

# THE REAL (RATHER THAN MODELLED) COST OF MEETING NITROGEN LIMITS - PART 1: AN ONGOING CASE STUDY OF A CANTERBURY DAIRY FARM

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## ***Abstract:***

Most of the analysis considering both the implications, and opportunities to farm within lower nutrient losses, is based on modelled datasets. Limited data is available from commercial size farms, or full system research whereby management practices have changed to farm within lower (estimated) nutrient losses.

Lincoln University Dairy Farm (LUDF) is an exception, having modified farm management part way through the 2013-14 production season, specifically to lower the predicted N-loss. Additional changes have been implemented for the 2014-15 season, seeking further reductions in N-losses while regaining some of the profitability lost in the previous season.

The farm is a well-known, frequently visited commercial demonstration farm, operated by the South Island Dairying Development Centre (SIDDC) to showcase best practice sustainable, profitable farming. Annual benchmarking indicates the farm operates in the top 2-3% based on profitability.

The self-imposed (2013-14 season) target to hold nitrogen losses within historical levels achieved the desired reduction in N-loss but eroded profitability by over \$80,000 (\$500/ha), providing a real example or case study of an option to reduce N-loss and its associated cost. If extrapolated across the Canterbury region's 1000 dairy farms, this impact would markedly change the local economy.

Uncomfortable with the impact on profitability, yet seeing potential legislative reductions in N-loss effective in its local catchment from 2017, LUDF is voluntarily changing its management for the 2014-15 season to operate with lower predicted N-loss. The farm is adopting research undertaken within the Pastoral 21 (P21) research programme whereby farm systems research with self-contained farmlets has shown an irrigated, nil-infrastructure, low input (N-fertiliser and supplement) system is theoretically as profitable as the previous system at LUDF, yet should further reduce the catchment nutrient loss.

Details of the 2013-14 season changes and results to date for 2014-15 are presented, highlighting the actual costs and implications of farming within nutrient loss restrictions.

## ***Introduction***

New Zealand farmers deal continuously with change, uncertainty and volatility, and to date have developed farm systems to accommodate, or mitigate the major challenges typically occurring on farm. Increased awareness and interest in nutrient losses from farms, coupled with the related regulatory response<sup>1</sup> has added nutrient losses to the uncertainty associated with farm planning and forecasting probable future returns. A high profile Canterbury dairy farm provides the following case study to highlight management changes and considerations in response to the increasing focus on nutrient losses.

## ***Lincoln University Dairy Farm (LUDF)***

LUDF is a commercial demonstration dairy farm operated by the South Island Dairying Development Centre<sup>2</sup> (SIDDC) on behalf of the university to showcase best practice sustainable, profitable dairy farming. It attracts 3000 - 3500 visitors per year plus approximately 1000 visitors per month to its web-based weekly farm walk notes and Facebook page. Additional details are provided in Appendix 1.

The farms 2011 – 2015 objective is:

To maximise sustainable profit embracing the whole farm system through:

- increasing productivity;
- without increasing the farm's total environmental footprint;
- while operating within definable and acceptable animal welfare targets; and
- remaining relevant to Canterbury (and South Island) dairy farmers by demonstrating practices achievable by leading and progressive farmers.
- LUDF is to accept a higher level of risk (than may be acceptable to many farmers) in the initial or transition phase of this project.

Whilst defining the farms total environmental footprint remains a work in progress, it quickly became evident the farms nitrogen loss to water as predicted by Overseer® would need to be held to the historical levels of 2010/11, and prior years as part of the farms total environmental footprint. The total land required for the milking platform, and support land for wintering dry cows, replacement stock and growing supplements is included in the farms reference to its whole farm system and its total environmental footprint.

A number of farm system changes, including the use of two herds to better manage young cows and cows with low body condition scores, and the enhanced use of nitrogen fertiliser were implemented in 2011/12 and resulted in improved productivity as the farm grew more pasture, increased the efficiency of conversion of feed to milk, improved profitability and held the milking platform N-losses through additional use of the mitigation technology 'Eco-n' (active ingredient DCD).

The temporary suspension of this mitigation technology in early 2013 required a review of the farm system for the 2013-14 season. Analysis of the potential yield of the farm indicated

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<sup>1</sup> Regulatory responses vary across NZ; in part reflecting the variation in current nutrient loads within catchments and their capacity to accommodate current and predicted future nutrient inflows.

<sup>2</sup> SIDDC is a partnership between Lincoln University, DairyNZ, Ravensdown, LIC, Plant & Food Research, AgResearch and SIDE.

reduced N-fertiliser may provide sufficient pasture to maintain the farms productivity but result in a tighter N-cycle and therefore similar N-loss but without the mitigation technology Eco-n.

### ***Constraining Productivity to Meet N-loss Targets***

Forecasting probable N-losses<sup>3</sup> part way through 2013-14 season indicated the LUDF milking platform was heading towards a full year N-loss 10% higher than the immediate past year. This was the result of a cooler and wetter than normal season coupled with less nitrogen fertiliser, no Eco-n effect and the resultant higher use of imported supplementary feed. Unable to accept this impact (given the farms objective) LUDF sought the least cost means of staying within its historical N-loss.

LUDF's decision to adhere to its previous N-loss was voluntary, in response to its objectives. Most farms (to date) have had weather and product prices as the key drivers causing mid – season changes in farm system. By responding to the additional driver of N-loss, the farm has provided a clear case study of the impact of changing the production system to meet environmental targets. This decision was endorsed by SIDDC and Lincoln University to highlight the significance of the farms environmental objectives.

A range of farm management changes (e.g. modifying stocking rate, supplementation strategies, N-fertiliser use, on-off grazing systems) were evaluated in terms of their impact on predicted N-loss, farm profitability and feasibility. Some changes were simply not feasible mid-way through the production year, including changing the type of imported supplementary feed (it had largely already been fed), or building any substantial form of facility to enable on-off grazing.

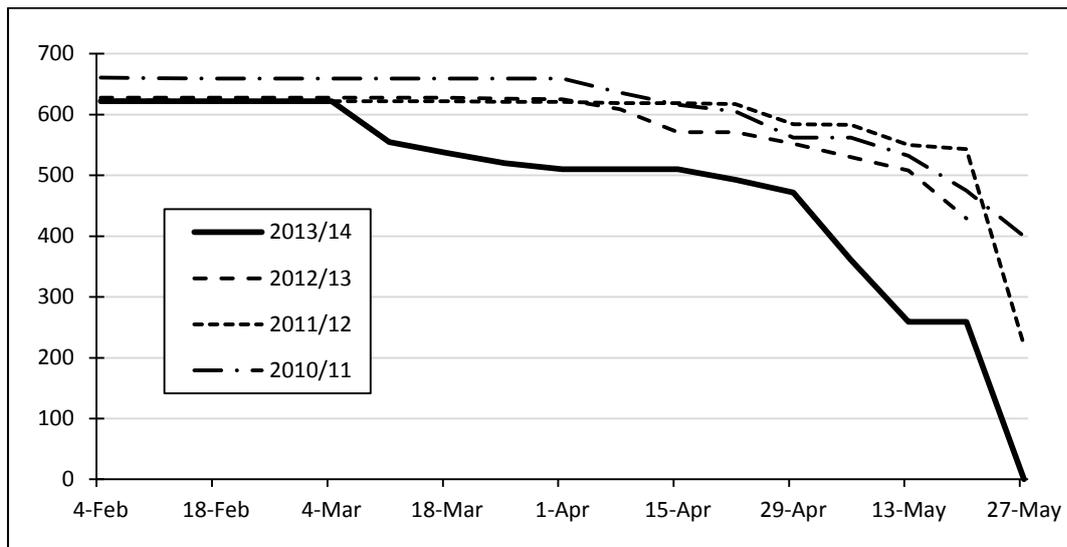
### ***Early Culling of Surplus Animals***

Decreasing the number of animals on farm through the autumn and thus the total feed intake and requirement for additional imported feed was feasible if those animals not required on farm in subsequent seasons (culls or empty cows) were sold early in the autumn rather than at the end of the season. A smaller autumn feed supply, consumed by fewer animals, would reduce urinary N load on the environment. The farm adopted this strategy and sold culls and empties in early March, managing the remaining cows based on the feed grown through the autumn period.

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<sup>3</sup> Nitrogen losses reported in this paper are those predicted with Overseer Version 6.1

Figure 1: Calved Cows on Farm

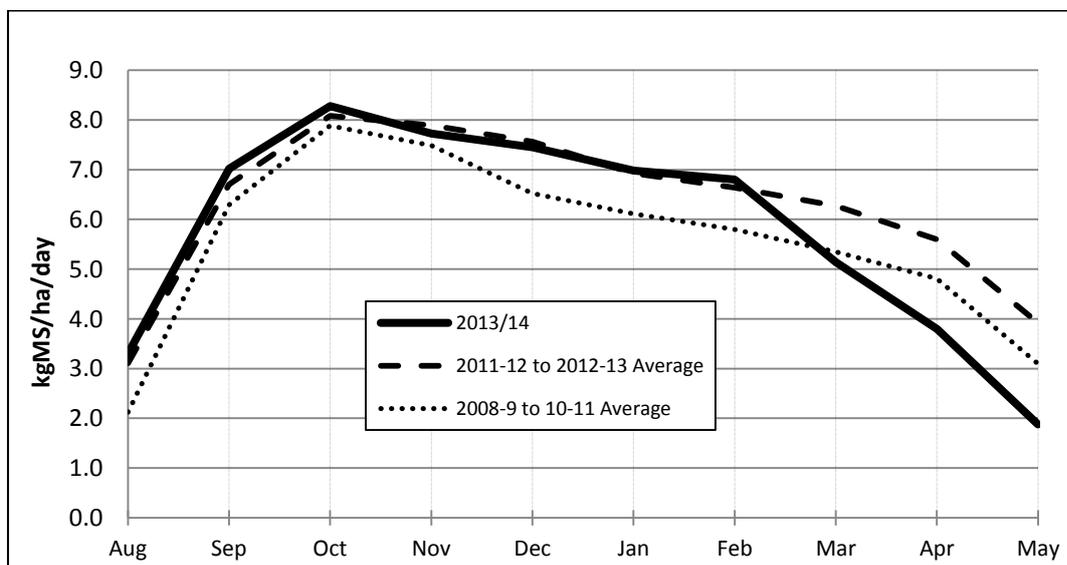


This change was forecast to reduce milk production by 5-10%, reduce imported silage required (and therefore feed costs) and reduce net income by approximately \$100,000. Asking farm staff to constrain production when the milk price was at a record high was viewed with caution by many farmers and onlookers who saw the lost profit as an opportunity to generate additional funds, to re-invest in additional or future on-farm mitigation.

***Effects on Milk Production and Profitability***

Final year production was 8% lower than budgeted, reducing gross income for the farm by \$204,000. Reducing further imported silage use is estimated to have saved approximately \$120,000 leaving a reduction in farm income of approximately \$84,000. Given the farm is now smaller than the average size dairy farm in Canterbury, the losses for most farms would be larger than this if replicated across the region. This is less overseas income earned for NZ and less income circulating through the local economy.

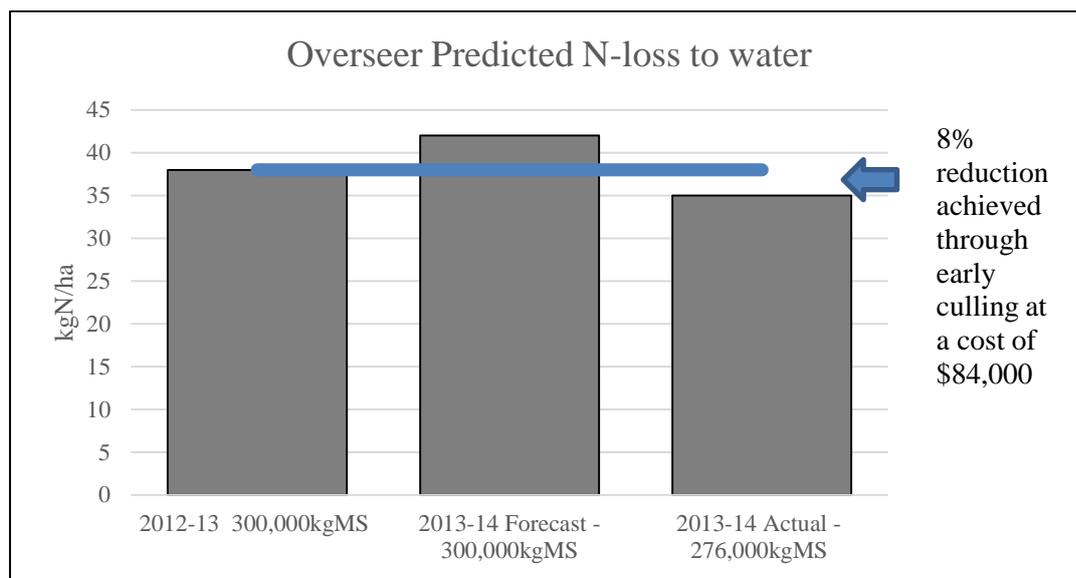
Figure 2: Average Monthly Production – (Milksolids per hectare)



### ***Predicted N-loss to water***

The full year predicted N-loss to water as modelled in Overseer for the 2013-14 season is approximately 35 kgN/ha, less than the 38 kgN/ha predicted for the previous 2012-13 season and significantly less than the 42 kgN/ha initial forecast for the full season. The strategy, as modelled by Overseer, was therefore successful in terms of reducing predicted N-loss.

Figure 3: Overseer Predicted N-loss to water



Note: LUDF N-losses above are modelled with the presumption of (free draining) Templeton soils across the whole farm. The actual soils on LUDF range from very free draining soils to poorly drained soils. Actual losses differ to those above but the relativity of management / farm system changes on N-loss is similar.

### ***Changing drivers of farm performance***

LUDF achieved its objective of farming within its historical footprint by choosing to focus on the predicted N-loss rather than respond to the clear (and proven) market signals for additional autumn milk production. Compromise was required in regard to the farms overall objective, with profitability given away to achieve the farms environmental goals. The farm was able to reduce N-loss by 17% (relative to what could have occurred), from approximately 42kgN/ha to approximately 35kgN/ha. Adding the opportunity cost of \$84,000 (\$525/ha) gives a mitigation cost of \$75/kgN in the 2013/14 season.

### ***Considering the alternatives***

LUDF is located within the 'Selwyn-Waihora' zone within the Canterbury Regional Council. Farms within this zone are likely to be asked to reduce N-loss to lower the total N-load from agriculture into the local catchment. Whilst details are still being determined, individual farms are likely to be asked to farm within a specified N-loss target per hectare for their individual farm type, location and soil type, and some farms may be asked to reduce N-losses below these levels. See Appendix 2 for a summary of the proposed changes by sector.

Given these changes are coming, both in LUDF's catchment and across other catchments in New Zealand, LUDF has determined it will seek to operate in the 2014/15 season, at a lower N-loss than previously, to document how the farm can respond to these requirements, and the implications, costs and opportunities that may arise from this.

LUDF's objectives require it to consider the whole catchment effect of its business, not just the milking platform. This requires consideration of the effect of LUDF's decisions on its wider support land as well as the milking platform. Simply shifting the load from LUDF to another parcel of land is not an option for LUDF but may be a viable means of reducing total N-loss for farms with full control of their entire land area.

Two clear pathways were evident for LUDF to further reduce its total N-losses from the catchment:

1. Invest in infrastructure on-farm to reduce the grazing / standing time on paddocks. This has been shown to reduce N-loss if the effluent can be stored from the standoff facility and exported or re-applied to land at times of the season and rates that ensure plant uptake of the nutrients.
2. Reduce the number of animals farmed to reduce the annual volume of feed required for maintenance, while seeking higher production per cow to generate sufficient income and profit. This option has been operating nearby at the Lincoln University Research Dairy Farm (LURDF) as part of Objective 3 of the Pastoral 21 (P21) Phase 2 research programme, Next Generation Dairy Systems for Canterbury.

Three years of data from this farmlet<sup>4</sup> study (see LUDF focus day handouts from July 2012 and July 2013) showed milk production levels of over 500kgMS/cow were achieved with 3.5 cows/ha, 160kg/ha nitrogen fertiliser and less than 300kgDM imported supplement/cow. Profitability was calculated as comparable to LUDF with lower N-losses on the milking platform, and lower total losses, in part influenced by fewer cows wintered, fewer replacements, and less supplementary feed.

The data to date for this farm system has shown the repeatability of the system within the research framework. Extending this onto multiple farms now requires both scaling up of the research and further development of the decision rules to optimise grazing management and appropriately use the resources and inputs. This includes additional learning to balance pasture quality and supply with early season demand.

Encouraged by the results from this research, LUDF has chosen to implement a nil-infrastructure, low input model for 2014-15, replicating the system employed in the P21 research and seeking to lower N-losses and return profitability to previous levels.

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<sup>4</sup> Farmlet studies typically refer to small scale research, operating as much as possible as if the farmlet is simply a smaller scale of a commercial farm. This study occurs with 29 cows on 8.3 ha to achieve a stocking rate of 3.5 cows/ha.

### ***Nil Infrastructure / low input farming***

The essence of this system is:

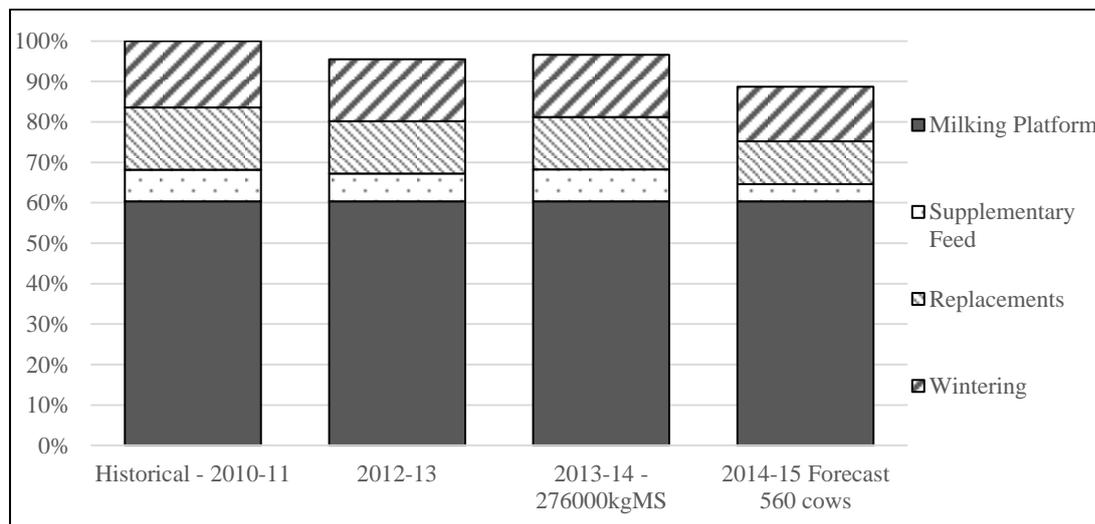
- Reducing the stocking rate as much as possible so that more of the total available feed is used in milk production (and less is required for maintenance of additional animals)
- Reducing the need for brought in feed and nitrogen fertiliser due to lower animal demand for a similar level of milk production.

Note this is a low input system, but not a zero input system. It is seeking to optimise the use of nitrogen fertiliser and imported supplementary feed inputs along with the farms potential pasture production but without the use of any standoff / feeding pad / housing infrastructure.

### ***Accounting for LUDF across the Whole Farm System (the Catchment Effect)***

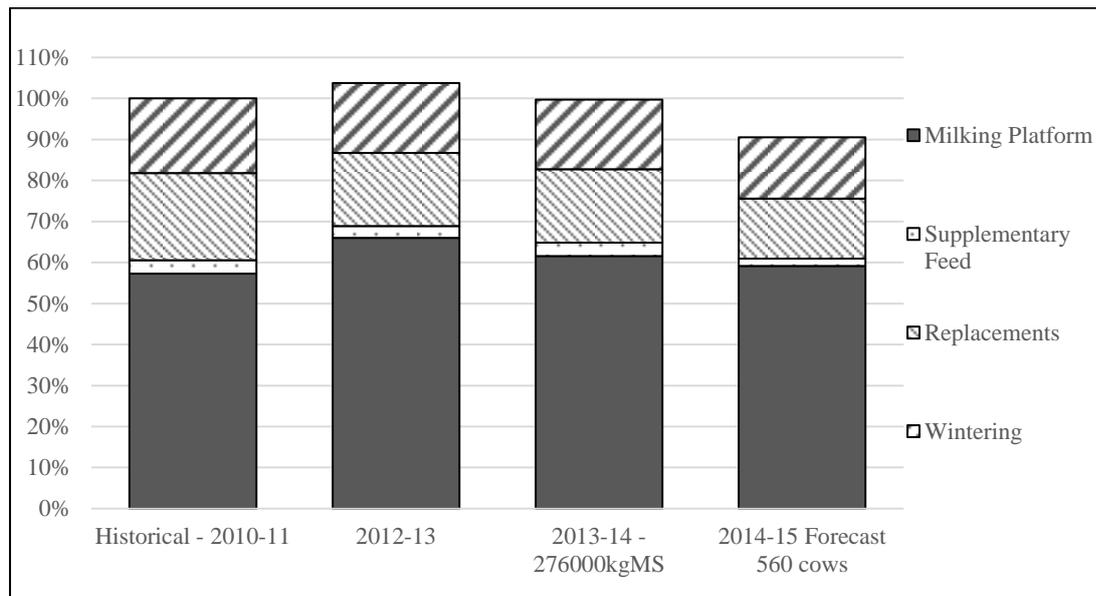
As can be seen below, LUDF's requirement for additional land is reduced as the demand for land for wintering and replacements goes down with fewer animals farmed.

Figure 4: Total Land Required - relative to Historical LUDF land use



Total nitrogen loss to water within the catchment is influenced by the average rate of N-loss per hectare in each parcel of land and the amount of land required. The graph below (based on Overseer modelling of each parcel of land) suggests a small decrease in N-loss at the catchment level occurred as the result of the 2013/14 decisions (relative to historical losses) whereas the combined effect of slightly lower losses on the milking platform and fewer animals wintered and as replacements predicts total catchment losses could be approximately 10% lower (than the historical N-losses), with the nil-infrastructure, low input system. This should be considered alongside milk production, which if similar to the P21 results, will produce a little more milk in total, from less land and less total N-loss to the catchment. The importance of considering the farms total land use and the significance of wintering and replacements is also evident in this graph.

Figure 5: Total Nitrogen Loss to Water - relative to Historical LUDF losses



**Caveat:**

It is important to note the Nitrogen losses to water for the 2014-15 season will be entirely dependent on the actual production and use of inputs. The losses portrayed above are based on LUDF using 160 kgN/ha, 300kg supplement/cow, a stocking rate of 3.5 cows/ha and production of 500kgMS/cow. If the system cannot be effectively operated at this level, N-loss may be substantially different – on both the milking platform and at the catchment level – and profitability may be severely constrained.

**Relative Profitability**

On-farm profitability is substantially driven by the combination of milk production, operating expenses and payout. Most farmers can influence or control the first two of these but have limited influence on the actual payout, making year to year comparisons of actual profit difficult given the variability in milk payout.

The following table provides a relative comparison of the profitability of LUDF in the past two seasons, with the budgeted profit for the 2014-15 season. Income has been standardised at a payout of \$6.10 /kgMS. The budgeted cash farm working expenses for 2014-15 are approximately 5% lower than the past seasons, reflecting some of the potential cost savings from fewer cows on farm. The actual profitability is very sensitive to production in this system, with little room to make savings in expenditure if production is below budget. A 2% decrease in production for example is forecast to decrease profit by 6%, while a 5% decrease in production could decrease profit by 15%.

Table 1: Comparison of the profitability of LUDF in the past two seasons

Production Season:	2012 -13 Actual (Unconstrained Productivity)	Actual 13-14 (Mid-Season Constraint)	2014-15 Budget (Optimistic and production sensitive goal)
Total Milk production (kgMS)	300,484	276,019	280,000
Gross Farm Revenue*	\$1,989,549	\$1,858,148	\$1,823,311
Cash Farm Working Expenses	\$1,184,967	\$1,182,117	\$1,120,335
Total Operating Expenses	\$1,289,967	\$1,298,117	\$1,236,335
Dairy Operating Profit	\$699,582	\$560,031	\$586,976
DOP/ha	\$4,372	\$3,500	\$3,669

\*Note – Revenue assumes \$6.10/kgMS all years

### ***Discussion***

Dairy farming systems, like most business practice evolves over time in response to increased knowledge and understanding, individual and industry innovation, market signals, relative profitability, alternative land uses, customer preferences and feedback, and local / central government regulation. This combination has led to seasonal supply milk production systems dominating in NZ. The increase in regulation, or potential regulation on nutrient losses from farms is driving substantial change in farm systems, or serious consideration of major on-farm changes.

Language and terminology also evolve as systems change and develop. Farm performance to date is described in relation to productivity or profitability per unit of land or unit of production (e.g. kgMS/ha, FWE/kgMS). Future farm performance may well be described in relation to purchased nitrogen over exported nitrogen or profit per kg N-loss, and include total land and catchment scale N-load per unit of milk production.

Whilst the timing and degree of change required on farms to meet possible regulations regarding nutrient losses is largely unknown at present, it's likely a number of existing farms will in the future have to operate with much tighter (lower) N-loss than has been required of them to date. This may result in a few farms changing out of dairy farming to an alternative land use. In reality this always occurs to a varying degree, particularly on smaller farms where less intensive land use may allow semi-retirement for an owner-operator.

Many other dairy farmers, faced with changing nutrient losses will adapt in whatever means they can / is required to meet the nutrient loss targets for their farms. The use of stand-off type infrastructure (from simple feedpads / stand-off areas to partially or fully housed systems) is likely to significantly change the operation of these farms, potentially moving them away from seasonal supply grazed farms to much more like Northern Hemisphere farm systems (at least for part of the season). Imported feed for lactation and the dry period, coupled with nil or limited grazing during / immediately prior to major (potential) leaching

periods could result in a much higher percentage of the diet from a 'cut and carry' type system. The high capital cost of these systems will require high yields per cow (as more of the infrastructure will be driven by the number of cows milked) and high total production to dilute operating costs and provide a return on the total assets invested (enabling interest and principal repayments).

Other farms may develop systems requiring no infrastructure, choosing instead to run less intensive, low N-loss systems with much lower capital costs. The need for high lifetime productivity, and very high business efficiency with low unit costs may also result in high production per cow, but driven by the grazed forage intake not total feed intake. Preliminary analysis of total productivity, - that is total milk production from the total land area supporting milk production - is often similar for high infrastructure and less intensive, nil-infrastructure systems if the land required for all feed crops is included. This will become clearer over time, once data is available for well-run farms in both systems. If total productivity is similar, and total catchment losses can also be held to similar levels from each system, farmers will be able to choose higher or lower intensity systems based on their own preferences, available capital, and values. In either case, the systems may look markedly different to dairy farming as we currently know it.

## **APPENDIX 1**

### ***Further background information on LUDF***

#### *History:*

The 186 hectare irrigated property, of which 160 hectares is the milking platform, was a former University sheep farm until conversion in 2001. The spray irrigation system includes two centre pivots, small hand shifted lateral sprinklers, and k-lines. The different soil types on the farm represent most of the common soil types in Canterbury.

#### *Stage 1: 2001/2 and 2002/3*

The farm initially wintered approximately 630 cows, peak milking just over 600 and producing about 1400kgMS/ha from 200kgN/ha and up to 550kg DM/cow of imported feed. The milk payout (income) in 2002/3 was \$4.10/kgMS.

#### *Stage 2: 2003/4 through to 2010/11*

The stocking rate increased to between 4 and 4.3 cows per ha or 654-683 cows peak milked. Production averaged 1700kgMS/ha and 411kgMS/cow. LUDF ran a single herd, the focus was simple systems, low and consistent grazing residuals.

#### *Stage 3: 2011/12 to 2013/14*

The strategic objective (below) was implemented in a move into 'Precision Dairying'. This focused on minimum standards not averages, two herds, higher productivity and initially higher profitability from a similar environmental impact. Production lifted to 1878kgMS/ha or 477kgMS/cow from 630 cows. The temporary suspension of Eco-n (DCD) in 2013 required a change in farm practice in 2013/14 in the attempt to hold nitrogen losses without the mitigation effect of Eco-n.

#### *Stage 4: 2014/15*

LUDF is adopting a 'Nil-Infrastructure, low input' farm system emerging from the P21 (Pastoral 21) research programme, in partial response to the tightening environmental requirements of some catchments across NZ. Targeted milk production is 1750kgMS/ha or 500kgMS/cow from 3.5 cows/ha with up to 150kgN/ha and 300kgDM/cow imported supplement.

### ***Strategic Objective - 2011 – 2015:***

To maximise sustainable profit embracing the whole farm system through:

- increasing productivity;
- without increasing the farm's total environmental footprint;
- while operating within definable and acceptable animal welfare targets; and
- remaining relevant to Canterbury (and South Island) dairy farmers by demonstrating practices achievable by leading and progressive farmers.
- LUDF is to accept a higher level of risk (than may be acceptable to many farmers) in the initial or transition phase of this project.

## **APPENDIX 2**

### ***Proposed Variation 1 to the Canterbury Land and Water Regional Plan***

#### **Amendments to Section 11 - Selwyn – Waihora - Managing Land Use to Improve Water Quality**

##### 11.4.6

Limit the total nitrogen load entering Te Waihora/Lake Ellesmere by restricting the losses of nitrogen from farming activities, industrial and trade processes and community sewerage systems in accordance with the target (the limit to be met over time) and limits in Table 11(i).

##### 11.4.7 – 11.4.11 (Refer to Proposed Variation 1)

##### 11.4.12

Reduce discharges of nitrogen, phosphorus, sediment and microbial contaminants from farming activities in the catchment by requiring farming activities to:

- (a) Not exceed the nitrogen baseline where a property's nitrogen loss calculation is more than 15 kg of nitrogen per hectare per annum; and
- (b) Implement the practices set out in Schedule 24; and
- (c) Implement a Farm Environment Plan prepared in accordance with Schedule 7 Part A, from 1 July 2015, when a property is greater than 10 hectares and is within the Lake Area in the Cultural Landscape/Values Management Area; and
- (d) Exclude stock from drains, in addition to the regional requirements to exclude stock from lakes, rivers and wetlands.

##### 11.4.13

From 1 January 2017, further reduce discharges of nitrogen, phosphorus, sediment and microbial contaminants from farming activities in the catchment by requiring farming activities to:

- (a) Implement a Farm Environment Plan prepared in accordance with Schedule 7 Part A, where a property is greater than 50 hectares; and
- (b) Where a property's nitrogen loss calculation is greater than 15 kg of nitrogen per hectare per annum, meet the Good Management Practice Nitrogen and Phosphorus Loss Rates for the property's baseline land use.

##### 11.4.14

From 1 January 2022, to achieve the water quality limits in Section 11.7.3 require farming activities to:

- (a) Implement a Farm Environment Plan prepared in accordance with Schedule 7 Part A, where a property is greater than 20 hectares; and
- (b) Where a property's nitrogen loss calculation is greater than 15 kg of nitrogen per hectare per annum, make the following further percentage reduction in nitrogen loss rates, beyond those set out in Policy 11.4.13(b), to achieve the catchment target for farming activities in Table 11(i):

- (i) 30% for dairy
- (ii) 22% for dairy support; or
- (iii) 20% for pigs; or
- (iv) 13% for irrigated sheep, beef or deer; or
- (v) 10% for dryland sheep and beef; or
- (vi) 7% for arable; or
- (vii) 5% for fruit, viticulture or vegetables; or
- (viii) 0% for any other land use.

#### 11.4.15

In circumstances where the reductions required in Policy 11.4.14(b) are unable to be achieved by 2022, any extension of time to achieve the reductions will be considered having regard to:

- (a) The implications on achieving the catchment nitrogen load target in Table 11(i) by 2037; and
- (b) The nature of any proposed steps to achieve the reduction; and
- (c) The sequencing, measurability and enforceability of any steps proposed.

#### 11.4.16

Despite Policy 11.4.14 and 11.4.15, from 2037 no property or farming enterprise shall leach more than 80 kg of nitrogen per hectare per annum.

#### 11.4.17

To achieve the farming activity water quality targets in Section 11.7.3 require all farming activities within the command area of any Irrigation Scheme listed in Table 11(j), where they are irrigated with water from the Scheme:

- (a) To collectively not exceed the Irrigation Scheme Nitrogen Limits in Table 11(j); and
- (b) Where properties convert from dry land to irrigated land use, the nitrogen loss rates from the outset shall be managed in accordance with Policy 11.4.14(b).