Nitrogen leaching estimates for sheep and beef farming in the Mangatainoka catchment

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Contents

Summary

Project

Horizons Regional Council has contracted Landcare Research to estimate nitrogen leaching losses from sheep and beef farms in the Mangatainoka catchment.

Objectives

- Identify sheep and beef farms in the Mangatainoka catchment, and group them into representative farm types.
- Estimate nitrate-leaching from representative farms using Overseer® Nutrient Budgets.
- Estimate the contribution of sheep and beef leaching to nitrogen loads in the Mangatainoka River.
- Compare Overseer® N-leaching estimates from versions 5 and 6, to derive an adjustment factor that can be used to convert historical Overseer® 5 modelling results to version 6 equivalents.

Methods

- GIS analysis is used to identify and classify the catchment's sheep and beef farms into ten farming classes based on factors that influence nitrate leaching.
- Three different methods are used to provide estimates of nitrate leaching:

  1. The GIS option: Block-level modelling of 123 farms using data sourced from existing spatial databases. Two methods are used to extend results to the remaining farms. Method 1a extrapolates by farm class averages, while Method 1b extrapolates by a leaching-to-stocking rate relationship for each farm class.

  2. The consultant option: Comprehensive modelling of five representative sheep and beef production systems common to the catchment, as identified by an experienced local farm consultant. Extrapolation by a GIS classification of farm types (Method 2a) and an expert proportional allocation of farm types (Method 2b).

  3. The SLUI option: Overseer® models for 14 sheep and beef farms in and around the catchment were sourced from the Sustainable Land Use Initiative (SLUI). Average N-leaching for the 14 farms was applied to all sheep and beef farms in the catchment.

- An Overseer® version 5.4.10 to 6.2.0 conversion factor is derived from a regression of N-leaching results from 137 Overseer® sheep and beef farm models.
- An attenuation factor of 0.50 sourced from literature is used to estimate soluble inorganic nitrogen loading from sheep and beef farms to the Mangatainoka River.

Results

- Sheep and beef farming accounts for 44% of catchment area. This is lower than previously reported 2007 values (47%) but the difference may be partly accounted for by a growth in dairying (30% to 39%).

- Overseer® Version 6.1.0 produced N-leaching estimates for Mangatainoka sheep and beef farms that were 31% higher than Version 5.4.10 (R^2 = 0.82). An adjustment factor of 1.31 is used to adjust historical version 5 N-leaching results reported for other catchments (so they can be considered against the N-leaching modelling results of this report).
- Methods 1 and 3 produced N-leaching estimates averaging 9.6 to 12.2 kg N/ha/yr[1]. These align well with published estimates for sheep and beef farming, but both methods omit the effects of farm management policy and practice.
- Method 2 produced a high average N-leaching loss at 20.2 kg N/ha/yr[1], with farm management effects (fertiliser, supplementary feeding, stock policies, fodder cropping) accounting for 22% of the loss. High average rainfall also has a significant effect. Reducing annual rainfall to a uniform 1,300 mm/yr (average for farms in the lower 2/3rds of the catchment) decreased average Method 2 N-leaching to 17 kg N/ha/yr[1].
- Average N-leaching from all methods (M1a, M1b, M2, and M3) was 13.2 kg N/ha/yr[1].
- Combining the strengths of Method 1 (large sample and strong extrapolation) with those of Method 2 (inclusion of farm management effects) produced an integrated estimate of 12.9 kg N/ha/yr[1]. This is higher than sheep and beef averages reported for other Manawatu catchments (9–10 kg N/ha/yr[1]), but sheep and beef farms in the Mangatainoka have a particularly high average annual rainfall of 1,650 mm/yr.
- Total sheep and beef N-loading estimates to the Mangatainoka River varied by method, ranging from 92 t N/yr for the SLUI option (Method 3), through to 189 t N/yr for the consultant option (Method 2a). Weighting Method 1b with the management effects of Method 2 (22% increase in N-leaching) produced an integrated estimate of 123 t N/yr.

Conclusions

- Sheep and beef farming accounts for 44% of catchment land use.
- Our best estimate of nitrate leaching from sheep and beef farming in the Mangatainoka catchment is an average of 12.9 kg N/ha/yr[1]. This estimate is based on weighting Method 1b results with the management effects of Method 2, and is similar to the average result for all methods (13.2 kg N/ha/yr[1]).
- Total inorganic nitrogen loading to the Mangatainoka River from sheep and beef farming is estimated at 123 t N/yr using the same weighting (average for all methods was 128 t N/yr).
- An adjustment factor of 1.31 was identified for converting historical Overseer® version 5 sheep and beef farming N-leaching estimates to Overseer® version 6.1.0 equivalents (i.e. v.6 N-leach = 1.31x where x is v.5 N-leach in kg N/ha/yr).

Supply of Overseer® files

Overseer® files created during this study are available from the online version of Overseer (https://secure.overseer.org.nz/live/): account ***amanders@inspire.net.nz***, user name ***Olympus***, and password ***mangatainoka1***. SLUI Overseer® files were not created for this project, but can be requested from LandVision.

[1] Overseer® Version 6.1.0

1 Introduction

In order to manage the allocation of resources effectively (be it contaminant load or water use), the National Policy Statement Freshwater requires Regional Councils to produce a set of accounts (for contaminants and water use) every 5 years for Freshwater Management Units within each regional council boundary. For contaminant loads in particular this requires not only knowing about how much of a contaminant is present within a freshwater management unit but where it is coming from.

Previous investigations have improved the level of knowledge of nutrient leaching under the more intensive land use types, especially for dairy farming in the Mangatainoka catchment (Taylor et al. 2014).

However, estimates of nutrient leaching from extensive sheep and beef farming (the major land use within the region) tend to rely on literature values. Horizons has identified that estimates of nutrients leached from sheep and beef farms is as an area within the nutrient accounting framework that requires strengthening.

2 Background

2.1 Mangatainoka catchment

The Mangatainoka River catchment encompasses 43 240 ha from Mount Bruce in the south, up to the conflux of the Mangatinoka and Tiraumea Rivers near Ngawapurua settlement in the north (Fig. 1). Landscape is predominantly flat alluvial and aggradation terrace (42%), Tertiary soft-rock hill country (44%), and hard-rock mountain terrain (13%) associated with the Tararua Ranges.

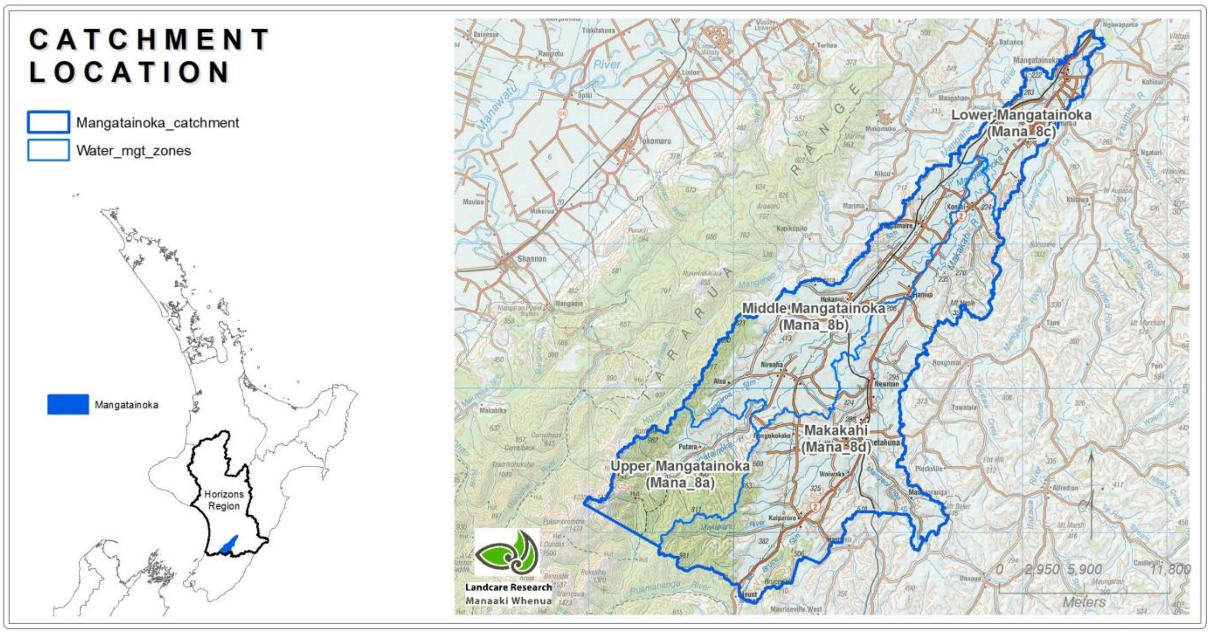

Figure 1 Mangatainoka catchment location and sub-catchments.

Approximately 75% of the catchment is pastoral farmland. Land use is dominated by sheep and/or beef farming (47%), dairy (30%), and the balance (22%) is native or forested land (Clark & Roygard 2008).

2.2 Water quality and nitrate leaching

The water quality of the Mangatainoka catchment is generally low for suspended sediment loads, but high for nitrate and phosphate levels (Roygard et al. 2012). However, this varies by location, with the upper Mangatainoka having significantly better water quality (attributed to a large area of native forest), while the mid and lower reaches regularly exceed nitrogen and phosphorus targets (in some cases loads are twice the targeted loads). Point source discharges from industry and municipal sewage contribute, but it is diffuse-source losses primarily from farming that are considered to make the largest contribution (98% of the nitrate and approximately 80% of the phosphate load).

In 2012 a 2-year long project was initiated to characterise and mitigate nitrate leaching from dairy farms within the catchment (Taylor et al. 2014). A high percentage of targeted dairy farms were involved (83 of a possible 88), with each farm completing both a comprehensive Overseer® nutrient budget and an Environmental Farm Plan. Nitrate leaching per farm averaged 34 kg N/ha/yr, with a range of 16 to 65 kg N/ha/yr.

While dairy farming is thus likely to make a major contribution, no work has yet been done regarding the other dominant land use in the catchment – sheep and beef.

2.3 Objectives

The purpose of this study is to estimate nitrate-leaching loss contributions from sheep and beef farms in the Mangatainoka catchment. Component objectives include:

- Identify sheep and beef farms in the Mangatainoka catchment, and group them into representative categories according to farm type characteristics likely to influence nitrate leaching.
- Estimate nitrate-leaching from representative farms using Overseer® Nutrient Budgets.
- Estimate the contribution of sheep and beef leaching to nitrogen loads in the Mangatainoka River.

3 Methods

3.1 Identify sheep and beef farms in the Mangatainoka catchment

All farms that intersect the Managatainoka catchment boundary were selected from the AgriBase database (March 2014). Large satellite farms with only a small proportion of land located within the catchment were manually removed, and state forest was clipped to the catchment boundary. AgriBase FARM_TYPEs BEF, SHP and SNB, were classified as sheep and beef farms. All other FARM_TYPEs were classified as *Other_landuse*, except where sheep and/or beef stock units represented >25% of total stock units (stock unit numbers calculated using the stock density method of WRC, 2015).

Missing farms were identified by selecting Land Information New Zealand (LINZ) Primary Parcels where a gap in the AgriBase was evident. Parcels were classified as potential sheep and beef if:

- there was no statutory intent (i.e. parcels intended as railways, roads, schools, etc. were classified as Other_landuse except where the parcel was obviously pastoral land determined by inspecting each parcel over orthophotos)
- grassland area was >25% of total parcel area (grassland from the Land Cover Database 4, LCDB4)
- parcel size was >5 ha
- hill country represented >50% of parcel area (using the hill country layer and definition of Basher et al. (2008), modified to include mountain lands).

Resulting potential sheep and beef farms were further classified according to data completeness and logical consistency (Fig. 2). *Core* status was assigned where stock numbers were available from the AgriBase; where >40% of total farm area occurred within the catchment boundary; where farm/parcel size was >10 ha; and where AgriBase data were logically consistent. Farms with good data but that had less than 40% of their area within the catchment, were assigned *secondary* status. The remaining *tertiary* status farms and parcels either had no AgriBase data, or exhibited unusable data inconsistencies (e.g. overlapping polygons, questionable stocking rates >26 su/ha).

The resulting layer provides both an estimate of all sheep and beef farms in the catchment, and a segregation of farms according to suitability and method of Overseer® modelling (i.e. those with and without livestock data).

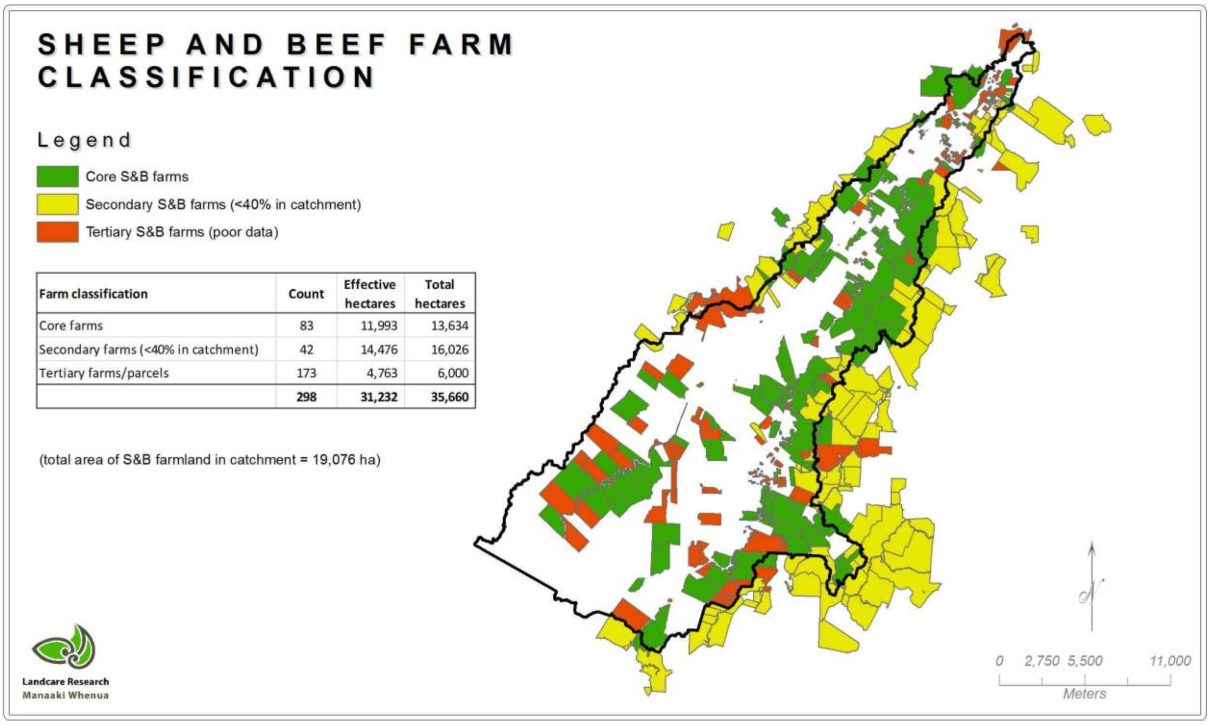

Figure 2 Sheep and beef farm classification for the Mangatainoka catchment.

3.2 Representative farm types and modelling strategies

In the field of statistics, a representative sample is a subset of a population that accurately reflects the entire population. It is employed when it is impractical or impossible to use each individual from the entire population. A representative sample should be an unbiased indication of what the population is like.

Constructing representative farms is always challenging because of the inherent variability of individual farms. Variability arises through differences in patterns of climate, natural resources (soils, topography), land use, management systems, and personal preferences of individual farmers. No two farms are ever truly alike, although they may share some similarities.

The traditional approach is largely subjective, and often involves a combination of landscape type and production system characteristics. Beef+LambNZ use eight farm classes to represent all sheep and beef farms in their economic analyses and reporting (Table 1). These are broad and subjective classes, the origins of which extend back at least to the 1960s. They lack adequate detail and class definition for application to the Mangatainoka catchment.

Table 1 Representative groups of sheep and beef farms used by Beef+LambNZ for economic analysis (B+LNZ, 2015).

Representative group	Estimated number of farms
South Island High country	220
South Island Hill country	850
North Island Hard hill country	1155
North Island Hill country	4020
North Island Intensive finishing	1490
South Island Finishing breeding	2657
South Island Intensive finishing	1306
South Island Mixed finishing	592
Total all classes	12290

Other studies have constructed their own project-specific classifications. Matheson et al. (2012) used soils and expert local knowledge to construct six dairy farming zones for the Rotorua catchment, and slope classes for two dry-stock farming zones (data from actual representative farms from within each zone were used for Overseer® modelling). Bell et al. (2013) used 14 representative farms to extrapolate nitrogen-leaching losses to 440 farms in two Manawatu-Wanganui catchments. Soil texture, natural drainage classes, and irrigation were used to define 7 farm types in a 'West Coast catchment', while rainfall, irrigation, and DairyNZ farm system types were used to define the balance in a 'Tararua catchment'. Choice of criteria appears to be subjective, involving a consideration of 'key features influencing nitrogen leaching' and local knowledge from DairyNZ consultants and Horizons Regional Council staff.

In this project we use three techniques to represent and model sheep and beef farms in the Mangatainoka catchment:

1. The GIS option: Simple modelling of many farms where livestock data are available. Two methods are used to extend results to farms without livestock data. Method 1a extrapolates by farm class averages, while Method 1b extrapolates by a farm class N-leaching to stocking rate relationship.

2. The consultant option: Comprehensive modelling of a set of representative sheep and beef production systems common to the catchment, as identified by local farm systems expertise. Extrapolation is by a GIS classification of farm types (Method 2a) and an expert proportional allocation of production system contributions (Method 2b).

3. The SLUI option: Use existing Overseer® models built for local sheep and beef farms that are involved in the Sustainable Land Management Project. The average N-leaching from these SLUI farms is then applied to all sheep and beef farms in the catchment.

In the final analysis we weight the GIS option with the management effects of the consultant option, to provide an improved estimate.

3.3 Method 1: Many farms modelled simply (GIS option)

A GIS analysis based on variables known to influence nitrate leaching is undertaken to identify representative sheep and beef farm classes in the Mangatainoka catchment. The proportion of farms with available livestock data are modelled through Overseer® and the results are aggregated by representative farm class and extrapolated to the farms without livestock data.

3.3.1 Variables that influence nitrate leaching

A generic 600-ha sheep and beef farm model was constructed for sensitivity analysis of Overseer® inputs. A set of six variables were individually modified (uniform increments) with successive Overseer® runs, and changes in nitrogen leaching outputs were recorded. Variables include:

- Soil types within the catchment.
- Overseer® slope groups.
- Annual rainfall.
- Stocking rate.
- Ratio of sheep to beef stock units.
- Ratio of effective to total farm area.

Choice of variables were based on those known to influence nitrogen leaching, and those that we could extract from GIS data (other variables are relevant but there is little validity in evaluating their sensitivity if they cannot be used to build the representative farm types). Results are presented as Appendix 1. Percent change in minimum and maximum values likely to be encountered in the Mangatainoka catchment for each variable were used to rate the relative impact on nitrogen leaching for each variables (Table 2).

Table 2 Potential impact of five variables on Overseer® nitrogen leaching[1]

	Expected catchment range		**N-leaching range[2]**		**Percent change**	**Relative impact[3]**
	Minimum	**Maximum**	**Minimum**	**Maximum**		
Soils	Kairanga	Ruahine	1535	4026	162%	10
Ovr. slopes	Steep	Flat	3465	4055	17%	-
Stocking rate (su/ha)	1.5	30	1107	3749	239%	14
Effective area (%)[4]	0	90	1162	2542	119%	7
Rainfall (mm/yr)	1110	3090	3797	7541	99%	6

[1] Considerable care is required with the interpretation of this table. Intent is to gain an idea of relative importance. Results only apply to the particular farm modelled.

[2] Kg N/yr total farm loss.

[3] Multiple difference from the lowest score. For example, stocking rate in this instance has 14 times more potential impact on nitrogen leaching than has Overseer slope categories.

[4] Stock units maintained at 17 su/ha and a sheep:beef ratio of 50:50.

3.3.2 Representative sheep and beef farm classes

Representative sheep and beef farm classes were created using proxies for factors influencing N-leaching as follows:

- Soils represented by characteristic Rock Type categories from the NZ Land Resource Inventory (NZLRI) were reclassified as hard rock (greywacke), and soft Tertiary-aged sedimentary rocks. Lowland alluvial flats and aggregation terraces were classed as either Gley or non-Gley soils. These proxies were used to simplify the number of possible categories (from 25 soil types down to 5 proxies).
- Overseer slope groups from NZLRI slopes were simplified to hill and non-hill country.
- Rainfall summarised to farm centroids and classed into catchment-specific classes of Moderate (<1300 mm), High (1300–1800 mm), and Very High (>1800 mm) using the natural breaks method of data clustering (Jenks 1967).
- Potential stock carrying capacity from the NZLRI was used as a proxy for stocking rate because of a reasonable relation (R^2=0.82) with AgriBase total stock units (Fig. 3). High (>17 su/ha) and Low (<17 su/ha) were used to differentiate hill country.
- Ratio of sheep to beef was not used (no equivalent GIS data source).
- Ratio of effective to total farm area, calculated as the ratio between LCDB4 grassland and non-grassland. This was later dropped from the analysis as a poor predictor.

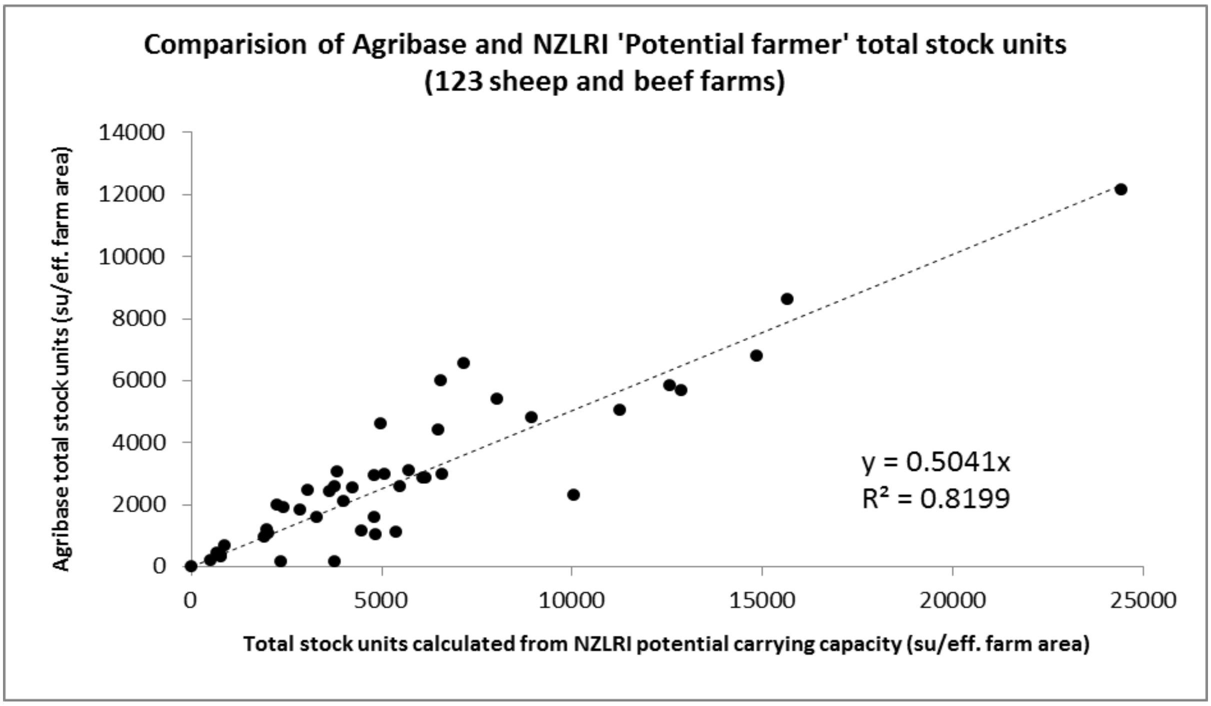

Figure 3 Relationship between NZLRI potential stock carrying capacity and stocking rate for Mangatainoka sheep and beef farms (from useable AgriBase livestock data).

Classifications that were calculated on an areal basis (soil/geology, slope) were assigned to farms according to dominance (i.e. the largest area of a classification within the farm determined the whole-farm classification). This is based on the principle that the dominant characteristic is often used to define spatial features. For example, hill country is defined as landscapes with >50% hills (Milne et al. 1991).

Initially, 15 classes were identified but the non-hill country classes individually represented small areas. The majority of non-hill classes were combined by omitting rainfall zones, resulting in a total of 10 classes (Table 3, Fig. 4).

Table 3 Final sheep and beef classes for the Mangatainoka catchment

	Farm count	**Average for farms within each class**			
		Area (ha)	**Effective (ha)**	**Pot. SR (su/ha)**	**Rain (mm/yr)**
Alluvial	62	13	12	25.3	1345
Alluvial Gley	37	24	24	26.4	1348
Terrace lands	54	44	40	25.3	1571
Tertiary LP hill country (<1300)	20	368	340	17.8	1210
Tertiary LP hill country (1300–1800)	16	219	203	18.0	1411
Tertiary HP hill country (<1300)	16	397	382	19.5	1214
Tertiary HP hill country (1300–1800)	44	122	115	21.4	1441
Tertiary HP hill country (>1800)	12	199	167	20.6	2302
Hard rock LP hill country (1300–1800)	13	117	98	17.5	1688
Hard rock LP hill country (>1800)	24	210	123	13.7	2520
	298				

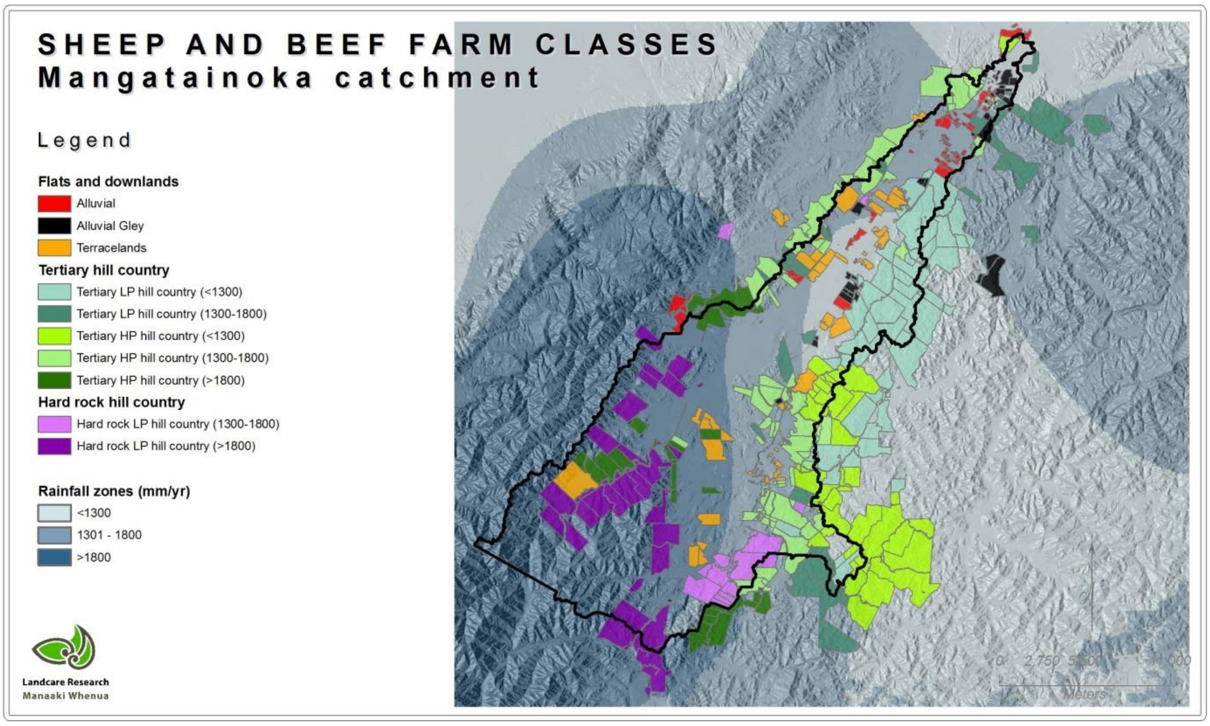

Figure 4 Representative sheep and beef farming types (ten classes).

3.3.3 Overseer® modelling

A total of 123 farms had useable livestock data and were thus eligible for Overseer® modelling. Two GIS files were generated for each farm – one for the whole farm, the other for individual farm blocks. Whole-farm inputs include stock unit numbers for both sheep and beef calculated from the AgriBase using the method of WRC (2015). Wool production was estimated at 5.5 kg per sheep stock unit.

Each farm was subdivided to include up to seven possible block types:

- Topography blocks based on Overseer® slope classes from the NZLRI. Four possible blocks of Flats (0–7°), Rolling (7–15°), Easy Hill (15–25°), and Steep Hill (>25°).
- Tree block. One possible block as Trees if the property has an area of LCDB4 vegetation cover that is not grassland.
- Catchment blocks. Two possible blocks to differentiate parts of a farm inside and outside of the catchment.

Block input variables included:

- Overseer slope class (from NZLRI).
- Block area (hectares).
- Relative yield (estimated from NZLRI potential stock carrying capacities).
- Soil drainage class (FSL database).

- Distance from the coast. Calculated in a GIS using Euclidean distance from coast summed to a farm centroid.
- Annual rainfall, temperature, and potential evapotranspiration summed to a farm centroid.
- Pasture utilisation, assumed to range from 65% for steep-land to 80% for flats.
- Dominant soil series from the FSL (or Soil Order if a particular soil series was unavailable in Overseer®).
- Soil fertility defaults were used except for Olsen P, which is estimated as twice the stocking rate plus 7 (Clothier et al. 2007; Parfitt et al. 2008).
- Superphosphate fertiliser applied at 16.7 kg/ha/su according to Morton et al. (1994) as maintenance levels for Wairarapa sedimentary soils.

Nitrate leaching-loss estimates were recorded at both the whole farm level, and for individual blocks.

3.3.4 Extrapolation methods

Two methods were used to extrapolate the results from the 123 farms to all other sheep and beef farms in the catchment.

Method 1a

Results were extrapolated at the block level. Modelled N-leach values were used where available (i.e. for the 123 farms with livestock data). N-leach average values were generated for each unique farm class + block type combination, and linked back into the database to populate blocks that did not have livestock data. Multipart polygons were exploded, and all polygons outside the catchment were assigned an N-leaching value of zero. N-leach values were multiplied by geometric hectares to estimate total nitrate leaching from sheep and beef farms in the catchment (kg N/yr).

Method 1b

‘N-leaching by stocking rate’ relationships for each farm class were identified (Fig. 5) and used to populate N-leaching estimates to farms without livestock data. Agribase stocking rate was used where available (total farm stock units/geographic effective area) and NZLRI ‘potential carrying capacity’ adjusted by 0.50 (see previous Fig. 3) was used to populate stocking rates for properties without Agribase livestock data.

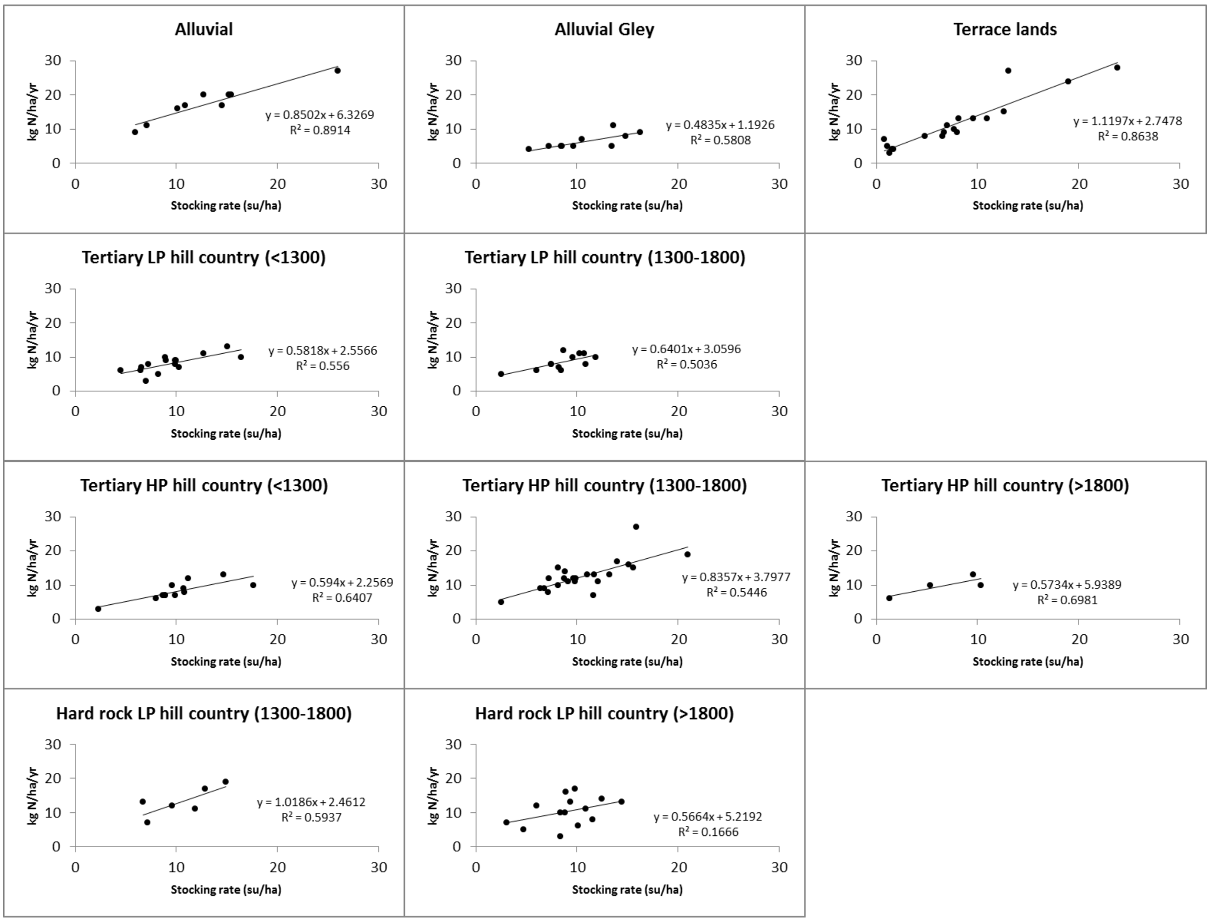

Figure 5 Relationship of farm class N-leaching to stocking rate, used to estimate N-leaching for farms without livestock data.

3.3.5 Advantages and disadvantages

The 'model many farms simply' method has the advantage of representing a large number of sheep and beef farms within the catchment, with a reasonably robust method of extrapolation to farms that do not have livestock data. Disadvantages include a reliance on AgriBase data, which may or may not be correct, and the absence of production and management system considerations particular to the way Mangatainoka farmers may operate their farms. Farm management was noted as the key variable that influences nitrate leaching on Mangatainoka dairy farms (Taylor et al. 2014).

3.4 Method 2: Few farms modelled comprehensively (consultant option)

This is a common strategy used in most studies where nitrogen leaching loss estimates are required for large areas. A small number of farms are modelled, with each farm model (or set of models) representing a grouping of similar types of production system. Representative farm systems are defined and parameterised by a farm management expert familiar with the production systems that are common to the local area of interest.

3.4.1 Representative production system design and parameterisation

Sheppard Agriculture were contracted to identify typical sheep and beef farming systems common to the Mangatainoka catchment (full details in Appendix 2). Three dominant systems were identified; two of which are further differentiated by farming intensity:

1. Medium to steep hill country system (hard hill extensive). Sheep and beef breeding operation over 500 ha effective, 2 ha of crop/new grass, 8.3 su/ha, and a 73:27 sheep:cattle ratio.

2. Intensive medium to steep hill country system (hard hill intensive). Sheep and beef breeding over 450 ha effective, 6 ha of crop/new grass, 9.6 su/ha, 65 kg/ha of urea on flats, and 69:31 sheep:cattle ratio

3. Terrace & easy rolling system (easy hill extensive). Predominantly hill country (80%) sheep and beef trading and breeding, 350 ha effective, 65 kg/ha urea on flats, 16 ha crop/new grass, 31 t DM supplements, 11.4 su/ha, and 70:30 sheep:cattle ratio.

4. Intensive terrace & easy rolling system (easy hill intensive). Predominantly flat (60%) sheep and beef breeding and trading system, 350 ha effective, 16 ha crop/new pasture, 60 t DM supplementary feed, 12.7 su/ha, 63:37 sheep:beef ratio, and urea used in spring across the whole farm (65 kg/ha).

5. Flats finishing operation. Sheep and beef trading system, with purchased ewes with lambs at foot, and bull beef operations. Predominantly flat, 12.2 su/ha, 15 ha crop/new grass, 30 ha of chicory/plantain, 42 t DM supplements, 62:38 sheep:cattle ratio.

A key distinction with these five models is that they include management and policy influences, such as stock policies (types and numbers as the change throughout the year), fodder cropping and re-grassing programmes, and fertiliser policies including the use of urea.

3.4.2 Extrapolation

Two methods are used to extrapolate the results to catchment sheep and beef farms.

Method 2a

An attempt is made to distribute modelling results by GIS. Agribase sheep and beef farms were classified according to criteria of Table 4. These are general criteria inferred largely from the model type name rather than criteria supplied by Sheppard Agriculture. The latter exhibited too much overlap in topographical, Land Use Capability, and soil type criteria, to be used with confidence. Stocking rate is estimated firstly from the Agribase, and then by the relationship with NZLRI ‘potential carrying capacity’ (from the relation in previous Fig. 3). Rainfall averages for each class are estimated via GIS analysis (Table 5).

Table 4 Criteria used to classify sheep and beef farms into Method 2 farm types

Production system	Criteria		Allocation result	
	Farm slope	Stocking rate	Percent of total analysis area	As a percent of analysis area in catchment
Medium to Steep Hill Country (Intensive)	>67% eff. area has slopes >26°; <15% eff. area has slopes <7°	SR 8.1 to 10.5	29%	23%
Medium to Steep Hill Country (Extensive)		SR <8.1	17%	13%
Flat Finishing Operation	>65% of eff. area has slopes <7°; no slopes >26°	>12 su/ha	2%	4%
Terrace and Easy Rolling Country (Intensive)	All other combinations not covered by classes above	SR >10	30%	26%
Terrace and Easy Rolling Country (Extensive)		SR <10	19%	29%
Lifestyle and small farms	Total farm area <20 ha		2%	4%

Method 2b

Sheppard Agriculture is familiar and experienced with sheep and beef farming in the Mangatainoka catchment. They provided an estimate of the relative proportion of each model farm system in the catchment (Table 5).

Table 5 Expert estimate of the relative proportion of Method 2 farms found in the Mangatainoka catchment, and rainfall averages used in Method 2 Overseer® models

Production system	Relative proportion in catchment	Rainfall averages used in modelling (mm/yr)
Medium to Steep Hill Country (Intensive)	20%	1681
Medium to Steep Hill Country (Extensive)	30%	1717
Flat Finishing Operation	4%	1432
Terrace and Easy Rolling Country (Intensive)	15%	1649
Terrace and Easy Rolling Country (Extensive)	25%	1649
Lifestyle and small farms	4%	-

3.4.3 Advantages and disadvantages

The key advantage is that we achieve an expert representation of production systems common to sheep and beef farms in the Mangatainoka. The key disadvantage is the limited number of farm models, and a weakly defensible system of extrapolating the results to all sheep and beef farms in the Mangatainoka catchment.

3.5 Method 3: The SLUI option

The Sustainable Land Use Initiative (SLUI) is Horizon's flagship soil conservation programme that aims to reduce erosion and sediment loss from the Region's hill country farms. A Whole Farm Plan (WFP) is prepared for each SLUI farm, part of which involves the collection of farm data to run the Overseer® model to produce a nutrient budget and an estimate of nitrate leaching.

Fourteen hill country sheep and beef farms located near or within the Mangatainoka catchment are involved in the SLUI programme (Fig. 6). Landvision Limited prepared the WFPs for these properties, and has supplied Overseer® Version 5 and 6.2 models for each property. Average farm size is 614 ha, with a range of 220–1288 ha.

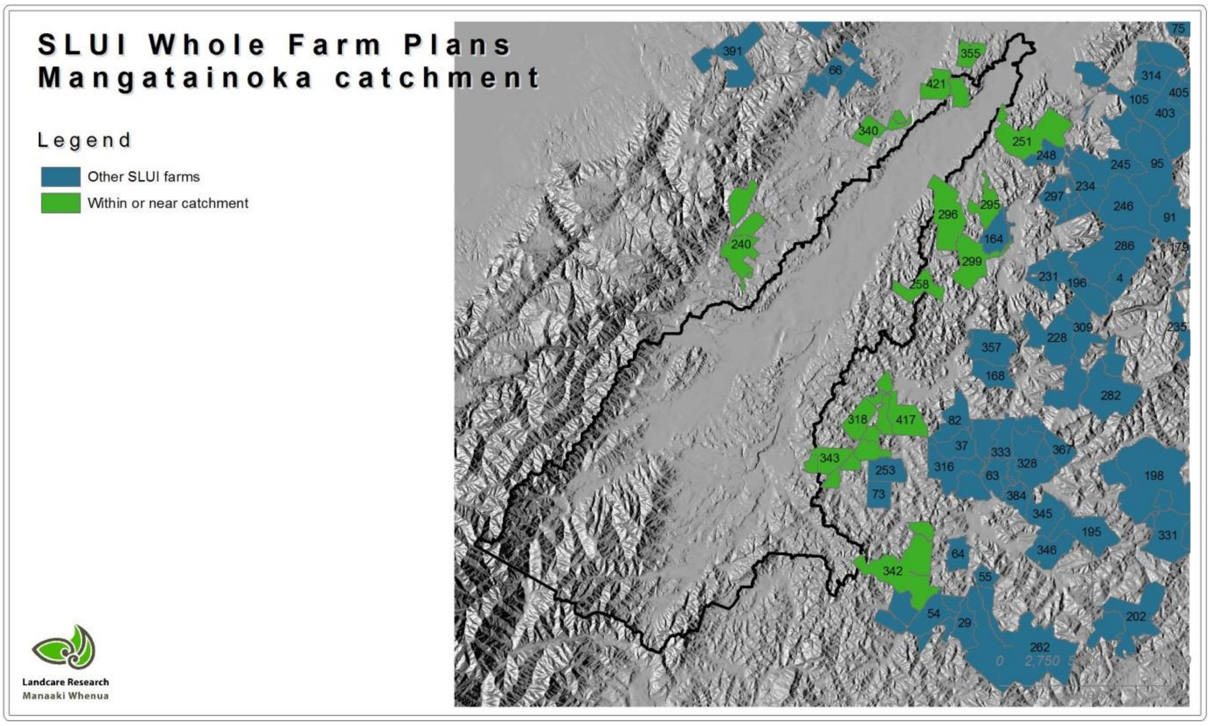

Figure 6 SLUI farms located near or within the Mangatainoka catchment.

3.5.1 Advantages and disadvantages

SLUI nutrient budgets represent modelling of actual farm systems, and are therefore considered here as the most reliable data. The key disadvantage is a small number of farms, none of which are located completely within the catchment. The sample is also biased towards larger farms in lower rainfall environments.

3.6 Load estimates to the Mangatainoka River

Overseer® estimates nitrogen leaching losses from the root-zone. Nitrogen that is lost between source and waterways is typically estimated using a coefficient (often referred to as nitrogen attenuation coefficient, attenuation factor, or transmission coefficient) which is estimated as the difference between known or modelled root-zone losses within a catchment, and measured in-stream nitrogen loads for that catchment.

Alexander et al. (2002) estimated nitrogen attenuation factors ranging from 0.25 to 0.61 for the five catchments of the Waikato River. HBRC (2012) estimated attenuation factors ranging from 0.25 to 0.55 for four policy zones in the Hawkes Bay. Other researchers have found values ranging from 0.30 to 0.75 (as noted in Clothier 2008 and Bell et al. 2013).

Clothier (2009) describes the method used to calculate attenuation factors for both dairy farming, and sheep and beef farming, in the Upper Manawatu Water Management Zone. They found that both land uses had the same attenuation factor of approximately 0.50. This is now commonly used in other studies, often as the 'rule of thumb' in the absence of having better information (MfE 2014).

We use this 0.50 attenuation factor in this study on the basis that it was calculated for a nearby catchment in the Horizons Region, and it is beyond the scope of this project to undertake a land-use- and catchment-specific analysis of attenuation factors.

3.7 Overseer® version comparison

Overseer® underwent a major version transition with the release of Overseer® 6 in 2012. Introduction of calculations on a monthly basis put much greater emphasis on soil drainage characteristics, and generally resulted in much increased estimates of N-leaching for farms with a predominance of well-drained soils, and reduced N-leaching for farms with poorly drained soils (Taylor et al. 2014).

While not an objective of this study, we have used both Overseer® 5.4.10 and 6.2.0 to estimate N-leaching from the 123 GIS farms and the 14 SLUI farms. The purpose is to identify a coefficient that can be used to convert N-leaching values reported for Version 5 modelling, so they can be compared with the estimates made in this report.

3.8 Supply of Overseer® files

Overseer® files created during this study are available from the online version of Overseer (https://secure.overseer.org.nz/live/): account ***amanders@inspire.net.nz***, user name ***Olympus***, and password ***mangatainoka1***. The SLUI Overseer® files were not created for this project, but can be requested from LandVision.

4 Results

4.1 Sheep and beef farming in the Mangatainoka catchment

Based on the criteria used in this report, there are 298 sheep and/or beef farms with land in the catchment. The total area of these sheep and beef farms is 35 660 ha (includes land outside the catchment), of which 88% is effective grassland. Approximately 160 are small farms <20 ha in size, accounting for a relatively small area of 710 ha (680 ha effective).

The area of sheep and beef farmland within the catchment is calculated at 19 075 ha (44% of catchment area), with 16 270 ha effective (38% of catchment area).

Clark & Roygard (2008) estimated catchment land use in 2007 at 47% sheep and beef, 30% dairy, and 22% as native or commercial forest. Dairy has since expanded (Taylor et al. (2014) now estimate dairy at 39%), possibly explaining the reduction in sheep and beef farming area.

4.2 Overseer® version comparison

Version 6 produced estimates that were generally higher than Version 5. With the GIS method (Method 1), approximately 78% of farms had increased N-losses (mean percent increase of 24%, with a range of +7% to +57%), 13% exhibited no change, and 9% of farms had reduced N-leaching losses (mean percent decrease of –18% with a range of –9% to –40%).

From a regression perspective, Version 6 produced whole farm N-leaching estimates that were 32% higher ($R^2 = 0.83$), and block estimates that were 18% higher ($R^2 = 0.69$).

The 14 SLUI farms had mostly positive differences, with an average increase of 35% for 11 farms (9% to 86% range), one farm with no change, and two farms with a reduction of –29% (same value for both farms). Net change was a 23% increase by regression ($R^2 = 0.50$).

The level of increase for both datasets was a 31% increase ($R^2 = 0.82$). This falls within values reported elsewhere. Manderson (2015) found an average 29% increase (R2 = 0.77) for the 21‘MAF monitor farm’ models, while Hawke’s Bay Regional Council found increases of 27% and 34% for two Ruataniwha Plains datasets (Ian Millner, HBRC, pers. comm.).

4.3 Modelling results by method

4.3.1 Method 1: Model many farms simply (GIS method)

Nitrate leaching for the 123 farms averaged 10.6 kg N/ha/yr with a range of 3–28 kg N/ha/yr (Table 6). Losses are greatest from the lowland Alluvial farm class, and lowest from the Alluvial Gley class (mostly reflecting the Overseer® Version 6.2.0 emphasis on soil drainage). Extrapolation methods exhibited little difference, with Method 1a resulting in a catchment farm loss of 198 t N/yr and river loading of 99 t N/yr, while Method 1b was slightly higher with a total loss of 202 t N/yr, and a 101-t N/yr river loading.

Table 6 Summarised Overseer® results (Version 6.2.0) for 123 farms, Method 1

Farm class	Farms (count)	Nitrate leaching (kg N/ha/yr)		
		Minimum	**Mean**	**Maximum**
Alluvial	9	9	17.4	27
Alluvial Gley	10	4	6.4	11
Hard rock LP hill country (>1800)	14	3	10.4	17
Hard rock LP hill country (1300–1800)	6	7	13.2	19
Terrace lands	18	3	11.7	28
Tertiary HP hill country (<1300)	12	3	8.3	13
Tertiary HP hill country (>1800)	4	6	9.8	13
Tertiary HP hill country (1300–1800)	23	5	12.7	27
Tertiary LP hill country (<1300)	15	3	8.1	13
Tertiary LP hill country (1300–1800)	12	5	8.5	12
Summary values	123	3	10.6	28

4.3.2 Method 2: Model few farms well (consultant method)

Nitrate leaching for the five model farms averaged 20.2 kg N/ha/yr with a range of 14.3 to 26.8 kg N/ha/yr. Results for simplified versions of each model (management and specific policy detail were removed) were considerably lower (Table 7), but still relatively high compared with other methods.

Extrapolation by Method 2a produces an estimate of 377 t N/yr for total leaching losses from sheep and beef farms, and 189 t N/yr as a corresponding load to the Mangatainoka River. This decreases to 322 t N/yr and 161 t N/yr using Method 2b (expert distribution of farm types).

Table 7 Overseer® results for Method 2 farm models

Farm model	N-leaching (kg N/ha/yr)		
	Full farm model	**Simplified model[1]**	**% change**
Terrace and Easy Rolling Country (Extensive)	22.8	15.1	–34%
Terrace and Easy Rolling Country (Intensive)	26.8	18.2	–32%
Flat Finishing Operation	24.9	17.4	–30%
Medium to Steep Hill Country (Extensive)	12.3	11.8	–4%
Medium to Steep Hill Country (Intensive)	14.3	13.2	–8%
Averages	20.2	15.1	–22%

[1] Simplified model represents the removal of management and specific policy detail from each farm model (urea, cropping, re-grassing programme, seasonal stock flows, and supplementary feeding).

4.3.3 Method 3: The SLUI option

Average N-leaching loss of the 14 SLUI farms was 9.6 kg N/ha/yr (Table 8). Applied to all sheep and beef land within the catchment, total N-leaching loss would equate to 184 t N/yr, representing a loading to the Mangatainoka River of 92 t N/yr.

Table 8 Summarised Overseer® results (Version 6.2) for 14 SLUI farms

WFP ID	Farm	Area (ha)	WFP	Nitrate leaching (kg N/ha/yr)
240	Farm #1	906	2009/INT/804	16
299	Farm #2	568	2010/INT/1007	6
421	Farm #3	486	2012/INT/1234	8
343	Farm #4	517	2011/INT/1078	13
417	Farm #5	786	2012/INT/1230	5
318	Farm #6	681	2010/INT/1034	12
342	Farm #7	1,288	2011/INT/1077	8
258	Farm #8	321	2010/INT/840	5
340	Farm #9	337	2011/INT/1074	9
251	Farm #10	879	2010/INT/815	11
295	Farm #11	325	2010/INT/896	9
296	Farm #12	727	2010/INT/1004	9
355	Farm #13	220	2011/INT/1110	12
473	Farm #14	557	2013/INT/1327	12
	Average			**9.6**

4.4 Summary and comparison of all methods

Mean nitrate leaching results for Methods 1 and 3 (Table 9) are comparable to results from other studies. For example, Landvision analysed Overseer® results for 59 SLUI properties in the Upper Manawatu catchment in 2012. Mean N-leaching calculated using Overseer® Version 5 was 8 kg N/ha, which broadly translates to a Version 6 equivalent of 10.5 kg N/ha/yr (from Section 5.2). Clothier (2009) reports on a study for the Upper Manawatu catchment where sheep and beef N-losses were estimated to average 9.2 kg N/ha/yr, with a range of 7.9 to 11.8 kg N (Version 6 equivalents). Roygard & Clark (2012) estimated average sheep & beef losses for the Mangatoro catchment at 10.5 kg N/ha/yr (Version 6 equivalents). The Overseer® sheep and beef farm benchmark is 5–20 kg N/ha/yr.

Table 9 Summary results for all methods

Method	Extrapol-ation method	Average N-leach (kg N/ha/yr)	N-leach range (kg N/ha/yr)	Total S&B N-leach (t N/yr)	Total S&B N-load (t SIN/yr)
1. Model many farms simply	1a	10.6	3–28	198	99
	1b	12.2	5–28	202	101
2. Model few farms well	2a	20.2	12–27	377	189
	2b	-	-	322	161
3. SLUI option	-	9.6	-	184	92
Average all methods	-	13.2	-	257	128
Combination of M1b & M2	-	12.9	-	246	123

The relatively lower estimate for Method 3 (9.6 kg N/ha/yr) is not unexpected, as the 14 SLUI farms are generally large with modest stocking rates. It is also worth noting that the SLUI models contain little or no management components, meaning they are directly comparable to the results of Method 1.

In contrast, mean nitrate leaching results for Method 2 stand out as being particularly high (Fig. 7) as they sit at the upper end of Overseer® sheep and beef benchmark values. In part, there could be a small bias in the design of Method 2 models, as the designs were likely generalised from Sheppard Agriculture's client database (farmers that use consultants will generally be in the top 40% of performance).

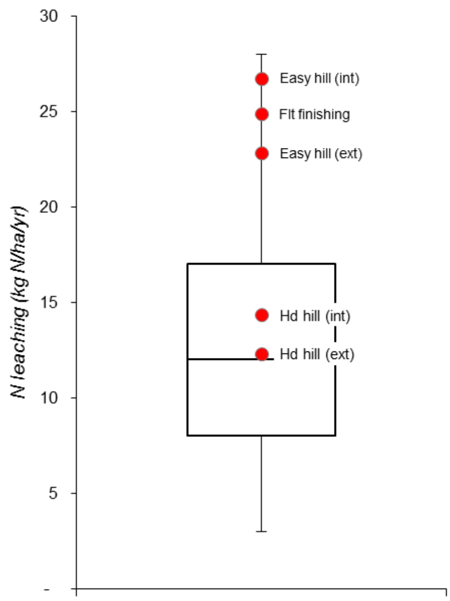

Figure 7 Method 2 results for each of the 5 farm models plotted over boxplot of Method 1 results for all farms

Notwithstanding, however, we cannot fully conclude that these high values do not provide a fair representation of N-leaching. Average rainfall across all sheep and beef farms is particularly high (1650 mm/yr). Reducing this to a uniform 1300 mm/yr (average for farms in the lower 2/3rds of the catchment) decreases Method 2 N-leaching losses to 17 kg N/ha/yr. Further, Method 2 models include management practices that increase nitrate-leaching (particularly the cropping). Excluding these management effects decreases N-leaching by an average of 22% (previous Table 7).

While still relatively high, we should perhaps be expecting higher values to begin with. Roygard & Clark (2012) estimated N-leaching losses from sheep and beef farms in three large catchments using a 'by difference' method. N-leaching estimates were made for all other land uses, and the remaining unaccounted difference in river loads was allocated to sheep and beef farms. Adjusted to Overseer® Version 6, sheep and beef N-losses were estimated at 12.9 kg N/ha/yr for all three catchments, 16.0 kg N/ha/yr for the Manawatu catchment, and 22.7 kg N/ha/yr for the Mangatainoka catchment (all estimates exclude negative values). Mangatainoka was acknowledged as having especially high values, although the precise cause was unknown.

The main constraint to the use of Method 2 results is the weaknesses inherent to the extrapolation techniques. We simply do not have enough information about the actual distribution and representation of Method 2 farm models. In contrast, Method 1b uses a comparably stronger and more defensible extrapolation, but is limited by the omission of farm management and policy components. Our compromise is to combine the best of both, by using Method 2 to weight the results of Method 1b. The result is an integrated estimate of 12.9 kg N/ha/yr, which is similar to the average of all other methods combined (13.2 kg N/ha/yr).

4.4.1 Sheep and beef contribution to river N-loads

Results are variable (Table 9). The estimate based on SLUI farms was lowest at 92 t N/yr, while the consultant option (Method 2) produced the highest estimate at 161–189 t N/yr. The GIS option (Method 1) produced a lower estimate at 99–101 t N/yr. Average for all methods was 128 t N/yr. Combining the farm management effects of Method 2 (+22% increase in N-leaching attributable to farm management practice and policies) with the extrapolation technique of Method 1b resulted in an integrated estimate of 123 t N/yr.

5 Conclusions

- Sheep and beef farming accounts for 44% of catchment land use by farm area.
- Methods 1 and 3 produced nitrate leaching estimates averaging 9.6–12.2 kg N/ha/yr. These align well with other published estimates for sheep and beef farming, but omit the effects of farm management policy and practice.
- Method 2 produced a high average N-leaching loss at 20.2 kg N/ha/yr, with farm management effects (fertiliser, supplementary feeding, stock policies, fodder cropping) accounting for 22% of the loss. High average rainfall also has a significant effect. Reducing annual rainfall to a uniform 1300 mm/yr (average for farms in the lower 2/3rds of the catchment) decreased average Method 2 N-leaching to 17 kg N/ha/yr.
- Our best estimate of nitrate leaching from sheep and beef farms is 12.9 kg N/ha/yr. This estimate is based on weighting Method 1b results with the management effects of Method 2. This is higher than sheep and beef averages reported for other Manawatu catchments (9–10 kg N/ha/yr), but sheep and beef farms in the Mangatainoka have a particularly high average annual rainfall of 1650 mm/yr.
- Total inorganic nitrogen loading to the Mangatainoka River from sheep and beef farming is estimated at 123 t N/yr. Results by modelling method varied, ranging from 92 to 189 t N/yr.

6 Acknowledgements

We gratefully acknowledge the assistance of Maree Clark and Jon Roygard from Horizons Regional Council; special thanks to Lachie Grant from LandVision for suppling Overseer models of SLUI farms, and to Greg Sheppard who was able to draw on his wealth of local knowledge to construct representative farming systems. This project was made possible through funding provided by the Ministry of Business, Innovation & Employment (Science and Innovation) in the form of a medium advice Envirolink grant (#1509-HZLC112).

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Appendix 1 – Overseer sensitivity

A generic 600-ha sheep and beef farm model was constructed for sensitivity analysis of Overseer® inputs within the Mangatainoka catchment. A selection of five variables was individually modified (uniform increments) with successive Overseer® runs, and changes in nitrogen leaching outputs were recorded and graphed.

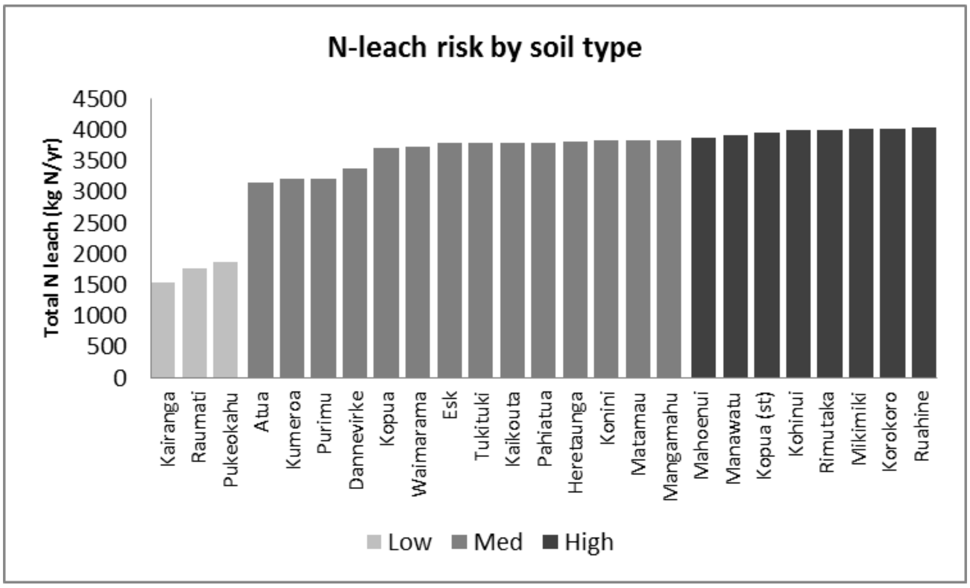

Figure 8 N-leaching by soil types within the Managatainoka catchment for a generic 600-ha sheep and beef farm. Gley and Melanic soils had the least leaching, while shallow and stony soils had the highest leaching rates. High leaching from the Manawatu soil, and moderate leaching from the Tukituki soil, were both surprising (and were double checked because of this).

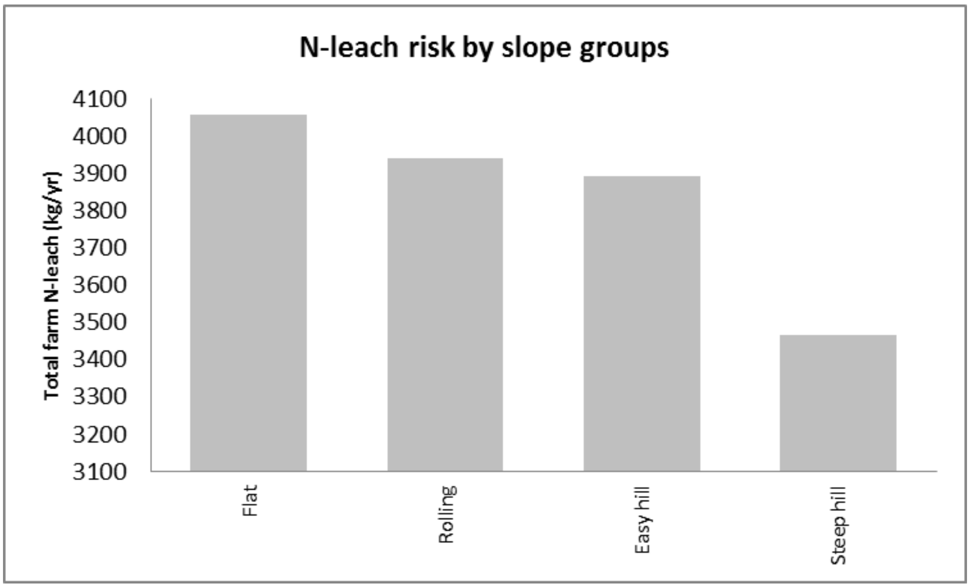

Figure 9 N-leaching by Overseer slope groups. High leaching for flat slopes, while low leaching for steep hill slope categories.

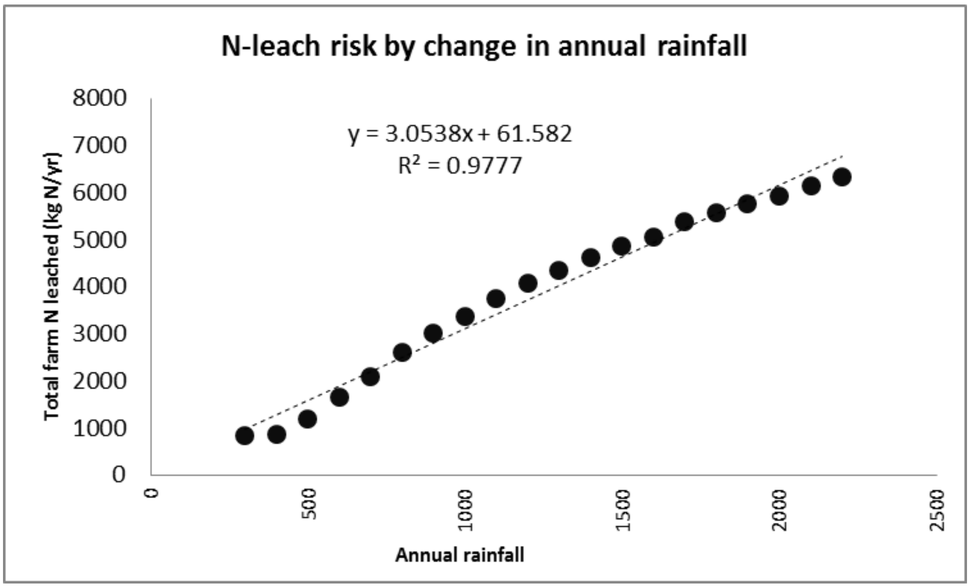

Figure 10 N-leaching by rainfall increase. Non-linear relationship; with N-leaching increasing with annual rainfall. Six times more influence on N-leaching than slope class.

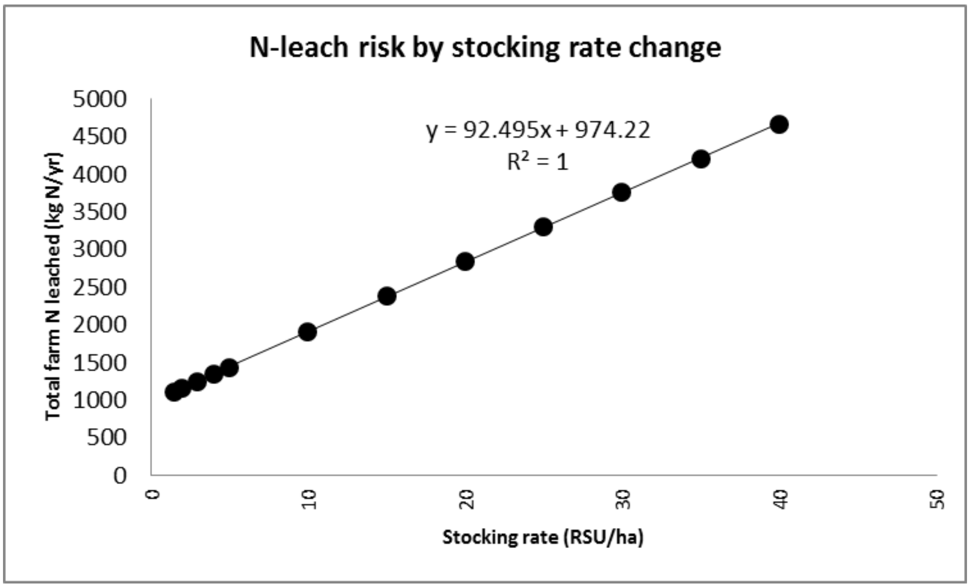

Figure 11 N-leaching by stocking rate increase. Of the variables examined, stocking rate appears to have the highest single influence on the level of N-leaching. Fourteen times more influence than slope class.

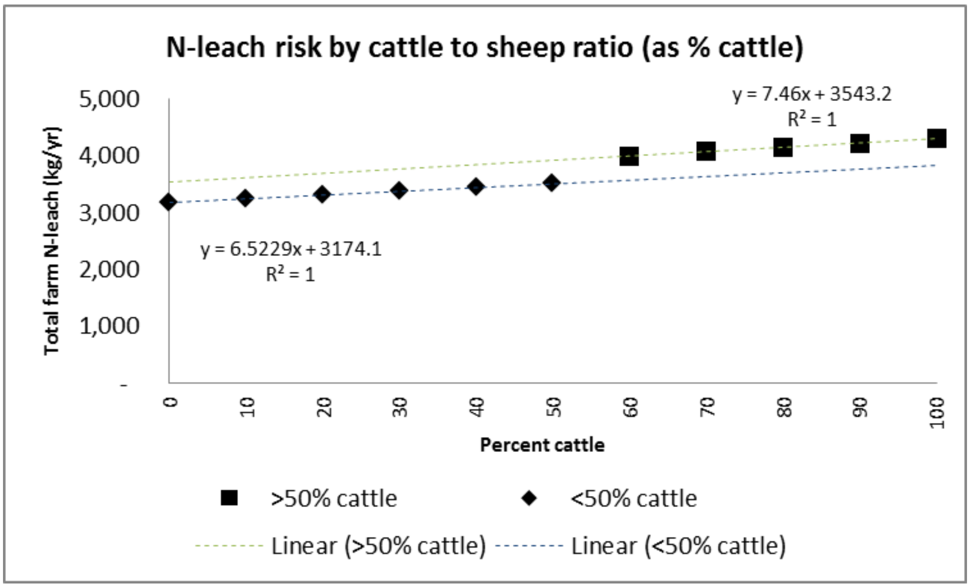

Figure 12 N-leaching increase by the ratio of sheep-to-beef. An increasing proportion of cattle increases N-leaching, although the effect is not great (only twice the impact on N-leaching).

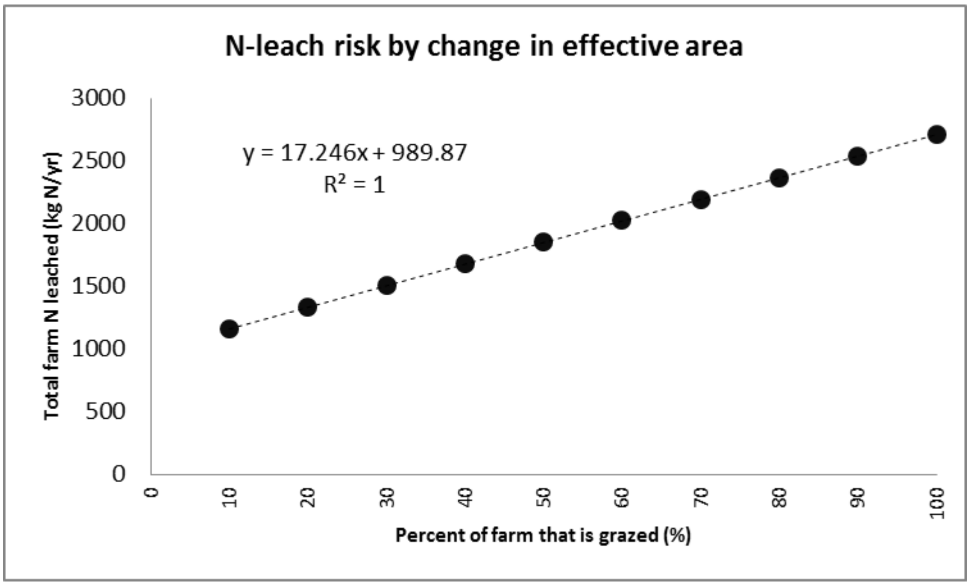

Figure 13 N-leaching increase by the change in farm effective area. This is included to recognise the averaging effect of non-pastoral land covers on the calculation of whole-farm N-loss. Leaching increases with the proportion of grass. Seven times more influence than slope class.

Appendix 2 – Production system model descriptions

Sheppard Agriculture Ltd were contracted to design 7 farm production systems that represent sheep and beef farms in the Mangatainoka catchment.

Overview

Within the Mangatainoka River catchment there are three predominant farm-land types. These farm types relate specifically to the topography of the land resource that is being farmed. These are:

- Medium to steep hill country
    - Predominantly sheep and beef breeding
    - Extensive farm management (5–9 su/ha wintered)
- Flat to easy country
    - Predominantly dairy farming
- Flat/terrace and rolling to easy hill country
    - Some dairy farming
    - Predominantly sheep and beef breeding and finishing
    - Some intensive bull beef and lamb trading
    - Intensive farm management (9–14 su/ha wintered)

The following notes are formed to provide some guidance to the construction of representative farms reflecting the three types of operations noted above. All notes should be considered as generalisations and do not absolutely reflect all farm operating systems.

Medium to Steep Hill Country - *Intensive 450 ha effective*

Blocks: 1. Flat to rolling 20 ha – class III – IV, improved pasture, alluvium

2. Rolling to moderately steep 130 ha – class VI, sedimentary

3. Steep to very steep 300 ha – class VII, sedimentary

Livestock: Sheep and Beef breeding, retaining lambs to sell prime over the summer, autumn and winter. Livestock as at 30 June:

	Number	Comment/Notes
MA Ewes	2185	Romney ewes, 125% lambing from mid-September
Ewe Hoggets	660	60% lambing start October
Trade Hoggets	390	Sold by end September
Breeding Rams	30	Romney
Sheep Stock Units	2983	3728 Standard MPI Stock units

MA Cows	80	Angus, Angus x Hereford
R2yr Heifers	49	30 In Calf, Surplus sold at 2.5 yrs
R1yr Heifers	50	Mated at 15 months of age
R1yr Steers	50	20 sold at 18 months
R2yr Steers	30	Sold prime 2.5 yrs
Breeding Bulls	4	
Cattle Stock Units	1354	1507 Standard MPI Stock units
Total Stock Units	4337	
Stocking rate (su/ha)	9.6	
Sheep:Cattle Ratio	69:31	

Fertiliser: At present time these farmers are applying approx. 80% of Maintenance fertiliser. Assume Maintenance fertiliser is 1.6 kgP/su. Therefore, full maintenance fertiliser = 79 T Superphosphate and 80% of this is 63.2 T. Applied at rate of 220 kg/ha on blocks 1 and 2 (30 T) and rest (30.2 T) to block 3 at average rate of 100 kg Super/ha.

Also Fertiliser for crop/new grass – 250 kg/ha Cropmaster DAP.

Nitrogen use limited to 20 ha of flat to rolling country at a rate of 65 kg Urea/ha.

Soil Fertility: Olsen P 13–15 (average)

Feed Crops: 6 ha summer Pasja/Kale

Supplements made or imported: (kg DM or quantity of bales) – Nil

Medium to Steep Hill Country - Extensive 500 ha effective

Blocks: 1. Flat to rolling 20 ha – class III – IV, improved pasture, recent alluvium

2. Rolling to moderately steep 130 ha – class VI, sedimentary

3. Steep to very steep 350 ha – class VII, sedimentary

Livestock: Sheep and Beef breeding with all lambs sold by May. Livestock as at 30 June:

	Number	Comment/Notes
MA Ewes	2500	Romney ewes, 125% lambing from mid-September
Ewe Hogget’s	750	Not Lambing
Breeding Rams	30	Romney
Sheep Stock Units	3049	Standard MPI Stock units
MA Cows	100	Angus, Angus x Hereford
R2yr Heifers	25	In Calf

R1yr Heifers	58	Mated at 15 months of age
R1yr Steers	25	Sold as yearlings
R2yr Steers		
Breeding Bulls	4	
Cattle Stock Units	1119	Standard MPI Stock units
Total Stock Units	4168	
Stocking rate (su/ha)	8.3	
Sheep:Cattle Ratio	73:27	

Fertiliser: At present time these farmers are applying approximately 70% of Maintenance fertiliser. Assume Maintenance fertiliser is 1.6 kgP/su. Therefore full maintenance fertiliser = 78.4 T Superphosphate and 70% of this is 54.9 T. Applied at rate of 200 kg/ha on blocks 1 and 2 (30 T) and rest (24.9 T) to block 3 at average rate of 71 kg Super/ha.

Also Fertiliser for crop/new grass – 250 kg/ha Cropmaster DAP.

Nitrogen – not used by these farmers.

Soil Fertility: Olsen P 11–13 average

Feed Crops: 2 ha summer Pasja / Kale

Supplements made or imported: (kg DM or quantity of bales) – Nil

Terrace and Easy Rolling Country - *Intensive 350 ha effective*

Blocks: 1. Flat to undulating 210 ha – class II – III, alluvium and loess

2. Rolling to moderately steep 140 ha – class IV loess /sedimentary

Livestock: The sheep operation revolves around trading 2000 lambs and hoggets throughout the year. In addition, 1600 ewes and 450 ewe hoggets are wintered. The cattle enterprise consists of purchasing 250 100-kgLwt bulls in November and finishing 150 at 18–20 months of age. The remaining 100 bulls are finished at 30 months of age in November through February. Winter stock numbers are noted in table below:

	Number	Comment/Notes
MA Ewes	1600	140% Lambing
Ewe Hoggets	450	85% Lambing
Trade Hoggets	1100	2000 lambs/Hogget’s traded through year
Breeding Rams	15	
Sheep Stock Units	2807	
R1yr Bulls	250	

R2yr Bulls	100
Cattle Stock Units	1625
Total Stock Units	4432
Stocking rate (su/ha)	12.7
Sheep:Cattle Ratio	63:37

Fertiliser: Superphosphate at 300 kg/ha on block 1 and 200 kg/ha on block 2. Two applications of Urea at 65 kg/ha on Block 1, and 1 application of Urea at 65 kg/ha on Block 2.

Soil Fertility: Olsen P 20

Feed Crops: 16 ha annual pasture renewal, autumn sown oats (grazed Aug/Sept) base fertiliser Cropmaster 20 at 250 kg/ha. Spring sown Pasja (grazed Feb/March). Autumn sown permanent pasture.

Supplements made or imported: (kg DM or quantity of bales) – Hay for cattle 60 TDM made on 14 ha of farm.

Terrace and Easy Rolling Country - *Not so Intensive 350 ha*

Blocks: 1. Flat to rolling 70 ha – class II – IV, improved pasture, alluvium

2. Strongly rolling to moderately steep 140 ha – class IV - VI, loess/ sedimentary

3. Strongly rolling to steep 140 ha – class VI - VI, sedimentary

Livestock: Predominantly a traditional trading operation with steers (purchased as weaners in March) as opposed to bulls. Some breeding ewes and ewe hoggets also wintered. Lamb/hogget trading limited to 2000. Half these traded over the summer and the remainder over winter and early spring – essentially 2 trades.

	Number	Comment/Notes
MA Ewes	2000	140% Lambing
Ewe Hoggets	600	85% Lambing
Trade Hoggets	500	2000 lambs/Hoggets traded through year
Breeding Rams	15	
Sheep Stock Units	2832	
R1yr Steers	150	
R2yr Steers	100	
Cattle Stock Units	1175	
Total Stock Units	4007	
Stocking rate (su/ha)	11.4	
Sheep:Cattle Ratio	70:30	

Fertiliser: Superphosphate at 300 kg/ha on Block 1, Superphosphate at 200 kg/ha on Block 2 and 150 kg/ha on block 3. Urea applied at 65 kg/ha on Block 1 in the late winter/spring.

Soil Fertility: Olsen P 16–18 average

Feed Crops: 16 ha annual pasture renewal through a system of autumn sown oats (grazed Aug/Sept) base fertiliser Cropmaster 20 at 250 kg/ha. This is followed in spring with Pasja (grazed Jan/March) before being resown into permanent pasture (Cropmaster 20 at 250 kg/ha applied) in autumn.

Supplements made or imported: (kg DM or quantity of bales) – Hay for wintering cattle – 31 250 kgDM harvested from 8 ha on farm.

Flat Finishing Operation

Blocks: 1. Flat to undulating 210 ha – class II – III, alluvium and loess

2. Rolling to moderately steep 140 ha – class IV loess /sedimentary

Livestock: A much more complex trading business with now breeding ewes wintered. Rather ewes with lambs at foot are purchased in spring. At weaning ewes are sold and lambs finished through summer. The cattle enterprise consists of purchasing 250 100-kgLwt bulls in November and finishing 150 at 18–20 months of age. The remaining 100 bulls are finished at 30 months of age in November through February. Winter stock numbers are noted in table below:

	Number	Comment/Notes
Trade Hoggets	3300	12 000 lambs and hogget's traded through the year
Sheep Stock Units	2640	Does not show 1600 ewes purchased with lambs at foot in spring
R1yr Bulls	250	
R2yr bulls	100	
Cattle Stock Units	1625	
Total Stock Units	4265	
Stocking rate (su/ha)	12.2	
Sheep:Cattle Ratio	62:38	

Fertiliser: Superphosphate at 300 kg/ha on 210 ha of best country and 200 kg/ha on 140 ha block 2. Two applications of Urea at 65 kg/ha on Block 1 in spring and autumn and 1application of Urea at 65 kg/ha on Block 2 in the spring.

Soil Fertility: Olsen P 20–25 on best country and 18–22 on hill country

Feed Crops: 15 ha annual pasture renewal involving autumn sown oats grazed July and August (base fertiliser of Cropmaster 20 at 250 kg/ha). In spring this area is sown into Pasja (grazed Feb/March). The following autumn it is sown into

permanent pasture.
A further 30 ha has been established in chicory/plantain forage crops.

Supplements made or imported: (kg DM or quantity of bales) – 42TDM of hay fed to R1yr and R2 Yr Bulls whilst on GF Oats crop.

Stock flows

Stock Flow	Medium to Steep Hill - Intensive											
	July	August	Septembe	October	Novembe	Decembe	January	February	March	April	May	June
MA Ewes	2185	2185	2185	2185	2100	2100	2100	2185	2200	2200	2200	2185
Ewe Hogget's	660	660	660	600	600	600	600				660	660
Lambs				3127.25	3127.25	3127.25	3000	2500	2000	1500		
Trade Lambs	390	250	120								500	390
Rams	30	30	30	30	30	30	30	30	30	30	30	30
MA Cows	80	80	80	80	80	65	65	65	65	65	80	80
R2yr Heifers	49	49	49	49	49	49	49	49	49	30	49	25
R1yr Heifers	50	50	50	50	50	50	49	49	49	49	50	50
Calves				100	100	100	100	100	100	100		
R1yr Steers	50	50	50	50	50	50	50	50	50	30	50	50
R2yr Steers	30	29	29	29	29	29	29	29	29		30	30
R1yr Bulls												
R2yr Bulls												
Bulls	4	4	4	4	4	4	4	4	4	4	4	4

Stock Flow	Medium to Steep Hill - Not so Intensive											
	July	August	Septembe	October	Novembe	Decembe	January	February	March	April	May	June
MA Ewes	2500	2450	2450	2450	2400	2350	2350	2600	2600	2600	2500	2500
Ewe Hogget's	750	750	750	750	725	700	700				750	750
Lambs				3125	3125	3125	3000	2500	2000	1500		
Trade Lambs												
Rams	30	30	30	30	30	30	30	30	30	30	30	30
MA Cows	100	100	100	100	100	90	90	90	90	90	100	100
R2yr Heifers	25	25	25	25	25	25	25	25	25	25	25	25
R1yr Heifers	58	58	58	58	58	25	25	25	25	25	58	58
Calves				116	116	116	116	116	116	116		
R1yr Steers	25	25	25	25	25						25	25
R2yr Steers												
R1yr Bulls												
R2yr Bulls												
Bulls	4	4	4	4	4	4	4	4	4	4	4	4

Stock Flow	Terrace and Easy Rolling - Not so Intensive											
	July	August	Septembe	October	Novembe	Decembe	January	February	March	April	May	June
MA Ewes	2000	1980	1900	1860	1860	1860	1860	2050	2050	2050	2050	2000
Ewe Hogget's	600	600	550	550	550	550	550					
Lambs				3310	3310	3310	1800	1500	1200	900		
Trade Lambs	500	900	600	100		500	400	600	500	500	700	1100
Rams	15	15	15	15	15	15	15	15	15	15	15	15
MA Cows												
R2yr Heifers												
R1yr Heifers												
Calves									100	150		
R1yr Steers	150	150	150	150	150	150	150	150	150	150	150	150
R2yr Steers	100	100	100	100	100	100	100	80	50		125	100
R1yr Bulls												
R2yr Bulls												
Bulls												

Stock Flow	Terrace and Easy Rolling - Intensive											
	July	August	Septembe	October	Novembe	Decembe	January	February	March	April	May	June
MA Ewes	1600	1525	1480	1480	1480	1480	1480	1650	1650	1650	1650	1600
Ewe Hogget's	450	450	425	410	410	410	410					
Lambs				2805	2805	2805	1800	1500	1200	900		
Trade Lambs	1100	900	600	100		500	400	600	500	500	700	1100
Rams	15	15	15	15	15	15	15	15	15	15	15	15
MA Cows												
R2yr Heifers												
R1yr Heifers												
Calves				250	250	250	250	250	250	250		
R1yr Steers												
R2yr Steers												
R1yr Bulls	250	250	250	250	250	250	225	190	150	125	250	250
R2yr Bulls	100	100	100	100	90	70	45	20			100	100
Bulls												

Stock Flow	Flats Finishing Operation											
	July	August	Septembe	October	Novembe	Decembe	January	February	March	April	May	June
MA Ewes		1600	1600	1600	1600							
Ewe Hogget's												
Lambs		1600				2000	400		2000	2000	2000	2000
Trade Lambs	3300	4100	3100	2100	1600	3000	2900	2400	3900	4300	5000	3300
Rams												
MA Cows												
R2yr Heifers												
R1yr Heifers												
Calves				250	250	250	250	250	250	250		
R1yr Steers												
R2yr Steers												
R1yr Bulls	250	250	250	250	250	250	225	190	150	125	250	250
R2yr Bulls	100	100	100	100	90	70	45	20			100	100
Bulls												

Maximum weights

Hard Hill Breeding				Hard Hill Breeding & Finishing		
Livestock Weights	Flock Average June 30	Max Liveweight		Livestock Weights	Flock Average June 30	Max Liveweight
MA ewes	60	75		MA ewes	63	75
Ewe Hoggets	40	55		Ewe Hoggets	42	55
Trade lambs	40	45		Trade lambs	40	45
Rams	100	120		Rams	100	120
MA Cows	480	550		MA Cows	480	550
R2yr Hfrs	440	500		R2yr Hfrs	440	500
R1yr Hfrs	230	300		R1yr Hfrs	230	300
R1yr Strs	250	350		R1yr Strs	250	350
R2yr Sts				R2yr Sts	380	450
R1yr Bulls				R1yr Bulls		
R2yr Bulls				R2yr Bulls		
Breeding Bulls	700	1000		Breeding Bulls	700	1000
Flat to Easy Hill Breeding & Finishing				**Flat to Easy Hill Finishing/Trading**		
Livestock Weights	Flock Average June 30	Max Liveweight		Livestock Weights	Flock Average June 30	Max Liveweight
MA ewes	65	85		MA ewes	60	60
Ewe Hoggets	45	60		Ewe Hoggets	0	0
Trade lambs	45	50		Trade lambs	40	45
Rams	100	120		Rams	0	0
MA Cows	500	560		MA Cows		
R2yr Hfrs	460	520		R2yr Hfrs		
R1yr Hfrs	240	300		R1yr Hfrs		
R1yr Strs	260	350		R1yr Strs	280	370
R2yr Sts	400	450		R2yr Sts	420	500
R1yr Bulls				R1yr Bulls	260	350
R2yr Bulls				R2yr Bulls	450	520
Breeding Bulls	700	1000		Breeding Bulls	0	0

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