farm income on farm working expenses (Table 2).

An average debt of $200 per stock unit ($645,600 total debt) has been used as a representative value for the Red Meat farm. Extensive properties, such as this, rely on modest levels of debt to ensure their long term financial sustainability. As these properties are mostly unirrigated, cash reserves must be available to support the business to feed stock or insulate against lost income in the advent of adverse weather events such as droughts, snow or storms. This model has an interest cover ratio of 2.3. A resilient Red Meat business is maintained with an interest cover ratio (before depreciation and tax) of 2.0 or greater to ensure it has sufficient cash flow to withstand unforeseen costs or lost income.

This farm is profitable currently, however, it has a limited ability to support any additional debt if revenue generation does not increase proportionally and with improved reliability.

The cumulative nitrogen losses from the property average 19 kilograms per hectare per year (Table 3), however, it is important to note that the individual blocks of the farm range in their emissions from 7 kilograms per hectare per year to 146 kilograms per hectare per year. A similar trend applies to phosphorus with an average emission of 0.4 kilograms per hectare per year and a range of 0.0 to 1.6 kilograms of phosphorus per hectare per year. The blocks that generate the greatest nutrient losses are the more intensive blocks, both as forage crops and as pasture.

Of the 4,193 kilograms of carbon dioxide equivalent greenhouse gasses emitted by this property, 94 percent of the emissions are nitrous oxide and methane.

5.2. Dairy – Status Quo

5.2.1. Farm description

5.2.1.1. General farm

These models are based on a South Canterbury dairy farm, operating near to steady-state equilibrium due to being converted several years ago. Moderate productivity which is broadly in line with LIC regional dairy statistics (see Appendices). The farm base model producing 435 kgMS per cow against the 2017/18 South Canterbury average of 392 kgMS per cow and 413 kgMS per cow for North Canterbury. Production per hectare is 1450 kgMS compared against the 2017/18 South Canterbury average of 1,350 kgMS per hectare and 1,420 kgMS per hectare for North Canterbury. Stocking rate at 3.3 cows per hectare is slightly lower than the 3.44 cows per hectare 2017/18 South Canterbury average, and 3.43 cows per hectare for North Canterbury. Overall this farm represents good efficient pasture-based milk production, which is supported with grain feeding and silage feeding on the shoulders of the season.

The farm scale is large at 300 hectares against the 2017/18 South Canterbury average of 230 per hectares and 234 hectares for North Canterbury. This scale and the stocking rate assist in simplifying some aspects of analysis. The farm has one minor and two major waterways which run through the dairy platform, providing ample scope for modelling riparian margins and mitigations as requested. All waterways are currently fenced as per GMP requirements.

The farm operates with five fulltime and two part-time staff, featuring modern efficient infrastructure for operation at Good Management Practice (GMP) levels. Infrastructure includes a rotary dairy shed, effluent storage tank, centre pivot and K-Line (moveable sprayline) irrigation, bridged waterway crossings, a road underpass and soil moisture sensors.

The farm has 219 hectares of relatively flat land and 81 hectares of rolling low hill country with some steep areas, making it a well balanced unit for determining impacts of changes of farm system on different land contour aspects.

The farm supplies Fonterra, having full allowance of supplier shares.

5.2.1.2. Land

318 ha title

- 300 ha effective.
- 81 ha rolling downs.
- 219 ha flat.

    10 ha fodder beet crop rotates over selected blocks.

    290 ha pasture yielding 14.1 tDM/ha per annum.

    10% annual regrassing.

- 300 ha irrigated.
    - 134 ha centre pivot.
    - 166 ha K-Line.

- 18 ha in-effective (tracks / yards / other).

Soils

- 196 ha shallow silt loam soils, moderately well drained and slightly stony with moderate profile available water (PAW): Darnley*f.*
- 26 ha shallow loam soils, well drained and moderately stony with low to moderate PAW: Rakaia*f*.
- 82 ha moderately deep silt loam (hill) soils, imperfectly drained stoneless soil with moderate to high PAW: Timaru*f*.

5.2.1.3. Stock numbers and performance

Cow herd:

- Kiwi-Cross herd.
- 94 BW.
- 1030 wintered off farm.
- 1000 peak milk numbers.
- 434,996 kgMS total production (Table 5).

Replacement stock:

- 250 heifer calves reared, grazed off farm from 1st December to 30th April (5 months).
- 250 heifer rising 2-year, grazed off farm 1st May to 30th April (12 months).
- 240 heifer in-calf, grazed off farm for month of May (1 month).

Table 4: Dairy: Status Quo – Supplementary feeds used and allocated.

Feed	tonnes DM offered													kg
	Jun 18	Jul 18	Aug 18	Sep 18	Oct 18	Nov 18	Dec 18	Jan 19	Feb 19	Mar 19	Apr 19	May 19	Total	/milker
F4 Hay/Straw bought		0	20	8									28	28
C2 Fodder Beet											68	131	199	199
F1 Meal and Grains bought		1	13	20	15	30	20		14	15	5		133	133
F2 Pasture Silage		3	60	39								37	139	139
Total													**498**	**498**

- 133 tDM Cereal grain bought in and fed in dairy shed (Table 4).
- 139 tDM pasture silage (27 tDM of which is made on platform) fed in season shoulders.
- 199 tDM fodder beet grown and fed to milking and dry cows in autumn.

Table 4: Dairy: Status Quo - Farmax physical summary.

Category	Description	Value	Units
Farm	Effective Area	300	ha
	Stocking Rate	3.3	cows/ha
	Potential Pasture Growth	14.2	t DM/ha
	Nitrogen Use	215	kg N/ha
	Feed Conversion Efficiency (eaten)	10.6	kg DM eaten/kg MS
Herd	Cow Numbers (1st July)	1,030	cows
	Peak Cows Milked	1,000	cows
	Days in Milk	0	days
	Avg. BCS at calving	4.9	BCS
	Liveweight	1,421	kg/ha
Production	Milk Solids total	434,996	kg
(to Factory)	Milk Solids per ha	1,450	kg/ha
	Milk Solids per cow	435	kg/cow
	Peak Milk Solids production	2.01	kg/cow/day
	Milk Solids as % of live weight	102.0	%
Feeding	Pasture Eaten per cow *	3.6	t DM/cow
	Supplements Eaten per cow *	0.4	t DM/cow
	Off-farm Grazing Eaten per cow *	0.6	t DM/cow
	Total Feed Eaten per cow *	4.6	t DM/cow
	Pasture Eaten per ha	12.0	t DM/ha
	Supplements Eaten per ha	1.5	t DM/ha
	Off-farm Grazing Eaten per ha	3.9	t DM/ha
	Total Feed Eaten per ha	17.3	t DM/ha
	Supplements and Grazing / Feed Eaten *	23.1	%
	Bought Feed / Feed Eaten *	4.2	%

(*) feed eaten by females > 20 months old / peak cows milked

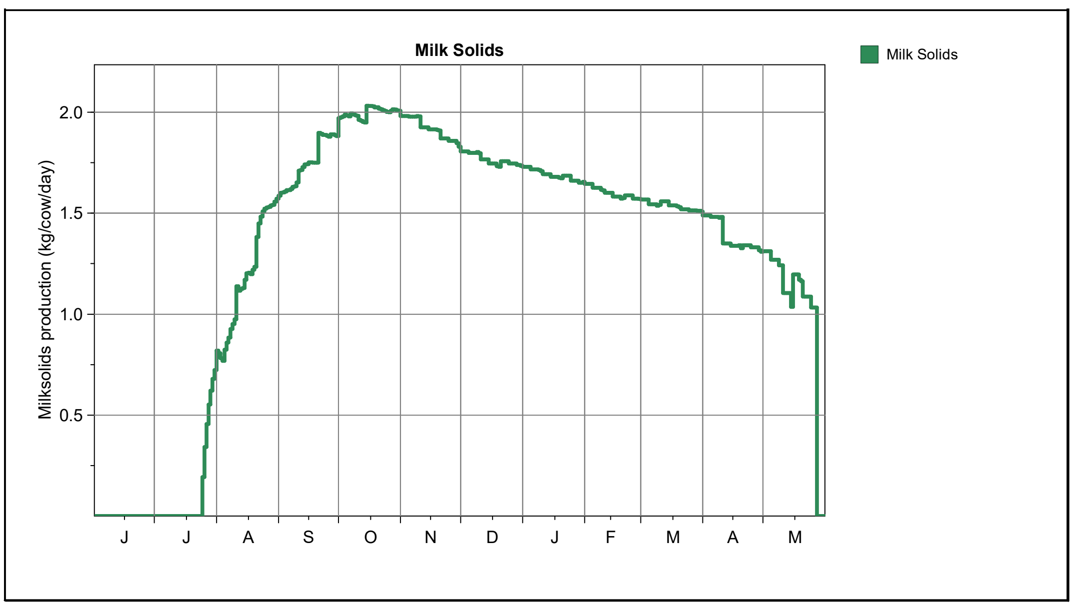


Figure 4: Dairy: Status Quo - Farmax lactation curve.

5.2.2. Modelling outputs

5.2.2.1. Financial budget summary

Table 6: Budget summary: Dairy - Status Quo.

	Status Quo
Nett Farm Income	$2,911,306
less Farm Working Expenses	$1,833,772
gives Earnings Before Interest and Tax	$1,077,534
less Capital Replacement / Depreciation	$98,375
less Interest (on original term debt)	$681,750
less Interest (marginal per scenario)	-
less Interest (on working capital)	$4,834
gives Taxable Surplus	$292,575
less Tax Provision (at 30%)	$87,773
gives* Disposable Surplus	**$204,803**

*Note: No debt/principal repayments are made in these models.

5.2.2.2. Emission results

Table 7: Emission summary: Dairy - Status Quo.

	Status Quo
Nitrogen	
Total kg	21,017
kg/ha	66
Phosphorus	
Total kg	463
kg/ha	1.5
Greenhouse gases (CO2 equivalent)	
Total kg	5,512,212
kg/ha	17,334

5.2.3. Discussion

The farm financial performance (Table 6) is solid and reflects an efficient Canterbury dairy farm system operating in presently good market conditions for both milk and meat (the status quo milksolids pricing is $6.00 per kilogram and a $0.30 total dividend is used to reflect the long term average). The cost structure is based on the farm businesses actual expenditure, it reflects industry averages across individual cost categories within the budgeting, and the Farm Working Expenses are at $4.22 per kilogram of milksolids which is in line with MRB financial benchmarks. Nitrogen leaching (Table 7) as assessed by Overseer is moderate at 66 kilograms per hectare and phosphorus leaching is moderate to high for a Canterbury dairy farm at 1.5 kilograms per hectare which is reflective of the fact that 27 per cent of the dairy platform area is on rolling hill aspect.

5.3. Dairy Support – Status Quo

5.3.1. Farm description

5.3.1.1. General farm

Situated in Canterbury the property has approximately 100 hectares of rolling downs with the remaining area being flat. All of the farmed area is able to be cultivated and harvested. Irrigation is applied to 260 hectares via three centre pivot irrigators. For the purposes of this project a ratio of approximately 27 per cent heifers to cows grazing has been modelled (ie 460 heifers : 1,700 cows) in an attempt to reflect typical industry standards. This is not what actually takes place on the property. To make the farm system operate efficiently a beef finishing programme has been implemented to balance the feed supply and demand. Most properties undertaking dairy support will be more integrated with other farming enterprises such as cropping and/or sheep and beef and as a result dairy support is often a smaller proportion of the total farm income.

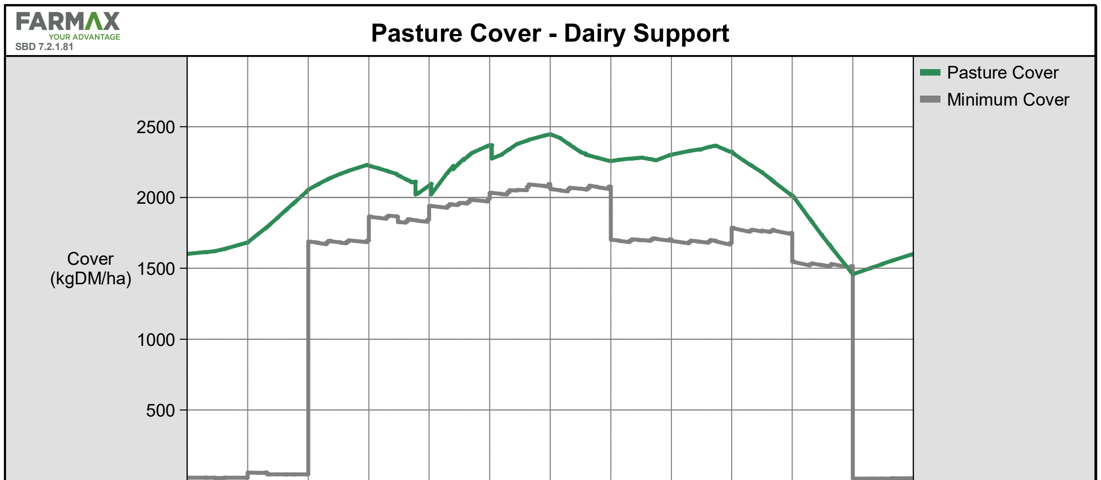
All cropping requirements are undertaken by contractors. Most plant and vehicle costs are associated with livestock feeding and husbandry. There are only two full time employees, although 640 hours of casual labour is budgeted to cover the busy winter period and staff holidays.

5.3.1.2. Land

475ha title

- 260 hectares are pivot irrigated – 8 year rotation
  32.5 ha fodder beet (Oct – Aug) – 23 tDM/ha
  32.5 ha green chop cereal silage (Sept – Dec) – 6 tDM/ha
  32.5 ha kale (Jan – Aug) – 12 tDM/ha
  32.5 ha barley grain (Sept – Feb) – grain sold (8.5 t/ha) / straw kept (3.5 tDM/ha)
  Pasture for 5.5 years – Annual production before nitrogen of 13.12 tDM/ha.
- 24 hectares dryland – Corner areas of pivot irrigators – 8 year rotation
  3 ha fodder beet (Oct – Aug) – 18.5 tDM/ha
  3 ha green chop cereal silage (Sept – Dec) – 4.0 tDM/ha
  3 ha kale (Jan – Aug) – 9.0 tDM/ha
  3 ha barley grain (Sept – Feb) – grain sold (7.5 t/ha) / straw kept (3.5 tDM/ha)
  Pasture for 5.5 years – Annual production before nitrogen of 8.5 tDM/ha.
- 176 hectares dryland – 7 year rotation
  25.1ha kale (Nov – Aug) – 11 tDM/ha
  25.1ha fodder beet (Oct – Aug) – 18.5 tDM/ha
  25.1ha summer rape (Oct – Apr) – 8 tDM/ha
  Pasture for 4.5 years – Annual production before nitrogen of 8.5 tDM/ha
  Approximately 100 hectares of the dryland area is rolling downs.
- 15 hectares are in-effective

Figure 5 displays the monthly pasture covers for the whole property, while Figures 6 and 7 show the cropping rotations for the irrigated and dryland areas.



(kgDM/ha)	Start	J	A	S	O	N	D	J	F	M	A	M	J
Pasture Cover	1,602	1,684	2,057	2,227	2,083	2,371	2,447	2,258	2,304	2,323	2,013	1,459	1,602
Minimum	21	21	44	1,696	1,843	1,989	2,095	2,077	1,704	1,680	1,749	1,516	16

Figure 5: Dairy support: Status Quo - Monthly pasture covers.

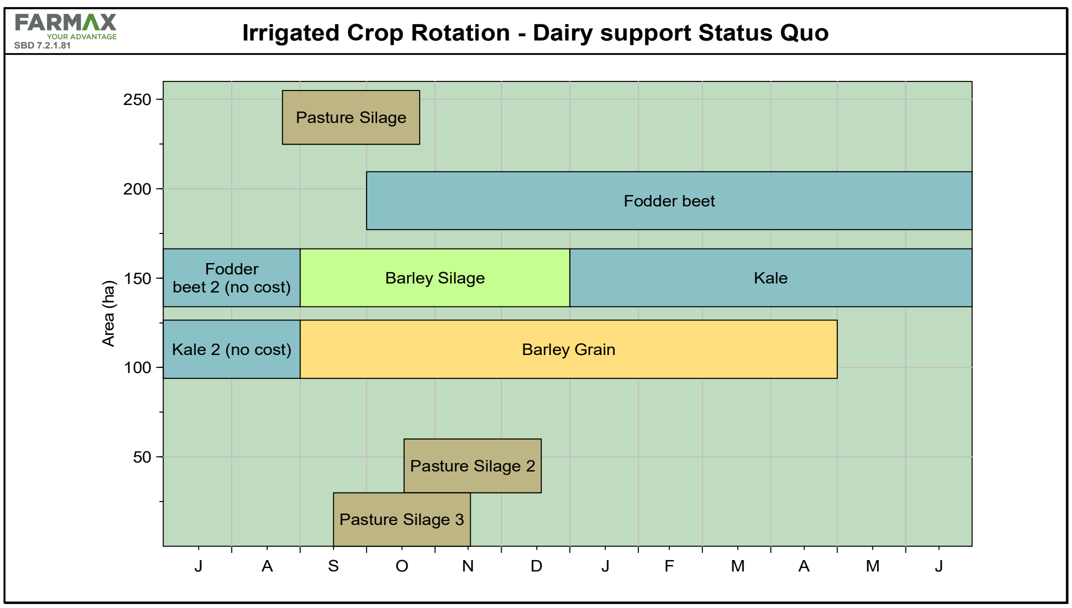


Figure 6: Dairy support: Status Quo - Irrigated Crop Rotation (Farmax).

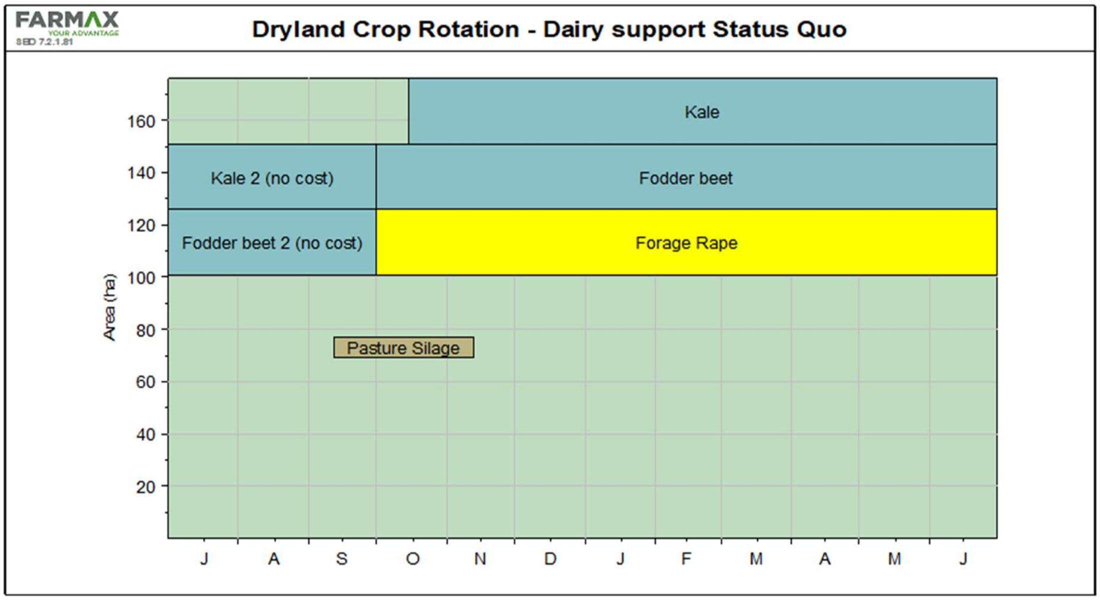


Figure 7: Dairy - Status Quo - Dryland Crop Rotation (Farmax).

5.3.1.3. Stock numbers and performance

Heifers:

- Dairy heifers grazed on the property (Figure 8)
- 460 calves (on farm for approximately 20 months)
- Calves arrive in November/December at 105 kilograms liveweight
- 23 dry heifers depart in April
- Remaining animals go back to the dairy farm for calving on the 15th of July
- 13 bulls are on farm to mate the heifers from October to December.

Cows:

- 1700 cows arrive from dairy farm(s) on the 1st of June and depart on average after 70 days.

Steers:

- 155 steer calves purchased at 100 kilograms in November/December
- 320 steer calves purchased at 230 kilograms in April/May
- 364 head are sold from January to June (average date of 7th April) at an average carcass weight of 282 kilograms
- 105 head are taken through the second winter and sold in October and November at an average carcass weight of 338 kilograms.

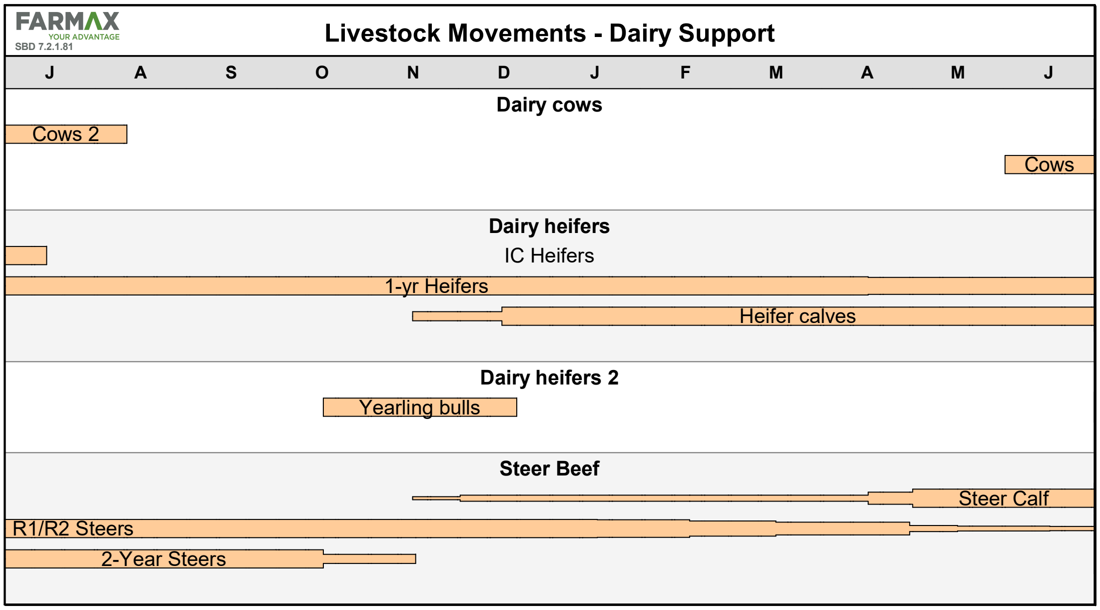


Figure 8: Dairy support: Status Quo - Livestock movements throughout the year.

5.3.1.4. Supplements

Barley straw

- 125 tDM is made on the property
- 190 tDM is purchased onto the property

Silage

- 295 tDM of surplus pasture is made into both pit silage and baleage
- 207 tDM of greenchop cereal silage

Barley grain

- 299 t of barley grain sold off farm.

5.3.2. Modelling outputs

5.3.2.1. Financial budget summary

Table 8: Budget summary: Dairy support - Status Quo.

	Status Quo
Nett Farm Income	$1,446,792
less Farm Working Expenses	$958,792
gives Earnings Before Interest and Tax	$488,000
less Capital Replacement / Depreciation	$81,800
less Interest (on original term debt)	$336,150
less Interest (marginal per scenario)	-
less Interest (on working capital)	$14,674
gives Taxable Surplus	$55,376
less Tax Provision (at 30%)	$16,613
gives* Disposable Surplus	**$38,763**

*Note: No debt/principal repayments are made in these models.

5.3.2.2. Emission results

Table 9: Emissions summary: Dairy support - Status Quo.

	Status Quo
Nitrogen	
Total kg	31,364
kg/ha	68
Phosphorus	
Total kg	102
kg/ha	0.2
Greenhouse gases (CO2 equivalent)	
Total kg	4,485,920
kg/ha	9,752

5.3.3. Discussion

Financial results for the Status Quo dairy support farm are presented in Table 8. Term debt levels have been based on $13,000 per irrigated hectare and $8,000 per effective dryland hectare, totalling $4,980,000. Based on a medium-term interest rate of 6.75 per cent this results in term debt servicing of $731 per hectare. Working capital debt is relatively low at $32 per hectare as the majority of livestock are not owned. With an Earnings Before Interest, Tax and Depreciation (EBITD) of $1055 per hectare, this results in an Interest Coverage Ratio (ICR) of 1.38. Whilst the business can survive at this low ICR, it is desirable that it be above 1.5 to provide security and enable debt repayment and or further development. To achieve an ICR of 1.6 under the current debt structure an EBITD of $1,221 per hectare is required or alternatively interest costs need to reduce to $659 per hectare. Improvements to the EBITD could be enhanced by undertaking more of the crop cultivation and drilling, although this would require further investment in plant and machinery.

Capital Replacement/Depreciation has been based on replacing plant at $35,000 per annum ($350,000 @ 10 per cent) and depreciating the irrigation system at 4 per cent per annum.

The Status Quo model is an intensive farm system with 277 hectares being drilled into a crop or new pasture each year. The majority of the crop/pasture establishment is undertaken by contractors. Therefore, costs associated with cropping and feed conservation including, contractors costs, fertiliser and lime, seeds and weed and pest control contribute to 55.9 per cent of the Farm Working Expenditure (excluding interest). Other large cost categories include labour (14.4 per cent) and irrigation charges (9.5 per cent).

The property is situated on well drained Ruapuna silt loam soils with a moderate Plant Available Water (PAW) of 69 mm and is in a higher rainfall zone (903 mm based on NIWA data). Whilst every attempt has been made to implement a farm system under Good Management Practice (GMP), including utilisation of soil moisture probes, direct drilling where possible, minimising fallow periods and targeted fertiliser applications, the nitrogen loss to water is modelled at 68 kilograms per hectare per annum (Table 9). This is predominately due to the large number of cattle being fed, the free draining soils and higher rainfall.

5.4. Arable / Mixed Cropping – Status Quo

5.4.1. Farm description

5.4.1.1. General farm

This anonymous farm was chosen as a case study farm, due to the significant number of waterways on the property. All paddocks have at least one fenceline adjacent to a waterway. This *coastal* property does have a high proportion of natural waterways relative to a typical *mid*-Plains Canterbury arable farm (whom tend to have man-made waterways), although many coastal Canterbury properties do have different types of waterways. This farm fairly represents many coastal Canterbury properties.

This arable / mixed cropping farm system is based on grain and small seeds. 81 per cent of gross farm income is from grain and seed crops, 14 per cent from trading lambs, 3 per cent from dairy calve grazing, and 2 per cent from grass baleage sales.

The modelled farm employs two full time and one harvest / irrigation season casual labour unit. Direct-drilling, spraying, fertiliser spreading and harvesting is all carried with own labour and machinery.

The farm has very skilled management, keenly investing in new technology. The operation is certainly environmentally conscious, operating at Good Management Practice (GMP) levels.

5.4.1.2. Land

348 ha total area modelled

- 315 ha irrigated, flat land (approximately two-thirds pivot irrigators, one-third travelling irrigators, shallow wells)
- 10 ha dryland, flat land
- 23 ha in-effective.
- Soil types
    - 220 ha (approximately two-thirds) of the area classified as Prebbleton silt loam (Prebb_5a.1)
    - 105 ha (approximately one-third) of the area classified as Wakanui silt loam (Wakanui_27a.1).
- Mean annual rainfall 544 mm per annum.
- Annual potential evapotranspiration 877 mm per annum.

5.4.1.3. Pasture

No permanent pasture

- Lambs and calves mostly graze ryegrass seed and white clover seed crops, when those crops are not closed for seed.
- 10 ha of lucerne is also used in the non-winter months for grazing and one baleage cut.

5.4.1.4. Crops

325 ha effective area

- 315 ha irrigated, flat land

    Seven year crop rotation (Figure 9)

    45 ha Italian ryegrass seed crop

    45 ha Garden seed peas

    45 ha Autumn sown feed wheat

    15 ha Linseed (for food grade oil)

    15 ha Sunflower (for food grade oil)

    15 ha Hemp (for food grade oil)

    45 ha Spring sown malting barley

    45 ha White clover seed crop

    45 ha Winter sown milling wheat.

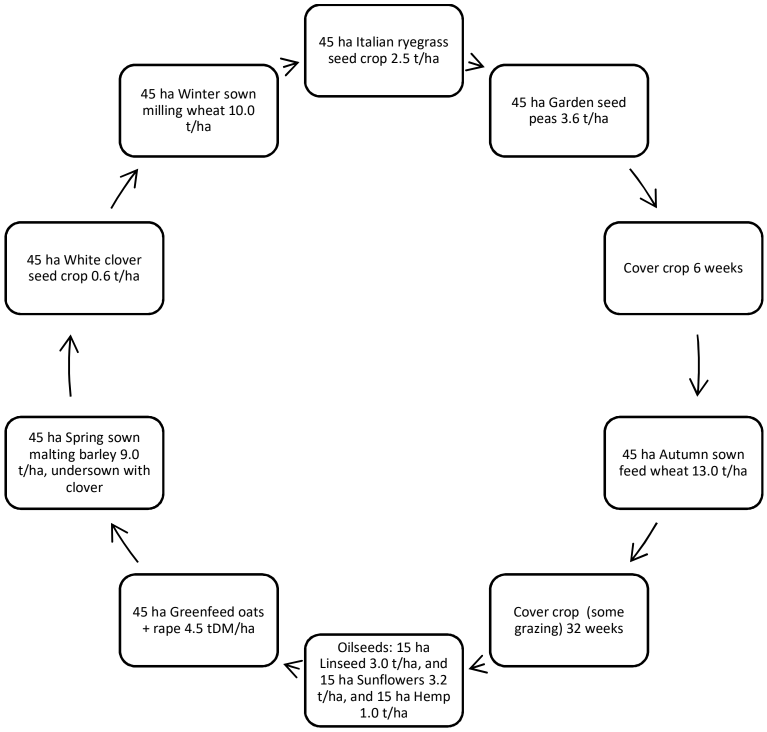


Figure 9: Arable mixed cropping: Status Quo. 7 year crop rotation, 45 hectare blocks.

- 10ha dryland, flat land

  10 ha lucerne.

5.4.1.5. Stock numbers and performance

Sheep

- 2100 trading lambs purchased 15th March at 30 kg per head liveweight
- 2800 trading lambs purchased 15th April at 31 kg per head liveweight
- 4802 trading lambs sold to meat works, drafting throughout May to August at 19.6 to 24.9 kg per head carcase weight.

Cattle

- 210 dairy heifer calves, arrive 15th February at 120 kg per head liveweight (five months old), transferred back to dairy farm on 30th June at 148 kg liveweight (nine months old).

5.4.1.6. Supplements

No supplementary feed purchased – self sufficient.

- All wheat, barley and ryegrass straw is chopped/spread/retained at harvest. None is baled.
- 540 bales of pasture baleage @ 250 kilogram drymatter per bale are made on farm
  - 263 bales are used on farm
  - 277 bales are sold.
- 120 bales of lucerne baleage @ 250kg drymatter per bale are made on farm
  - All are used on farm – none sold.

5.4.2. Modelling outputs

5.4.2.1. Financial budget summary

Table 10: Budget summary: Arable mixed cropping - Status Quo.

	Status Quo
Nett Farm Income	$1,534,634
less Farm Working Expenses	$969,222
gives Earnings Before Interest and Tax	$565,412
less Capital Replacement / Depreciation	$218,200
less Interest (on original term debt)	$296,156
less Interest (marginal per scenario)	-
less Interest (on working capital)	$22,117
gives Taxable Surplus	$28,939
less Tax Provision (at 30%)	$8,682
gives* Disposable Surplus	**$20,257**

*Note: No debt/principal repayments are made in these models.

5.4.2.2. Emission results

Table 11: Emission summary: Arable mixed cropping - Status Quo.

	Status Quo
Nitrogen	
Total kg	8,381
kg/ha	24
Phosphorus	
Total kg	178
kg/ha	0.5
Greenhouse gases (CO2 equivalent)	
Total kg	2,117,232
kg/ha	6,084

5.4.3. Discussion

The Farmax biophysical model was used to show that the stock policies and stocking rate (1.1.1.5.) are feasible and sustainable in terms of balancing feed supply with animal demand on a daily time-step throughout the year.

Financial analysis (Table 10) of the farm model objectively represented a Canterbury arable mixed cropping farm. Gross Farm Income was a strong $4722 per hectare and Farm Working Expenses of $2982 per hectare were within typical ranges leading to an above typical Earnings Before Interest Tax Depreciation (EBITD) of $1740 per hectare ($565,000). This EBITDA actually represents the top 10 per cent of similar type farm systems in Canterbury. The majority of mixed cropping farms in Canterbury would not be as profitable as this farm. However once interest on typical debt and working capital levels were accounted for, plus provisions for capital replacement (proxy for depreciation), provision for income tax, the bottom-line true (disposable) cash surplus was only $24,172 per annum. Note that no mortgage principle repayments have been allowed for in the financial budgets – the Disposable Surplus illustrates what is potentially available for debt repayment. Note also that as soon as the Disposable Surplus becomes a deficit, the farms would simply not be financially sustainable, due to the model being designed in a steady-state cyclical mode.

Capital Replacement has been based on replacing 10 per cent of the total plant & machinery per annum, and 4 percent of the irrigation hardware.

When the farm was first modelled, it had a good EBITD per hectare, but at only 231 hectare effective, it did not have enough economy-of-scale to be financially sustainable. MRB made the decision to scale up the effective area (and consequent income and expense items) by 40 per cent therefore to 335 hectares, which is in fact more aligned to a typical Canterbury mixed cropping farm.

The farm has heavy soils and is in a low rainfall zone. The nitrate discharge to water may well be greater on a lighter (less soil water holding capacity) soil type, especially if greater average rainfall. Nitrogen discharge of 24 kilograms per hectare (Table 11) would be considered fairly typical of mixed (meaning including arable crop and livestock) cropping farms on heavy soils in Canterbury. The phosphorus discharge of 0.5 kilogram phosphorus per hectare would also be considered fairly typical of mixed (meaning including arable crop and livestock) cropping farms in Canterbury.

The farm operates at GMP levels, for example: direct drilling, cover crops, stock exclusion from waterways, careful and targeted use of soluble phosphorus fertiliser (variable rate technology). Fertiliser applications are calculated against crop needs. Livestock impact on the soil is carefully managed during the year. Crop rotations maintain organic matter levels as respectfully as possible including full straw/residue soil incorporation. Soil moisture monitoring is carried out during the irrigation season. Cover crops are utilised to protect topsoil and enhance soil biology in otherwise fallow periods.

6. Results and Discussion – Scenario 1: Nitrogen Loss Cap

Once the Status Quo management and production was described for each case study farm, Scenarios were co-modelled with Farmax, Overseer and the MRB financial budget spreadsheet. Outcomes are presented and discussed.

Scenario 1 limits the nitrogen losses to an output cap of 60 kilograms per hectare per annum.

6.1. Red Meat / Hill Country – Scenario 1: Nitrogen Loss Cap

6.1.1. Scenario introduction

No additional modelling was undertaken for the Red Meat model for Scenario 1: Nitrogen Loss Cap. The Red Meat Status Quo modelling indicated losses of 19 kilograms per hectare per year which is less than the 60 kilograms per hectare per year maximum cap emission target in Scenario 1.

It is important to consider, as discussed in the Status Quo section above, that there are blocks within this property that emit up to 146 kilograms of nitrogen per hectare per year. The blocks that generate the highest emissions are the more intensive blocks, both as forage crops and as pasture. It is important to consider that the intensive part of this farm is similar to that of some 'finishing only' Red Meat properties. If the intensive part of this property was to be looked at in isolation, considerable changes to the farm programme would be required to enable the farm to meet the proposed Nitrogen Loss Cap of 60 kilograms per hectare per year (Scenario 1).

6.2. Dairy – Scenario 1: Nitrogen Loss Cap

6.2.1. Farm description

6.2.1.1. General farm

The main changes to the farm system to accommodate the Nitrogen Loss Cap scenario have been earlier culling, reduced nitrogen fertiliser application rates over the growing season and removal of April applied nitrogen fertiliser. The biophysical modelling (Farmax Dairy) has been recalibrated with reduced pasture intakes across part of the season to a level that allows the average pasture cover to remain in a feasible zone and the opening and closing average pasture covers remain matched as per the base model.

Reduced pasture intakes and the earlier culling overall reduce milksolids production for the farm, affecting the financial model by reducing costs of less nitrogen fertiliser purchased, freight and application. The earlier culling has a small positive impact on working capital as the cull income is received one month earlier for 80 animals.

6.2.1.2. Area

As per Status Quo

- No physical base model variations.

6.2.1.3. Stock numbers and performance

As per Status Quo, and stocking rate has been held at the same level

- Earlier culling timing: 80 cows cull timing bought forward from 20th April to 15th March.
- This has been done as a mechanism to reduce autumn deposited urine patches and risk of nitrate leaching.
- Drying off date remains the same.

Table 12: Dairy: Scenario 1 Nitrogen Loss Cap - Farmax physical summary comparison.

FARMAX YOUR ADVANTAGE Dairy 7.1.2.41

Compare Physical Summary
Jun 18 - May 19

Category	Description	MfE Dairy	MfE Dairy		Units
		Model Base File	ModelNCapsFile (JG 15 May 19	Difference	
Farm	Effective Area	300	300	0	ha
	Stocking Rate	3.3	3.3	0.0	cows/ha
	Potential Pasture Growth	14.2	14.2	0.0	t DM/ha
	Nitrogen Use	215	177	-39	kg N/ha
	Feed Conversion Efficiency (eaten)	10.6	10.7	0.1	kg DM eaten/kg MS
Herd	Cow Numbers (1st July)	1,030	1,030	0	cows
	Peak Cows Milked	1,000	1,000	0	cows
	Days in Milk	262	259	-2	days
	Avg. BCS at calving	4.9	4.9	0.0	BCS
	Liveweight	1,421	1,421	0	kg/ha
Production	Milk Solids total	434,996	420,630	-14,366	kg
(to Factory)	Milk Solids per ha	1,450	1,402	-48	kg/ha
	Milk Solids per cow	435	421	-14	kg/cow
	Peak Milk Solids production	2.01	2.01	0.00	kg/cow/day
	Milk Solids as % of live weight	102.0	98.7	-3.4	%
Feeding	Pasture Eaten per cow *	3.6	3.5	-0.1	t DM/cow
	Supplements Eaten per cow *	0.4	0.4	0.0	t DM/cow
	Off-farm Grazing Eaten per cow *	0.6	0.6	0.0	t DM/cow
	Total Feed Eaten per cow *	4.6	4.5	-0.1	t DM/cow
Diagnostics	Pasture Eaten per ha	12.0	11.6	-0.3	t DM/ha
	Supplements Eaten per ha	1.5	1.5	0.0	t DM/ha
	Off-farm Grazing Eaten per ha	3.8	3.8	0.0	t DM/ha
	Total Feed Eaten per ha	17.2	16.9	-0.4	t DM/ha
	Supplements and Grazing / Feed Eaten *	23.0	23.4	0.4	%
	Bought Feed / Feed Eaten *	4.2	4.3	0.1	%

(*) feed eaten by females > 20 months old / peak cows milked

6.2.1.4. Crop areas

As per Status Quo

- No physical base model variations.

6.2.1.5. Supplements

As per Status Quo.

Table 13: Dairy: Scenario 1 Nitrogen Loss Cap. Supplementary feed use and allocation.

FARMAX YOUR ADVANTAGE Dairy 7.1.2.41

Supplement Usage Summary for MfE Dairy
Jun 18 - May 19

Feed	tonnes DM offered													kg
	Jun 18	Jul 18	Aug 18	Sep 18	Oct 18	Nov 18	Dec 18	Jan 19	Feb 19	Mar 19	Apr 19	May 19	Total	/milker
F4 Hay/Straw bought		0	20	8									28	28
C2 Fodder Beet											65	131	196	196
F1 Meal and Grains bought		1	13	20	15	30	20		14	14	4		131	131
F2 Pasture Silage		3	60	39								35	136	136
Total													**491**	**491**

- Same feeding levels in autumn months apply, the only difference is the total kilograms of drymatter of supplement per cow which drops by 7.0 kgDM due to the earlier culling.

6.2.1.6. Nitrogen fertiliser

Changes from “Status Quo”:

- Nitrogen fertiliser applications reduced (Table 12) by 17.7 per cent from 215 kilograms nitrogen per hectare in the Status Quo model to 177 kilograms of nitrogen per hectare in the Nitrogen Loss Cap scenario, this has been done as a mechanism to reduce total nitrogen inputs and subsequent leaching risk. April nitrogen application has been removed all together and the balance of the drop is spread evenly over the season’s base applications of nitrogen fertiliser.

6.2.2. Modelling outputs

6.2.2.1. Financial budget summary

Table 14: Budget summary: Dairy: Scenario 1 - Nitrogen Loss Cap.

	Status Quo	**Scenario 1 Nitrogen cap**
Nett Farm Income	$2,911,306	$2,820,769
less Farm Working Expenses	$1,833,772	$1,814,149
gives Earnings Before Interest and Tax	$1,077,534	$1,006,620
less Capital Replacement / Depreciation	$98,375	$98,375
less Interest (on original term debt)	$681,750	$681,750
less Interest (marginal per scenario)	-	$0
less Interest (on working capital)	$4,834	$5,526
gives Taxable Surplus	$292,575	$220,969
less Tax Provision (at 30%)	$87,773	$66,291
gives* Disposable Surplus	**$204,803**	**$154,678**

*Note: No debt/principal repayments are made in these models.

6.2.2.2. Emission results

Table 15: Emission summary: Dairy: Scenario 1 - Nitrogen Loss Cap.

	Status Quo	Scenario 1 Nitrogen cap
Nitrogen		
Total kg	21,017	18,605
kg/ha	66	59
Phosphorus		
Total kg	463	455
kg/ha	1.5	1.4
Greenhouse gases (CO2 equivalent)		
Total kg	5,512,212	5,236,188
kg/ha	17,334	16,466

6.2.3. Discussion

The physical impacts of the Nitrogen Loss Cap scenario are a reduction in total production of 14,366 kilograms of milksolids or 3.3 per cent, the nitrogen leaching is reduced (Table 15) by 2,414 kilograms total (11.5 per cent) down to 59 kilograms nitrogen discharge per hectare. Total phosphorus losses reduce marginally by 1.7 per cent. The efficiency of pasture conversion to milksolids drops marginally while the pasture harvested per cow falls from 3.7 tonnes of drymatter to 3.6 tonnes of drymatter. The financial results (Table 14) of the Nitrogen Cap scenario is a 3.1 per cent reduction in nett income, partially offsetting an 1.1 per cent reduction in Farm Working Expenditure. The overall impact gives a 24 per cent reduction in Disposable Surplus.

These results apply specifically to this case study farm. A farm running a similar system on lighter soils would likely require a greater degree of mitigation, with subsequent greater negative impact on production and profitability expected.

Note there has been no sensitivity testing regards milk price to determine impact of variations in milk income.

6.3. Dairy Support – Scenario 1: Nitrogen Loss Cap

6.3.1. Scenario introduction

Scenario 1 Nitrogen Loss Cap, requires altering the farm system so that a maximum nitrogen discharge of 60 kilograms of nitrogen per hectare is not exceeded.

6.3.2. Farm description

6.3.2.1. General farm

Aspects of the farm system were changed in an attempt to reduce the Status Quo nitrogen discharge from 68 to the 60 kilogram of nitrogen discharge per hectare per annum cap. Most winter feed areas of kale were taken out and replaced with a mixture of extra fodder beet, summer rape and cereal silage and grain. To reduce nitrogen loss, urea use on pasture was significantly reduced and cereal crops were grown after all fodder crops to utilise any surplus nitrogen. These changes meant less cows were able to be grazed on the property, and surplus cereal and pasture silage was sold. It should be noted that some dairy farmers prefer to graze their heifers on kale, so this farm system will not suit everyone as it assumes heifers are fed on fodder beet.

With changes to the farm system the proportion of heifers to cows has altered from the Status Quo of 27 per cent heifers (460 heifers : 1700 cows) to 44 per cent heifers (460 heifers : 1040 cows). Normally if this occurred the dairy farmer would find alternative grazing arrangements, while the grazing property would find extra heifers to graze. However, from an industry perspective all properties could not graze proportionally more heifers and less cows at a national scale. To achieve a reduction in the nitrogen loss on dairy support properties by reducing the number of cows grazed, will require alternative feeding systems for cow wintering, such as wintering barns or feed pads.

The change in proportion of heifers to cows to 27 per cent (Status Quo) to 44 per cent represents 660 less cows than the Status Quo. Based on this analogy these cows would need to be grazed by alternative methods. A full analysis of pad/barn feeding has not been undertaken as part of this project, although scenario 3 integrates a feed barn into the farm system. Given the potential impact of feed barns/pads on the environment and financial viability of dairy or dairy support businesses, it could warrant further investigation in a separate project.

6.3.2.2. Area

Crop policies changes to achieve the nitrogen cap

- 260 hectares are pivot irrigated – 7 year rotation
  - 37.1 ha summer rape (Oct - Apr) – 8 tDM/ha
  - 37.1 ha green chop oat silage (Apr – Sep) – 6 tDM/ha
  - 37.1 ha fodder beet (Oct – Aug) – 23 tDM/ha
  - 37.1 ha barley grain (Sept – Feb) – grain sold (8.5 t/ha) / straw kept (3.5 tDM/ha)
  - Pasture for 4.5 years – Annual production before nitrogen of 13.12 tDM/ha.
- 24 hectares dryland – Corner areas of pivot irrigators – 8 year rotation
  - 3.4 ha summer rape (Oct - Apr) – 7 tDM/ha
  - 3.4 ha green chop oat silage (Apr – Sep) – 5 tDM/ha
  - 3.4 ha fodder beet (Oct – Aug) – 18.5 tDM/ha
  - 3.4 ha barley grain (Sept – Feb) – grain sold (7.5 t/ha) / straw kept (3.0 tDM/ha)
  - Pasture for 4.5 years – Annual production before nitrogen of 8.5 tDM/ha.
- 176 hectares dryland – 7 year rotation
  - 25.1 ha summer rape (Oct - Apr) – 7 tDM/ha
  - 25.1 ha green chop oat silage (Apr – Sep) – 5 tDM/ha
  - 12.6 ha fodder beet (Oct – Aug) – 18.5 tDM/ha

12.5 ha kale (Nov – Aug) – 11.0 tDM/ha

25.1 ha barley grain (Sept – Feb) – grain sold (7.5 tDM/ha) / straw kept (3.0 tDM/ha)

Pasture for 4.5 years – Annual production before nitrogen of 8.5 tDM/ha

Approximately 100 hectares of the dryland area is rolling downs.

- 15 hectares are in-effective.

6.3.2.3. Stock numbers and performance

Changes to livestock numbers compared to the Status Quo areas follows:

- Maintain dairy heifer grazing at 460 head
- Decrease in cow grazing from 1700 head to 1040 head
- Decrease in beef calves from 475 head to 445 head.

6.3.2.4. Supplements

Changes to supplements compared to the Status Quo are as follows:

- Barley straw:

    140 tDM is made on the property

    65 tDM is purchased onto the property.

- Silage:

    50 tDM of surplus pasture is made into baleage

    270 tDM of surplus pasture silage sold

    365 tDM of greenchop oat silage made into pit silage and baleage

    250 tDM of barley whole crop silage sold .

- Barley grain:

    341 t of barley grain sold off farm.

6.3.3. Modelling outputs

6.3.3.1. Financial budget summary

Table 16: Budget summary: Dairy support - Scenario 1 Nitrogen Loss Cap.

	Status Quo	Scenario 1 Nitrogen cap
Nett Farm Income	$1,446,792	$1,365,517
less Farm Working Expenses	$958,792	$914,931
gives Earnings Before Interest and Tax	$488,000	$450,586
less Capital Replacement / Depreciation	$81,800	$81,800
less Interest (on original term debt)	$336,150	$336,150
less Interest (marginal per scenario)	-	$0
less Interest (on working capital)	$14,674	$23,604
gives Taxable Surplus	$55,376	$9,032
less Tax Provision (at 30%)	$16,613	$2,710
gives* Disposable Surplus	**$38,763**	**$6,322**

*Note: No debt/principal repayments are made in these models.

6.3.3.2. Emission results

Table 17: Emission summary: Dairy support - Scenario 1 Nitrogen Loss Cap.

	Status Quo	Scenario 1 Nitrogen cap
Nitrogen		
Total kg	31,364	26,970
kg/ha	68	59
Phosphorus		
Total kg	102	93
kg/ha	0.2	0.2
Greenhouse gases (CO2 equivalent)		
Total kg	4,485,920	3,774,760
kg/ha	9,752	8,206

6.3.4. Discussion

The EBITD (Table 16) is significantly lower than in the Status Quo model, despite the decrease in farm working costs. This is a direct result of reduced grazing income, caused by the reduction in feed produced. Some extra income is received from the sale of both surplus grass silage and barley whole crop silage, but this only partially offsets the reduction in grazing income. Casual labour, repairs and maintenance, vehicle running costs, feed conservation costs and straw purchases have been reduced compared to the Status Quo, to reflect less cows being fed during the winter.

For grass silage sold, extra fertiliser input has been budgeted to compensate for nutrient transfer off farm. However, the sale of other silage (e.g. barley silage) assumes that sufficient fertiliser was applied during the production of the crop.

No consideration has been given to the cost of transferring feed to a feed pad/barn, although it can be assumed this would significantly increase the cost of winter cow grazing.

The decrease in nitrogen loss (Table 17) between the two farm systems is not as large as expected (68 compared to 59 kilograms nitrogen discharge per hectare) considering the significant changes that were implemented and the cost of achieving this.

6.4. Arable / Mixed Cropping – Scenario 1: Nitrogen Loss Cap

6.4.1. Scenario introduction

As agreed in the Scope of Works, no nitrogen cap was to be modelled for the arable mixed cropping system. The reason is that for the majority of farms that this case study farm represents, those farms operate below the scenario of the proposed 60 kg nitrogen per hectare cap.

Note that this arable model includes livestock albeit only to a low relative stocking rate. This model does not include process vegetable / market garden crops. Both these scenarios would likely see an increased nitrate discharge.

7. Results and Discussion – Scenario 2: Livestock Exclusion

The Livestock Exclusion Scenario models the impacts of a five metre exclusion setback, of livestock from intermittent and permanent waterways.

7.1. Red Meat / Hill Country – Scenario 2: Livestock Exclusion

7.1.1. Scenario introduction

The Livestock Exclusion scenario requires the fencing-off of all intermittent (note not ephemeral) and permanent water courses with a five metre setback. Due to the steep contour of 70 per cent of this hill country case study farm, the setbacks of streams in the upper reaches are up to 375 metres in some places, with the average setback being 22.7 metres.

Stock exclusion fencing for both sheep and cattle in steep blocks requires a bulldozer to clear a path to install a fence, the installation of a multi-wire or netting fence, the installation of a reticulated stock water system (to replace the streams that the livestock were drinking from), and land stabilisation in some places.

To achieve the Livestock Exclusion scenario, this property would require:

- 30,492 metres of sheep proof fencing
- 4600 lineal metres of land stabilisation above proposed fence lines with poplar poles
- 5.26 hectares of wetland re-vegetation
- 9583 metres of stock water pipe installed (including excavator)
- 7 tank sites installed for stock water reticulation (tanks and excavation)
- 31 stock water troughs installed for stock water reticulation.

The total direct capital expenditure on fencing, revegetation of wetlands, reticulated stock water installation and land stabilisation to meet the Stock Exclusion scenario requirements is calculated to be $1,370,981.

The total cost of stock exclusion to this property is compounded by a reduction in productive land to riparian plantings. The lost land value is calculated to be $182,400 (based on 53 hectares of land fenced off to riparian margins that would have been carrying a further 152 stock units valued at $1200 per stock unit).

It may be both practical and economically feasible to consider stock exclusion from only land management units that carry a higher stocking intensity (further discussion 7.1.3.1.).

7.1.1.1. Land

545 hectares effective area. Read these figures in conjunction with the Interim Report 1 Status Quo figures.

- 373 ha tussock hill (steep)
- 68 ha developed downs (Figure 10)

    - 5.8 ha forage rape (winter)
    - 5.8 ha forage leafy turnip (summer)
    - 56.4 ha pasture.
- 104 ha easy to flat paddocks
    - 24 ha dryland
        - 4 ha lucerne
        - 20 ha pasture
    - 30 ha sprinkler irrigation (Figure 11)
        - 6 ha forage rape (multi-graze summer/winter)
        - 6 ha forage rape (winter)
        - 6 ha annual ryegrass
        - 18 ha pasture
    - 50 ha centre pivot irrigation (Figure 12)
        - 7 ha forage oats and grass (winter)
        - 7 ha fodder beet
        - 7 ha forage rape (summer)
        - 36 ha pasture.
- 53 ha newly ineffective land resulting from setbacks
    - 47 ha was in tussock hill
        - 3.7 ha wetlands
        - 43.3 ha stream setbacks
    - 2 ha was in developed downs
        - 2.0 ha stream setbacks
    - 4 ha was in easy to flat paddocks
        - 1.6 ha wetlands
        - 2.4 ha stream setbacks.

7.1.1.2. Crop rotations

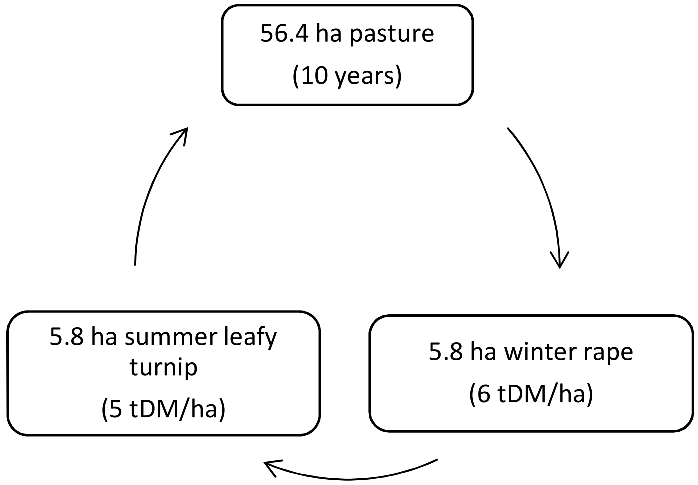


Figure 10: Red meat / hill country: Scenario 2 Stock Exclusion. Developed downs crop rotation.

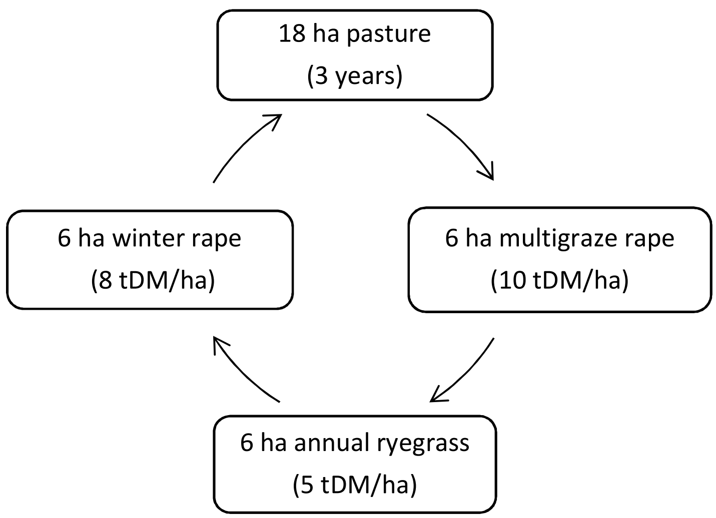


Figure 11: Red meat / hill country: Scenario 2 Stock Exclusion. Sprinkler paddocks crop rotation unchanged from the Status Quo farm operation.

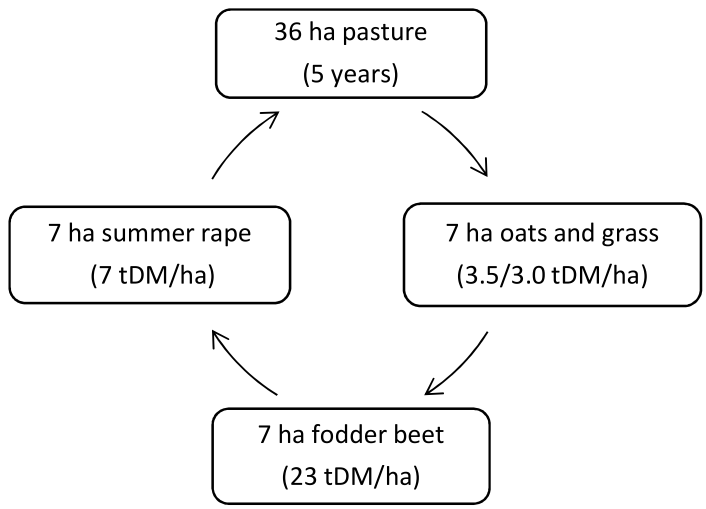


Figure 12: Red meat / hill country: Scenario 2 Stock Exclusion. Centre pivot paddocks crop rotation unchanged from the Status Quo farm operation.

7.1.1.3. Stock numbers and performance

Cattle (unchanged compared to the Status Quo model):

- 160 cows including first calving heifers (calving 1 August at 94%, finishing progeny)
- 30 R2 heifers mated
- 45 R2 heifers sold (30 sold store in October at 315 kg liveweight; 15 sold in March at 266 kg carcass)
- 75 R1 heifers weaned and wintered
- 75 R1 bulls weaned and wintered
- 75 R2 bulls sold (30 sold in October for breeding; 45 sold in March to June at 285 kg carcass)
- 5 breeding bulls.

Sheep (reduced all classes by 7% relative to Status Quo):

- 1023 ewes (lambing 5 September at 150%, 13% weaning draft to works, remainder finished to 18.5 kg carcass February to May)
- 279 ewe lambs kept as replacements (lambing 10 September at 71%, lambs finished to 18.5 kg carcass February to May)
- 326 traded lambs bought in and finished
- 14 rams.

7.1.1.4. Supplementary feed

25 tonnes drymatter pasture and lucerne silage made, and fed on crops over winter.

7.1.1.5. Commentary

The farm owners and managers assert that the practical limitations of excluding cattle (and consequently all stock) from all water courses on this property, would require them to retire approximately 50 per cent of their hill block. The managers note it would likely be unfeasible to economically manage the stock and land from a practical point of view. Notwithstanding probable impracticality, for the purposes of this exercise, the farmers and consultant elected to assume that all remaining land would still be possible to farm, with no additional labour.

A large proportion of the area reserved for riparian margin in the tussock hill block has been identified as only 50 per cent productive as the remainder of the block. It has been assumed that the productivity of the remaining area, increases by 6 per cent to compensate for unproductive areas previously farmed.

There are additional indirect costs (in excess of the direct cost of infrastructure investment) to this property that would be incurred by fencing off water courses. If less land is available to be farmed, the stocking rate is reduced, profitability is reduced, therefore the land value is less. With riparian areas allocated mainly in the hill block where ewes are typically run in conjunction with cattle, the sheep stock numbers were reduced by 7 per cent (both breeding and trading numbers) to ensure the system is physiologically viable.

The additional debt required to exclude stock completely from water courses on steep hill blocks makes this property economically unviable. However, if water courses were only required to be fenced off where stocking rates were at a higher intensity, the cost of the setback fencing and re-vegetating wetlands would reduce to $261,993. The cost of only fencing the high stocking intensity areas is still a very big increase in debt servicing for the business, but much more financially and physically viable than fencing off all water courses in low stocking rate parts of the farm.

A summary of development costs and depreciation are as follows:

Land stabilisation with poplar poles:	$20,700
Wetland re-vegetation:	$416,592
Fencing and fence line clearing:	$650,205
Stock water reticulation in hill blocks:	$283,484
TOTAL:	$1,370,981

7.1.2. Modelling outputs

7.1.2.1. Financial budget summary

Table 18: Budget summary: Red Meat / Hill Country - Scenario 2 Stock Exclusion.

	Status Quo	Scenario 1 Nitrogen cap	Scenario 2 Stock exclusion
Nett Farm Income	$380,922	n.a.	$364,957
less Farm Working Expenses	$274,065	n.a.	$294,209
gives Earnings Before Interest and Tax	$107,031	n.a.	$70,748
less Capital Replacement / Depreciation	$37,750	n.a.	$57,459
less Interest (on original term debt)	$43,578	n.a.	$43,578
less Interest (marginal per scenario)	-	n.a.	$91,446
less Interest (on working capital)	$4,015	n.a.	$9,474
gives Taxable Surplus	$21,688	n.a.	-$131,209
less Tax Provision (at 30%)	$6,506	n.a.	$0**
gives* Disposable Surplus	**$15,182**	**n.a.**	**-$131,209**

*Note: No debt/principal repayments are made in these models.

**Note: Assume no tax refund, as the business has become unsustainable.

7.1.2.2. Emission results

Table 19: Emission summary: Red Meat / Hill Country - Scenario 2 Stock Exclusion.

	Status Quo	Scenario 1 Nitrogen cap	Scenario 2 Stock exclusion
Nitrogen			
Total kg	11,588	n.a.	10,891
kg/ha	19	n.a.	18
Phosphorus			
Total kg	260	n.a.	140
kg/ha	0.4	n.a.	0.2
Greenhouse gases (CO2 equivalent)			
Total kg	2,507,414	n.a.	2,515,786
kg/ha	4,193	n.a.	4,207

7.1.3. Discussion

While the Earnings Before Interest Tax and Depreciation (EBITD) has reduced by 34 per cent (Table 18) relative to the Status Quo model, the debt has increased threefold from $200 per stock unit wintered ($645,600 total debt servicing), to $642 per stock unit wintered ($2,000,351) in the Stock Exclusion model. The resulting debt servicing has lifted from $14.70 per stock unit, to $46.40 per stock unit (316 per cent increase), evaporating all of the EBITD. Even if the status quo farm held no debt to begin with, which is uncommon, there would be insufficient EBITD to cover all the new Stock Exclusion fencing.

It is not economically viable to fence off all waterways and wetlands on hill country properties.

The increase in riparian plantings and reduction in stock carried has improved nitrogen losses (Table 19) by only 697 kilograms (1 kilogram of nitrogen per hectare per year). The riparian plantings and fencing off of waterways has reduced phosphorus losses by 42 per cent or 0.2 kilograms per hectare per year.

7.1.3.1. Option of setbacks only on higher stocking rate land management units

It may be both practical and economically feasible, to consider stock exclusion from only land management units that carry a higher stocking intensity.

Our assumption is that intensive stock grazing is classed as land capable of being re-pastured to improved species, therefore capable of providing a stock carrying capacity of 7.5 stock units per hectare (su/ha). A breakdown of the capital expenditure, depreciation and annual maintenance split between intensive (greater than or equal to 7.5 stock units per hectare) and extensive (less than 7.5 stock units per hectare) is detailed in Tables 20 and 21.

Table 20: Breakdown of costs associated with livestock exclusion on extensive land management units.

Land Class: Stocking intensity <7.5 su/ha			
	Capital Cost	**Depreciation**	**Maintenance**
Land Stabilisation	$17,100	$855	$2,454
Wetland Planting	$290,664	$0	$0
Water Course Fencing	$399,984	$8,000	$8,000
Stock Water Scheme	$255,086	$5,102	$6,377
TOTAL	**$962,834**	**$13,956**	**$16,831**

Table 21: breakdown on costs associated with livestock exclusion on intensive land management units.

Land Class: Stocking intensity ≥7.5 su/ha			
	Capital Cost	**Depreciation**	**Maintenance**
Land Stabilisation	$3,600	$180	$517
Wetland Planting	$125,928	$0	$0
Water Course Fencing	$250,221	$5,004	$5,004
Stock Water Scheme	$28,399	$568	$710
TOTAL	**$408,148**	**$5,752**	**$6,231**

7.2. Dairy – Scenario 2: Livestock Exclusion

7.2.1. Scenario introduction

The Stock Exclusion scenario requires the fencing-off of all intermittent (note not ephemeral) and permanent water courses with a five metre setback. The property has 3 main streams / waterways with a combined total length of 5,103 metres. For simplification of calculations and to determine the maximum potential impact of the proposed NES regulation it has been assumed existing fencing of waterways is on the bank edge and the full 5-metre setback area applies for the full waterway length.

7.2.2. General farm

Overall the scenario changes are a loss of 4.8 effective hectares of irrigated grazed dairy platform, correspondingly 16 less cows milked. No changes in irrigation shares or charges are factored in as the practical consequence would likely be to retain and use full existing water supply over marginally reduced (-1.6 per cent) overall irrigated area.

Additional fencing has been costed in at market rates to add the new 5 metre setback fences from waterways which totals to $58,957 (see appendices) and is added in as new lending at the Status Quo interest rate of 6.75 per cent.

7.2.3. Area

Total area as per the Status Quo model

- Effective area changes:
  - Minus (–) 4.8 ha total area taken up by 5 metre setback on waterways through the property:
    - – 1.9 ha on flat Darnley soils blocks (Stream 1)
    - – 1.3 ha on flat Rakaia soils block (Stream 2)
    - – 1.6 ha on hill Timaru Hill soils block (Stream 3)
  - Total stream length 5103 metres combined through property:
    - Area lost is less than 5103 x 10 metres as some length of waterways are on boundary and the effective area lost is only 5 metres one side for this length.
    - Is currently fenced existing (per GMP) but at 1-2 metre variable setbacks, assume new fencing replaces this and it is also assumed the full 5 metres each side of the watercourse comes off effective area.

7.2.4. Stock numbers and performance:

Stocking rate on effective area held - as per the base Status Quo modelled stocking rate

- 1000 cows / 300 hectare effective base file area = 3.3 cows per hectare (Table 22)
- 984 cows /295.2 hectare effective Stock Exclusion file area = 3.3 cows per hectare
- Per cow production held at same level of 435 kgMS per cow
- Total production reduces to 428,370 kgMS .

Table 22: Dairy: Scenario 2 – Stock Exclusion. Farmax physical summary comparison between Status Quo and Scenario 2.

FARMAX YOUR ADVANTAGE Dairy 7.1.2.41

Compare Physical Summary
Jun 18 - May 19

Category	Description	MfE Dairy Model Base File	MfE Dairy Stock Exclusion	Difference	Units
Farm	Effective Area	300	300	0	ha
	Stocking Rate	3.3	3.3	-0.1	cows/ha
	Potential Pasture Growth	14.2	14.2	0.0	t DM/ha
	Nitrogen Use	215	215	0	kg N/ha
	Feed Conversion Efficiency (eaten)	10.6	10.6	0.0	kg DM eaten/kg MS
Herd	Cow Numbers (1st July)	1,030	1,014	-16	cows
	Peak Cows Milked	1,000	984	-16	cows
	Days in Milk	262	262	0	days
	Avg. BCS at calving	4.9	4.9	0.0	BCS
	Liveweight	1,421	1,399	-22	kg/ha
Production	Milk Solids total	434,996	428,370	-6,626	kg
(to Factory)	Milk Solids per ha	1,450	1,428	-22	kg/ha
	Milk Solids per cow	435	435	0	kg/cow
	Peak Milk Solids production	2.01	2.01	0.00	kg/cow/day
	Milk Solids as % of live weight	102.0	102.1	0.0	%
Feeding	Pasture Eaten per cow *	3.6	3.6	0.0	t DM/cow
	Supplements Eaten per cow *	0.4	0.4	0.0	t DM/cow
	Off-farm Grazing Eaten per cow *	0.6	0.6	0.0	t DM/cow
	Total Feed Eaten per cow *	4.6	4.6	0.0	t DM/cow
Diagnostics	Pasture Eaten per ha	12.0	11.8	-0.2	t DM/ha
	Supplements Eaten per ha	1.5	1.5	0.0	t DM/ha
	Off-farm Grazing Eaten per ha	3.9	3.9	0.0	t DM/ha
	Total Feed Eaten per ha	17.3	17.1	-0.2	t DM/ha
	Supplements and Grazing / Feed Eaten *	23.1	23.1	0.0	%
	Bought Feed / Feed Eaten *	4.2	4.2	0.0	%

(*) feed eaten by females > 20 months old / peak cows milked

7.2.5. Crop areas

As per Status Quo. No variation applied to fodder beet area as too small a change in cow numbers to warrant this.

7.2.6. Supplementary feed

Similar per cow feeding rates as per Status Quo:

- Slight lift in fodder beet rate (Table 23) and corresponding drop in silage May fed rates.

Table 23. Dairy: Scenario 2 Stock Exclusion. Farmax summary of supplementary feed use.

FARMAX YOUR ADVANTAGE Dairy 7.1.2.41

Supplement Usage Summary for MfE Dairy
Jun 18 - May 19

Feed	tonnes DM offered													kg
	Jun 18	Jul 18	Aug 18	Sep 18	Oct 18	Nov 18	Dec 18	Jan 19	Feb 19	Mar 19	Apr 19	May 19	Total	/milker
F4 Hay/Straw bought		0	20	7									27	28
C2 Fodder Beet											67	132	199	202
F1 Meal and Grains bought		1	13	20	15	30	20		13	15	5		131	133
F2 Pasture Silage		3	59	39								32	133	135
Total													**490**	**498**

- 131 tDM cereal grain bought in and fed in dairy shed.
- 133 tDM pasture silage (27 tDM of which is made on platform) fed in season shoulders.
- 199 tDM fodder beet grown and fed to milking and dry cows in autumn.

7.2.7. Modelling outputs

7.2.7.1. Financial budget summary

Table 24. Budget summary: Dairy - Scenario 2 Stock Exclusion.

	Status Quo	Scenario 1 Nitrogen cap	Scenario 2 Stock exclusion
Nett Farm Income	$2,911,306	$2,820,769	$2,867,927
less Farm Working Expenses	$1,833,772	$1,814,149	$1,817,436
gives Earnings Before Interest and Tax	$1,077,534	$1,006,620	$1,050,491
less Capital Replacement / Depreciation	$98,375	$98,375	$98,375
less Interest (on original term debt)	$681,750	$681,750	$681,750
less Interest (marginal per scenario)	-	$0	$3,980
less Interest (on working capital)	$4,834	$5,526	$5,876
gives Taxable Surplus	$292,575	$220,969	$260,510
less Tax Provision (at 30%)	$87,773	$66,291	$78,153
gives* Disposable Surplus	**$204,803**	**$154,678**	**$182,357**

*Note: No debt/principal repayments are made in these models.

7.2.7.2. Emission results

Table 25. Emission summary: Dairy - Scenario 2 Stock Exclusion.

	Status Quo	Scenario 1 Nitrogen cap	Scenario 2 Stock exclusion
Nitrogen			
Total kg	21,017	18,605	20,450
kg/ha	66	59	64
Phosphorus			
Total kg	463	455	453
kg/ha	1.5	1.4	1.4
Greenhouse gases (CO2 equivalent)			
Total kg	5,512,212	5,236,188	5,408,544
kg/ha	17,334	16,466	17,008

7.2.8. Discussion

The physical impacts of the Stock Exclusion scenario (compared to Status Quo) are a reduction in total production of 6,626 kilograms of milksolids or 1.5 per cent. Nitrogen leaching is reduced (Table 25) by 567 total kilograms or 2.7 per cent. Total phosphate losses reduce by 2.1 per cent. Greenhouse gases decrease by 3 percent as measured in CO2 equivalents. The financial results of the stock exclusion scenario (Table 24) are a 1.5 per cent reduction in net income, this partially offset by an 0.9 per cent reduction in farm working expenditure - farm working expenditure dropped only marginally with less variable inputs however fixed costs and overheads remained the same. The overall impact gives a 11 per cent reduction in disposable surplus.

There has been no sensitivity to milk price tested to determine impact of variations in milk income.

7.3. Dairy Support – Scenario 2 - Livestock Exclusion

7.3.1. Scenario introduction

Scenario 2 - Stock Exclusion, requires the fencing off of all permanent and intermittent (but not ephemeral) water ways with a five metre set back. The impact of this on feed and livestock production, capital costs, farm profitability and nitrogen and phosphorous discharge has been modelled. Three wire electric fencing has been used to contain the small calves that are farmed.

7.3.1.1. General farm

The case study farm is predominantly flat, with relatively few waterways at only 1750 meters of streams. MRB decided to scale up the length of waterways on the modelled farm so that livestock exclusion area was at least one per cent of the farm area. An exclusion of 5390 lineal metres of streams was modelled with five metres from the bank on each side of the waterway fenced off from cattle. 2570 metres of stream was considered to run through irrigated farmland and 2820 metres through dryland. It is likely that other properties with more undulating terrain in different localities will have a greater proportion of waterways to exclude livestock from. Note that on properties where steeper topography or meandering streams are present, the stock exclusion area will be larger than ten metres as it is difficult and expensive to get the fence uniformly five metres from the stream.

It is assumed that the streams on the irrigated part of the modelled farm have been contoured to fit with the centre pivots, such that crossings required for livestock are minimal (three crossings). However, given a large proportion of the dryland (100 hectares) is modelled as rolling downs, there are a greater number of livestock crossings required (7 crossings).

No provision for retrofitting of Variable Rate Irrigation (VRI) systems, to prevent irrigating the livestock exclusion zones, has been budgeted.

Given the land adjoining the streams is already well established in pasture, no additional riparian planting of the livestock exclusion zones has been budgeted.

The reduction of 5.4 hectares of effective farmland, due to livestock exclusion, has resulted in only moderate reductions in productivity.

7.3.1.2. Area

The 5.0 metre setback scenario leads to a decrease of effective farmed area of 2.6 hectares and 2.8 hectares of irrigated and dryland respectively. There has been minimal impact on the cropping rotation and areas in pasture compared to the Status Quo scenario.

- 260 hectares are pivot irrigated – 8 year rotation. Each crop reduced by 0.3 hectares:
  - 32.2 ha fodder beet (Oct – Aug) – 23 tDM/ha
  - 32.2 ha green chop cereal silage (Sept – Dec) – 6 tDM/ha
  - 32.2 ha kale (Jan – Aug) – 12 tDM/ha
  - 32.2 ha barley grain (Sept – Feb) – grain sold (8.5 t/ha) / straw kept (3.5 tDM/ha)
  - 2.6 ha new setback / livestock exclusion
  - Pasture for 5.5 years – Annual production before nitrogen of 13.12 tDM/ha.
- 24 hectares dryland – Corner areas of pivot irrigators – 8 year rotation:
  - Unchanged from Status Quo.
- 176 hectares dryland – 7 year rotation:
  - 24.7 ha kale (Nov – Aug) – 11 tDM/ha
  - 24.7 ha fodder beet (Oct – Aug) – 18.5 tDM/ha
  - 24.7 ha summer rape (Oct – Apr) – 8 tDM/ha
  - 2.8 ha new setback / livestock exclusion
  - Pasture for 4.5 years – Annual production before nitrogen of 8.5 tDM/ha
  - Approximately 100 hectares of the dryland area is rolling downs.
- 15 hectares are in-effective.

7.3.1.3. Stock numbers and performance

Changes to livestock numbers are minimal as follows:

- Decrease in dairy heifer grazing from 460 head to 455 head
- Decrease in cow grazing from 1700 head to 1680 head
- Decrease in beef calves from 475 head to 469 head.

7.3.1.4. Supplements

Small reduction regards supplementary feeds:

Barley straw

- 122 tDM is made on the property
- 188 tDM is purchased onto the property.

Silage

- 292 tDM of surplus pasture is made into both pit silage and baleage
- 205 tDM of green chop cereal silage.

Barley grain

- 296 t of barley grain sold off farm.

7.3.2. Modelling outputs

7.3.2.1. Financial budget summary

Table 26. Budget summary: Dairy support - Scenario 2 Stock Exclusion.

	Status Quo	**Scenario 1 Nitrogen cap**	**Scenario 2 Stock exclusion**
Nett Farm Income	$1,446,792	$1,365,517	$1,430,222
less Farm Working Expenses	$958,792	$914,931	$948,822
gives Earnings Before Interest and Tax	$488,000	$450,586	$481,400
less Capital Replacement / Depreciation	$81,800	$81,800	$81,800
less Interest (on original term debt)	$336,150	$336,150	$336,150
less Interest (marginal per scenario)	-	$0	$6,169
less Interest (on working capital)	$14,674	$23,604	$15,183
gives Taxable Surplus	$55,376	$9,032	$42,098
less Tax Provision (at 30%)	$16,613	$2,710	$12,629
gives* Disposable Surplus	**$38,763**	**$6,322**	**$29,469**

*Note: No debt/principal repayments are made in these models.

7.3.2.2. Emission results

Table 27. Budget summary: Dairy support - Scenario 2 Stock Exclusion.

	Status Quo	Scenario 1 Nitrogen cap	Scenario 2 Stock exclusion
Nitrogen			
Total kg	31,364	26,970	31,016
kg/ha	68	59	67
Phosphorus			
Total kg	102	93	101
kg/ha	0.2	0.2	0.2
Greenhouse gases (CO2 equivalent)			
Total kg	4,485,920	3,774,760	4,460,620
kg/ha	9,752	8,206	9,697

7.3.3. Discussion

EBITD is reduced by approximately $6,600 (Table 26) from the Status Quo, despite the relatively small reduction in productive area, compared to Status Quo. However, the $91,397 capital investment for fencing-off waterways results in increased debt servicing of $6169 per annum. Note that properties with a greater presence of streams and more difficult fencing topography, would incur higher fencing costs and may have proportionately higher land area excluded from livestock production.

Fencing costs were based on three wire electric fences at an erected cost of $6.50 and $7.00 per metre on the irrigated and dryland areas respectively. Additional costs accounted for are: irrigator tie downs, access to excluded areas via bungy gates, and installation of culverts for livestock crossings. A summary of the livestock exclusion cost is as follows:

Fencing costs	$74,190
Pivot crossing tie downs	$2,520
23 gates (bungy cord)	$1,587
10 x 300 mm culverts	<u>$13,100</u>
Total Cost	$91,397

The Overseer nutrient budget model reports a slight decrease (Table 27) of nitrogen discharge (compared to the Status Quo analysis) and no difference in phosphorus discharge on a per hectare basis. Table 27 describes small reductions calculated for both nitrogen and phosphorus on the total farm basis. This result is likely due the same per hectare production (hence same discharge per hectare), but on less hectares.

7.4. Arable Mixed Cropping – Scenario 2: Livestock Exclusion

7.4.1. Scenario introduction

Changes have been made to the farm system as per the Scenario 2 – Stock Exclusion.

Stock exclusion for this case study Arable Mixed Cropping farm predominantly means fencing setbacks from the many waterways. Status Quo fences are at the shoulders/apex of the banks of the waterways which represent the 'high-tide' mark when the waterways are at full flow. The new scenario fences are at a setback 5.0m from the Status Quo fences.

All new setback fences are permanent netting fences therefore are lamb and calf proof (being the stock classes in this case study). Temporary fences are not valid as i) The continual rotation of crops means livestock graze 60% of the farm during the year anyway, ii) The fences are not in straight lines but follow meandering waterways meaning setting up temporary fences is very slow, iii) temporary electric netting lamb proof fencing is laborious, more so when continually erecting/dismantalling. These reasons mean that practically the fences have to be permanent.

There are no wetlands on the property.

The 5.0 metre setbacks get drilled with a grass-mix and left to grow rank as a riparian buffer, while preventing establishment of weeds that will cross-contaminate the in-paddock (pure) seed crops that are being produced by the farm. (Even then grass seed growers will be nervous about a dense strip of other grasses being left rank alongside a seed crop).

7.4.1.1. Area

Effective area changed due to the 5.0 metre setback reducing the productive area of the farm by 7.2 hectares.

Total area modelled remains at 348 hectares total, made up of:

- 315 irrigated hectares reduced to 308 hectares flat land (approximately two-thirds pivot irrigators, one-third travelling irrigators, shallow wells)
- 10 dryland hectares reduced to 9.8 hectares dryland, flat land
- 23 hectares increased to 30.2 hectares in-effective / non-productive
- Soil types:
    - 220 ha (approximately two-thirds) of the area classified as Prebbleton silt loam (Prebb_5a.1)
    - 105 ha (approximately one-third) of the area classified as Wakanui silt loam (Wakanui_27a.1)
- Mean annual rainfall 544 millimetres per annum
- Annual potential evapotranspiration 877 millimetres per annum.

7.4.1.2. Pasture

The 'pasture' description remains as per the Status Quo. Whilst there is no permanent pasture:

- Lambs and calves mostly graze (approximately 176 hectares, varying throughout the year) ryegrass seed and white clover seed crops. Although there is no grazing off those seed crops when they are closed for seed production.

- 9.8 hectares of lucerne is also used in the non-winter months for grazing and one baleage cut.

7.4.1.3. Crop areas and yields

Crop areas reduced due to the 5.0 metre fencing setback. 325 hectares reduced to 317.8 hectares effective farm area:

- Irrigated area reduced by 7 hectares, equating to 1 hectare per crop less, in the 7 year rotation i.e. 45 to 44 hectares per crop.

308 hectares irrigated, flat land:

Seven year crop rotation (Figure 13) and per hectare yields remain the same as the Status Quo model:

44 ha Italian ryegrass seed crop

44 ha Garden seed peas

44 ha Autumn sown feed wheat

14.7 ha Linseed (for food grade oil)

14.7 ha Sunflower (for food grade oil)

14.7 ha Hemp (for food grade oil)

44 ha Spring sown malting barley

44 ha White clover seed crop

44 ha Winter sown milling wheat.

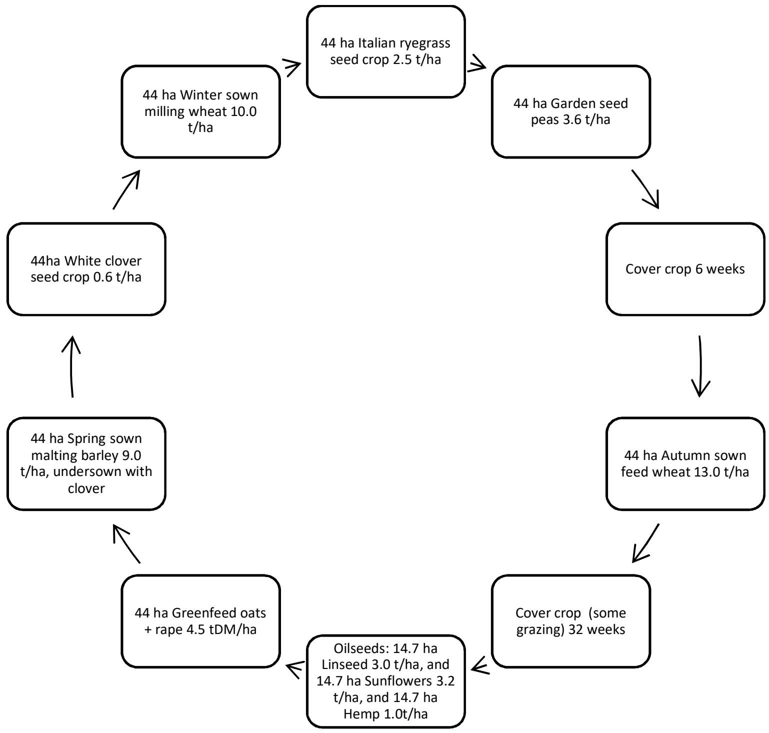


Figure 13: Arable mixed cropping 7 year crop rotation, now reduced to 44 hectares blocks as an outcome of the 5.0 metre fencing setbacks, reducing effective farm area.

- 10 hectares of dryland (flat land) was reduced to 9.8 hectares due to the 5.0 metre setback:

  9.8 ha lucerne.

7.4.1.4. Stock numbers and performance

Livestock numbers were reduced due to the 5.0 metre setback reducing effective farm area. Individual per head performance remained the same:

Sheep numbers remain the same:

- 2100 trading lambs purchased 15th March at 30 kg per head liveweight
- 2800 trading lambs purchased 15th April at 31 kg per head liveweight
- 4802 trading lambs sold to meat works, drafting throughout May to August at 19.6 to 24.9 kg per head carcase weight.

Cattle numbers decrease:

- 210 reduced to 190 dairy heifer calves, arrive 15th February at 120 kg per head liveweight (five months old), transferred back to dairy farm on 30th June at 148 kg liveweight (nine months old).

7.4.1.5. Supplements

Pasture baleage made and sold in the Arable Status Quo model was marginally too high. This point was not realised before presenting the Interim Report 1. The amendment has been made in each model. The affect on the overall analysis is very minimal. Figures below are correct.

Due to the 5.0 metre setbacks reducing effective farm area, less supplementary feed is made, and consequently less is sold.

Still no supplementary feed purchased, as the farm is self-sufficient regards feed.

- All wheat, barley and ryegrass straw is chopped/spread/retained at harvest. None is baled.
- 540 reduced to 528 bales of pasture baleage @ 250 kilograms drymatter per bale, are made on farm
    - 263 reduced to 253 bales are used on farm (less cattle)
    - 277 reduced to 275 bales are sold.
- 120 reduced to 118 bales of lucerne baleage @ 250 kilograms drymatter per bale, are made on farm
    - All lucerne used on farm – none is sold.

7.4.2. Modelling outputs

7.4.2.1. Financial budget summary

EBITD decreases (Table 28) $19,113, while marginal capital for the cost of creating 5.0m setbacks is $124,720 leading to marginal interest of $8,419 per annum. The impact is decrease of $19,597 of disposable surplus leading to virtually a breakeven financial scenario.

Table 28: Budget summary: Arable mixed cropping - Scenario 2 Stock Exclusion.

	Status Quo	**Scenario 1 Nitrogen cap**	**Scenario 2 Stock exclusion**
Nett Farm Income	$1,534,634	n.a.	$1,502,834
less Farm Working Expenses	$969,222	n.a.	$956,535
gives Earnings Before Interest and Tax	$565,412	n.a.	$546,299
less Capital Replacement / Depreciation	$218,200	n.a.	$218,200
less Interest (on original term debt)	$296,156	n.a.	$296,156
less Interest (marginal per scenario)	-	n.a.	$8,419
less Interest (on working capital)	$22,117	n.a.	$22,622
gives Taxable Surplus	$28,939	n.a.	$902
less Tax Provision (at 30%)	$8,682	n.a.	$271
gives* Disposable Surplus	**$20,257**	**n.a.**	**$631**

*Note: No debt/principal repayments are made in these models.

7.4.2.2. Emission results

Total nitrogen and phosphate loads are reduced (Table 29) due to less hectares being in production.

Table 29: Emission summary: Arable mixed cropping - Scenario 2 Stock Exclusion.

	Status Quo	Scenario 1 Nitrogen cap	Scenario 2 Stock exclusion
Nitrogen			
Total kg	8,381	n.a.	8,184
kg/ha	24	n.a.	24
Phosphorus			
Total kg	178	n.a.	174
kg/ha	0.5	n.a.	0.5
Greenhouse gases (CO2 equivalent)			
Total kg	2,117,232	n.a.	2,078,604
kg/ha	6,084	n.a.	5,973

7.4.3. Discussion

7.4.3.1. Setback discussion

This anonymous farm was chosen as a case study farm, due to the significant number of waterways on the property. Many paddocks have at least one fenceline adjacent to a waterway. This *coastal* farm does have a high proportion of *natural* waterways relative to a typical *mid-Plains* Canterbury arable farm which tend to have relatively more *man-made* waterways, albeit many coastal Canterbury properties do have different types of waterways. This farm does fairly represent many farms along coastal Canterbury and Lake Ellesmere surrounds also.

In the Status Quo state, the farm presently has all waterways fenced off (therefore livestock are excluded). The fences are on the shoulders of the banks, of the waterways.

An arable farm system would usually cultivate each hectare annually. When a new setback is fenced, the 5.0 metre strip of land would be in a harvested state ready for a new crop to be sown. Rather than very expensive shrub/tree plantings, it is envisaged (arable especially) farms would sow a grass-herb (no nitrogen fixing legumes) permanent riparian setback. These small seeds could be established using a common seeding drill within the width of the setback, before the new fence is erected.

If, the setback was planted with (native) type shrub/tree species the cost would be in the vicinity of $3.70 to $7.50 per square meter, or $37-75,000 per hectare over 7.2 hectares equals say $400,000 capitalised at 6.75 percent interest = $27,000 interest-only. On top of removing productive land, such costs would meet strong pushback from landowners. Farms like the case study farm simply could not afford to do this based on cashflow. A financier would not lend on the Arable Scenario 2 budget (given it is breakeven with no principle being paid down) even before any impacts of setbacks were considered.

Preparation and fencing of setback creates increased long term debt of $124,720, leading to additional interest of $8,419 per annum, placing further pressure on cashflow.

Research suggests (Parkyn, 2004) that grass-based setbacks are effective at filtering surface runoff (nutrients and sediment), likely due to i) the grass having a dense root and shoot mass, ii) shrub type buffer strips tend to have a lot of bare soil, or low-density weeds, in between the plants where surface water channels establish.

7.4.3.2. Financial discussion

The effect of 7.2 hectares less production/income leads to $31,000 less income (Table 28), in turn leading to a bottomline disposable surplus of merely $660. Due to these financial models being of a cyclical steady-state type representing year-on-year, it would be unsustainable for such a farm only to have a breakeven bottomline. A crucial note is that no mortgage principle is being paid down in the financial models in this project. Moreover, it should have been noted in the Status Quo commentary, that this case study farm has an affordable shallow well water source. In contrast a large proportion of irrigated Canterbury farms source water from significantly more expensive irrigation schemes. If this case study farm employed irrigation scheme water, in effect the Status Quo financials would run at an unsustainable cash deficit.

The Status Quo commentary stated that the case study farm actually represents (regards EBITD *on a per hectare basis*) toward the top 10 per cent of similar type farm systems in Canterbury.

The Status Quo Arable financial model has a typical (Canterbury arable) mortgage debt of $13,500 per hectare. The once productive 7.2 hectares of land, that becomes unproductive in setback, still has $97,200 owing to the financier, that will instead need to be subsidised from other productive hectares (that themselves are only breakeven, whilst not paying down any principle). Furthermore the market value of these 7.2 hectares suddenly falls from approximately $40,000 per hectare on this case study farm, down to a negligible value (as it does not yield any income). In effect, the 7.2 hectares would be in a negative equity situation.

7.4.3.3. Nutrient discussion

The Overseer nutrient budget model reports no difference (compared to the Status Quo analysis) for nitrogen or phosphorus discharge on a per hectare basis, while a reduction is seen on a sum-total farm basis (Table 29). This result is likely due the same per hectare production (hence same discharge per hectare), but on less hectares.

8. Results and Discussion – Scenario 3: Land Intensification

Land Intensification considers a range of scenarios that typically increase/maintain production, while trying to decreasing/maintaining nitrogen and phosphate losses. The dairy and dairy support farms have two Scenarios each.

8.1. Red Meat / Hill Country – Scenario 3: Land Intensification – Without increasing nitrogen and phosphorus discharge

8.1.1. Scenario introduction

The Red Meat / Hill Country property is 82 per cent rolling to steep contour that is at risk of becoming summer dry. Only 18 per cent of the total land area has a more reliable feed growth profile, incorporating 80 hectares of irrigation.

To increase the productivity of this property, this Intensification Scenario focuses on increased forage and silage cropping to both grow more total feed on the property and provide that feed in the summer and winter months. The Status Quo model manages the pasture feed deficit over the summer and winter months by employing some forage cropping and a livestock policy that results in a reduced stocking rate over these months.

To further intensify the property, the Intensification Scenario has focused on increasing carcass weight produced by 20 per cent, while maintaining or reducing nitrogen and phosphorus losses, and maintaining or improving profitability.

By reducing ewe numbers by 25 per cent, and feeding grain, modelling suggests that lambing could increase to 160 per cent (from 150 per cent per cent in the Status Quo model), with all lambs finished by end of March rather than end of May in the Status Quo model. To replace the ewes, 40 trading beef steers are bought in May to be sold to the meat processor in November, 85 dairy grazing calves and 85 dairy grazing rising two heifers have been brought in.

To provide the feed for the additional livestock, additional summer and winter fodder crops have been grown and grazed, in conjunction with additional pasture and cereal baleage conserved for winter feeding, and barley grain has been purchased in and fed.

To accommodate more cattle in the Intensification Scenario, contractors have been used for the feed conservation and crop establishment, resulting in no additional labour requirements for the farm.

8.1.1.1. Area

598 ha effective area

- 420 ha Tussock hill (steep)
- 70 ha Developed downs (Figure 14)

    14 ha forage leafy turnip (summer)

    56 ha pasture

- 108 ha easy to flat paddocks
    - 28 ha dryland
        - 4 ha lucerne
        - 24 ha pasture
    - 30 ha sprinkler irrigation (Figure 15)
        - 6 ha forage rape (multi-graze summer/winter)
        - 6 ha forage rape (winter)
        - 6 ha cereal silage
        - 18 ha pasture
    - 50 ha centre pivot irrigation (Figure 16)
        - 7 ha forage oats and grass (winter)
        - 14 ha fodder beet
        - 7 ha forage maize (summer)
        - 7ha cereal silage
        - 36 ha pasture

8.1.1.2. Crop rotations

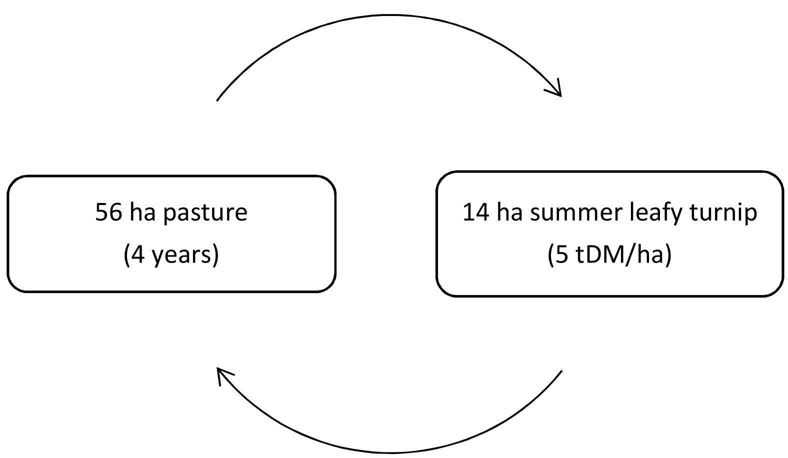


Figure 14: Red meat / hill country: Scenario 3. Developed downs crop rotation.

The developed downs, intensified crop rotation is changed from the Status Quo model to exclude winter grazing of nitrogen rich forages over winter, and shorten the pasture phase. The exclusion of winter brassica grazing results in less risk of phosphate run-off in at risk winter months. The reduction in the pasture phase duration to four years from 10 years in the Status Quo model, reduces the amount of nitrogen that the pasture fixes, therefore the amount of nitrogen available through mineralisation during cropping is reduced. Less freely available nitrogen in the profile results in less leaching.

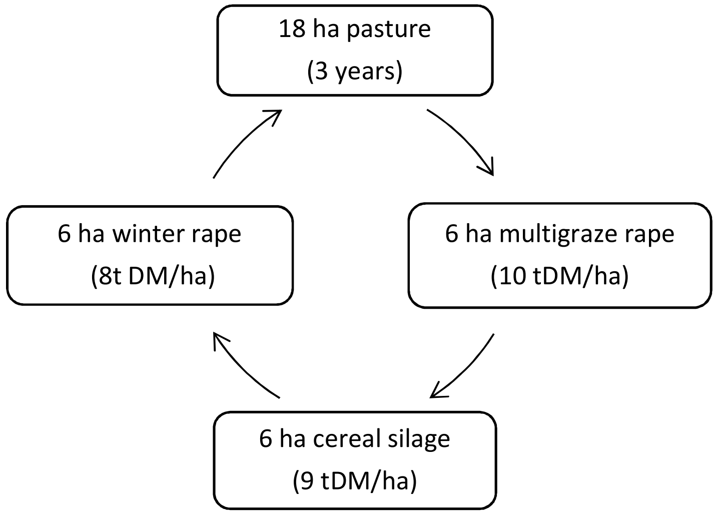


Figure 15: Red meat / hill country: Scenario 3. Sprinkler paddocks crop rotation.

The sprinkler paddocks, intensified crop rotation excludes annual ryegrass from the Status Quo model in favour of cereal silage. The cereal silage is both deeper rooting, able to extract more deposited nitrogen after the first brassica crop, and is lower in protein than pasture silage, making it a better supplementary feed partner for feeding to brassica crops over winter.

By feeding a diet of low protein, high carbohydrate supplement (cereal silage) with a high protein, low carbohydrate forage (rape, turnips or kale) the animal apportions more nitrogen (proportionally) to product and less by-passed to urine (a key driver of nitrogen leaching).

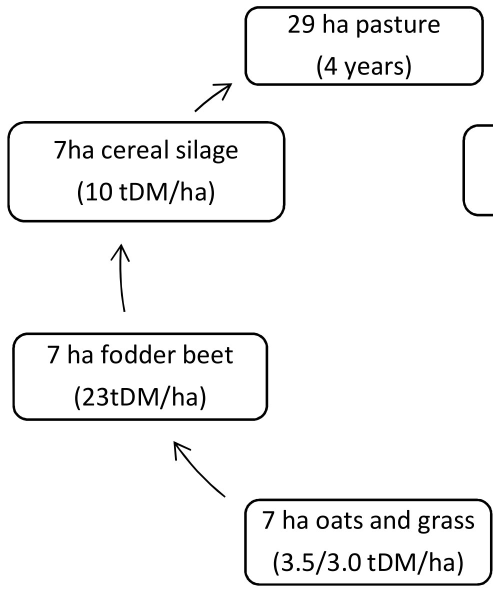


Figure 16: Red meat / hill country: Scenario 3. Centre pivot paddocks crop rotation.

On the centre pivot, intensified crop rotation, summer rape has been exchanged for forage maize as this has proportionally lower nitrogen and higher carbohydrates, balancing the animals diet, resulting in a lower urinary nitrogen concentration, reducing the risk of leaching from urine patches while grazing this crop.

Forage oats are sown after maize as they have a high winter growth potential compared to grass. The oats provide the best chance of catching urinary nitrogen deposited during maize grazing before leaving the soil profile.

Cereal silage is sown after the second fodder beet crop as cereals are both deeper rooting, so are able to extract more deposited nitrogen after the forage crop, and is lower in protein than pasture silage, making it a better supplementary feed partner for feeding with higher protein forage crops such as brassicas.

8.1.1.3. Stock numbers and performance

Cattle

- 160 cows (calving 1 August at 94%, finishing progeny).
- 30 R2 heifers mated.
- 45 R2 heifers sold (30 sold store in October at 315 kg liveweight; 15 sold in March at 266 kg carcass).
- 75 R1 heifers weaned and wintered.
- 75 R1 bulls weaned and wintered.
- 75 R2 bulls sold (30 sold in October for breeding; 45 sold in March to June at 285 kg carcass weight)
- 40 R2 steers and heifers bought in May at 420 kg, and sold in November (sold at 315 kg carcass weight)

- 5 breeding bulls.

Sheep

- 825 ewes (25% decrease compared to status quo)

  Lambing 5th September at 160% (increase 10% performance compared to Status Quo)

  30% weaning draft to works (increase 230% compared to status quo),

  Remainder finished to 18.5 kg carcass weight February to May).

- 225 ewe lambs kept as replacements (25% decrease compared to Status Quo)

  Lambing 10th September at 90% (increase 27% compared to Status Quo)

  Lambs finished to 18.5 kg carcass February to May.

- Nil traded lambs bought in and finished.
- 12 rams (25% decrease compared to Status Quo)

Dairy Grazers

- 85 R1 dairy grazing calves (arrive 100 kg in December, achieve 228 kg by end June)
- 85 R2 dairy grazers (start 228 kg July, removed from property 494 kg end of July)

8.1.1.4. Supplements

- 73 tDM pasture and lucerne silage made and fed on fodder beet.
- 125 tDM cereal silage made and fed on pasture and brassica crops over winter.
- 32 t (28 tDM) barley grain fed to 1050 hoggets and ewes for 90 days before mating.

8.1.2. Model outputs

8.1.2.1. Financial Budget Summary

Table 30: Budget summary: Red Meat / Hill Country - Scenario 3 Land Intensificaction.

	Status Quo	Scenario 1 Nitrogen cap	Scenario 2 Stock exclusion	Scenario 3 Intensification
Nett Farm Income	$380,922	n.a.	$364,957	$439,525
less Farm Working Expenses	$274,065	n.a.	$294,209	$340,972
gives Earnings Before Interest and Tax	$107,031	n.a.	$70,748	$98,553
less Capital Replacement / Depreciation	$37,750	n.a.	$57,459	$37,750
less Interest (on original term debt)	$43,578	n.a.	$43,578	$43,578
less Interest (marginal per scenario)	-	n.a.	$91,446	-$3,878
less Interest (on working capital)	$4,015	n.a.	$9,474	$1,444
gives Taxable Surplus	$21,688	n.a.	-$131,209	$19,659
less Tax Provision (at 30%)	$6,506	n.a.	$0**	$5,898
gives* Disposable Surplus	**$15,182**	**n.a.**	**-$131,209**	**$13,761**

*Note: No debt/principal repayments are made in these models.

**Note: Assume no tax refund, as the business has become unsustainable.

8.1.2.2. Emission Results

Table 31. Emission summary: Red Meat / Hill Country - Scenario 3 Land Intensificaction.

	Status Quo	Scenario 1 Nitrogen cap	Scenario 2 Stock exclusion	Scenario 3 Intensification
Nitrogen				
Total kg	11,588	n.a.	10,891	11,408
kg/ha	19	n.a.	18	19
Phosphorus				
Total kg	260	n.a.	140	269
kg/ha	0.4	n.a.	0.2	0.4
Greenhouse gases (CO2 equivalent)				
Total kg	2,507,414	n.a.	2,515,786	3,104,816
kg/ha	4,193	n.a.	4,207	5,192

8.1.3. Discussion

To increase productivity, a cattle focused system was elected. Cattle are more efficient converters of feed to meat than sheep. To maintain the labour requirement of the farm, no additional trading lambs have been sourced.

With a reduction in sheep numbers and an increase in cattle numbers, larger urine patches and more of them, could induce elevated nitrogen losses. Nitrogen losses are maintained (Table 31) by changing winter brassica crops (high protein and therefore can result in high concentration nitrogen in urine) for low protein fodder beet and catch crops. By deferring grazing of winter forages from May in the Status Quo model to June in the Intensification Scenario, there is no fallow between winter crops and spring crops. There is less bare ground in high runoff risk months of July and August, and there is less urine deposited on soil after forage crop grazing at a time of year that has a high risk of leaching associated.

By reducing sheep numbers and increasing cattle numbers with more forage crops and conserved feeds, the intensified farm model produces 85,354 kilograms of carcass weight (including calculated carcass weight gain of grazing cattle), which is 14,212 kilograms (20 per cent) more than the 71,142 kilograms of carcass weight produced in the Status Quo model.

By changing forage crop and supplementary feed crop type from protein based in the Status Quo model to carbohydrate based in the Intensification model, the farm is able to maintain nitrogen losses while increase phosphorus losses by only three percent.

When reading a small change in phosphorus losses, it is important to consider that Overseer is a mathematical model of biological systems in a dynamic environment, and as such makes many assumptions to predict phosphorus losses. The AgResearch report "Review of the phosphorus loss sub-model in OVERSEER" (2016) gives detail of the limitations of the phosphorus sub model, describing the pastoral model, in most applications, as robust, but outlines the difficulties associated with validating the arable crop block, forage crop block, and other farm sources sub-models when there is limited scientific data to validate the assumptions used in the model.

While nitrogen and phosphorus losses are maintained at levels similar to Status Quo results (Table 29), green house gas emissions increase by 24 per cent. This is partly a result of the fact that there is more feed grown, imported and consumed on the property by ruminants.

While nett farm income (Table 30) in the Intensification Scenario increases by $58,603 from the Status Quo nett farm income, the costs associated with growing feed to match the revised animal demand profile induce a total farm working expenses increase of $66,664.

As a result of bringing in dairy grazing heifers, there are 275 ewes, 75 hoggets and 3 rams sold. The reduced number of capital stock held reduces the overall debt position of the business by $57,450, and the regular income from contract grazing stock means that the overdraft facility is reduced in comparison to the Status Quo model.

The resulting tax paid, cash farm surplus in the intensification model is maintained at similar level to the Status Quo model, while increasing carcass weight produced by 20 per cent, maintaining nitrogen losses, but resulting in a 3 per cent increase in phosphate losses.

While productivity can be increased as demonstrated in Scenario 3, the shift in enterprise focus away from sheep, towards cattle, increases business risk as the system has less flexible stock classes which are required in dryland farming. Consequently, to mitigate some of the feed security risks in scenario 3 by implementing more forage crops, profitability is not necessarily increased.

8.2. Dairy – Scenario 3: Land Intensification - Level 1: Intensify current land use without increasing nitrogen & phosphorus discharge.

8.2.1. Scenario introduction

To achieve the target of increasing milk production by 20 per cent through intensification of the dairy system, whilst holding nitrogen and phosphorus discharge rates, the nitrogen fertiliser use rates and stocking rate have been held at the Status Quo model levels, the production has been ramped up through feeding more imported supplementary feed, while fodder beet on platform has been removed from the system and substituted mostly with maize silage.

8.2.1.1. Area

As per the Status Quo base model.

8.2.1.2. Stock numbers and performance

Livestock numbers as per the Status Quo base model.

- Production has been increased from 434,996 kgMS in the base model by 20 per cent to 522,090 kgMS (Table 30) in the Level 1 intensification scenario. This improvement in per-cow production performance is driven by increased supplementary feed fed throughout the milking season and an assumed higher standard of management which is factored into the labour costings.

Table 30: Dairy: Scenario 3.1 - Intensification +20% production without increasing nitrogen and phosphorus discharge. Farmax physical summary comparison between Status Quo and Scenario 3.1.

FARMAX YOUR ADVANTAGE Dairy 7.1.2.41

Compare Physical Summary
Jun 18 - May 19

Category	Description	MfE Dairy Model Base File	MfE Dairy Model Intensification 1 File	Difference	Units
Farm	Effective Area	300	300	0	ha
	Stocking Rate	3.3	3.3	0.0	cows/ha
	Potential Pasture Growth	14.2	14.2	0.0	t DM/ha
	Nitrogen Use	215	215	0	kg N/ha
	Feed Conversion Efficiency (eaten)	10.6	10.1	-0.5	kg DM eaten/kg MS
Herd	Cow Numbers (1st July)	1,030	1,030	0	cows
	Peak Cows Milked	1,000	1,000	0	cows
	Days in Milk	262	266	4	days
	Avg. BCS at calving	4.9	5.2	0.3	BCS
	Liveweight	1,421	1,474	53	kg/ha
Production	Milk Solids total	434,996	522,090	87,094	kg
(to Factory)	Milk Solids per ha	1,450	1,740	290	kg/ha
	Milk Solids per cow	435	522	87	kg/cow
	Peak Milk Solids production	2.01	2.29	0.28	kg/cow/day
	Milk Solids as % of live weight	102.0	118.0	16.0	%
Feeding	Pasture Eaten per cow *	3.6	3.6	0.0	t DM/cow
	Supplements Eaten per cow *	0.4	1.0	0.6	t DM/cow
	Off-farm Grazing Eaten per cow *	0.6	0.7	0.1	t DM/cow
	Total Feed Eaten per cow *	4.6	5.3	0.7	t DM/cow
Diagnostics	Pasture Eaten per ha	12.0	12.0	0.0	t DM/ha
	Supplements Eaten per ha	1.5	3.5	2.0	t DM/ha
	Off-farm Grazing Eaten per ha	3.8	4.0	0.2	t DM/ha
	Total Feed Eaten per ha	17.2	19.5	2.3	t DM/ha
	Supplements and Grazing / Feed Eaten *	23.0	32.7	9.7	%
	Bought Feed / Feed Eaten *	4.2	20.6	16.4	%

(*) feed eaten by females > 20 months old / peak cows milked

8.2.1.3. Crop areas

Fodder beet as a crop grown on the dairy platform for autumn feeding of milking cows has been removed from the farm system. This was done to reduce the nitrogen loss impact of the higher stocking intensity grazing which occurs with crop feeding. The fodder beet has been substituted with mostly maize silage in the milking cow diet which is a lower protein content forage.

8.2.1.4. Supplements

Milking supplement increased by 720 kgDM from 470 kgDM per cow in the base model to 1190 kgDM per cow (Table 33).

Table 33. Dairy: Scenario 3.1 - Intensification +20% production without increasing nitrogen and phosphorus discharge. Farmax summary of supplementary feed use.

FARMAX YOUR ADVANTAGE Dairy 7.1.2.41

Supplement Usage Summary for MfE Dairy

Jun 18 - May 19

Feed	tonnes DM offered													kg
	Jun 18	Jul 18	Aug 18	Sep 18	Oct 18	Nov 18	Dec 18	Jan 19	Feb 19	Mar 19	Apr 19	May 19	Total	/milker
F3 Maize/barley Silage bought		5	66	54					16	93	123	99	456	456
F4 Hay/Straw bought		0	20	8									28	28
F1 Meal and Grains bought		1	26	67	91	60	62	62	55	61	59	39	584	584
F2 Pasture Silage		3	60	39							10	39	150	150
Total													**1,218**	**1,218**

- 584 tDM cereal grain bought in and fed in dairy shed
- 150 tDM pasture silage (27 tDM of which is made on platform) fed in season shoulder
- 456 tDM maize silage imported and fed in spring and late-summer/autumn.

8.2.2. Model outputs

8.2.2.1. Financial budget summary

Table 34. Budget summary: Dairy - Scenario 3 Land Intensificaction - Level 1: Intensify current land use without increasing nitrogen & phosphorus discharge.

	Status Quo	**Scenario 1 Nitrogen cap**	**Scenario 2 Stock exclusion**	**Scenario 3.1 Intensification**
Nett Farm Income	$2,911,306	$2,820,769	$2,867,927	$3,459,967
less Farm Working Expenses	$1,833,772	$1,814,149	$1,817,436	$2,262,196
gives Earnings Before Interest and Tax	$1,077,534	$1,006,620	$1,050,491	$1,197,771
less Capital Replacement / Depreciation	$98,375	$98,375	$98,375	$98,375
less Interest (on original term debt)	$681,750	$681,750	$681,750	$681,750
less Interest (marginal per scenario)	-	$0	$3,980	$0
less Interest (on working capital)	$4,834	$5,526	$5,876	$4,032
gives Taxable Surplus	$292,575	$220,969	$260,510	$413,614
less Tax Provision (at 30%)	$87,773	$66,291	$78,153	$124,084
gives* Disposable Surplus	**$204,803**	**$154,678**	**$182,357**	**$289,530**

*Note: No debt/principal repayments are made in these models.

8.2.2.2. Emission summary

Table 35. Emission results: Dairy - Scenario 3 Land Intensificaction - Level 1: Intensify current land use without increasing nitrogen & phosphorus discharge.

	Status Quo	Scenario 1 Nitrogen cap	Scenario 2 Stock exclusion	Scenario 3.1 Intensification
Nitrogen				
Total kg	21,017	18,605	20,450	20,007
kg/ha	66	59	64	63
Phosphorus				
Total kg	463	455	453	472
kg/ha	1.5	1.4	1.4	1.5
Greenhouse gases (CO2 equivalent)				
Total kg	5,512,212	5,236,188	5,408,544	6,096,060
kg/ha	17,334	16,466	17,008	19,170

8.2.3. Discussion

The physical impacts of the Level 1 Intensification scenario are an increase in total production of 87,094 kilograms of milksolids or 20 per cent, the nitrogen leaching is reduced (Table 33) by 1,010 kilograms total or 4.8 per cent. This is an interesting result and one not envisaged at the start of the modelling process, the key drivers of the reduction in nitrogen loss are the removal of the fodder beet crop on platform which contributed 9 per cent of the overall nitrogen loss in the base file, and the increase in the low protein / high carbohydrate component of the diet (increased cereal grain and maize silage) which dilutes the higher dietary protein content of pasture. Total phosphate losses increase marginally by 1.9 per cent. The pasture harvested per cow is maintain at 3.6 tonnes of drymatter, the pasture harvested per hectare also remains the same.

The financial results of the Level 1 Intensification scenario are a 19 per cent increase in nett income (Table 34), this partially offset by a 23 per cent increase in farm working expenditure. The increase in working expenditure includes increases in supplementary feed costs, animal health costs by 10 per cent, silage wagon maintenance costs, and feeding costs for increased supplementary feed. The overall impact gives a 41 per cent increase in disposable surplus which is a significant lift.

This demonstrates a system shift feeding the cows to increase their overall intakes to what would be considered a near maximum level for this herd in a system of this type, and assumes this is being achieved efficiently on top of an efficient pasture harvested base diet. For this reason the management wages have been increased by $20,000 to cater for the higher skilled manager required to execute this system effectively.

Effective stocking rate on pasture through the whole season is marginally reduced due to the former 10 hectares of fodder beet area being back in pasture. No specific regrassing costs have been added as these are long-term models replicating a steady-state system in place.

There has been no sensitivity to milk price tested to determine impact of variations in milk income.

8.3. Dairy – Scenario 3: Land Intensification - Level 2: Intensify current land use while decreasing nitrogen and phosphorus discharge.

8.3.1. Scenario introduction

To achieve a target of increasing milk production by 20 per cent through intensification of the dairy system, whilst targeting reducing nitrogen and phosphate discharge rates, the following changes have been made to the farm system from the base model:

- Nitrogen fertiliser use rates have been reduced
- Stocking rate has been held at the base model level
- Culling of 80 cows earlier by two months to reduce autumn stocking intensity
- Production has been ramped up through feeding more imported supplementary feed
- Fodder beet on platform has been removed from the system and substituted mostly with maize silage
- Grass silage feeding has been removed and substituted with a combination of cereal grain and maize silage.

8.3.1.1. Area

As per the Status Quo base model.

8.3.1.2. Stock numbers and performance

Stock numbers are as per the Status Quo base model, except the earlier culling.

- Production has been increased from 434,996 kgMS in the Status Quo model by 20 per cent to 522,090 kgMS (Table 36) in the Level 2 Intensification scenario. This improvement in per-cow production performance is driven by increased supplementary feed fed through the whole milking season and an assumed higher standard of management which is factored into the labour costings.

Table 36: Dairy: Scenario 3.2 – Intensification +20% production with targeted decreasing nitrogen and phosphorus discharge. Farmax physical summary comparison between Status Quo and Scenario 3.2.

FARMAX YOUR ADVANTAGE Dairy 7.1.2.41

Compare Physical Summary
Jun 18 - May 19

Category	Description	MfE Dairy Model Base File	MfE Dairy Model Intensification 2 File	Difference	Units
Farm	Effective Area	300	300	0	ha
	Stocking Rate	3.3	3.3	0.0	cows/ha
	Potential Pasture Growth	14.2	14.2	0.0	t DM/ha
	Nitrogen Use	215	197	-18	kg N/ha
	Feed Conversion Efficiency (eaten)	10.6	10.1	-0.5	kg DM eaten/kg MS
Herd	Cow Numbers (1st July)	1,030	1,030	0	cows
	Peak Cows Milked	1,000	1,000	0	cows
	Days in Milk	262	261	-1	days
	Avg. BCS at calving	4.9	5.2	0.3	BCS
	Liveweight	1,421	1,482	61	kg/ha
Production	Milk Solids total	434,996	522,089	87,093	kg
(to Factory)	Milk Solids per ha	1,450	1,740	290	kg/ha
	Milk Solids per cow	435	522	87	kg/cow
	Peak Milk Solids production	2.01	2.33	0.32	kg/cow/day
	Milk Solids as % of live weight	102.0	117.4	15.4	%
Feeding	Pasture Eaten per cow *	3.6	3.5	-0.1	t DM/cow
	Supplements Eaten per cow *	0.4	1.1	0.7	t DM/cow
	Off-farm Grazing Eaten per cow *	0.6	0.7	0.1	t DM/cow
	Total Feed Eaten per cow *	4.6	5.3	0.7	t DM/cow
Diagnostics	Pasture Eaten per ha	12.0	11.7	-0.3	t DM/ha
	Supplements Eaten per ha	1.5	3.7	2.2	t DM/ha
	Off-farm Grazing Eaten per ha	3.8	4.1	0.3	t DM/ha
	Total Feed Eaten per ha	17.2	19.4	2.2	t DM/ha
	Supplements and Grazing / Feed Eaten *	23.0	34.2	11.2	%
	Bought Feed / Feed Eaten *	4.2	24.6	20.4	%

(*) feed eaten by females > 20 months old / peak cows milked

8.3.1.3. Crop areas

Fodder beet as a crop grown on the dairy platform for autumn feeding of milking cows has been removed from the farm system, this was done to reduce the nitrogen loss impact of the higher stocking intensity grazing which occurs with crop feeding. The fodder beet has been substituted with mostly maize silage in the milking cow diet which is a lower protein content forage.

8.3.1.4. Supplements

Milking supplement increased by 785 kgDM from 470 kgDM per cow in the base model to 1255 kgDM per cow (Table 37).

Table 37. Dairy: Scenario 3.2 – Intensification +20% production with targeted decreasing nitrogen and phosphorus discharge. Farmax summary of supplementary feed use.

FARMAX YOUR ADVANTAGE Dairy 7.1.2.41

Supplement Usage Summary for MfE Dairy

Jun 18 - May 19

Feed	tonnes DM offered													kg
	Jun 18	Jul 18	Aug 18	Sep 18	Oct 18	Nov 18	Dec 18	Jan 19	Feb 19	Mar 19	Apr 19	May 19	Total	/milker
F3 Maize/barley Silage bought	1	5	66	54				33	83	95	136	117	590	590
F4 Hay/Straw bought		0	20	8									28	28
F1 Meal and Grains bought		1	37	74	91	90	93	93	55	56	55	20	665	665
F2 Pasture Silage														
Total													**1,283**	**1,283**

- 665 tDM cereal grain bought in and fed in dairy shed
- 590 tDM maize silage imported and fed in spring and late-summer/autumn.

8.3.2. Model outputs

8.3.2.1. Financial budget summary

Table 38. Budget summary: Dairy - Scenario 3 Land Intensificaction - Level 2: Intensify current land use while decreasing nitrogen and phosphorus discharge.

	Status Quo	Scenario 1 Nitrogen cap	Scenario 2 Stock exclusion	Scenario 3.1 Intensification	Scenario 3.2 Intensification
Nett Farm Income	$2,911,306	$2,820,769	$2,867,927	$3,459,967	$3,451,968
less Farm Working Expenses	$1,833,772	$1,814,149	$1,817,436	$2,262,196	$2,291,386
gives Earnings Before Interest and Tax	$1,077,534	$1,006,620	$1,050,491	$1,197,771	$1,160,582
less Capital Replacement / Depreciation	$98,375	$98,375	$98,375	$98,375	$98,375
less Interest (on original term debt)	$681,750	$681,750	$681,750	$681,750	$681,750
less Interest (marginal per scenario)	-	$0	$3,980	$0	$0
less Interest (on working capital)	$4,834	$5,526	$5,876	$4,032	$4,854
gives Taxable Surplus	$292,575	$220,969	$260,510	$413,614	$375,603
less Tax Provision (at 30%)	$87,773	$66,291	$78,153	$124,084	$112,681
gives* Disposable Surplus	**$204,803**	**$154,678**	**$182,357**	**$289,530**	**$262,922**

*Note: No debt/principal repayments are made in these models.

8.3.2.2. Emission summary

Table 39. Emission results: Dairy - Scenario 3 Land Intensificaction - Level 2: Intensify current land use while decreasing nitrogen and phosphorus discharge.

	Status Quo	Scenario 1 Nitrogen cap	Scenario 2 Stock exclusion	Scenario 3.1 Intensification	Scenario 3.2 Intensification
Nitrogen					
Total kg	21,017	18,605	20,450	20,007	18,164
kg/ha	66	59	64	63	57
Phosphorus					
Total kg	463	455	453	472	468
kg/ha	1.5	1.4	1.4	1.5	1.5
Greenhouse gases (CO2 equivalent)					
Total kg	5,512,212	5,236,188	5,408,544	6,096,060	6,009,882
kg/ha	17,334	16,466	17,008	19,170	18,899

8.3.3. Discussion

The physical impacts of the Level 2 Intensification scenario are an increase in total production of 87,093 kilograms of milksolids or 20 per cent, the nitrogen leaching is reduced by 9 kilograms per hectare (Table 39) or 13.5 per cent on a total reduction basis. This is a positive result and this extent of reduction was not envisaged at the start of the modelling process. The key drivers of the reduction in nitrogen loss are the:

- removal of the fodder beet crop on platform which contributed 9 per cent of the overall nitrate loss in the base file;
- increase in the low protein / high carbohydrate component of the diet (increased cereal grain and maize silage) which dilutes the higher dietary protein content of pasture;
- replacement of higher protein content pasture silage in the diet with cereal grain;
- removal of April applied nitrogen fertiliser (substituted with increased supplement fed); and
- the earlier culling of 80 cows bought forward from 20th April to 28th February.

Total phosphorus losses increase marginally by 1.0 per cent, although on a per hectare basis they are the same as the Status Quo model so no reduction has been possible. The pasture harvested per cow falls marginally at 3.5 tonnes of drymatter, while the pasture harvested per hectare also falls marginally by 0.3 tonnes of drymatter. The modelling is indicative of the reduction in nitrogen fertiliser applied and may also be reflecting the limits of the supplement proportion of the diet being reached and some substitution of pasture for supplement could be occurring at these levels. Consideration will be given in the final report summary of the high levels of maize silage fed and the possible development of a feeding pad in this farm system, to increase utilisation of this feed (the wastage rate for maize silage in the Farmax modelling is 25 per cent) which could have further positive environmental and financial benefits.

The financial results of the Level 2 Intensification scenario are a 19 per cent increase in nett income (Table 38), this is partially offset by a 25 per cent increase in farm working expenditure. The increase in working expenditure includes increases in supplementary feed costs, animal health costs by 10 per cent, silage wagon maintenance costs, and feeding costs for increased supplementary feed. The decrease in costs of nitrogen fertiliser with the reduction of 18 kilograms of nitrogen per hectare is offset by the increased supplement required to replace the drop in pasture production. The overall impact gives a 28 per cent increase in disposable surplus which is a significant lift from the base scenario.

This demonstrates a system shift of feeding the cows to increase their overall intakes, to what would be considered a near maximum level for this herd in a system of this type and assumes this is being achieved efficiently on top of an efficient pasture harvested base diet. For this reason the management wages have been increased by $20,000 to cater for the higher skilled manager required to execute this system effectively. The earlier culling also requires a more front-loaded lactation curve relative to the Level 1 Intensification model to maintain the 20 per cent production lift which would require a high standard of management and execution of the farm plan. From a regional or national perspective increased skills of management may not be possible across the sector as there exists a range of management level skills and experience and this needs to be taken into account. Major changes to dairy farm systems also generally take multiple seasons to bed-in and execute well.

Effective stocking rate on pasture through the whole season is marginally reduced due to the former 10 ha of fodder beet area being back in pasture, no specific regrassing costs have been added as these are long-term models replicating a steady state system in place.

There has been no sensitivity to milk price tested to determine impact of variations in milk income.

8.4. Dairy Support - Scenario 3: Land Intensification - Level 1: Continue current land use while decreasing nitrogen and phosphorus discharge by 10 per cent

8.4.1. Scenario introduction

Scenario 3 Land Intensification – Level 1, requires the continuation of the Status Quo land use and production, while decreasing nitrogen and phosphorous discharge by ten per cent.

Continuation of current land use in this scenario, is considered to be grazing and finishing the same numbers of dairy heifers, cows and beef steers as was undertaken in the Status Quo scenario.

To achieve a reduction in nitrogen and phosphorus discharge by 10 per cent, a similar farm system to that used in Scenario 1 Nitrogen Loss Cap, has been modelled. To achieve the reduction in nitrogen discharge in Scenario 1, a significant number of animals had to be removed from the farm and surplus feed was sold. To maintain the same livestock numbers in the Land Intensification scenario as in the Status Quo, a covered feed barn sufficient to house and feed up to 670 cows has been installed. All of the feed is sourced from the farm, except a small amount of straw.

8.4.1.1. General farm

In Scenario 1 Nitrogen Loss Cap, 660 less cows and 30 less steers were farmed compared to the Status Quo and the surplus feed was sold off-farm. To maintain productivity in the Land Intensification scenario, a feed barn has been installed to feed the following livestock numbers:

- 670 cows for 70 days during June, July and August
- 150 R2 heifers transferred from pasture during April
- 330 R2 heifers transferred from pasture during May.

The cost of constructing the feed barn for 670 head capacity has been estimated at $1,300 per head totalling $871,000. It is assumed that consenting, site preparation and initial woodchip bedding expenses are included in this cost. Upgrading of the standard silage wagon to a 24 cubic metre feed mixer and increasing the tractor size has been estimated to cost $50,000.

The feed barn is based on wood chip bedding which absorbs all liquid effluent therefore eliminates the need for a storage pond and effluent distribution system. The top layer of the manure contaminated bedding is cleaned once the cows are removed and this remains in the shed until it is removed and spread on farm. On areas of the farm where manure from the feed barn is spread, the amount of standard fertiliser applied is reduced to achieve a similar nutrient input (nitrogen, phosphate, potassium and sulphate).

8.4.1.2. Area

The cropping and re-grassing programme is the same as modelled in the Nitrogen Loss Cap scenario as described below:

- 260 hectares are pivot irrigated – 7 year rotation
  - 37.1 ha summer rape (Oct - Apr) – 8 tDM/ha
  - 37.1 ha green chop oat silage (Apr – Sep) – 6 tDM/ha
  - 37.1 ha fodder beet (Oct – Aug) – 23 tDM/ha
  - 37.1 ha barley grain (Sept – Feb) – grain sold (8.5 t/ha) / straw kept (3.5 tDM/ha)
  - Pasture for 4.5 years – Annual production before nitrogen of 13.12 tDM/ha
- 24 hectares dryland – Corner areas of pivot irrigators – 8 year rotation.
  - 3.4 ha summer rape (Oct - Apr) – 7 tDM/ha
  - 3.4 ha green chop oat silage (Apr – Sep) – 5 tDM/ha
  - 3.4 ha fodder beet (Oct – Aug) – 18.5 tDM/ha
  - 3.4 ha barley grain (Sept – Feb) – grain sold (7.5 t/ha) / straw kept (3.0 tDM/ha)
  - Pasture for 4.5 years – Annual production before nitrogen of 8.5 tDM/ha.
- 176 hectares Dryland – 7 year rotation
  - 25.1 ha summer rape (Oct - Apr) – 7 tDM/ha
  - 25.1 ha green chop oat silage (Apr – Sep) – 5 tDM/ha
  - 12.6 ha fodder beet (Oct – Aug) – 18.5 tDM/ha
  - 12.5 ha kale (Nov – Aug) – 11.0 tDM/ha
  - 25.1 ha barley grain (Sept – Feb) – grain sold (7.5 t/ha) / straw kept (3.0 tDM/ha)
  - Pasture for 4.5 years – Annual production before nitrogen of 8.5 tDM/ha
  - Approximately 100 hectares of the dryland area is rolling downs.
- 15 hectares are in-effective.

8.4.1.3. Stock numbers and performance

- Livestock numbers are maintained at the same level as the Status Quo scenario.

8.4.1.4. Supplements

Barley straw

- 140 tDM made on the property and fed with winter feed crops
- 60 tDM purchased to feed with winter feed crops
- 36 tDM purchased to feed in the feed barn.

Pasture silage

- 420 tDM made into pit silage to feed in the feed barn
- 20 tDM made into baleage to feed with winter feed crops.

Oaten green chop silage

- 365 tDM fed with winter feed.

Barley whole crop silage

- 250 tDM made into pit silage and fed in the feed barn.

Barley grain

- 341 t of barley grain sold off farm.

8.4.2. Modelling outputs

8.4.2.1. Financial budget summary

Table 40: Budget summary: Dairy support - Scenario 3 Land Intensificaction - Level 1: Continue current land use while decreasing nitrogen and phosphorus discharge by 10 per cent.

	Status Quo	Scenario 1 Nitrogen cap	Scenario 2 Stock exclusion	Scenario 3.1 Intensification
Nett Farm Income	$1,446,792	$1,365,517	$1,430,222	$1,467,941
less Farm Working Expenses	$958,792	$914,931	$948,822	$1,051,532
gives Earnings Before Interest and Tax	$488,000	$450,586	$481,400	$416,409
less Capital Replacement / Depreciation	$81,800	$81,800	$81,800	$121,640
less Interest (on original term debt)	$336,150	$336,150	$336,150	$336,150
less Interest (marginal per scenario)	-	$0	$6,169	$62,168
less Interest (on working capital)	$14,674	$23,604	$15,183	$21,505
gives Taxable Surplus	$55,376	$9,032	$42,098	-$125,054
less Tax Provision (at 30%)	$16,613	$2,710	$12,629	$0**
gives* Disposable Surplus	**$38,763**	**$6,322**	**$29,469**	**-$125,054**

*Note: No debt/principal repayments are made in these models.

**Note: Assume no tax refund, as the business has become unsustainable.

8.4.2.2. Emission results

Table 41: Emission summary: Dairy support - Scenario 3 Land Intensificaction - Level 1: Continue current land use while decreasing nitrogen and phosphorus discharge by 10 per cent.

	Status Quo	Scenario 1 Nitrogen cap	Scenario 2 Stock exclusion	Scenario 3.1 Intensification
Nitrogen				
Total kg	31,364	26,970	31,016	27,579
kg/ha	68	59	67	60
Phosphorus				
Total kg	102	93	101	110
kg/ha	0.2	0.2	0.2	0.2
Greenhouse gases (CO2 equivalent)				
Total kg	4,485,920	3,774,760	4,460,620	5,608,320
kg/ha	9,752	8,206	9,697	12,192

8.4.3. Discussion

The nett farm income (Table 40) has been maintained at a similar level as the Status Quo model. However, farm working expenses have risen by $96,340 and capital replacement and interest costs have risen by $39,840 and $69,170 respectively. The main areas of increased farm working costs occur in bedding, feed conservation and contracting whilst fertiliser costs decreased, as imported fertiliser is substituted by manure cleaned from the shed. As with the other scenarios the capital replacement of plant and vehicles has been based on 10 per cent of capital value. However, the feed barn annual replacement cost has been based on 4 per cent of capital value.

For grass silage transferred to the feed barn, extra fertiliser input has been budgeted to compensate for nutrient transfer off the farm. However, the transfer of other silage (eg barley silage) assumes that sufficient fertiliser was applied during the production of the crop.

Based on the assumed inputs, this model is financially unsustainable and the utilisation of feed barns or feed pads to reduce nitrogen losses would require further investigation, if they were to be used more widely. More detailed analysis of shed construction costs, operating expenditure and animal performance would also need to be undertaken to validate the assumptions that have been used in this report.

The feed barn has enabled a reduction in nitrogen discharge by over 10 per cent (Table 41) whilst maintaining the stocking rate of the Status Quo scenario. Phosphorus discharge has risen by approximately 8 per cent, however 46 kilograms of the phosphorus discharge in Overseer is reported as coming from "Other farm sources" compared 39 kilograms in the Status Quo scenario. Phosphorus losses to "Other farm sources" contributes a large proportion of the total phosphorus discharge in all scenarios and this category of loss is difficult to change when altering farm systems within the same farm type. Furthermore, a change in the total discharge of phosphate of 10 per cent from the Status Quo represents 10.2 kilograms of phosphorus over the effective farm area of 460 hectares. This is the equivalent of 113 kilograms of superphosphate in total or 0.25 kilograms per hectare. Limitations of the Overseer phosphorus sub-model are discussed in the opening commentary of this report.

The suitability of using Overseer to determine the amount and concentration of waste collected and removed from feed barns/pads and the impact this has on nitrogen and phosphorus discharge should be further investigated before concluding if barns/pads are a feasible solution to mitigating nitrogen and phosphorus losses, while maintaining productivity.

8.5. Dairy Support - Scenario 3: Land Intensification - Level 2: Dairy conversion without increasing nitrogen and phosphorus discharge

8.5.1. Scenario introduction

Scenario 3 Land Intensification converts the Status Quo Dairy Support farm to dairy, without increasing nitrogen or phosphorus loss. The Status Quo nitrogen loss (Table 45) was 68 kilograms nitrogen and 0.2 kilograms phosphorus per hectare.

The dairy support farm effective area was large enough to establish a milking platform and a self-sufficient support block (heifers all year, and wintering of cows). This was an actual farm conversion that Macfarlane Rural Business have supported during the 2018/19 season.

8.5.1.1. Area

Total area modelled remains at 475 hectares total, made up of:

- The dairy platform is on 230 irrigated hectares predominately flat land (all pivot irrigators). The soils are well-drained Ruapuna silt loams. There is 30 hectares of dryland in the corners of this block. 260 hectares total area is allocated for dairy production
- 200 hectares dryland support block. It is generally summer safe to support growing dairy heifers and winter feeds without irrigation
- 15 hectares in-effective / non-productive
- Mean annual rainfall 800 millimetres per annum
- Annual potential evapotranspiration 877 millimetres per annum
- This is a higher altitude farm at 380 metres above sea level.

8.5.1.2. Pasture

Dairy platform:

- 230 hectares of permanent pasture under centre pivots, yielding 12.9 tDM/ha per annum. Liquid effluent is applied via the pivots. The lower growth is a reflection of the higher altitude of the farm.
- 7 hectares of fodder beet is grown for autumn feeding to milking cows to extend lactation with the lower autumn pasture growth rates.

Support block:

- 200 hectares dryland pastures with the potential to grow 9.6 tDM/ha per annum.

8.5.1.3. Crop areas and yields

Forage/fodder crops only grown on the support block, within a seven year crop rotation (Figure 17):

100 ha Pasture

25 ha Fodder beet followed by green chop oat silage

25 ha Kale followed by green chop oat silage

Back to pasture.

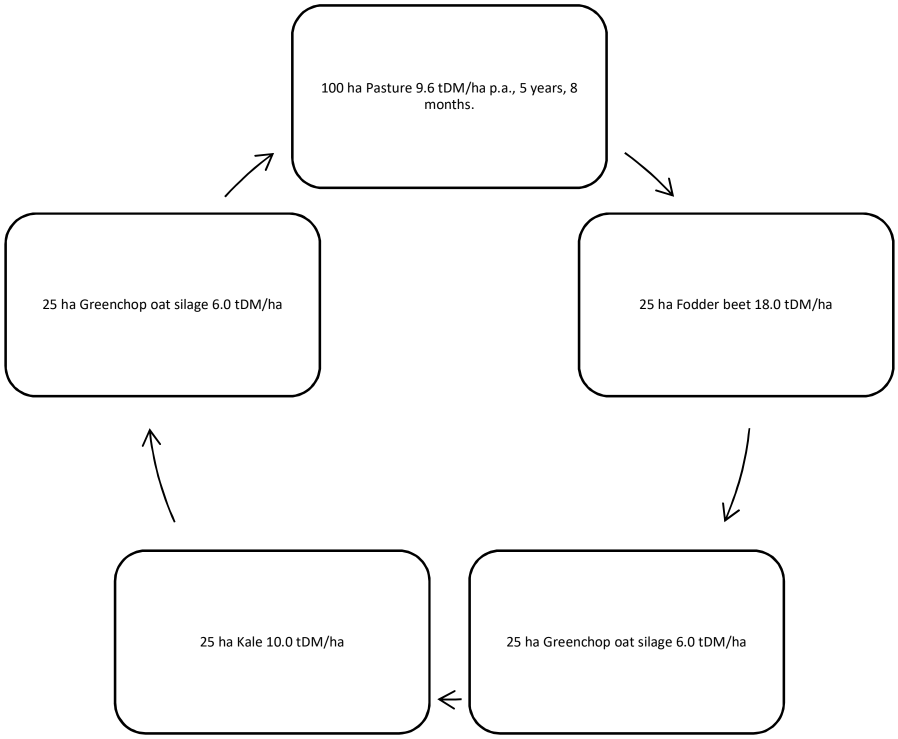


Figure 17: Dairy support: Scenario 3 Land Intensification - Level 2: Dairy conversion without increasing nitrogen and phosphorus discharge. 7 year crop rotation, 25 hectares for each slot in the rotation.

8.5.1.4. Stock numbers and performance

Heifers and cows are wintered 'on-farm' within the 460 hectares effective.

Dairy platform:

- 850 cows wintered, 820 cows at peak-milk (Table 39)
- Calving date 11th August for mixed age cows
- Cows producing 477 kilograms milk solids per cow
- Cows culled early (1st April), final tidy up culls 28th May with the balance milking until 31st May.
- A high standard of management is required to execute this farm program and achieve this lactation curve. MRB has farmer clients in the same district achieving this level of production, and higher.

Support block:

- 200 yearling heifers
- 200 calves reared.

8.5.1.5. Supplements

The farm is self-sufficient regards baleage and silage and winter feed. No surplus balage or silage is sold. Grain is purchased for feeding in the milking shed (Table 40).

Dairy platform:

- 230 hectares of irrigated permanent pasture

- 7 hectares of fodder beet @ 18 tDM/ha fed in the autumn
- 30 hectares of dryland permanent pasture
- 350 tonne drymatter of grass silage cut per annum to maintain pasture quality for high performing cows
- 177 tonnes of barley grain purchased.

Support block:

- 200 hectares of permanent pasture and crop rotation (Figure 17)
- Cereal silage made (Figure 18).

8.5.2. Modelling outputs

Table 42. Dairy Support: Scenario 3 Land Intensification – Farmax Dairy Biophysical summary of the dairy farm and support farm program, long term steady-state basis.

FARMAX YOUR ADVANTAGE Dairy 7.1.2.41

Physical Summary for MfE Dairy Scenario Testing

Jun 19 - May 20

Category	Description	Value	Units
Farm	Effective Area	460	ha
	Stocking Rate	1.8	cows/ha
	Potential Pasture Growth	11.5	t DM/ha
	Nitrogen Use	147	kg N/ha
	Feed Conversion Efficiency (eaten)	11.2	kg DM eaten/kg MS
Herd	Cow Numbers (1st July)	850	cows
	Peak Cows Milked	820	cows
	Days in Milk	275	days
	Avg. BCS at calving	5.6	BCS
	Liveweight	893	kg/ha
Production	Milk Solids total	390,909	kg
(to Factory)	Milk Solids per ha	850	kg/ha
	Milk Solids per cow	477	kg/cow
	Peak Milk Solids production	2.09	kg/cow/day
	Milk Solids as % of live weight	95.2	%
Feeding	Pasture Eaten per cow *	4.0	t DM/cow
	Supplements Eaten per cow *	1.3	t DM/cow
	Off-farm Grazing Eaten per cow *	0.0	t DM/cow
	Total Feed Eaten per cow *	5.3	t DM/cow
	Pasture Eaten per ha	8.0	t DM/ha
	Supplements Eaten per ha	2.8	t DM/ha
	Off-farm Grazing Eaten per ha	0.0	t DM/ha
	Total Feed Eaten per ha	10.8	t DM/ha
	Supplements and Grazing / Feed Eaten *	24.9	%
	Bought Feed / Feed Eaten *	3.3	%

(*) feed eaten by females > 20 months old / peak cows milked

Table 43. Dairy Support: Scenario 3.2 Land Intensification – Dairy conversion without increasing nitrogen and phosphorus. Farmax Dairy supplements used.

FARMAX YOUR ADVANTAGE Dairy 7.1.2.41

Supplement Usage Summary for MfE Dairy Scenario Testing

Jun 19 - May 20

Feed	tonnes DM offered													kg
	Jun 19	Jul 19	Aug 19	Sep 19	Oct 19	Nov 19	Dec 19	Jan 20	Feb 20	Mar 20	Apr 20	May 20	Total	/milker
F2 Pasture Silage	10	12	76	28							97	124	349	425
Kale	110	110	29										249	304
Barley Grain			27	54							31	41	153	186
Wheat Silage	77	77	11										164	200
C2 Fodder Beet	178	180	84								62	72	575	702
Total													**1,489**	**1,816**

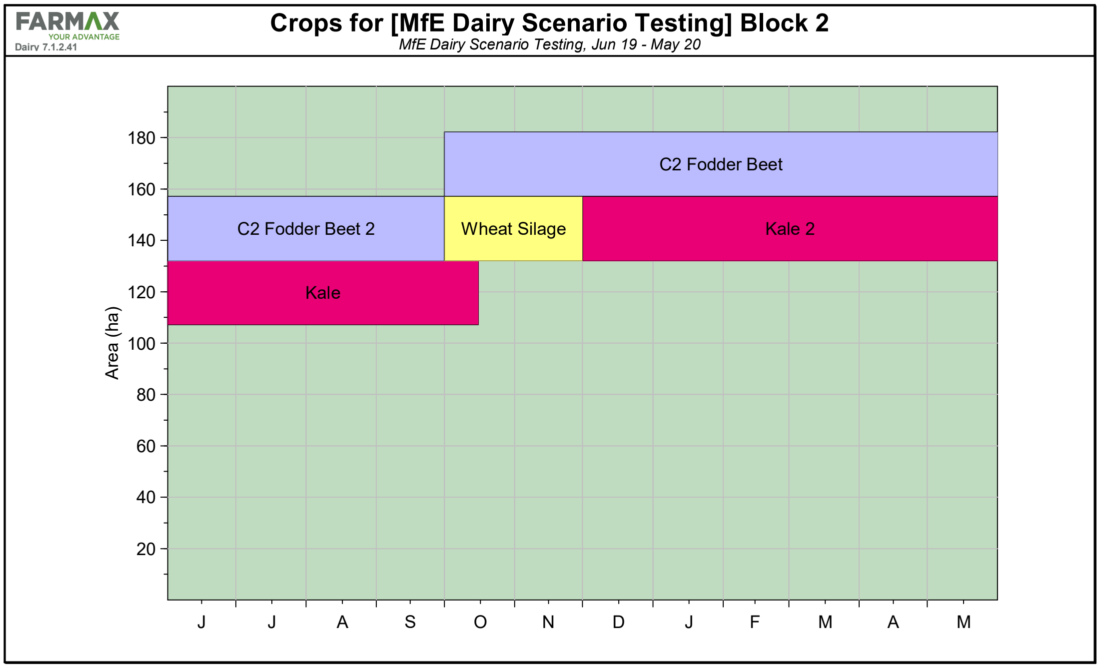


Figure 18. Arable mixed cropping: Scenario 3 Land Intensification – Dairy conversion without increasing nitrogen and phosphorus. Crops and silage, whole farm, long term steady-state basis.

8.5.2.1. Financial budget summary

EBITD increases (Table 44) compared to Status Quo. Capital investment increases and debt increases substantially due to the farm being converted to dairy.

Table 44: Budget summary: Dairy Support - Scenario 3 Land Intensificaction - Level 2: Dairy conversion without increasing nitrogen and phosphorus discharge.

	Status Quo	Scenario 1 Nitrogen cap	Scenario 2 Stock exclusion	Scenario 3.1 Intensification	Scenario 3.2 Intensification
Nett Farm Income	$1,446,792	$1,365,517	$1,430,222	$1,467,941	$2,591,327
less Farm Working Expenses	$958,792	$914,931	$948,822	$1,051,532	$1,400,387
gives Earnings Before Interest and Tax	$488,000	$450,586	$481,400	$416,409	$1,190,940
less Capital Replacement / Depreciation	$81,800	$81,800	$81,800	$121,640	$146,000
less Interest (on original term debt)	$336,150	$336,150	$336,150	$336,150	$336,150
less Interest (marginal per scenario)	-	$0	$6,169	$62,168	$495,383
less Interest (on working capital)	$14,674	$23,604	$15,183	$21,505	$7,484
gives Taxable Surplus	$55,376	$9,032	$42,098	-$125,054	$205,923
less Tax Provision (at 30%)	$16,613	$2,710	$12,629	$0**	$61,777
gives* Disposable Surplus	**$38,763**	**$6,322**	**$29,469**	**-$125,054**	**$144,146**

*Note: No debt/principal repayments are made in these models.
**Note: Assume no tax refund, as the business has become unsustainable.

8.5.2.2. Emission results

Overseer reports (Table 45) a small decrease of total nitrogen discharge and a significant increase of phosphorus discharge, relative to the Status Quo dairy support farm system.

Table 45: Emission results: Dairy Support - Scenario 3 Land Intensificaction - Level 2: Dairy conversion without increasing nitrogen and phosphorus discharge.

	Status Quo	Scenario 1 Nitrogen cap	Scenario 2 Stock exclusion	Scenario 3.1 Intensification	Scenario 3.2 Intensification
Nitrogen					
Total kg	31,364	26,970	31,016	27,579	29,960
kg/ha	68	59	67	60	64
Phosphorus					
Total kg	102	93	101	110	190
kg/ha	0.2	0.2	0.2	0.2	0.4
Greenhouse gases (CO2 equivalent)					
Total kg	4,485,920	3,774,760	4,460,620	5,608,320	6,164,920
kg/ha	9,752	8,206	9,697	12,192	13,402

8.5.3. Discussion

8.5.3.1. Dairy conversion discussion

Scenario 3 takes the farm that was set up as a dairy support farm system, and describes it operating as a steady-state self-sufficient (own wintering) dairy farm. The basis of the scenario is based on no further increased nitrogen or phosphorus loss.

To show the total impact of a dairy conversion we have modelled the converted farm as a self-sufficient wintering and replacement basis. This type of conversion is now more common with smaller herd sizes to avoid the challenges of large herd management.

The costs of the conversion are based on actual costs for this property. The cows are based on the autumn 2019 market prices. The plant and machinery, for dairy is similar to dairy support with no extra debt incurred.

8.5.3.2. Financial discussion

The farm system modelled is a low foot print, low input farm system, with a low cost structure and will be resilient in most milksolids-price scenarios. The effect of comparing the two farm systems in a steady-state business regards EBITD, capital, and Disposable Surplus is shown in Table 44. The lift in profitability from dairy farming more than covers the additional interest from the costs of conversion and purchasing livestock. This budget highlights why many Canterbury farmers have chosen to convert of the last two decades. Dairy support, sheep and beef farmers have been able to increase their profitability while stepping back from the day to day running of the farm.

The capital expenditure budget includes provision for purchasing Fonterra shares at $6.00 per share. We have assumed a 5 per cent return on investment on Fonterra shares ($0.30 dividend). With cost of capital (interest) at 6.75 per cent. The purchase of Fonterra shares has a negative cashflow impact.

The equity position of this case study is marginal based on current acceptable banking ratios. A debt level (Status Quo plus new lending) of $12.3 million, would be 52 per cent of assets at current market prices for land, stock and plant. The cash surplus would all be tied up in debt repayment until the debt was at a comfortable level.

8.5.3.3. Nutrient discussion

The Overseer nutrient budget model reports a 4.4 per cent reduction (compared to the Status Quo analysis) for nitrogen, while phosphorus discharge on a sum-total farm basis increases from 102 to 190 kilograms phosphorus (+ 86 per cent) (Table 45). The Overseer phosphorus sub-model calculations need further understanding.

8.6. Arable Mixed Cropping – Scenario 3: Land Intensification - Arable to Dairy Conversion without increasing nitrogen and phosphorus discharge

8.6.1. Scenario introduction

Scenario 3 Land Intensification attempts to convert the Status Quo arable farm to dairy, without increasing nitrogen or phosphorus loss. The Status quo nitrogen loss (Table 47) was 24 kilograms of nitrogen discharge per hectare per annum, while phosphorus was 0.5 kilograms phosphorus discharge per hectare per annum.

The arable farm effective area was large enough to establish a milking platform and a self-sufficient support block (heifers all year, and wintering of cows).

8.6.1.1. Area

Total area modelled remains at 325 hectares effective, (348 hectares total), made up of:

- 315 irrigated hectares flat land (approximately two-thirds pivot irrigators, one-third travelling irrigators, shallow wells)
- 10 dryland hectares re-instated to irrigated, flat land
- 23 hectares in-effective / non-productive
- Soil types:
    - 220 ha (approximately two-thirds) of the area classified as Prebbleton silt loam (Prebb_5a.1)
    - 105 ha (approximately one-third) of the area classified as Wakanui silt loam (Wakanui_27a.1)
- Dairy platform:
    - 210 ha irrigated by centre pivots, on the Prebbleton silt loam
    - 10 ha irrigated by a travelling irrigator, on the Prebbleton silt loam
- Support block:
    - 10 5ha irrigated by travelling irrigators, on the Wakanui silt loam
- Mean annual rainfall 544 millimetres per annum
- Annual potential evapotranspiration 877 millimetres per annum.

8.6.1.2. Pasture

Dairy platform:

- 210 ha of permanent pasture under centre pivots, yielding 16.9 tDM/ha per annum. Liquid effluent is applied via the pivots
- 10 ha irrigated by a travelling irrigator, yielding 14.9 tDM/ha per annum.
- No forage/fodder crops.

Support block:

- 105 ha irrigated by travelling irrigators, yielding 14.9 tDM/ha per annum
    - Effluent solids spread prior to establishment of winter greenfeed crops.

8.6.1.3. Crop areas and yields

Forage/fodder crops only grown on the support block, within a seven year crop rotation (Figure 19):

75 ha Pasture

15 ha Fodder beet followed by green chop oat silage

15 ha Kale followed by green chop oat silage

Back to pasture.

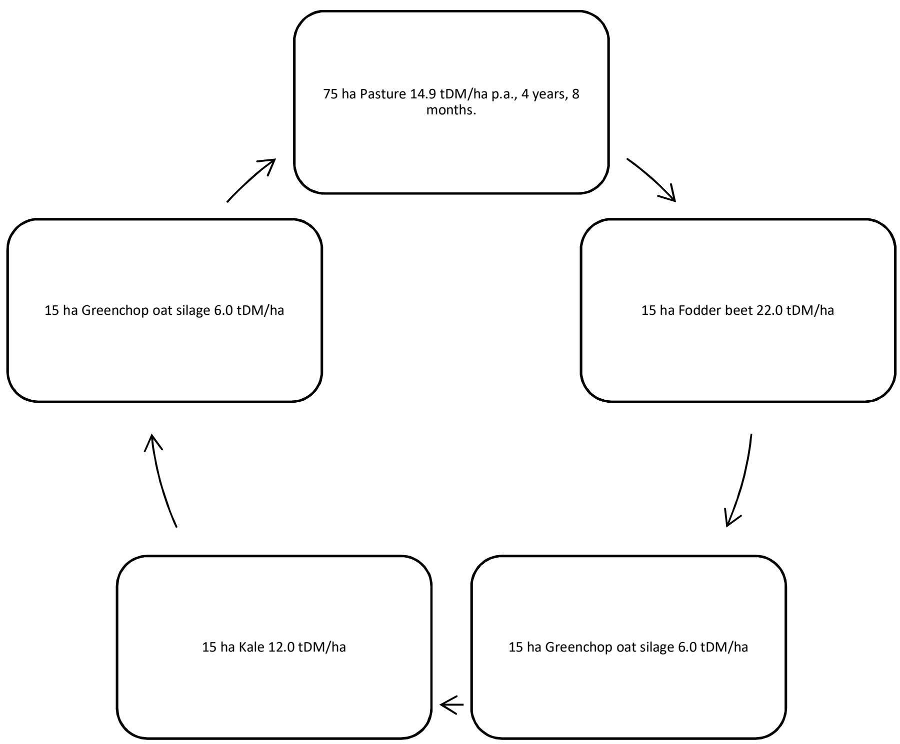


Figure 19: *Arable mixed cropping: Scenario 3 Land Intensification - Dairy support block 7 year crop rotation, 15 hectares each crop block.*

8.6.1.4. Stock numbers and performance

Heifers and cows are wintered 'on-farm' within the 325 hectare effective.

Dairy platform:

- 810 cows wintered, 782 cows at peak-milk
- Calving date 31st July. Low altitude farm
- Cows producing 484 kilograms milksolids per cow
- Cows culled early (1st April)
- Lactation curve and the pasture growth curve are based on Lincoln University Dairy Farm (similar district), although the productivity is slightly more conservative
- A high standard of management is required to execute this farm program.

Support block:

- 200 in-calf heifers
- 200 calves reared

8.6.1.5. Supplements

The farm is self-sufficient regarding baleage and silage. No surplus baleage or silage is sold. Grain is purchased for feeding in the milking shed.

Dairy platform:

- 210ha of permanent pasture:
  - 80 tonnes drymatter of grass silage cut per annum
- 10ha under a travelling irrigator:
  - 20 tonnes drymatter of grass silage cut per annum
- No forage/fodder crops on the platform
- 282 tonnes of barley grain purchased.

Support block:

- 105ha irrigated by travelling irrigators
  - 253 tonnes drymatter of grass silage cut per annum
- 15 ha of fodder beet and 15 ha of kale for winterfeed
- 30ha of green chop oat silage immediately after the winter greenfeed.

8.6.2. Modelling outputs

8.6.2.1. Financial budget summary

Table 46 illustrates that while profitability has increased, capital investment and debt have increased markedly.

Table 46: Budget summary: Arable mixed cropping – Scenario 3: Land Intensification - Arable to Dairy Conversion without increasing nitrogen and phosphorus discharge.

	Status Quo	**Scenario 1 Nitrogen cap**	**Scenario 2 Stock exclusion**	**Scenario 3 Intensification**
Nett Farm Income	$1,534,634	n.a.	$1,502,834	$2,529,415
less Farm Working Expenses	$969,222	n.a.	$956,535	$1,299,971
gives Earnings Before Interest and Tax	$565,412	n.a.	$546,299	$1,229,444
less Capital Replacement / Depreciation	$218,200	n.a.	$218,200	$146,000
less Interest (on original term debt)	$296,156	n.a.	$296,156	$296,156
less Interest (marginal per scenario)	-	n.a.	$8,419	$486,668
less Interest (on working capital)	$22,117	n.a.	$22,622	$2,711
gives Taxable Surplus	$28,939	n.a.	$902	$297,909
less Tax Provision (at 30%)	$8,682	n.a.	$271	$89,373
gives* Disposable Surplus	**$20,257**	**n.a.**	**$631**	**$208,536**

*Note: No debt/principal repayments are made in these models.

8.6.2.2. Emission Results

Overseer reports (Table 47) a 15 per cent decrease of total nitrogen discharge, while a 29 per cent increase of phosphorus discharge, relative to the Status Quo arable mixed cropping farm system. Greenhouse gases increase significantly at 269 per cent.

Table 47: Emission summary – Arable mixed cropping – Scenario 3: Land Intensification - Arable to Dairy Conversion without increasing nitrogen and phosphorus discharge.

	Status Quo	**Scenario 1 Nitrogen cap**	**Scenario 2 Stock exclusion**	**Scenario 3 Intensification**
Nitrogen				
Total kg	8,381	n.a.	8,184	7,094
kg/ha	24	n.a.	24	20
Phosphorus				
Total kg	178	n.a.	174	230
kg/ha	0.5	n.a.	0.5	0.7
Greenhouse gases (CO2 equivalent)				
Total kg	2,117,232	n.a.	2,078,604	5,697,804
kg/ha	6,084	n.a.	5,973	16,373

8.6.3. Discussion

8.6.3.1. Dairy conversion discussion

This intensification scenario takes the property that was set up as an arable mixed cropping system, and operates it as a steady-state self-sufficient (own wintering) dairy farm. However the objective of the scenario is to not allow increased nitrate or phosphate losses over the Status Quo.

To show the full impact of a dairy conversion, we have employed a farm system whereby the main dairy farm winters its own cows and replacement heifers. This type of conversion with smaller herd sizes is becoming increasingly common to manage large herd challenges. In the past 2 seasons, the conversions that Macfarlane Rural Business have supported have been this type of farm system.

The costs of the conversion are based on MRB first-hand experience of two recent 2019 Canterbury dairy conversions. Cow values are based on autumn 2019 market prices. The dairy conversion Intensification models assumes the arable farmer will sell the harvesting and cultivation machinery then replace it with dairy equipment with no extra debt incurred. This assumption is typical of these types of conversions.

8.6.3.2. Financial discussion

Table 46 compares the steady-state financial performance of the arable farm conversion compared to the previous arable scenarios. The lift in profitability from dairy farming more than covers the additional interest from the costs of conversion and livestock purchases. This significant lift in profitability highlights why many Canterbury farmers have chosen to convert over the last two decades.

The capital expenditure budget includes provision for purchasing Fonterra shares at $6.00 per share. We have assumed a five per cent return on investment on Fonterra shares ($0.30 dividend). With cost of capital (interest) at 6.75 per cent. The purchase of Fonterra shares has a negative cashflow impact.

The equity position of this converted dairy farm scenario for this case study is low. The debt to equity ratio is 58 per cent. To strengthen the businesses debt to equity ratio, after being converted, a strong focus on allocating cash surplus to debt reduction would be required for a number of years. The debt levels are on the marginal limit of current acceptable banking ratios.

8.6.3.3. Nutrient discussion

The Overseer nutrient budget model indicates a reduction of nitrogen discharge of 3 kilograms per hectare per annum (compared to the Status Quo analysis). However, phosphorus discharge has increased 0.2 kilograms per hectare per annum (Table 47).

The leading contributor to increased phosphorus losses is from non-paddock activities ("Other Losses" as termed in Overseer). The remainder of the farm has reduced phosphorus losses (Table 48) relative to the arable farm in the Status Quo model.

Table 48: Overseer report phosphorus losses for the arable Status Quo model compared to the arable-dairy conversion in Scenario 3 Land Intensification.

	Status Quo model	Dairy (converted arable) model
Total whole farm losses	174 kgP	231 kgP
less "Other losses"	14 kgP	145 kgP
equals Productive farm losses	160 kgP	86 kgP

Whilst the whole farm phosphorus loss increases 57 kilograms phosphorus per annum in the dairy model, the productive area of the farm reduced 46 per cent. The driver for the phosphorus losses is the "Other losses" at 145 kilograms phosphorus per annum, which is explained by leaching losses of phosphorus alongside laneways.

Overseer assumes that 30 per cent (Gray *et al*, 2016) of the phosphorus deposited on to lanes is lost from the farm. The other 70 per cent of phosphorus deposited on lanes is expected to remain on the lane or to be returned to the adjacent paddocks.

For this project, with regards to how we can pilot Overseer, we cannot reduce the phosphorus loss any further, as we have reached the models lowest defaults.

A logical practical approach (although no option to model this within Overseer) that could be considered to mitigating phosphorus losses alongside laneways, could be to direct-drill a 4.5 metre width of autumn cereal parallel to laneways. The cereal could uptake the excess phosphorus, assumed to be lost from the farm from tracks and lanes. 57 kilograms of phosphorus would need to be mopped up to bring the dairy conversion back in line with the Status Quo arable model. (Assumptions: 1750 m of laneways dual-camber. Camber pitched 1.5% to either side of laneway. 4.5 m drill). 1.5 hectares of 9.0 tonne drymatter per hectare green leaf biomass would be required. This is a feasible solution.

9. Key results summary

Table 49. Case study farm scenario testing, key summary results / trends.

Key Indicator	Status Quo	Scenario 1 Nitrogen Loss Cap	Scenario 2 Stock Exclusion	Scenario 3/3.1 Land Intensification	Scenario 3.2 Land Intensification
Red Meat/ Hill Country					
Disposable surplus	$15,182	-	-$131,209	$13,761	-
kg N / ha discharge	19	-	18	19	-
kg P / ha discharge	0.4	-	0.2	0.4	-
kg GHG / ha emissions	4193	-	4207	5192	-
Dairy					
Disposable surplus	$204,803	$154,678	$182,357	$289,530	$262,922
kg N / ha discharge	66	59	64	63	57
kg P / ha discharge	1.5	1.4	1.4	1.5	1.5
kg GHG / ha emissions	17,351	16,446	17,008	19,170	18,899
Dairy Support					
Disposable surplus	$38,763	$6,322	$29,469	-$125,054	$144,146
kg N / ha discharge	68	59	67	60	64
kg P / ha discharge	0.2	0.2	0.2	0.2	0.4
kg GHG / ha emissions	9752	8206	9697	12,192	13,402
Arable mixed cropping					
Disposable surplus	$20,257	-	$631	$208,536	-
kg N / ha discharge	24	-	24	20	-
kg P / ha discharge	0.5	-	0.5	0.7	-
kg GHG / ha emissions	6084	-	5973	16,373	-

10. Limitations

10.1 The validity of the modelled Scenarios in this project, in terms of representing Canterbury, need to be tested with a broader range of climate and soil types, but ultimately different regions in New Zealand also.

10.2 This report is limited to assessing the effects of the Scenarios at a farm level, and not beyond the farm gate. The implications of the modelled Scenarios will also impact on the wider community as cash farm expenditure and labour requirements vary between Scenarios.

10.3 It is important to consider that many linear assumptions are made in models and as a consequence modelled outcomes should be read whilst considering a margin of error. Farmax and Overseer are mathematical models of biological systems in a dynamic environment, and as such make many assumptions to predict nutrient losses. Being models, they are only as accurate as the scientific evidence that has been programmed into the model, for the particular software version at the time of running the model.

10.4 Within Overseer the phosphorus losses must be carefully considered. The AgResearch report "Review of the phosphorus loss sub-model in OVERSEER" (2016) gives detail of the limitations of the phosphorus sub-model.

10.5 We are unsure if Overseer allows for the interception, of surface phosphorus runoff, by rank grass riparian buffer strips.

10.5 Within Overseer there is an abundance of drainage trial data for nitrogen on pastoral systems and some arable crops, but there is considerably less data to validate the nitrogen sub-models for forage and specialist seed crops.

10.6 The Scenarios have not been modelled together.

10.7 No sensitivity analysis undertaken during the current modelling.

10.8 For simplification of calculations and to determine the potential impact of the proposed NES changes, it has been assumed existing (or non-existent) fencing of waterways are on the bank edge, and a full 5-metre minimum setback area applies for the full waterway length (both sides of the waterway). However in many cases i.e. Dairy, many waterways have already been fenced with setbacks of between zero and three metres. Land already lost to existing setbacks, particularly for Dairy have not been taken into account. Some farms, especially hill country farms (sloping with 'meandering' waterways), will be impacted considerably more than the intended five metre metric.

11. Further work

11.1. The Scenarios modelled have evaluated the financial and environmental effect of feed pads and barns at a very preliminary level. They are extremely complex systems to evaluate. Further examination is required to fully understand the benefits and impacts of these tools.

11.2. Policy changes that impact negatively on either farm profitability, or induce additional capital expenditure to maintain an existing farm programme, can impact negatively on asset values. Investors (farmers or otherwise) invest on the basis of return on capital. Agricultural businesses typically generate between 2.5 per cent and 6.0 per cent return on invested capital depending on commodity prices and input costs. If policy change requires significant investment in fencing or animal shelters, the underlying land value is eroded by the equivalent of the additional investment required to maintain a return on capital.

The proposal to fence a five meter riparian margin adjacent to all intermittent and permanently flowing waterways could see a reduction of 39,867 hectares (1.6 per cent of current effective land area) of intensively farmed land and a reduction of 106,129 hectares (7.3 per cent of current effective land area) of extensively farmed land in Canterbury. The estimated total cost of land asset value through productive land lost to riparian margins is estimated at a total of $1,122,465,942 (average $219,700 per farm). Further examination is required to understand the impact of large-scale productive land loss, of a proposal of this nature should it be pursued.

11.3. Throughout the various Scenarios, nitrogen discharges to water (per hectare basis, not concentration basis) are improved or maintained. Phosphorous losses in those same scenarios were able to be maintained or improved, with the exception of dairy support and the arable-dairy conversions in Scenario 3. These models incurred a slight increase in phosphorus losses which may be mitigated practically on farm, but not within the Overseer software. Careful consideration should be given to the drivers of water quality, as mass load discharge (kilograms per hectare basis) influences water quality of the receiving environment in different ways depending on soil type and climate. An interaction between mass load and concentration ultimately defines water quality of the receiving environment. Some farms in high rainfall areas, on light soils can lose in excess of 60 kilograms of nitrogen per hectare per year. However due to the high volume of drainage from the soil profile, the concentration of nitrogen in the drainage is less than 5 parts per million. In contrast, on heavy soils and low rainfall areas, nitrogen losses to water can be less than 25 kilograms per hectare per year, while volume of drainage is low, concentration in drainage can be in excess of 30 parts per million. A regional impact study would be advantageous in assessing the cumulative effect of the scenarios on water quality.

11.4. A regional social impact study would be advantageous in assessing the cumulative effect of the scenarios on rural communities.

11.5. The proposed policies should be discussed with prominent financial institutions in New Zealand who are key stakeholders regarding rural debt.

12. References

Gray C.W., Wheeler D., McDowell R.W., 2016. Review of the phosphorus loss submodel in OVERSEER®. Report prepared for OVERSEER® owners under AgResearch core funding contract A21231(A).

Ministry of Business, Innovation and Employment, 2017. Small businesses in New Zealand. June, 2017. https://www.mbie.govt.nz/assets/30e852cf56/small-business-factsheet-2017.pdf

Parkyn S., 2004. Review of Riparian Buffer Zone Effectiveness. MAF Technical Paper No: 2004/05. Prepared for MAF Policy. ISBN No: 0-478-07823-4, ISSN No: 1171-4662.

13. Glossary

Overseer	Biological nutrient budgeting tool used to estimate gaseous, drainage and nutrient emission from an agricultural, horticultural or viticulture system.
Farmax	Agricultural system modelling tool that is developed and used to indicate the agronomic feasibility of an existing or proposed system.
Budget	(Financial Budget) used to indicate the financial outcome of a scenario.
kgDM	Kilograms of Dry Matter (the simplest measure of the energy in a feed), gross weight of a feed (wet weight) is of no benefit to an animal, the component of dry matter in the feed drives the production of the livestock.
tDM	Tonnes Dry Matter. The nutrient and feed value containing proportion of feed, excluding water.
ha	Hectare.
kgMS	Kilograms of milk solids; it is the solids component of the milk which is the basis on which New Zealand dairy farmers are paid for their milk.
kg	Kilogram.
CW	Carcass weight; this is the weight of meat and bone that the producer (farmer) is paid on when the animal is sent to slaughter.
LW	Live weight; the weight of the animal while it is alive.
WHC	Water Holding Capacity; all the soil water can hold between Field Capacity and Permanent Wilting Point.
Short Rotation	Pasture that is designed to last 3-5 years. They are cross between an Italian and Perennial grass, with better winter activity than a perennial.

Italian	Grass species that is designed to last 1-2 years and has good winter activity.
Feed Pad	Place where stock are taken off the paddock and fed supplementary feeds to avoid paddock damage and improve feed utilisation.
Holding Pad	Place where stock are taken off the paddock to avoid paddock damage.
Barn	Shed built to house and feed livestock, typically over winter.
Utilisation	The amount of feed that is consumed by the animal as a proportion of the feed allocated. The rest is wasted to the ground.
Supplement	Additional feed bought in to one farm from another farm or from storage to feed to livestock when the pasture or fodder crop is not sufficient to sustain the animal.
GFI	Gross Farm Income.
FWE	Farm Working Expenditure.
EBITD	Earnings Before Interest Drawings, Tax & Depreciation.
DS	Debt Servicing (includes interest and rent but not principle).
Tax	Income tax at 28% for companies, 33% for trusts.
Disposable Surplus	Surplus after tax, interest, capital replacement (depreciation), capital expenditure, personal drawings. This is the cash that is left for debt repayment and discretionary expenditure.
GMP	Good Management Practice; generally reflects what the top 50% of farmers are doing right now (June 2012), fairly well reflects complying with supplier regulations and local government law.

14. Appendices

Note - The large Appendices section will be forwarded to MfE as a separate volume.