Rotorua NDA Impact Analysis

Phase 1 Project

FINAL REPORT 16 JUNE 2014

Prepared by

Perrin Ag Consultants Ltd

REPORT PREPARED BY

PERRIN
AG CONSULTANTS

REGISTERED FARM MANAGEMENT CONSULTANTS

Perrin Ag Consultants Limited
1330 Eruera Street, P O Box 596, Rotorua

Phone: 07 349 1212 Fax: 07 349 1112
Mobile: 021 955 312 (D J Perrin) / 0292 955 312 (T Laan)
0293 955 312 (L Matheson) / 0273 403 984 (D Walker)

Email: consult@perrinag.net.nz

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EXECUTIVE SUMMARY

The Bay of Plenty Regional Council ("BOPRC") is in the process of developing Nitrogen Discharge Allowances ("NDA") for all pastoral land in the Lake Rotorua catchment with the purpose of improving water quality by reducing nitrogen and phosphorus inflows into the lake. The BOPRC and the Stakeholder Advisory Group ("StAG") have suggested draft restricted NDA levels of 35kgN/ha/year for dairy, 13kgN/ha/year for drystock farms and 3kgN/ha/year for trees. The draft NDA values are based on analyses using versions of Overseer 5.

Perrin Ag Consultants Ltd ("PAC") was engaged to analyse the financial implications of the NDA levels at an individual farm level. This was accomplished using a range of hypothetical and real farm case studies that were deemed to be illustrative of farms within the Lake Rotorua catchment. The case study farms were modelled in Farmax and Overseer to determine how operating profitability changed as farmers made realistic decisions to optimise their farm systems in a restrictive N loss environment. These changes were limited to those appropriate within the existing farming systems.

Reducing nitrogen losses in existing pastoral grazing systems primarily requires changes that should reduce the inefficient cycling of N that occurs in pastoral systems. Some of these strategies can result in an accompanying improvement in farm financial performance, but invariably it appears to be farm systems that have lower levels of productivity that have the greatest capacity to reduce whole system N losses while maintaining or increasing underlying profitability. This assumes that such farms and farmers have the capacity to achieve these higher levels of productivity. However, where farms already utilise N efficiently, system changes to reduce N losses were found to result in losses of farm profitability.

The case studies analysed suggest that farming under a restricted nitrogen loss regime, like that proposed for the Lake Rotorua catchment, is likely to have differing financial impacts across farms and farm systems.

The dairy farm case studies typically relied on a combination of lower annualised stocking rates, improved per cow milk solids production and replacing high N feed and high N loss feed with low protein alternatives to achieve N loss targets. However, despite these changes, most of the case studies experienced some degree of decline in operating profit (EBIT), ranging between 0% and 10%, in reaching the proposed limits. It is recognised there is likely to be a knowledge/capacity gap within many existing dairy farmers that needs to be bridged to allow many of these mitigations to be implemented. There may be some structural and industry issues that will also need to be addressed e.g. providing large quantities of low N forage/feed with its own manageable environmental footprint.

Dry stock case study farms typically relied on firstly eliminating the use of N fertiliser where it was deemed to be unprofitable and eliminating winter cropping to lower N losses. After that maximising meat, wool and feed sold off farm from the available feed and/or shifting feed used for livestock maintenance into more N efficient livestock classes were key strategies.

In the case studies, mixed sheep, beef and deer systems appeared to have a greater ability to meet suggested targets, particularly the single NDA limit of 13kg N/ha/year, without nominal reductions in profitability from current levels, borne out by the fact that many of the case studies already operated under, at or close to that NDA limit. However, the extent to which these changes resulted in profit increasing, decreasing or remaining unchanged relied heavily on the relative profitability of the various enterprises and their mix in the system. As with the dairy farm cases studies, the ability of individual farmers to implement higher levels of productivity within their systems is likely to be a significant factor in whether or not N mitigation can be successfully implemented without reduction in operating profit. Further reductions beyond this level [13kg N/ha/year] will likely have negative implications for sheep & cattle farmer profits, particularly once productivity improvements have been exhausted. Those systems exposed/taking advantage of the dairy industry's requirement for off-farm grazing are potentially amongst those most affected by the need to reduce N losses.

It is also important to recognise that the forecast reductions in operating profit will have differing implications for farm businesses, given their individual balance sheet configuration and the extent of commitments on their business that fall outside of the operating profit measure. In this sense, operating profit provides an excellent measure of system resilience to N loss restrictions, but not necessarily that of individual farm businesses in the community.

The proposed NDA restrictions for the Rotorua catchment will undoubtedly require some degree of farm system change over the coming years and some economic and social disruption to the farming (and wider) communities. The extent to which farm systems will be financially affected by this, against the normal backdrop of price and climate volatility and the differing goals and objectives of individual farmers, is difficult to determine. Our analysis suggests that improving productivity and system efficiency will be vital elements in ensuring farm businesses stay viable.

For both drystock and dairy farmers, level of farming efficiency and/or profitability can be expected to follow a normal distribution. Hence there will always be below-average and above-average farmers. The notion that below-average farmers can somehow become average or above-average farmers is somewhat simplistic. Level of farming performance is influenced by a range of drivers including business and personal goals, and management skills. Whilst the former might be influenced by regulation, it is not a simple task to lift inherent farm management skills. **The BOPRC will need to actively engage with industry to ensure that farmers are adequately supported to make these changes.**

While Overseer is currently the best tool available for estimating the likely impact of farm system change on nutrient losses from the farm system, the significant and sometimes inconsistent increases in forecast N losses from the case studies when modelled in Overseer v6.1.2 provide some cause for concern, particularly for non-dairy farmers. Accordingly, we recommend farmers and regulators focus on the implementation of management and system changes to increase individual animal productivity, reduce inefficient N use and reduce the incidence and intensity of urine patches during the late autumn and winter periods with a view that these will result in real and measurable reductions in N losses once apparent Overseer irregularities are resolved.

The conclusions reached from this analysis are undoubtedly limited by the small sample size (18 case studies) and the fact that only four were real farms, although the hypothetical farms were largely based on real enterprises. It is therefore impossible to make any valid catchment extrapolation, although we note this was not an expectation or deliverable from Phase 1 of the project. The use of EBIT as a profitability measure also focuses on the financial impacts at a farm system level, rather than at an individual farm business level. While this provides for comparisons between individual farm types and enterprise mixes, it doesn’t provide any insight into the overall resilience of the individual farm businesses that will be affected by the proposed NDA limits.

As regards expanding on findings from this Phase 1 project which considers financial implications for individual farms in the Rotorua catchment, we would recommend additional analysis on:

(i) Separating the impact of productivity improvements from pure mitigation activity i.e. “optimise” farm system first and then apply mitigation actions;

(ii) The implications of managing the impacts of wintering milking cows on dairy platforms, with or without infrastructure i.e. barns;

(iii) Considering elevated per cow production levels (System 5 farms, >500kg MS/cow) for a real dairy farm system, perhaps in conjunction with (i) above;

(iv) Considering the resilience of the low N loss scenarios for case studies under more extreme pasture growth conditions (i.e. drought in 2012/13, wet year in 2011/12) and the input/output prices that accompanied these;

(v) Expanding financial analysis of the real farm case studies to an NPAT level or looking at the NPAT impact for hypothetical case studies using assumed equity levels, and then sensitising against cost of capital.

(vi) Looking at less simplified afforestation options for mitigation on more marginal sheep & beef land;

(vii) An alternative deer farming scenario, say a velvet/stud operation

In the context of the wider catchment impact analysis flagged to follow the Phase 1 project, we would recommend that stakeholders examine:

(i) The implications of large scale adoption of preferred mitigation tools on the cost/benefit of these e.g. trebling maize silage use in the local dairy industry;

(ii) Alternatives for sourcing low protein feed stuffs;

(iii) Downstream community economic effects from potential losses in profitability;

(iv) The impact of land values over time and how real farms might be affected by this.

PERRIN AG CONSULTANTS

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1. BACKGROUND AND TERMS OF REFERENCE

1.1. The Bay of Plenty Regional Council ("BOPRC") are in the process of developing Nitrogen Discharge Allowances ("NDA") for all pastoral land in the Lake Rotorua catchment with the purpose of improving water quality by mitigating nitrogen and phosphorus inflows into the lake over time.

1.2. Currently the BOPRC and the Stakeholder Advisory Group ("StAG") have suggested draft proposed NDA levels of 35kgN/ha/year for dairy, 13kgN/ha/year for drystock farms and 3kgN/ha/year for trees ("35:13:3") with an option to assess NDA ranges as follows: 30-40 kg N/ha/year for dairy and 10-20 kg N/ha/year for drystock.

1.3. The draft NDA values have been derived from prior analysis that used several Overseer 5 versions, notably the N loss assumptions that were used in the ROTAN catchment model. The BOPRC is addressing this by migrating Rule 11 benchmarks from Version 5 to 6 which will enable ROTAN to be rerun. However, this is expected to take some months.

1.4. The BOPRC engaged Perrin Ag Consultants Ltd ("PAC") to undertake analysis on the financial implications of the restricted NDA levels (35:13:3 and ranges) at an **individual farm level**, in order to:

(i) support consultation on the draft NDA scheme, especially by enabling farmers to understand likely NDA impacts on farm systems similar to their own farm;

(ii) inform decisions on potential adjustments to the draft NDA levels and the underlying allocation regime; and

(iii) support subsequent impact analysis at the overall catchment level.

1.5. This analysis was to be based around a mixture of hypothetical dairy and drystock farm systems broadly representative of actual farming activity in the catchment and real case study farms within the catchment

1.6. Given the NDA regime is likely to be implemented using Overseer Version 6, stakeholders had requested that, for consistency and "future-proofing", this NDA impact analysis be based on the latest Overseer version (6.1.2, noting the update from 6.1.1 occurred midway through the analysis). Therefore an interim method was proposed to adjust the current nominal NDA values to levels consistent with v6.1.2. However, given significant issues with outputs for pumice soils in the latest versions of Overseer, some slight changes to the proposed version adjustment methodology have been made (see 2.15 below).

A note on definitions

Dry stock farming is considered to include any given combination of commercial sheep, beef and deer farming activity, including of dairy support operations that are not considered part of a self-contained dairy unit where the entire land area is potentially milked on during the year.

2. METHODOLOGY

2.1. The analysis was governed by methodology outlined by the BOPRC in the Request for Quote documents ("RFQ").

2.2. The analysis was based around a mix of broadly representative[1] hypothetical and real farms.

2.3. Guidelines from the BOPRC as to the nature of the hypothetical farm systems that were to be analysed were reviewed and adjusted utilising best professional judgement in order to deliver better illustration of the major farm systems within the Lake Rotorua catchment. This was essentially done by identifying real farm systems that the authors were familiar with and deriving hypothetical models, representative of soil type, contour, productivity, pasture growth rates and size. This was considered a critical element in ensuring the realism of the farm systems being assessed, particularly as regards capturing an accurate range of typical pasture growth parameters and existing management ability.

2.4. Each of the fourteen hypothetical and four real farm systems were modelled to represent the status quo[2] in FarmaxPro or FarmaxDairyPro as appropriate and in Overseer v5.4.11[3]. Each farm was then modelled to reflect two alternative NDA scenarios:

(i) **Range NDA**, defined as being 25% less than the current level of N loss, subject to being within the range of 30-40kg N/ha/year for dairy systems and 10-20kg N/ha/year for drystock systems.

(ii) **Single NDA**, being 35kg N/ha/year for dairy farms and 13kg N/ha/year for drystock systems.

Where the current level of N loss was assessed as being below the single NDA target, or where the Range and Single NDA target were equivalent, no additional modelling was deemed necessary.

2.5. The system changes modelled in the range and single NDA scenarios were done on the basis of targeting key pathways within the N cycle, simultaneously trying to minimise

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[1] In terms of farm system.

[2] Defined as reflective of typical current systems and practices.

[3] Overseer 5.4.11 was unable to model farm systems where large amounts of pasture is harvested for silage or where cropping areas take up large parts of the effective area. Where this occurred, the farm system was modelled in 6.1.2 and an equivalent 5.4.11 value "derived" from the relative changes in estimated N losses observed in similar models.

any reduction in profitability associated with achieving the required extent of N loss, albeit within the broad parameters of the existing systems.

2.6. In general, the following system changes were applied more or less sequentially, typically based on where the greatest reductions were expected to occur for the least cost:

(i) reducing total N within the pastoral system (reducing/eliminating imported N – fertiliser, high N feed);

(ii) stopping management practices that can elevate N losses to water ("winter" N applications, cropping [particularly for winter forage[4]]);

(iii) improving use of dietary N within the animal to reduce N concentration in urine (increasing proportion of low protein feeds);

(iv) increasing the amount of N leaving the system in saleable product (improving livestock based productivity measures like weight gain, reproductive efficiency, milk solids production – essentially feed conversion efficiency);

(v) reducing the proportion of N leaving the system via animal urine patches (eliminating intensive winter grazing, changing stock class ratios, reducing seasonal stocking rates, reducing stock numbers); and

(vi) using the professional judgement and practical experience from closely working with real farm systems, including the Rotorua district, to make other appropriate system changes to improve operating profit within the implied restrictions of (i) to (v) above.

2.7. Note that in the context of dairy farm systems, the upgrading of effluent systems, while identified by the BOPRC as a possible mitigation, was not considered in this analysis, given that in the authors' experience most dairy farms in the Rotorua catchment have effluent systems sufficient to reduce the risk of direct N losses from dairy effluent to within "measurement" tolerance in Overseer.

2.8. Where possible, an attempt was made to retain the general policy direction of the individual farm systems e.g. dairy support properties were left as dairy support. Afforestation was not initially considered as an option given both the anecdotal and previously documented reluctance of farmers to adopt large scale afforestation to achieve N loss targets. However the effect of afforestation was considered for two dry

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[4] Soil mineralisation, luxury N applications, concentrated urine deposition, bare ground preventing N uptake

stock scenarios where other options were limited. We note that perceived farmer reluctance to afforestation is likely to be the result of a number of factors, which might include a lack of wider industry understanding about the potential financial returns of forestry options. More information about the viability of integrating forestry into farm systems, either with or without incentive payments, should be considered in further economic analysis in relation to meeting N targets.

2.9. All farm system scenarios were modelled to ensure “feasibility” and a realistic level of pasture harvest in Farmax given typical pasture growth for the case study properties (based on that derived from the base model). These scenarios were then assessed for practical implementation and realism based on the authors’ professional judgement and practical experience.

2.10. Given the 18-20 year timeframe proposed for farmers to make the necessary changes to meet the draft NDA targets, under the terms of the RFQ, “productivity” improvements were allowed as a means of mitigating the financial impacts of system. In the context of **this analysis, productivity improvements have essentially been restricted to those relating to livestock performance and efficiency, with pasture growth parameters left unchanged**. The extent to which improved productivity of farm systems within the analysis was modelled tended to reflect (a) lifting below average performance to at least average performance levels within the catchment and (b) incremental improvements, rather than either fixed levels of productivity, optimal productivity or a % increase in productivity KPIs. Any modelled increases reflect the authors’ own professional assessment of each farm systems’ immediate capacity for productivity increase, rather than what is ultimately achievable. This has resulted in the “optimised” scenarios still having a range of productivity levels.

2.11. Of course the inclusion of productivity improvements within a mitigation framework potentially confounds estimates of changes in profitability associated with achieving N loss reduction. Unlike some other previous studies (UWNES 2009, FSP 2012), the individual financial impact of discrete nitrogen mitigation strategies was not calculated, nor was this contrasted with the financial impact of discretely considered efficiency gains.

2.12. However, given the variation of farm systems and underlying levels of performance within the catchment, this approach does provide some insight into the types of changes some farmers might be required to make to achieve lower N losses with the least loss in profitability.

2.13. Farmax outputs were then used in Perrin Ag's own financial analysis models[5] to calculate standardised farm system **operating profitability**, as measured by earnings before interest and tax ("EBIT")[6], as required by the BOPRC's terms of reference. Overseer 5.4.11 outputs were able to be directly used to provide estimates of annual pastoral N losses from the farm systems. In line with the RFQ, the analysis made no provision for the likely balance sheet/capital impacts that the system changes might incur, nor did it consider what changes in EBIT might mean as regards net profit after tax ("NPAT") and discretionary cashflow.

2.14. Product and input prices used in all financial analysis reflected current seasonal averages for the 2013/14 year (which the authors considered appropriate as regards medium pricing expectations). The solitary exclusion was the milk price, which achieved record levels in 2013/14 for all of the three milk processers Rotorua farmers are currently supplying or able to supply. In this instance a medium term milk price of $6.60/kg MS was used. These are summarised in Appendix 5 & 6. Quantities of all key marginal inputs (feed, labour, N usage, freight, shearing, dairy expenses, animal health) were varied appropriately according to the individual scenario, while maintenance fertiliser reflected the realistic levels of nutrients required to support the modelled stocking rate and/or pasture harvest, balanced for imported and exported nutrients in feed. Fixed costs and overheads were typically calculated on modelled farm area or stock numbers as appropriate. Farm expenditure for base modelling, which was derived from the forecast and actual expenditure for Perrin Ag supervised farms, was validated against external sources (Beef + Lamb New Zealand Economic Service 2013, DairyNZ 2013) to ensure relativity with industry averages.

2.15. All of the Overseer 5.4.11 files were then converted to Overseer v6.1.2 using the prescribed Data Input Standards for Overseer[7] and the equivalent levels of N losses calculated. This is a slight departure from the prescribed methodology as per the RFQ, which proposed all N losses and scenario targets subsequent to the status quo model (which was to be used for scaling purposes with v6.1.2) be calculated directly in Overseer 6.1.2. The major reasons for this change, which was agreed to in consultation with the BOPRC, was initially due to the delay in the release of the version 6 update and the uncertainty around the extent of the changes to that version, as well as the wide

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[5] These were Excel spreadsheet models extensively utilised within Perrin Ag for budgeting and reconciling financial performance amongst its farm supervision client base.

[6] EBIT = revenue less operating expenses adjusted for changes in livestock numbers and values and depreciation

[7] Note that due to the expected changes in the pending upgrade, the climate data tool in Overseer 6 wasn't utilised; rather benchmarking climate data was manually input.

degree of variation in the percentage changes in N losses being calculated for individual farm scenarios when converting from Overseer 5.4.11 to an earlier upgrade, v6.1.1.

2.16. Accordingly, all N loss estimates referred to in the analysis, unless otherwise indicated, will refer to losses relative to ROTAN/5.4.11, with v6.1.2 losses specified or discussed where appropriate.

2.17. Provisional findings were presented to farmer stakeholders and StAG prior to release, with subsequent feedback incorporated or addressed in the final report. The report was also subject to external expert peer review and industry comment prior to publication.

3. THE FARM SYSTEMS

3.1. As mentioned in 2.3 above, all of the hypothetical farm systems modelled were loosely based on real farm operations as regards determining accurate pasture growth parameters, mix of operating policies and base productivity indices. As a result, the calculated levels of farm profitability and annual N losses can be considered somewhat illustrative of the range of farm systems within the Lake Rotorua catchment given the market environment in 2013/14.

3.2. However, this has resulted in the physical parameters of the farms having some slight differences from the proposed hypothetical systems in the RFQ documentation.

3.3. All of the hypothetical farm systems were deemed to be at a static stage of development, with all non-marginal expenditure assumed at business-as-usual ("BAU") levels and pasture growth parameters were based on what we considered to be "normal" climate expectations going forward.

3.4. Each of the hypothetical and real farm systems are briefly outlined and summarised in Table 1 and Table 2 below.

3.5. For the dairy systems these were:

(i) HH – high pasture eaten[8], high supplement per cow

(ii) HM – high pasture eaten, medium supplement per cow

(iii) HL – high pasture eaten, low supplement per cow

(iv) MM – medium pasture eaten, medium supplement per cow

(v) LH – low pasture eaten, high supplement per cow

(vi) LM – low pasture eaten, medium supplement per cow

(vii) RD1 – real farm (similar to HM)

(viii) RD2 – real farm (similar to LH)

3.6. Dairy farm EBIT ranged from $2,712/ha to $4,031/ha. Only one of the eight case studies was already assessed as leaching under or at the single NDA target of 35kg N/ha/year, with the range between 35kg/ha/year and 70kg N/ha/year.

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[8] The assessments of the degree of pasture eaten essentially related to the underlying amount of pasture grown as similar levels of pasture utilisation have been assumed across the dairy case studies.

3.7. For the dry stock systems the case studies were:

(i) HSB - high pasture harvested[9], sheep & beef breeding/finishing

(ii) LSB - low pasture harvested, sheep & beef breeding/finishing

(iii) SDG – sheep breeding/finishing and dairy grazing

(iv) SDW - sheep breeding/finishing and winter dairy grazing

(v) WGS – winter dairy grazing using crop and silage

(vi) DG – dairy heifer grazing

(vii) BBT – bull beef trading

(viii) DBF – deer breeding/finishing

(ix) S+BR1 – real farm (similar to DG)

(x) S+BR2- real farm (similar to HSB)

3.8. Dry stock farm EBIT ranged from $102/ha to $905/ha, with the four most profitable farm systems having either partial or full exposure to dairy support (grazing heifers, wintering dairy cows). Four of the case studies were already assessed as leaching under or at (≤13.4kg N/ha/year) the single NDA target of 13kg N/ha/year, with the range between 10.7kg/ha/year and 36.8kg N/ha/year.

3.9. There will undoubtedly be farmers with operations similar to the hypothetical farms that may have lower or higher profitability and different estimates of N losses. This is to be expected, given the variation between farm systems, the range of management ability and the considerable variation in goals and objectives between farm owners that influence management and governance decisions.

3.10. It is also important to remember that the standardised calculations of farm profitability will not be able to accurately represent the full range of variation in the aspects of farm businesses that typically impact on non-marginal elements of farm expenditure.

3.11. The calculated levels of base farm profitability should therefore not be considered as absolute measures of inherent system performance, but rather as a representative

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[9] The assessments of the degree of pasture eaten essentially related to the underlying amount of pasture grown as similar levels of pasture utilisation have been assumed across the drystock case studies.

baseline for assessing the impact of system changes to meet the potential levels of N loss reduction.

3.12. Full details of each of the case study farms are presented in Appendices 1-4.

Table 1: Summary of dairy farm systems

Base model	**HH**	**HL**	**HM**	**MM**	**LH**	**LM**	**RD1**	**RD2**
Pasture harvested (tDM/ha)	11.0	11.9	12.5	10.4	9.4	10.4	12.0	9.8
Cows/ha[1]	3.34	3.03	3.15	2.82	2.95	2.70	2.95	2.71
MS/cow[2]	376	355	368	351	373	351	444	425
MS/ha	1,256	1,073	1,161	991	1,101	946	1,310	1,152
Supplement fed (tDM/cow)[3]	1.60	0.52	1.11	0.83	1.44	1.05	1.22	1.83
N applied kg/ha/year	158	124	160	93	146	47	181	35
EBIT ($/ha)	$ 3,142	$ 3,386	$ 2,919	$ 2,919	$ 2,727	$ 2,712	$ 4,031	$ 2,907
N loss (kg N/ha/year)[4]	70	43	64	46	47	40	50	35

[1] Cows milked at peak (1 Dec) per effective milking area

[2] Milksolids to the factory per cow milked at peak

[3] Includes winter cow grazing

[4] Overseer 5.4.11

Table 2: Summary of drystock farm systems

Policy	**HSB**	**LSB**	**SDG**	**SDW**	**WGS**	**DG**	**BBT**	**DBF**	**S+BR1**	**S+BR2**
Pasture harvested (t DM/ha)	7.9	6.5	8.0	6.2	8.6	7.8	7.7	6.1	8.0	9.0
Stocking rate (SU/ha) [1]	14.4	11.8	14.6	11.3	15.2	14.1	14	11.2	15.2	16.3
Breeding ewes	48%	69%	66%	73%						59%
Breeding cows										41%
Dairy heifers			34%			100%			73%	
Winter cows				27%	100%				27%	
Beef trading	52%	31%					100%			
Deer								100%		
Net product (kg/ha)	363	297	345	285	185	409	499	133	353	335
Liveweight wintered (kg/ha)	613	579	573	2,051	6,400	487	475	520	3,394	888
Winter crop used (% farm area)	0%	3%	4%	11%	18%	0%	0%	4%	0%	0%
N applied (kg/ha/year)	6	11	7	16	0	30	80	10	92	1
Supplement harvested (% farm area)	34%	5%	19%	42%	213%	48%	34%	7%	137%	24%
EBIT ($/ha)	$ 102	$ 338	$ 401	$ 157	$ 905	$ 563	$ 301	$ 183	$ 484	$ 314
($/SU)	$ 7	$ 29	$ 27	$ 14	$ 60	$ 40	$ 22	$ 16	$ 32	$ 19
Netkg product/kg lwt wintered	59%	51%	60%	14%	3%	84%	105%	26%	10%	38%
N conversion efficiency	21%	21%	24%	12%		24%	19%	7%	9%	17%
N loss (kg N/ha/year) [2]	12.6	10.7	13.3	14.4	36.8	20.1	12.8	15.8	22.6	13.8

[1] Annualised stock units (6,000 MJ ME pasture intake/annum)

[2] Overseer 5.4.11

4. RESULTS

Dairy farm case studies

4.1. Analysis of the dairy case studies revealed negligible correlation between operating profit and annual nitrogen loss in the base situation or the range NDA scenario and only a limited relationship with the single NDA scenario (see Figure 1). Of course, a limited sample size (two actual and six hypothetical farm systems) across differing farm systems limits the extent to which such a conclusion can be drawn. However, it appears reasonable to suggest that, depending on exact system parameters, **there will probably be a range of profitability levels at any given level of N loss for dairy farms**.

4.2. When reducing current annual N losses by 25% (which may be less than the proposed NDA 35kg N/ha/year), all except one case study (MM) experienced some loss in EBIT, although in only two instances did this exceed more than a 5% reduction in EBIT (Table 3). When attempting to achieve the proposed single NDA target (35kg N/year) from current levels, EBIT also tended to be reduced, although one farm actually demonstrated slightly improved EBIT (Table 4).

4.3. Analysis of both scenario runs is suggestive that the lower dairy farm systems reduced annual N losses the “cost” of achieving lower N losses increased.

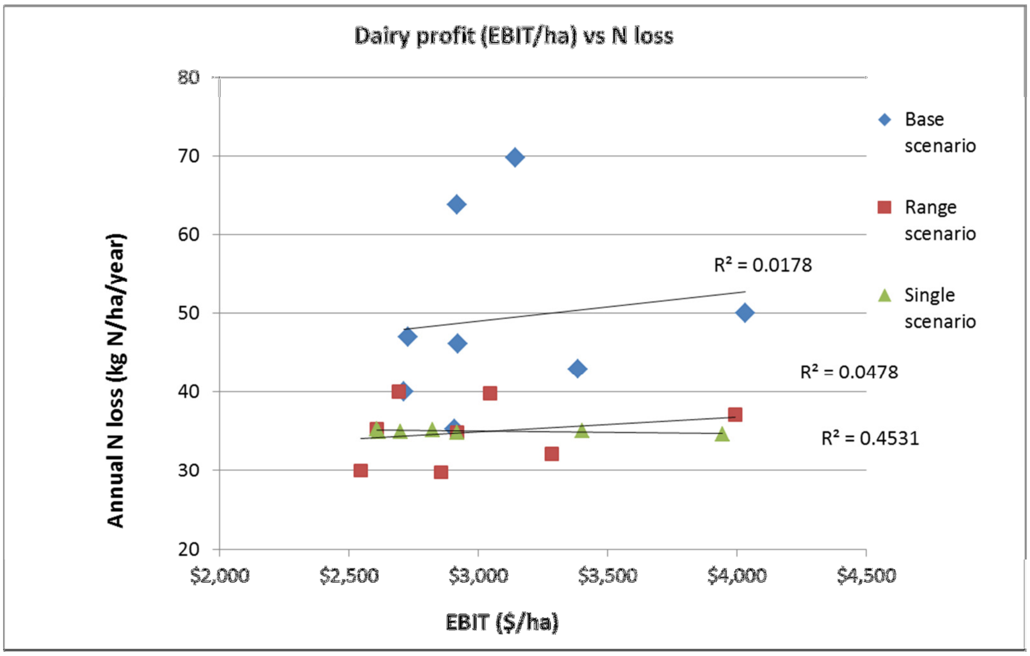

Figure 1: Dairy farm case study profitability compared with annual N losses

Table 3: Summary of range NDA scenario KPIs for the dairy case studies

Range scenario	HH	HM	HL	MM	LH	LM	RD1	RD2
Pasture harvested (tDM/ha)	10.8	10.9	11.5	10.4	9.0	8.7	11.8	9.8
Cows/ha[1]	2.53	2.56	2.62	2.57	2.89	2.28	2.95	2.71
MS/cow[2]	376	368	369	364	378	370	443	421
MS/ha	950	943	968	934	1,093	843	1,308	1,140
Supplement fed (tDM/cow)[3]	0.8	0.6	0.3	0.9	1.8	0.2	1.5	1.8
N applied kg/ha/year	61	76	79	46	56	27	137	36
EBIT/ha	$ 3,046	$ 2,693	$ 3,282	$ 2,916	$ 2,608	$ 2,546	$ 3,991	$ 2,856
Δ EBIT from Base	-$ 96	-$ 226	-$ 104	-$ 3	-$ 119	-$ 166	-$ 40	-$ 50
%	-3%	-8%	-3%	0%	-4%	-6%	-1%	-2%
N loss (kg N/ha/year)[4]	40	40	32	35	35	30	37	30
Δ N loss from Base	-30	-24	-11	-11	-12	-10	-13	-5
%	-43%	-37%	-25%	-25%	-25%	-25%	-26%	-16%
Δ EBIT/kg N reduced	-$ 3	-$ 9	-$ 10	-$ 0	-$ 10	-$ 17	-$ 3	-$ 9

[1] Cows milked at peak (1 Dec) per effective milking area

[2] Milksolids to the factory per cow milked at peak

[3] Includes winter cow grazing

[4] Overseer 5.4.11

Table 4: Summary of single NDA scenario KPIs for the dairy case studies

Single scenario	HH	HM	HL	MM	LH	LM	RD1
Pasture harvested (tDM/ha)	10.5	10.5	11.6	10.4	9.0	9.9	11.7
Cows/ha[1]	2.34	2.46	2.62	2.57	2.89	2.56	2.95
MS/cow[2]	375	368	383	364	378	369	442
MS/ha	878	905	1,005	934	1,093	944	1,306
Supplement fed (tDM/cow)[3]	0.8	0.6	0.4	0.9	1.8	1.1	1.6
N applied kg/ha/year	35	40	102	46	56	29	116
EBIT/ha	$ 2,822	$ 2,613	$ 3,399	$ 2,916	$ 2,608	$ 2,697	$ 3,943
Δ EBIT from Base	-$ 320	-$ 305	$ 14	-$ 3	-$ 119	-$ 15	-$ 88
%	-10%	-10%	0%	0%	-4%	-1%	-2%
N loss (kg N/ha/year)[4]	35	35	35	35	35	35	35
Δ N loss from Base	-35	-29	-8	-11	-12	-5	-15
%	-50%	-45%	-18%	-25%	-25%	-13%	-31%
Δ EBIT/kg N reduced	-$ 9	-$ 11	$ 2	-$ 0	-$ 10	-$ 3	-$ 6

[1] Cows milked at peak (1 Dec) per effective milking area

[2] Milksolids to the factory per cow milked at peak

[3] Includes winter cow grazing

[4] Overseer 5.4.11

4.4. Within the base scenarios, there was a strong correlation (R^2 = 84%) between the number of cows peak milked and annual N losses (Figure 2), which was not unexpected for dairy systems where grazed forages that are high in protein form the majority of the diet. This was despite the fact that there was some variation in the numbers of cows grazed off over winter (range from 42% to 100%). However, with the range and single NDA scenarios this correlation disappeared. It is likely that this is due to the overall suite of mitigations modelled on most of the dairy farm systems lowering the impact of the cow on the nitrogen cycle. In all cases this was achieved utilising infrastructure already in place within the farm systems i.e. no wintering facilities were assumed to be constructed.

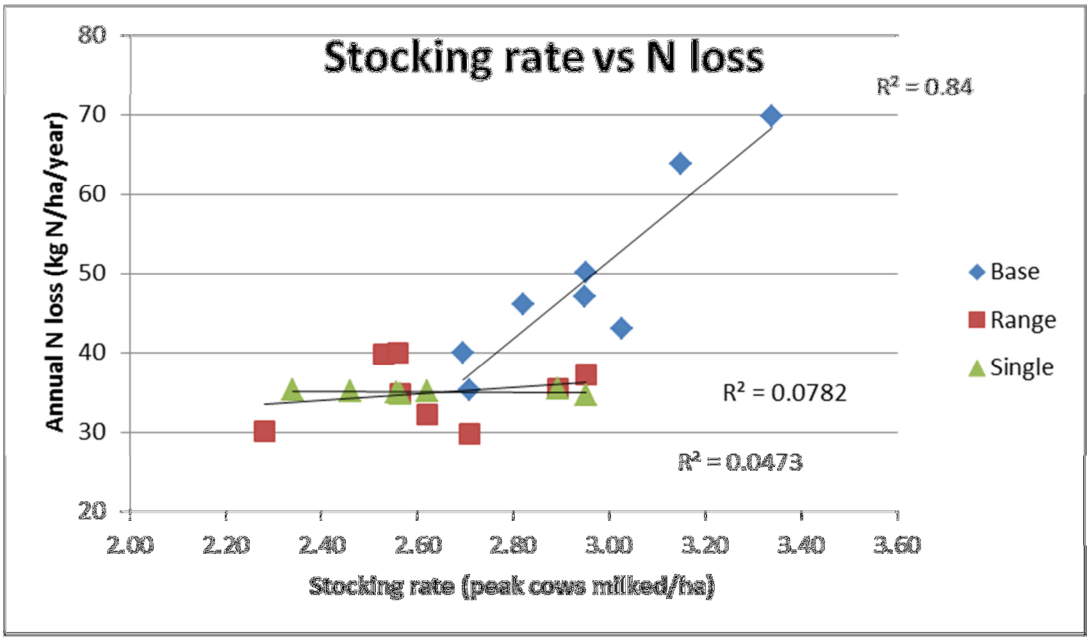

Figure 2: Dairy farm stocking rate compared with annual N losses

4.5. While stocking rate appears to have little influence on whole system N losses once inefficient parts of the N cycle have been targeted using mitigation strategies, increasing cow productivity is still an important factor in minimising the impact of lowering N losses. As can be seen in Table 5 below, when we consider the HM case study for both of its range NDA and single NDA scenarios (which both had lowered N fertiliser applications and reductions in stocking rate), increasing per cow production (managed with additional low N feed inputs and further slight reductions in cows numbers) contributed positively to EBIT without compromising N loss levels. In fact, it was deemed possible for the farm system to exceed its current levels of profitability at both reduced levels of N loss (at the assumed milk price).

Table 5: Sensitivity of profit and annual N losses to increases in per cow milk production

3. HM case study	N loss per effective area	Cow numbers	Production kg MS/ha	EBIT $/ha	Change in EBIT from Base %	Supplement t DM/cow	Nitrogen applied (kg N/eff ha)
Base	64	320	1161	$ 2,919		1.11	160
Range (368kg MS/cow)	40	260	943	$ 2,693	-7.7%	0.63	76.3
Range (403kg MS/cow)	40	252	1000	$ 2,988	2.4%	0.78	76.3
Range (430kg MS/cow)	40	245	1037	$ 3,247	11.3%	0.81	76.3
Single (368kg MS/cow)	35	250	905	$ 2,613	-10.5%	0.62	39.9
Single (404kg MS/cow)	35	242	961	$ 2,985	2.3%	0.67	39.9
Single (430kg MS/cow)	35	236	1000	$ 3,197	9.5%	0.81	39.9

4.6. Adopting lower N loss farm systems impacts on profitability through prices for key inputs and outputs. In case study HM, absolute operating profitability for different N loss systems differs little at lower milk prices, but as milk price increases, the lower N loss systems are unable to capture as much of the higher milk price (see Table 6 below). This is probably because (at least in this instance) (a) when the milk price is lows, the lower the cost of production (per kg MS) in the reduced N loss scenarios acts as a buffer to reduced revenue and (b) when the milk price is high, the value of the extra milk in the base scenario increases with increasing milk price. These systems appear to be more resilient at lower prices, but disadvantaged when milk prices are high.

Table 6: Comparison sensitivity in HM base, range and single NDA scenarios to milk price and maize silage price

Base - 64kg N/ha

Maize silage ($/kg DM)	Milk price ($/kg MS)				
	$ 5.80	$ 6.20	$ 6.60	$ 7.00	$ 7.40
$ 0.32	$ 1,990	$ 2,454	$ 2,919	$ 3,383	$ 3,847
$ 0.34	$ 1,990	$ 2,454	$ 2,919	$ 3,383	$ 3,847
$ 0.36	$ 1,990	$ 2,454	**$ 2,919**	$ 3,383	$ 3,847
$ 0.38	$ 1,990	$ 2,454	$ 2,919	$ 3,383	$ 3,847
$ 0.40	$ 1,990	$ 2,454	$ 2,919	$ 3,383	$ 3,847

Range - 40kg N/ha

Maize silage ($/kg DM)	Milk price ($/kg MS)				
	$ 5.80	$ 6.20	$ 6.60	$ 7.00	$ 7.40
$ 0.32	$ 1,951	$ 2,328	$ 2,705	$ 3,082	$ 3,459
$ 0.34	$ 1,945	$ 2,322	$ 2,699	$ 3,076	$ 3,453
$ 0.36	$ 1,939	$ 2,316	**$ 2,693**	$ 3,070	$ 3,447
$ 0.38	$ 1,933	$ 2,310	$ 2,687	$ 3,064	$ 3,441
$ 0.40	$ 1,927	$ 2,304	$ 2,681	$ 3,058	$ 3,435

Single - 35kg N/ha

Maize silage ($/kg DM)	Milk price ($/kg MS)				
	$ 5.80	$ 6.20	$ 6.60	$ 7.00	$ 7.40
$ 0.32	$ 1,901	$ 2,263	$ 2,625	$ 2,987	$ 3,349
$ 0.34	$ 1,895	$ 2,257	$ 2,619	$ 2,981	$ 3,343
$ 0.36	$ 1,889	$ 2,251	**$ 2,613**	$ 2,975	$ 3,337
$ 0.38	$ 1,883	$ 2,245	$ 2,607	$ 2,969	$ 3,331
$ 0.40	$ 1,877	$ 2,239	$ 2,601	$ 2,963	$ 3,325

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Dry stock farm case studies

4.7. Unlike the dairy case studies, there was a wide variation in the financial impact on dry stock businesses in having to reduce N losses (see Table 7 and Table 8 below). Six of the ten case studies were assessed as being able to lift EBIT alongside achieving a targeted 25% reduction in N losses, and in the single scenario analysis only one of the five applicable case studies had a significant reduction in EBIT. However, the wide range in livestock productivity and enterprise mixes between all of the case studies likely confounds these observations.

4.8. Contrasting the HSB and S+BR2 case studies provides a valuable example. Both properties were assessed as harvesting high amounts of pasture (7.9t DM/ha v 9.0t DM/ha) and not dissimilar annual leaching levels (12.6kg N/ha and 13.8kg N/ha). Stocking rate differences were essentially a result of the difference in pasture harvested. But at $102/ha ($7/SU), HSB had operating profits significantly lower than the level of the S+BR2 case study at $314/ha ($19/SU). When it came to considering system changes to reduce N losses by 25%, HSB (with 113% lambing) would realistically be able to lift ewe performance to buffer costs from other mitigation strategies. At 140% lambing in ewes and 80% lambing in ewe hoggets, S+BR2 probably has less opportunity to do so and accordingly, less palatable changes, like forestry, were considered to be required unless a change in enterprise mix was considered.

4.9. Land use change to production forestry (assumed as a simplified forestry rental at $200/ha, in line with methodology established in the 2012 Farmer Solutions Project) was assumed in two of the case study scenarios (WGS, S+BR2) as a (final) mitigation option, as was investing in a wintering facility for the WGS scenario. In both case studies these respective actions had significant negative financial impacts for the individual systems modelled and ultimately may not meet the brief of system optimisation, but do provide examples of how such changes might impact on profitability. Given the current profitability of many of the drystock systems analysed was assessed as greater than $200/ha and some farm systems had potential to further increase profitability despite N loss restrictions, blanket afforestation as a mitigation may not be an attractive option for farmers in the Rotorua catchment, particularly in the absence of applicable incentives. However, farmers may have to adapt their current livestock policy mixes to meet the N loss restrictions. The oversimplified forestry rental approach (assumed in this analysis to represent the financial alternative of forestry), and the impact that incentive payments from the BOPRC might have on farmer willingness to consider forestry as a viable mitigation option, particularly those with lower levels of operating profit, should be considered in future work.

4.10. In the case of the proposed wintering barn scenario (WGS range), winter grazing rates would need to increase by $22/cow/week (almost 100%) to $46/cow/week ($0.54/kg DM) to provide for the recovery of depreciation, opportunity cost of capital on the investment and the reduction in grazing income from being able to winter fewer cows. With the marginal return on feed eaten in a typical dairy farm operation at a $6.60/kg MS milk price being only $0.51/kg DM, there is unlikely to be a lot of incentive for dairy farmers to send cows off for wintering from a financial perspective at such winter grazing prices.

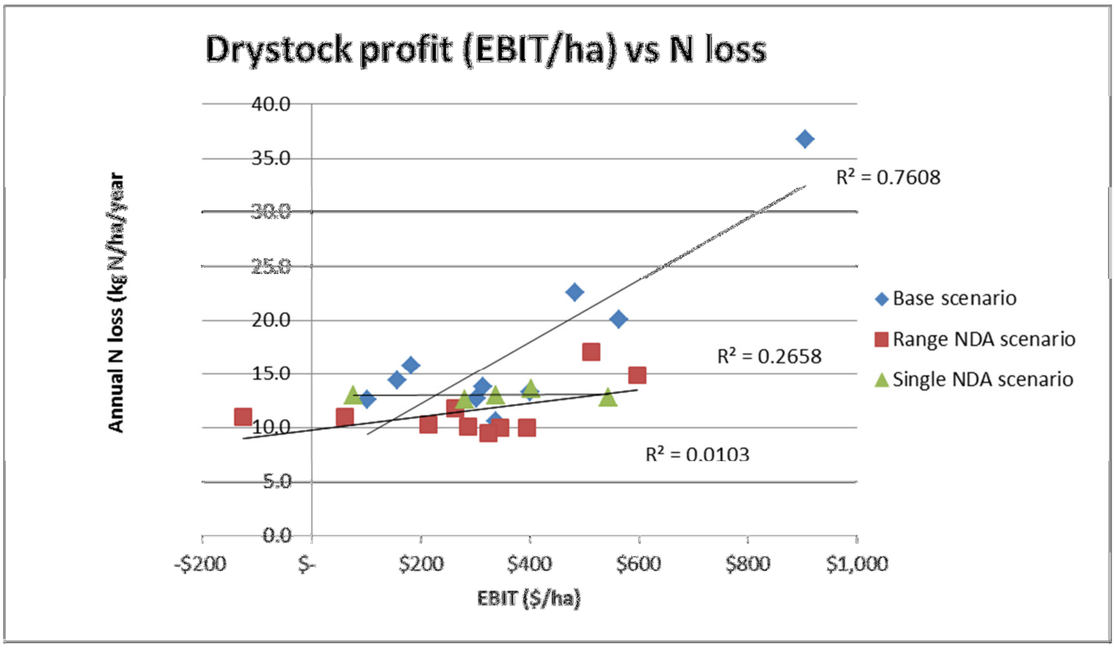

Figure 3: Dry stock farm case study profitability compared with annual N losses

4.11. In contrast to the dairy farm businesses, economic performance in the base drystock scenarios appeared to be strongly correlated (R^2 = 76%) with annual N loss, albeit this correlation falls to an R^2 of only 37% if the WGS case study is removed (see **Error! Reference source not found.**). This is potentially due to the high levels of profitability associated with dairy support activities, particularly winter cow grazing, and the accompanying increased risk of N losses from female cattle, noticeably over the winter period. However, once farm systems were altered to deliver the lower levels of N leaching in the range and single NDA scenarios, this correlation became weaker (range) to non-existent (single). This would appear to be associated with the farms highly exposed to dairy support (and with associated higher levels of N leaching) having to reduce this exposure in order to achieve the required reductions in N losses. However, outside of businesses exposed to dairy support, there would appear to be little relationship between profit and N losses.

Table 7 Summary of range NDA scenario KPIs for the dry stock case studies

Range scenario	**HSB**	**LSB**	**SDG**	**SDW**	**WGS**	**DG**	**BBT**	**DBF**	**S+BR1**	**S+BR2**
Pasture harvested (t DM/ha)	7.6	6.3	7.5	6.4	6.5	5.2	6.9	5.7	7.5	6.5
Stocking rate (SU/ha) [1]	13.8	11.5	13.6	11.5	13.6	9.4	12.5	10.4	13.7	11.8
Breeding ewes/lambs	66%	69%	72%	87%				6%		67%
Breeding cows										33%
Dairy heifers						100%			71%	
Winter cows			28%	13%	100%				29%	
Beef trading	34%	31%					100%			
Deer								94%		
Winter crop used (% farm area)	0%	2%	0%	0%	0%	0%	0%	0%	0%	0%
N applied (kg/ha/year)	0	0	0	16	0	30	0	33	32	0
New forestry (% farm area)	0%	0%	0%	0%	11%	0%	0%	0%	0%	32%
Supplement harvested (% farm area)	34%	5%	19%	42%	267%	131%	34%	7%	137%	35%
EBIT/ha	$ 287	$ 346	$ 395	$ 61	-$ 127	$ 597	$ 323	$ 263	$ 512	$ 213
Δ EBIT from Base	$ 185	$ 8	-$ 6	-$ 96	-$ 1,032	$ 34	$ 22	$ 80	$ 28	-$ 101
%	181%	2%	-1%	-61%	-114%	6%	7%	44%	6%	-32%
N loss (kg N/ha/year)[2]	10	10	10	11	11	15	10	12	17	10
Δ N loss from Base	-2	-1	-3	-3	-26	-5	-3	-4	-5	-3
%	-19%	-6%	-25%	-24%	-70%	-26%	-25%	-25%	-24%	-25%
Δ EBIT/kg N reduced	$ 76	$ 13	-$ 2	-$ 28	-$ 40	$ 6	$ 7	$ 20	$ 5	-$ 29

[1] Annualised stock units (6,000 MJ ME pasture intake/annum)

[2] Overseer 5.4.11

Table 8: Summary of single NDA scenario KPIs for the dry stock case studies

Single scenario	SDW	DG	DBF	S+BR1	S+BR2
Pasture harvested (t DM/ha)	6.4	4.9	6.0	6.1	6.1
Stocking rate (SU/ha) [1]	11.6	8.9	10.9	11.1	16.3
Breeding ewes/lambs	79%		6%		63%
Breeding cows	0%				37%
Dairy heifers	0%	100%		83%	
Winter cows	21%			17%	
Beef trading	0%				
Deer	0%		94%		
Winter crop used (% farm area)	11%	0%	0%	0%	0%
N applied (kg/ha/year)	0	0	47	0	1
New forestry (% farm area)	0%	0%	0%	0%	0%
Supplement harvested (% farm area)	42%	131%	7%	137%	24%
EBIT/ha	$ 77	$ 544	$ 281	$ 403	$ 287
Δ EBIT from Base	-$ 80	-$ 20	$ 98	-$ 80	-$ 27
%	-51%	0%	0%	0%	0%
N loss (kg N/ha/year) [2]	13.0	13	13	14	13
Δ N loss from Base	-1.4	-7	-3	-9	0
%	-10%	-36%	-25%	-56%	-2%
Δ EBIT/kg N reduced	-$ 55.8	-$ 3	$ 31	-$ 9	-$ 76

[1] Annualised stock units (6,000 MJ ME pasture intake/annum)

[2] Overseer 5.4.11

4.12. The considerable exposure dry stock farm systems have to product prices is demonstrated below, using the HSB case study as an example.

Table 9: Sensitivity analysis of the HSB case study to changes in lamb and beef prices for the base and range scenarios

Base

		Lamb ($/kg cwt)				
		$ 5.40	$ 5.60	$ 5.80	$ 6.00	$ 6.20
Beef ($/kg cwt)	$ 3.50	-$ 89	-$ 68	-$ 47	-$ 26	-$ 5
	$ 3.70	-$ 39	-$ 18	$ 3	$ 24	$ 45
	$ 3.90	$ 11	$ 31	$ 52	$ 73	$ 94
	$ 4.10	$ 60	$ 81	$ 102	$ 123	$ 144
	$ 4.30	$ 110	$ 131	$ 152	$ 173	$ 194

Range

		Lamb ($/kg cwt)				
		$ 5.40	$ 5.60	$ 5.80	$ 6.00	$ 6.20
Beef ($/kg cwt)	$ 3.50	$ 124	$ 153	$ 183	$ 212	$ 242
	$ 3.70	$ 158	$ 188	$ 217	$ 247	$ 276
	$ 3.90	$ 193	$ 223	$ 252	$ 282	$ 311
	$ 4.10	$ 228	$ 257	$ 287	$ 316	$ 346
	$ 4.30	$ 263	$ 292	$ 321	$ 351	$ 380

4.13. While the changes made to the HSB case study improved profitability (Table 9), the farm system was still subject to considerable variation in profits as meat schedules changed. Having higher base profitability, if driven through efficiencies and lowered cost of production, certainly improves business resilience, and keeps the system profitable at a wider range of price levels. But as with the HSB range scenario, a 7% reduction in lamb price still results in a 21% reduction in EBIT.

4.14. Sensitivity analysis of the impact that increasing livestock productivity within a farm system has on operating profit and N loss is also considered below. Increasing ewe lambing percentage within the base HSB model can have both a positive impact on N losses <u>and</u> profitability (Table 10).

Table 10: Sensitivity of profitability & annual N losses to lambing percentage for HSB case study

Lambing percentage	Total N loss	N loss per ha	EBIT/ha	EBIT/kg N
113%	4771	12.6	$ 102	$ 8.14
123%	4678	12.3	$ 112	$ 9.13
133%	4671	12.3	$ 148	$ 12.03
143%	4347	11.4	$ 202	$ 17.63

4.15. In the context of this farm system, increasing reproductive performance to 123% was achieved through better feeding, the next 10% through better lamb survival and the final 10% through improved base ewe fertility. In this example, purchased lambs were progressively eliminated from the farm system as bred lambs increased (with slight increases in EBIT) until at 133% total lamb numbers exceeded those in the base model. Additional lambs from ewes at 143% lambing allowed the less profitable (and high N leaching) cattle policy to be reduced.

5. DIFFERENCES IN ASSESSED LOSSES BETWEEN OVERSEER VERSIONS

5.1. As per 2.15 above, the comparative levels of N loss (and N loss reduction) assessed in Overseer 6.1.2 was calculated after modelling was completed in Overseer 5.4.11.

5.2. The differences for the dairy and drystock farms are presented below.

5.3. Dairy

5.3.1. On average, Overseer 6.1.2 assessed base N losses for the dairy farms between 42% (HM) and 75% (MM) higher than in Overseer 5.4.11. Over the ten farms considered, this represents an average estimate of 57% higher N losses in v 6.1.2 (see Table 11). However, the relationship between estimated N losses in the two versions is high, with an R^2 of 89%, which suggests that the relative impacts of differing dairy farm systems are being treated consistently in v 5.4.11 and v 6.1.2 (Figure 4).

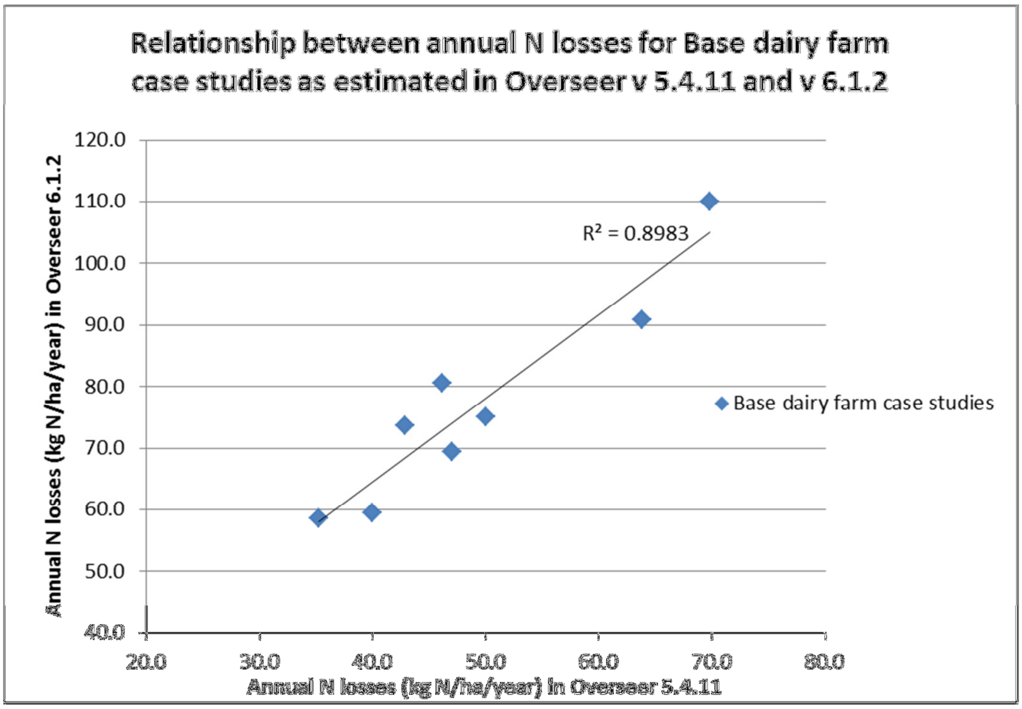

Figure 4: Relationship between annual N losses for the Base dairy farm case studies as estimated in Overseer v5.4.11 and v6.1.2

5.3.2. If we assumed that the equivalent 35kg N/ha/year NDA target for dairy farms was 57% higher in version 6.1.2, the adjusted NDA target for dairy farms would be 56kg N/ha/year. On this basis, of the eight dairy farm systems analysed, none would currently be under this adjusted NDA target, which is different with the assessment under 5.4.11 (where one RD2 was at the single NDA target level).

Table 11: Comparison of base N losses for dairy farms between Overseer v 5.4.11 and v 6.1.2

Farm	N loss (kg N/ha/year)		Variance in 6.1.2
	v 5.4.11	v 6.1.2	
1. HH	69.8	109.9	57%
2. HL	42.9	73.7	72%
3. HM	63.8	90.9	42%
4. MM	46.1	80.6	75%
5. LH	47.0	69.4	48%
6. LM	40.0	59.5	49%
7. RD1	50.0	75.0	50%
8. RD2	35.2	58.6	66%
Average variance			**57%**

5.3.3. Optimising farm systems to deliver a targeted 25% (actual 28%) reduction in N losses (the Range NDA scenario) as assessed in v 5.4.11 resulted in an average N loss reduction of 26% from the base level for the dairy farm systems when converted into v 6.1.2 (Table 12). There was again a strong relationship between estimates for most of the dairy farm systems, with an R^2 of 89% between the outputs of identical farm systems using the two versions of Overseer.

Table 12: Comparison of N loss reduction "Range" scenario dairy outcomes in Overseer 5.4.11 & 6.1.2

Farm	N loss	Δ Base	N loss	Δ Base
	v 5.4.11		v 6.1.2	
1. HH	39.8	-43%	59.6	-46%
2. HM	32.1	-25%	57.0	-23%
3. HL	40.0	-37%	61.7	-32%
4. MM	34.8	-25%	59.2	-27%
5. LH	35.3	-25%	53.4	-23%
6. LM	30.1	-25%	46.9	-21%
7. RD1	37.2	-26%	53.5	-29%
8. RD2	29.8	-15%	52.0	-11%
Average variance		**-28%**		**-26%**

This consistency was repeated for the Single NDA scenario (see Table 13), with the estimated reduction in N losses in v6.1.2 on average 28% lower than in v.5.4.11

Table 13: Comparison of N loss reduction "Single" scenario dairy outcomes in Overseer 5.4.11 and 6.1.2

Farm	N loss	Δ Base	N loss	Δ Base
	v 5.4.11		v 6.1.2	
1. HH	35.2	-50%	58.4	-47%
2. HM	35.1	-18%	61.0	-17%
3. HL	35.0	-45%	56.3	-38%
6. LM	35.0	-13%	53.5	-10%
7. RD1	34.6	-31%	53.4	-29%
Average variance		**-31%**		**-28%**

5.4. *Drystock*

5.4.1. On average, Overseer 6.1.2 assessed base N losses for the drystock farms between 37% (S+BR2) and 143% (SDW) higher than in Overseer 5.4.11. Over the ten farms considered, this represents an average estimate of 75% higher N losses in v 6.1.2 (Table 14). There appeared to be a high degree of correlation between the outputs of these base scenarios in both versions of Overseer, with an R^2 of 82% (Figure 5). However regression analyses are sensitive to outliers with large values, and removal of the WGS values from the dataset weakened the relationship, reducing the R^2 to 43%.

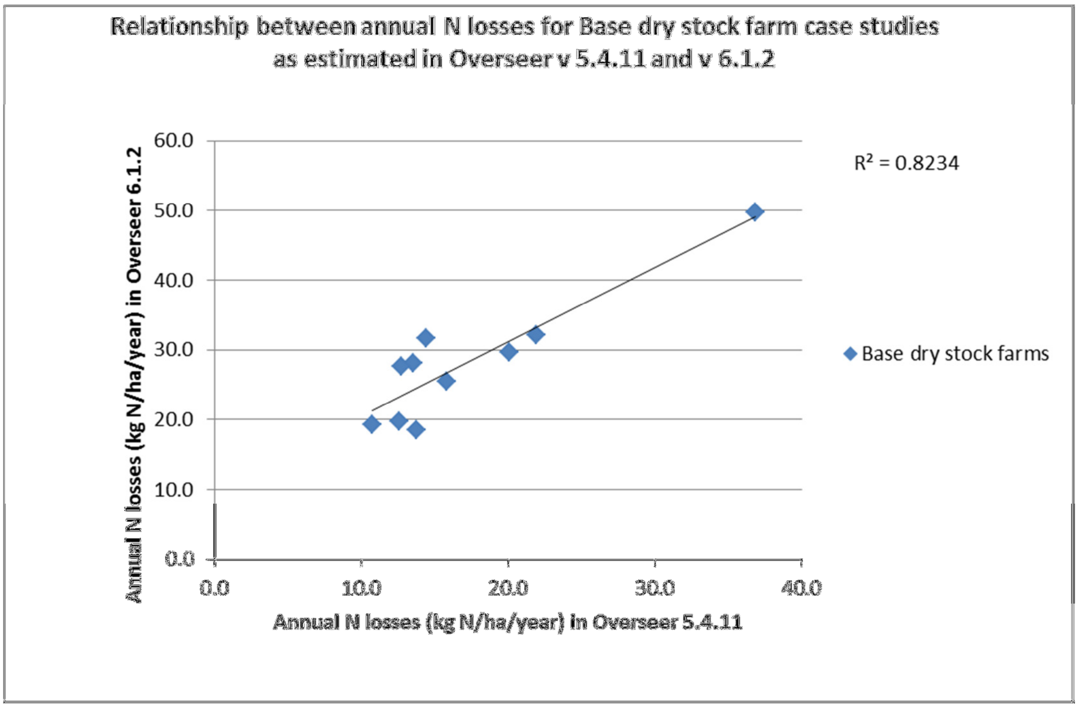

Figure 5: Relationship between annual N losses for the Base dry stock farm case studies as estimated in Overseer v5.4.11 and v6.1.2

Table 14: Comparison of base N losses for drystock farms between Overseer v 5.4.11 and v 6.1.2

Farm	N loss (kg N/ha/year)		Variance in 6.1.2
	v 5.4.11	v 6.1.2	
1.HSB	12.6	19.8	58%
2. LSB	10.8	19.3	80%
3.SDG	13.5	28.1	108%
4. SDW	14.4	31.6	119%
5. WGS	36.8	49.7	35%
6. DG	20.1	29.7	48%
7. BBT	12.8	27.7	117%
8.DBF	15.8	25.4	61%
9.S+BR1	21.9	32.1	47%
10.S+BR2	13.8	18.5	35%
Average variance			**71%**

5.4.2. If we assumed that the equivalent 13kg N/ha/year NDA target for drystock farms was 71% higher in version 6.1.2, the adjusted NDA target for drystock farms would be 22.2kg N/ha/year. On this basis, of the 10 drystock farm systems analysed, only three would currently be under this adjusted NDA target, the same number as the three currently, but only two of the case studies (HSB & LSB) are forecast to meet these limits under both versions of Overseer.

5.4.3. Optimising farm systems to deliver a targeted 25% (actual 28%) reduction in N losses (the Range NDA scenario) as assessed in v 5.4.11 also resulted in an average N loss reduction of 28% from the base level when converted into v 6.1.2 (see

5.4.4. Table 15). However, despite this apparent consistency, there was less consistency when considering individual farm case studies (see Figure 6, with an R^2 of only 31%). This may be due to differences in the way biophysical and climatic properties (soil, climate) and/or stock classes influence N leaching in the two models. This is an area that needs clarification from AgResearch (co-owners and developers of Overseer)

5.4.5. When the Range scenario outcomes were tested using v 6.1.2, on the same basis as in 5.4.2, all except the three sole dairy support systems and the singular deer case study would be deemed to be under the (adjusted) NDA target of 22.2kg N/ha/year.

Table 15: Comparison of N loss reduction "Range" scenario drystock outcomes in Overseer 5.4.11 & 6.1.2

Farm	N loss	Δ Base	N loss	Δ Base
	v 5.4.11		v 6.1.2	
1.HSB	10.1	-19%	16.1	-19%
2. LSB	10.1	-6%	16.8	-13%
3.SDG	10.0	-26%	15.8	-44%
4. SDW	9.8	-32%	13.2	-58%
5. WGS	11.0	-70%	32.9	-34%
6. DG	14.9	-26%	25.2	-15%
7. BBT	9.5	-25%	18.9	-32%
8.DBF	11.8	-25%	23.2	-9%
9.S+BR1	16.7	-24%	25.1	-22%
10.S+BR2	10.2	-26%	12.9	-30%
Average variance		**-28%**		**-28%**

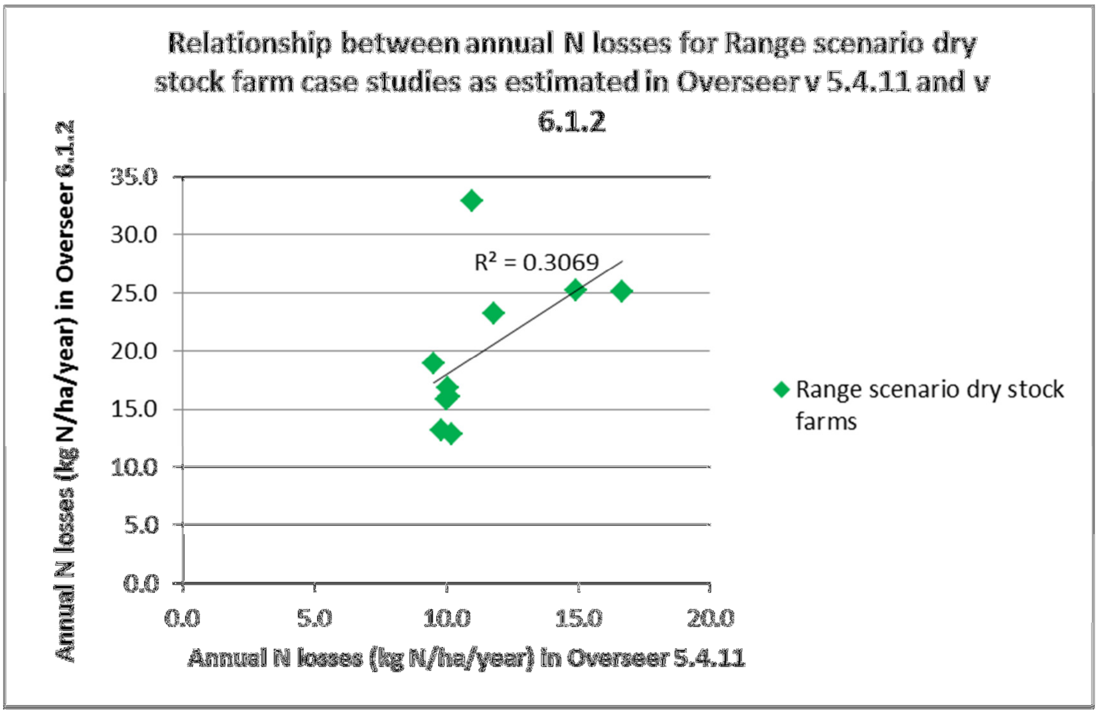

Figure 6: Relationship between annual N losses for the Range scenario dry stock farm case studies as estimated in Overseer v5.4.11 and v6.1.2

6. DISCUSSION

DAIRY

6.1. The change in operating profitability (EBIT) in each dairy system as the N loss reduction targets were achieved varied from 0% to -10%. When expressed on a \$/kg N loss reduction achieved, the reduction in profitability ranged from -\$0/kg N to -\$17/kg N. These results are consistent with those from the earlier Upper Waikato Nutrient Efficiency Study (2009). That study also allowed for productivity and efficiency gains within farm systems as they reacted to a requirement to reduce N losses to a level (26kg N/ha/year) substantially lower than that typical of most dairy farms in those catchments at the time. While differences in assumptions (particularly around milk price and cost structure) make direct comparisons difficult, the UWNES analysis demonstrated that there was capacity among some farm systems to offset the impact of lower N losses through improving efficiency and productivity.

6.2. For all of the systems considered, operating profit, when expressed per kg of N leached, increased relative to the base situation for both the range and single NDA scenarios.

6.3. All of the reductions modelled were achieved through management change, rather than land use change or significant investment in infrastructure, although the increased use of maize silage modelled in many of the scenarios (see below) assumed existing infrastructure (or lack thereof). Accordingly, potential investment in feed pads to minimise wastage and improve the financial outcomes from those modelled might be possible. In addition, no scenarios were considered whereby per cow performance was increased to levels beyond what is considered the typical upper limit of production for pastoral dairy systems in the Rotorua catchment (450kg MS/cow), although there are a number of farmers in the catchment who are producing at levels greater than 500kg MS/cow. There may be merit in exploring systems like this, potentially in conjunction with investment in infrastructure like barns.

6.4. While no one mitigation or combination of mitigations delivered an optimised outcome for each farm scenario, the following system changes were commonly adopted to reduce N losses and minimise losses in profitability:

(i) **Replacing high protein feeds (N fertiliser grown pasture, PKE and imported grass silage) with maize silage**: this approach was effective in reducing the amount of N cycling through the farm system and also improving the efficiency of dietary protein use by the cow. While under the assumptions used there is a higher relative cost of purchasing maize silage ($0.36/kg DM) compared with N fertiliser ($0.19/kg DM grown), the price is comparable with PKE ($0.37/kg DM) or baleage ($0.35/kg DM). Where the overall quantity of imported feed increased, it was possible to reduce maintenance phosphorus applications. While sourcing the increased levels of maize silage is undoubtedly manageable at an individual farm level, the implications for the catchment as a whole for a substantial increase in the quantities of maize silage used may be a considerable challenge. Across the eight case studies, the amount of maize silage used almost quadrupled to achieve range NDA N loss levels.

(ii) **Reducing stocking rate**: in all six of the hypothetical farm systems, a reduction in stocking rate (peak cows milked) was used to lower N losses. As modelled, this system changed lowered milk production per hectare in approximately half of the scenarios. However, only in the farm system with the lowest pre-existing level of pasture harvest did the amount of silage needing to be cut (to control potential spring feed surpluses) actually increase. In all of the other scenarios, pasture conservation was assessed as being able to remain unchanged. This was largely achieved by reducing the overall quantity of supplementary feed purchased. As a strategy, this will likely require an improvement in the pasture management skills of farmers.

(iii) **Cessation of cropping**: in all cases where “conventional”[10] cropping was utilised, this practice was discontinued. The primary reason for this was the higher N losses that occur from urine deposition from the highly stocked, repetitive grazing events once vegetative cover has been removed, as well as the potential for mineralisation from cultivation activity. The removal of bulk, high quality forage crops from farm systems was deemed feasible when modelled. Given that the use of forage crops in dairy systems within the Rotorua catchment or the rest of New Zealand is by no means universal, it was considered a feasible mitigation strategy to use. The reduction in feed availability was typically managed by the reduction in stocking rate and/or a redistribution in the timing of supplements used within the system. Of course, moving away from on-farm sources of feed is likely to increase the

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[10] Defined here as the strip grazing at a high instantaneous stock intensity of specialist annual forage crops

level of feed supply risk within some of the individual farm systems considered. At a whole-of-catchment or industry wide level, an increased reliance on imported feeds as an alternative to forages grown on farm may have significant impacts on farm operating expenses. This may need to be examined in considering wider catchment implications of achieving the proposed NDA limits.

(iv) **Improving per cow production**: small increases in per cow production were modelled in many of the range and single NDA scenarios, but unless this was accompanied by reductions in stocking rate, the impact on N loss was considered marginal. However, improving per cow productivity typically improves financial performance (dilution of fixed costs, reduction in direct animal costs and improvement in the marginal efficiency of imported feeds). As such, this may be a useful strategy for offsetting financial losses related to reducing N loss.

(v) **Increasing the number of cows wintered off**: All of the farm systems analysed utilised wintering off to some extent, ranging from 42% to 100% of the herd. In four of the systems, increasing the numbers of cows wintered off was used to meet N targets. Given the high N losses associated with wintering of dairy cows, this may not remain a viable option in the longer term when considered at a whole catchment/industry level. Although falling outside the terms of reference for this analysis, as with maize silage procurement, the wider implications of the viability of winter cow grazing, could be explored in further work.

DRYSTOCK

6.5. Five of the ten case studies were already assessed as having annual N loss levels essentially at or below the draft single NDA target (≤13.5kg N/ha) and had standardised operating profits ranging from $102/ha to $401/ha. These systems were dissimilar, but general observations about the four most profitable include:

- no/low levels of winter cropping; and
- feed demand well matched with underlying pasture growth potential;

- high sheep:cattle ratios with moderate to high levels of ewe efficiency and fast lamb growth achieving good carcass weights, offsetting less N efficient, but profitable, cattle policies (dairy heifers, two age classes wintered, stud beef cattle); or
- the farming of young, fast growing male cattle.

6.6. In most of the case studies, the reduction or elimination of N fertiliser was assessed as having a positive impact on overall farm profitability[11]. This is largely due to the fact that at the assumed level of pasture dry matter response (a standard 10kg DM/kg N applied, which the authors consider appropriate for the locality), the marginal cost of the feed grown (19c/kg DM) was higher than the marginal returns from the least profitable stock class. It would also appear that in most of the scenarios, the timing of the N fertiliser was such that it was either (a) being applied to directly support capital livestock, rather than higher value trading livestock, or (b) the removal of it from the system allowed the reduction in pasture grown to be managed with a reduction in the number of less profitable capital livestock classes to occur without compromising pasture quality. In several case studies the increased profit associated with eliminating N provided a buffer to the reduction in profit associated by the need to reduce high profit, high N loss stock policies, like dairy heifer grazing. We recognise that N fertiliser can provide an effective contingent feed source and reduce risk within the farm system through alleviating occasional short-term inequalities between feed supply and demand. However, if such contingencies continue to be required year-on-year, a review of overall stock numbers might provide a more profitable solution.

6.7. High levels of productivity, particularly as regards reproductive performance in ewes, and heavier, faster growing prime stock provide a valuable buffer against any need to reduce livestock numbers. In fact, the opportunity to increase productivity within two of the farm systems analysed contributed to the forecast increases in profitability despite lowering N losses. This demonstrates the current potential within some drystock farming systems to increase profitability, and is consistent with the findings of the UWNES (2009). Where productivity levels within the farms were already judged to be at the upper limits of what could realistically be expected to be achieved (such as sheep performance in the LSB and S+BR2 models), then targeting lowered N losses resulted in a reduction in profitability.

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[11] In the DBF scenario, N fertiliser was added back into the system to support winter finishing of purchased weaner stags with a gross margin of 29c/kg DM

6.8. Increasing sheep:cattle ratios was an outcome of achieving the range scenario N loss in four of the case studies. In all instances sheep numbers relative to cattle numbers were not lifted beyond levels currently in place on real farms within the wider Rotorua area[12]. However, this mitigation has been criticised in an earlier analysis (Park 2013) as being contrary to local farmer preference and NZ-wide trends. While the authors recognise that this may well be the case, in the context of the reduced N loss signature from sheep relative to cattle, some farmers may need to reconsider stock ratios in preference to other mitigation options.

6.9. Significantly increasing pasture conservation to deal with pasture surpluses from lowered stock numbers tended to be associated with reduced levels of profitability as a result of the assumed cost of conservation and the losses in pasture utilisation from the process of conservation, storage and subsequent feeding out. The converse of this was where this feed was assumed to be sold off-farm at $70/bale[13], which after harvest costs (ca. 23c/kg DM[14]) generated marginal profitability equivalent to 12c/kg DM; higher than some of the livestock policies.

6.10. Contract wintering of dairy cows as a sole policy was associated with high profitability in the analysis, with an associated reduction in profitability when numbers were reduced to achieve NDA targets. The marginal revenues from this activity [contract wintering] are high ($0.29/kg DM offered assuming a daily allowance of 12kg DM/cow and a weekly grazing rate of $24/cow). The associated costs in the modelled scenarios assumed provision of bulk feed for an 8-10 week window when pasture growth rates were relatively low, the use of a winter crop, and no other livestock on the property all season. However, the high N losses associated with wintering dairy cows on pasture/crop makes lowering N losses under this policy difficult without actually moving away from wintering cows as a farm enterprise. This potential need to reduce dairy cow wintering as a farm enterprise to reduce N losses on sheep & cattle systems is problematic when we consider that grazing dairy cows off-farm is a practice already widely utilised by Rotorua dairy farmers and, at an individual dairy farm level, the financial drivers might be for this to increase.

6.11. Notwithstanding the difficulties that we have had with accurately modelling a fully confined dairy cow wintering policy on a drystock farm in either version of Overseer, it would appear that achieving reductions in N losses within the 10-20kg N/ha range band

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[12] Although at 87% of livestock, sheep numbers in the range SDW scenario at the extreme range of what might be possible and need to be considered in the context of a small farm area

[13] Current market price in the Rotorua catchment. This implies a standing grass value of 12c/kg DM

[14] $46/bale harvesting plus post-cut fertiliser cost divided by 200kg DM/bale

might be possible under such a policy, but it is estimated to introduce significant costs (depreciation, cost of capital) to the enterprise which would require large increases in winter grazing rates to recover. If the market was unable to support such an increase, it would be preferable to simply replace wintering dairy cows with a less profitable, but more N efficient enterprise. Again, this has implications for the dairy industry as much as for the sheep & cattle sector. It would appear that with the exception of systems that are specifically structured around the grazing of dairy cows over the winter period, there exists significant potential for the drystock case study farms to achieve the draft NDA target of 13kg N/ha/year (or an adjusted v 6.1.2. target of 22.2kg N/ha/year) without reducing profitability and in some cases increasing profits. However, profitability would appear to be closely linked to high levels of productivity, which is largely dependent on existing management capability and the capacity for this to improve over time.

6.12. For both drystock and dairy farmers, level of farming efficiency and/or profitability can be expected to follow a normal distribution. Hence there will always be below-average and above-average farmers. The notion that below-average farmers can somehow become average or above-average farmers is somewhat simplistic. Level of farming performance is influenced by a range of drivers including business and personal goals, and management skills. Whilst the former might be influenced by regulation, it is not a simple task to lift inherent farm management skills.

LAND VALUE IMPACT

6.13. Farming under nitrogen loss restrictions undoubtedly removes flexibility in land use, irrespective of whether or not profitability is affected, which in our experience tends to be a contributing factor to land value.

6.14. Journeaux (2013) states there are three fundamental determinant of land price – productive value, consumptive value and speculative value, while Craven (2010) defined land value as “the perceived benefit of land use rights”.

6.15. The extent to which land values in the catchment will be potentially affected in the medium term as a result of the proposed NDA limits is difficult to determine, but will likely be impacted by any [perceived or actual] reduction in (a) potential profitability (productive value) and (b) land use flexibility, relative to other districts (productive and speculative value). Craven (2010) proposes that the imposition of regulatory costs and increased uncertainty (risk) will also have an [negative] impact. Journeaux (2013) further comments that underlying cost pressures on farm businesses [which ultimately lead to a reduction in profitability] ultimately lead to a downward pressure on land prices.

6.16. The reality is that all farming activities within New Zealand will probably have to, or are currently having to make changes to their farm systems to ensure they can continue to be profitable whilst maintaining an acceptable environmental footprint., The potential for this trend leading to lower land values is likely to have a significant impact on a proportion of farmers, particularly those highly leveraged, those considering exiting their investments, or those potentially forced to.

6.17. Whether or not land values remain static relative to other areas or actually experience overt devaluation will also be an important consideration.

6.18. Given that the Rotorua catchment will not be the first jurisdiction to have restrictive NDA regimes imposed on them, analysis of how land values have been affected in the Taupo District and the Horizons Region would be a useful starting point in increasing understanding of possible land value adjustment, notwithstanding proposed N limits for Rotorua may be more stringent than those in other areas. Craven (2010) provides a snapshot of this, with his analysis of dairy and drystock land sales within nutrient constrained catchments (Lakes Rotorua and Taupo) and non-constrained catchments in the same districts demonstrating the grand-parented N loss restrictions in place at the time had a negative impact on land prices.

6.19. Other factors that we believe may influence the likelihood of changes in land values in the Rotorua catchment (as well as the ability to find economically profitable ways to use land) directly associated with the proposed NDA limits include:

(i) the final allocation framework;

(ii) the implied value of “NDA” associated with any incentive funding;

(iii) the relative value (and importance) of phosphorus compared with N as regards water quality objectives;

(iv) the value of NDA in any trading system;

(v) the extent to which farmers who already operate “N” efficient systems are required to provide additional reductions in N loss, or the potential for NDA limits to penalise currently N efficient farmers via reductions in land values.

(vi) the extent to which permanent land use change, such as from pasture to forestry, is required to meet whole catchment N load targets.

6.20. Based on the analysis of the case studies in this report, it would appear that the combination of loss in flexibility, uncertainty associated with individual farmers' ability to adapt systems to manage N loss restrictions, and the overt loss of operating profit that accompanied the majority of farm system scenarios involving lower N losses is likely to have a downward impact on land values.

7. CONCLUSIONS AND RECOMMENDATIONS

7.1. **Farming under a restricted nitrogen loss regime**, like that proposed for the Lake Rotorua catchment, **is likely to have differing financial impacts on individual farmers**, and the extent to which this occurs will vary greatly across individual farm systems.

7.2. **Reducing nitrogen losses in existing pastoral grazing systems primarily requires changes that should reduce the inefficient cycling of N in pastoral systems**. The strategies modelled in this analysis relate to:

(i) reducing total N within the pastoral system (reducing/eliminating imported N – fertiliser, high N feed);

(ii) improving use of dietary N within the animal to reduce N concentration in urine (increasing proportion of low protein feeds);

(iii) increasing the amount of N leaving the system in saleable product (improving livestock based productivity measures like weight gain, reproductive efficiency, milk solids production – essentially feed conversion efficiency);

(iv) reducing the proportion of N leaving the system via animal urine patches (eliminating intensive winter grazing, changing stock class ratios, reducing seasonal stocking rates, reducing stock numbers); and

(v) stopping management practices that can elevate N losses to water ("winter" N applications, cropping [particularly for winter forage[15]])

7.3. **Some of these strategies can result in an accompanying improvement in farm financial performance**, particularly where (a) N is being currently being used inefficiently or unprofitably, or (b) where underlying market conditions can result in proposed system changes resulting in a more profitable configuration of stock classes. **But invariably, it appears to be farm systems that have lower levels of productivity (lambing percentage, slower livestock growth rates) that have the greatest capacity to reduce whole system N losses and maintain or increase underlying profitability as a consequence**. Analysis on two typical sheep & cattle and dairy farm systems (HSB and MM, respectively) demonstrate how improving livestock productivity can be positive for both profitability and N loss reduction at a whole system level. However, achieving the proposed system changes potentially

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[15] Soil mineralisation, luxury N applications, concentrated urine deposition, bare ground preventing N uptake

requires an increase in management skills, which may or may not be possible given existing knowledge base and management and ownership structures.

7.4. **Where farms already utilise N efficiently**, which is typically accompanied by observations of good livestock productivity and/or where there is no/limited scope to move into higher value production systems to buffer net production reductions, **system changes to reduce N losses invariably result in losses of farm profitability**.

7.5. In general, **the dairy farm systems analysed typically relied on a combination of lower annualised stocking rates** *[fewer urine patches]*, **improved per cow milk solids production** [*more N exported relative to maintenance feed/urine patches*] **and replacing high N feed** (particularly that from fertiliser nitrogen and PKE) **and high N loss feed** (winter crops) **with low protein alternatives**, like maize silage *[improving dietary N utilisation and lowering soil N losses]*.

7.6. These strategies effectively lowered overall dairy system N and improved the efficiency of use of the N remaining in the system. However, for the majority of the systems analysed, efficiency/productivity gains were insufficient to offset the overall production losses associated with lowering total milk production or the increased cost of production. Accordingly, operating profits decreased between 1% and 10% at the assumed medium term milk price (see Table 3 & Table 4 above).

7.7. The strategies considered for the sheep, cattle and deer systems were considerably more diverse, which is to be expected given the wide range of stock classes, stock policies and potential markets for farm outputs. **Dry stock system changes typically relied on eliminating the use of N fertiliser** [*reducing total system N*], particularly where it was unprofitable, **and eliminating winter cropping** [*lowering soil N losses*]. After that, **maximising meat, wool and feed sold off farm from the available feed** [*increasing N leaving the system*] **and/or shifting maintenance feed into more N efficient livestock classes** [*reducing N losses from the urine patch*] **were key strategies**.

7.8. **The extent to which these changes**, which were designed to reduce annual N loss, **resulted in profit increasing, decreasing or remaining unchanged relied heavily on the relative profitability of the various enterprises and their mix in the system**. Increasing feed conversion efficiency and eliminating the N fertiliser being used to support capital livestock tended to be positive for profitability, while eliminating cost-effective winter forage crops often had a negative effect on financial performance. Increasing sheep: cattle ratios only improved profitability if the cattle policy was less profitable than the sheep enterprise, while reducing the numbers of grazing livestock and selling pasture silage is only profitable if other industries are prepared to pay more for the feed than the farm system is able to make from its use internally. In general, the high profitability of wintering dairy cows on crop typically resulted in any changes away from this policy having a negative impact on profitability.

7.9. **It would still seem that most dairy farm systems currently operating in the catchment will experience some degree of profit decline in reaching the proposed limits**. Whether the extent of the proposed N loss restrictions will prove to be greater than those that can be expected to be put in place across New Zealand to address nationally declining water quality remains to be seen.

7.10. **Mixed sheep, beef & deer systems appear to have greater ability to meet targets, particularly the single NDA limit of 13kg N/ha/year, without nominal reductions in profitability**. **Further reductions beyond this level will likely have negative implications for profit, particularly once productivity improvements have been exhausted**. The restrictions also will undoubtedly limit the potential profits that might be available (given what is essentially a limit to further intensification has been imposed). Where dry stock farming systems are essentially extensions of dairy operations (run-off) there may be significant challenges as regards their integration within the wider business if stocking levels can't be maintained and demand for imported grass silage has to moderate to achieve dairy N targets.

7.11. **Many of the applicable mitigations at an individual farm level may have significant implications when considered at a catchment and ultimately at a national level.** These include the potential financial impact on key farm inputs (like maize silage or grass silage) or preferred stock classes (male cattle versus female cattle) and managing the export of nutrient losses to other farm types (wintering of dairy cattle) or other catchments (N loss from maize cropping). The particular quandary around how the farming sector balances the current profitability for both the dairy and drystock sectors associated with wintering dairy cows outside of the milking platform against the high N loss signature of this activity will require some considered thought.

7.12. **It is also important to recognise that the forecast reductions in operating profit will have differing implications for farm businesses, given their individual balance sheet configuration and the extent of commitments on their business that fall outside of the operating profit measure** – namely interest, tax, rent and then ultimately the free cashflow used for discretionary investment and expenditure. Business that are highly leveraged, have to pay high rentals, require significant reinvestment and/or are unable to deliver sufficient productivity improvements to offset profitability losses will probably be worse off under the proposed NDA restrictions than relatively small reductions in operating profit might suggest.

7.13. **The significant (and for the dry stock case studies inconsistent) increases in forecast N losses from the case studies when modelled in Overseer v6.1.2 do provide some cause for concern**. While it is realistic that some variation in assessed N losses will occur with version changes in Overseer, the extent to which this is occurring on the pumice-derived soils in the study seems irreconcilable with the relative stability of N loss estimates under Overseer 5, our own intuitive understanding of the N cycle and the whole catchment analysis used to calculate catchment targets (ROTAN). It is encouraging that the analysed mitigations are still delivering reductions in expected N losses in v6.1.2. While the extent of these reductions is almost identical for the dairy farm case studies, there is significant variation for the drystock case study farms. The changes observed suggest that Overseer 6 outputs for the pumice soils under high rainfall in the wider Rotorua district may not have been well validated against actual N leachate measurements from similar soil types under a wide enough range of stock classes; this issue needs to be discussed with AgResearch. Until these variances can be adequately explained and resolved, it is the authors' view that at this point it is unhelpful to rely on Overseer 6 outputs to guide farm system change and as the absolute measure of whole system N loss for farms within the Rotorua catchment. Instead **we recommend farmers and regulators currently focus on the implementation of management and system changes to increase individual animal productivity, reduce inefficient N use and reduce the incidence and intensity of urine patches during the late autumn and winter periods with a view that these will result in real and measurable reductions in N losses once Overseer irregularities are resolved**.

7.14. **The proposed NDA restrictions for the Rotorua catchment will undoubtedly require some degree of system change over the coming years**. The extent to which farm systems will be financially affected by this, against the normal backdrop of price and climate volatility and the differing goals and objectives of individual farmers, is difficult to determine. The historical strategies of intensification may no longer be an option to combat declining real prices with a restriction on N losses, but **our analysis suggests that improving productivity and system efficiency will be vital in ensuring farm business viability**. Given as a nation we only export 7% less lambs today from a sheep flock less than half the size that is was in the 1990's (*pers. comm.*

O'Brien 2014[16]), per cow milk production has increased from 259kg MS/cow in 1992/93 to 346kg MS/cow in 2012/13 (LIC, 2014) and there are considerable gaps between average and top 25% performers in both the dairy and sheep, cattle and deer sectors, ongoing productivity gains are realistic.

7.15. Of course, the concept of increasing productivity to increase profitability is not new and the fact that both the dairy and sheep, cattle and deer industries currently have a wide range of profitability is testament to the fact **that not all farmers have the desire, capacity or capability to farm the same way as the top % of their peers**. This is unlikely to change simply because of NDA restrictions.

7.16. **However, unless less productive, less efficient or less profitable farmers are able to improve performance to levels sufficient to offset or minimise the likely negative financial implications of meeting the proposed lowered levels of N loss, then their viability may be compromised.** While this analysis suggests that many of the case study farm systems might have the potential to reduce N losses whilst simultaneously increasing efficiency (and some even profitability), it would be dangerous to assume that this is universally possible and that this is a realistic outcome for all existing farmers

7.17. The 18-20 year timeframe proposed for the Rotorua catchment potentially provides sufficient time for the development and implementation of the necessary knowledge transfer programmes required to ensure as many farmers as possible can adjust and adapt to manage the implications that N loss reductions have for their systems. Invariably some farmers will need all of this time. **The BOPRC will need to actively engage with industry to ensure that farmers are adequately supported to make these changes.** There are current industry initiatives e.g. involving Beef + Lamb NZ and DairyNZ which may be able to be leveraged in this regard.

7.18. **It is highly likely that the imposition of NDA limits will cause some degree of economic and social disruption to the farming (and wider) community**, potentially culminating in some farmers exiting the catchment, with others sustaining significant reductions in business profitability (NPAT) or overall financial position associated with reduced land values.

7.19. **The conclusions reached from this analysis are undoubtedly limited by the small sample size (18 case studies)** and the fact that only four were real farms, although the hypothetical farms were largely based on real enterprises. **It is therefore difficult to**

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[16] Ben O'Brien, General Manager Market Access, Beef+Lamb New Zealand

make valid catchment extrapolations from this analysis, although we note this was not an expectation or deliverable from Phase 1 of the project. The use of EBIT as a profitability measure also focuses on the financial impacts at a farm system level, rather than at an individual farm business level. While this provides for comparisons between individual farm types and enterprise mixes, it doesn't provide any insight into the overall resilience of the individual farm businesses that will be affected by the proposed NDA limits.

7.20. As regards expanding on findings from this Phase 1 project with respect to the financial implications for individual farms in the Rotorua catchment, we would recommend additional analysis on:

(i) Separating the impact of productivity improvements from pure mitigation activity i.e. "optimise" the farm system first and then apply mitigation actions;

(ii) The implications of managing the impacts of wintering milking cows on dairy platforms, with or without infrastructure e.g. barns;

(iii) Considering elevated per cow production levels (System 5 farms, >500kg MS/cow) for a real dairy farm system, perhaps in conjunction with (i) above;

(iv) Considering the resilience of the low N loss scenarios for case studies under more extreme pasture growth conditions (i.e. drought in 2012/13, wet year in 2011/12) and the input/output prices that accompanied these.

(v) Expanding financial analysis of the real farm case studies to an NPAT level or looking at the NPAT impact for hypothetical case studies using assumed equity levels, and then sensitising against cost of capital.

(vi) Looking at less simplified afforestation options for mitigation on more marginal sheep & beef land;

(vii) An alternative deer farming scenario, say a velvet/stud operation

7.21. In the context of the wider catchment impact analysis flagged to follow the Phase 1 project, we would recommend that stakeholders examine:

(i) The implications of large scale adoption of preferred mitigation tools on the cost/benefit of these .e.g. trebling maize silage use in the local dairy industry;

(ii) Alternatives for sourcing low protein feed stuffs;

(iii) Downstream community economic effects from potential losses in profitability;

(iv) The impact of land values over time and how real farms might be affected by this.

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