MEASURING THE COMPARATIVE COST OF ENVIRONMENTAL COMPLIANCE AND MITIGATION OPTIONS FOR WAIKATO DAIRY FARM SYSTEMS

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Regulation has been used in the Waikato region as a means to limit and mitigate the negative environmental impacts of dairy under the National Policy Statement for Fresh Water. So far the focus has been on effluent storage, methods of application of effluent, and allocation of water. Future regulation is likely to include nitrogen loss limits, as it has in other regions. Management of nutrient cycles has now become a high priority for effective farm management. Understanding is essential to inform decisions on changes to farming systems. Significant research has been focused on determining mitigation strategies for nitrogen leaching (e.g., Basset-Mens et al., 2009; De Klein et al., 2010; Doole et al., 2013; Glassey et al., 2014; Howard, 2013). This research investigated the effect on N leaching and operating profit per hectare of four identified nitrogen (N) loss mitigation strategies for Waikato dairy farm systems of low, medium and high input (Hedley et al., 2006).

Approach

The base farm was chosen as 100 ha of sandy loam soils with 1250mm rain pa, representing a typical Waikato dairy farm.
The analysis focused on four previously identified N mitigation strategies for nitrogen leaching:

- Decreasing stocking rate *(-0.4 cows/ha)*
- Building increased effluent storage and expanding application area *(+100%)*
- Winter grazing herd through sensitive N leaching months *(100% wintered 4 weeks)*
- Cow housing shelter *(Duration controlled grazing model)*

The four identified scenarios were modelled for standardised farm systems of low (5% imported feed), medium (20% imported feed) and high (30% imported feed) input using Overseer v6 and Dairy Feed Planner to determine the implications for N leaching as well as operating profit. Farm operating profit per hectare was calculated as operating revenue less farm working expenses. Operating profit does not consider outstanding tax, interest or depreciation charges accumulated. Sensitivity analysis was used to show the extent to which each scenario impacted farm operating profit at a range of milk price payouts ($4.50 to $8.00 per kgMS).

Results and discussion

Destocking Scenario

Modelling of destocking indicated that it was possible to increase efficiency by reducing N leaching and increasing economic return per hectare (Table 1; 2). For the three farm systems modelled, destocking by 0.4 cows per hectare resulted in an average reduction in N leaching of 20% (Table 1). The range of N leaching between the low medium and high input systems was reduced to just 9 kg N per hectare compared with 15 kg N under the base farm scenario. Destocking increased the operating profit (Table 2) for both the medium and the high input system, reflecting lower feed cost and lower total operating cost. For the low input system, each kg of N loss mitigated resulted in a decrease in operating profit per hectare of $38. In comparison, the medium and high input systems gained $11 and $12 per hectare per unit of N mitigated respectively.

Table 1. Nitrogen leached from low, medium and high intensity dairy systems (kN/ha) for base and alternative nitrogen mitigation strategies

	Low	**Medium**	**High**
Base	32	43	47
Destocking	27	34	36
Increased effluent area & storage	30	39	42
Winter grazing	29	39	43
Cow housing	27	33	40

Table 2. Operating profit for low, medium and high intensity dairy systems ($/ha) for base and alternative nitrogen mitigation strategies

	Low	**Medium**	**High**
Base	2,839	2,552	2,325
Destocking	2,649	2,654	2,459
Increased effluent area & storage	-	-	-
Winter grazing	2,688	2,495	2,240
Cow housing	3,084	2,807	2,654

Increasing Effluent Storage and Application Area.

Nutrient modelling of an increased effluent storage and application area gave an average reduction in N leaching of 8.7% from the base scenario. Financially, the capital investment into effluent storage is large compared to the environmental benefits received by the farm system. However, 'proper' storage of effluent is increasing as a proxy measure of environmental performance by the general public as well as by dairy companies. The opportunity cost for not investing in correct storage and application is likely to increase as the use of fines and the threat of dairy companies refusing to collect milk becomes common practice.

Winter Grazing Scenario

Winter grazing the whole herd off the milking platform for the month of June reduced N leaching by up to 4 kg of N per hectare. The cost of winter grazing was modelled through increased annual feed cost. For no extra milk solid production the scenario incurred a seasonal net cost equal to the value of feed. The cost to reduce N ranged between $14 and $51 per kg N loss reduced. The comparative cost of compliance using a winter grazing strategy was greater for the low input system than for the high input system. This cost can be attributed to the low baseline leaching for the low input scenario as well as the higher feed cost as a percentage of revenue.

Cow Housing Scenario

Cow housing was the only scenario of the four modelled to show a reduction in N leaching above 10% of base, while lifting financial performance. Across each of the farm systems the average reduction in N leaching was 18%. The average increase in operating profit was 10.9% (Table 2). With the cow housing system, N leaching increased linearly from the low through high input systems, reinforcing the link between stocking rate and N leaching.

Financially, operating profit increased for each of the farm systems. The average increase in operating profit per hectare was 11%, ranging from 9 to 14% between the low and high input system, respectively. The change in operating profit per kg N mitigated was $49, $26 and $47 for the low medium and high input system, respectively. This was the highest of the four scenarios modelled.

Implications of Scenario Analysis

The modelling indicated that reductions in N leaching for farm environmental compliance were achievable through both farm management practice and additional farm infrastructure. All scenarios reduced N leaching, but to achieve acceptable environmental performance under limits based regulation the degree to which each scenario must be implemented varied according to system intensity. System intensity also had a significant effect on financial viability as measured through operating profit per hectare.

Nitrogen Leaching (Table 1)

In all scenarios, N leaching reduced from the base farm scenario. Of the four scenarios modelled, reductions in N leaching varied however both housing and destocking provided the minimum leaching achieved being 27 kg per hectare.

Both destocking, a farm management action and cow housing, a farm infrastructure investment, resulted in the highest reduction in N leaching compared to the base scenario. Notably, scenarios of increasing effluent area and wintering off provide significantly less scope to reduce N leached. The modelled scenarios for reducing N leaching can be summarised by two groupings. Destocking and cow housing reduced N leaching by 20% and 18% respectively, while effluent infrastructure and winter grazing reduced leaching by 8% and 9% respectively.

The base scenario with regard to N leaching and existing infrastructure is a major determinant as to which mitigation scenario to use to achieve compliance. Where relatively low reduction is required, increasing effluent area and pond, as well as wintering off, provide possible strategies. However to achieve a significant reduction in N leaching similar to the reduction required by the base farm scenarios in this analysis, a more significant mitigation is required such as destocking or cow housing. In all scenarios modelled, the medium and high input farm systems achieved larger reduction in N leaching measured in kg per hectare. This is due to the relatively low N leaching of the low input farm system in the base scenario and the difficulty in reducing low N leaching rates further without significantly compromising economic performance.

Nitrogen Leaching Efficiency (Table 3)

Considering Nitrogen Leaching Efficiency (NLE kgMS/kg N leached), there are clear advantages in the mitigation scenarios which show that key performance indicators regarding production and the environment can be met simultaneously. In the base farm scenario NLE ranged from 34 to 39 kgMS/kg N leached for the low to high input systems with N leaching 30 to 47 kg per hectare respectively. In each of the scenarios modelled, NLE increased through the reduction of N leaching (denominator effect). Further milk solid production remained unchanged, decreased to a lesser extent or increased (numerator effect). In modeling the cow housing scenario where leaching is reduced and milksolid production was increased the NLE is significantly increased from base levels (range 41 to 45 with N leaching of 27 to 40 kg per hectare).

Table 3. Nitrogen Leaching Efficiency for low, medium and high intensity dairy systems (kgMS/KgN leached) for base and alternative nitrogen mitigation strategies

	Low	**Medium**	**High**
Base	34	33	39
Destocking	38	37	47
Increased effluent area & storage	36	34	42
Winter grazing	38	34	42
Cow housing	41	41	45

Operating Profit (Table 2)

Measuring the financial implications of each mitigation strategy was considered through the change in operating profit per hectare (Table 2). In three of the four modelled scenarios there were significant changes to the farm with regard to management and therefore changes in operating revenue and costs. For the scenario of increasing effluent area and storage it was assumed there was no material impact on operating profit. Mitigation scenarios were assessed against a base operating profit of $2,839, $2,552 and $2,325 (Table 2) for the low, medium and high input farm, respectively. Average increases or decreases in operating profit per hectare were 1.02%, -4% and 11% for the destocking, winter grazing and cow housing scenario respectively.

Sensitivity to payout

Sensitivity modelling was used to show the breakeven point and comparative profitability at different milk pay out prices determined through operating profit per hectare.

For the low input farm system, all scenarios resulted in a positive operating profit per hectare. In contrast, for the medium input system, at a $4.50 payout the base scenario and the winter grazing strategy operated at a loss. After including non-farm working expenses, both $4.50 and $5.00 scenarios had very low net profitability. For the high input system, the relative breakeven from an operating profit perspective was between $5.00 and $5.50. However, when modelled with a high payout of $8.00, the high input system recorded significantly higher operating profit levels. Despite the capacity for greater returns from the higher input farms in high payout years the long term profitability (achieved in other systems) was not achieved at the current long term average milk price of $6.40.

Cost of reduction per unit of N (Figure 1)
An expression of the cost of compliance for each farm system is the change in operating profit per hectare for every kg of N leaching mitigated. Figure 1 shows the comparative changes in operating profit as a function of N leaching giving both an economic and environmental measurement. Destocking and cow housing, identified as the 'large reducers' were shown to have a positive effect on operating profit for every kg of N mitigated against the base scenario. An exception to this was the low input system destocking scenario whereby reducing the already low levels of leaching through decreasing stocking rate had a significant negative impact on operating profit for every kg of N leaching mitigated. For the winter grazing scenario, the increase in farm working expense for little increase milk revenue resulted in a negative change in operating profit for each kg of N mitigated.

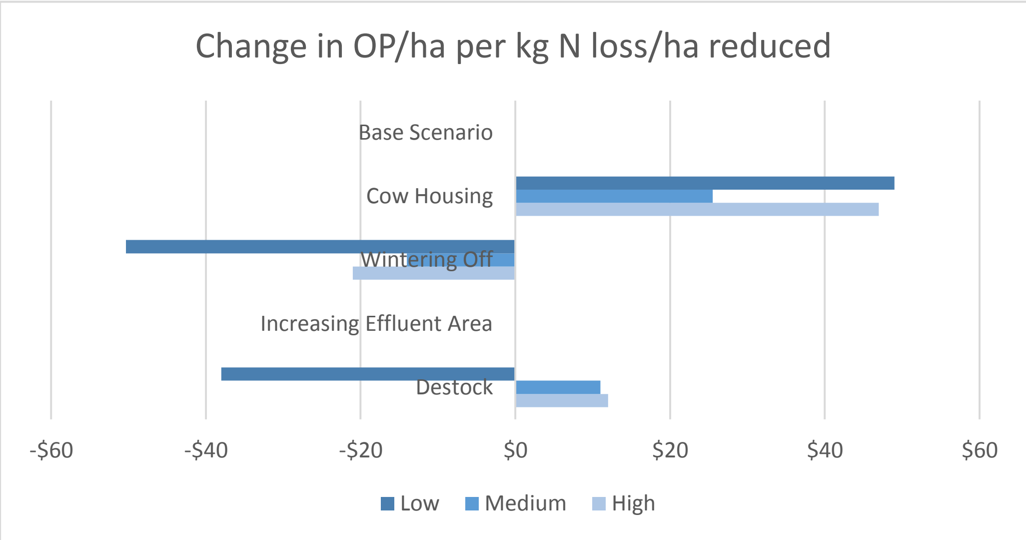

Figure 1 Effect of nitrogen mitigation strategies on change in operating profit for low, medium and high intensity systems ($/ha/kgNloss/ha reduced)

Conclusion
The comparative analysis of mitigation options across low, medium and high input systems indicated that there was no 'one fit' system for compliance. Mitigation options became inefficient where small reductions in N leaching were achieved as shown through the moderate reducing scenarios. Efficient reduction in N leaching (reductions greater than 10% and improved operating profit), were achieved through destocking and cow housing. Across all farm systems modelled the cow housing scenario provided both superior economic and environmental performance. There is, however, a high capital cost to implementing cow housing infrastructure and the capacity for farmers to implement a housing system is not always evident.

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