BEFORE HEARING COMMISSIONERS at CHRISTCHURCH

IN THE MATTER	of the Resource Management Act 1991
AND	
IN THE MATTER	of the proposed Variation 5 to the Proposed Canterbury Land and Water Regional Plan – Nutrient Management and Waitaki
BETWEEN	DairyNZ Limited
AND	Canterbury Regional Council

STATEMENT OF PRIMARY EVIDENCE OF DR STEWART FRANCIS LEDGARD FOR DAIRYNZ LIMITED

22 July 2016

DairyNZ

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CONTENTS

1. EXECUTIVE SUMMARY

1.1 Plan Change 5 (“PC 5”) describes the principles related to Good Management Practice (GMP) for nitrogen (N) fertiliser use to match plant requirements and minimise risk of losses.

1.2 A review of research on N fertiliser use on pastures highlighted that pasture growth and N uptake increases with added N (except in urine patches) up to rates above 400 kg N/ha/year, i.e. within the maximum indicated by rules for GMP. When used in split applications and avoiding winter, direct leaching losses of fertiliser-N are minor.

1.3 The pastoral fertiliser N modelling proxy developed for use in PC 5 is a simplified N budget approach. Its strengths are that it: aligns with the OVERSEER model (which is also used for estimating N leaching); can be applied at a farm block level; and in preliminary testing showed “sensible’ results, including identifying a reduction in N fertiliser rate on blocks receiving a high rate of N in farm dairy effluent.

1.4 Its main weakness is that, for grass/clover pasture, the N fertiliser “requirement” is determined by pasture production estimated via the OVERSEER model relative to a critical threshold value (e.g. about 7.5 t dry matter/ha/year for dairy pasture). Above this threshold, an N fertiliser rate is identified, while below it the difference is negative but is set to nil N fertiliser.

1.5 An alternative approach is to use a simple farm N surplus (N inputs minus N output in products). Strengths of this method are that it: is based on a well-recognised N balance approach; uses a limited amount of farm data that is readily obtainable; and excludes estimation of legume N_2 fixation, which is variable and difficult to accurately quantify.

1.6 The main limitation of the farm N surplus approach is in the need to define a threshold value, in a similar way as for the current N modelling proxy.

1.7 The section 42A report included a preliminary comparison of these methods, which concluded that that there would be no substantial difference in the N leaching from either N fertiliser method. Results depended on their respective threshold values.

1.8 For sheep and beef farms, the N modelling proxy often results in nil N fertiliser, despite their potential to respond to N fertiliser with negligible direct N leaching. For the N surplus approach, most sheep and beef farms would result in a low N surplus relative to a threshold, but for low N surpluses it is proposed that the N fertiliser rate would remain as the actual rate used in the baseline period rather than allowing an increase up to the threshold.

1.9 Thus, the threshold value(s) and how the fertiliser N modelling approach is implemented will determine the GMP N fertiliser rates.

2. INTRODUCTION

2.1 My full name is Dr Stewart Francis Ledgard.

2.2 I hold a Bachelor of Agricultural Science (Hons.1) (1979) majoring in Soil Science, and a Ph.D. in Biological Sciences (1984) from the Australian National University.

2.3 I have been employed as a principal scientist with AgResearch (New Zealand Pastoral Agricultural Research Institute Ltd) at Ruakura Research Centre since 1979. I have more than 30 years' experience as a scientist with a particular speciality in nitrogen (*N*) cycling in agricultural systems. During that time I have published 7 book chapters, 111 scientific journal papers and over 210 Conference papers.

2.4 I led a multi-disciplinary research programme entitled "*Nitrogen and Lake Taupo*" that finished in 2010. This programme was funded by the main government research funding body, Ministry of Business, Innovation and Employment ($2 million/year) and focused on the development and evaluation of technologies and management practices to reduce N leaching from farms around Lake Taupo.

2.5 I currently lead several research projects focussed on development and evaluation of practices and mitigations to decrease N loss from pastoral farm systems.

2.6 I have been and am currently also involved in Sustainable Farming Fund research programmes, working with farmer groups around Lakes Taupo and Rotorua and in central Waikato targeting farm systems and management practices to reduce N leaching from farms.

Background

2.7 I am familiar with the Environment Canterbury's (ECan's) PC 5 to the Canterbury Land and Water Regional Plan ("CLWRP") with respect to nutrient management and N fertiliser management in particular. My only direct involvement has been in providing an internal (within AgResearch) review on a draft of the fertiliser nitrogen modelling proxy, which is included within the Technical Report of Snow et al.. (2016). I have been asked by DairyNZ to provide evidence on the development of ECan's Farm Portal and N fertiliser proxy, including the section 42A Resource Management Act 1991 report prepared by its officials.

Code of Conduct

2.8 I have read the Environment Court's Code of Conduct for Expert Witnesses contained in the Environment Court's Practice Note 2014, and I agree to comply with it. In that regard, I confirm that this evidence is within my area of expertise except where I state that I am relying on the evidence of another person. I have not omitted to consider material facts known to me that might alter or detract from the opinions expressed in this evidence.

3. SCOPE OF EVIDENCE

3.1 My evidence will deal with the following:

(a) An introduction with higher level principles related to GMP for nutrient management and nitrogen fertiliser;

(b) A summary of research on pasture responses to nitrogen fertiliser, particularly at high rates of application;

(c) Review and comments on technical documents relating to development of the pastoral fertiliser nitrogen modelling proxy;

(d) A summary of strengths and weakness of the proposed fertiliser nitrogen modelling proxy;

(e) A summary of strengths and weakness of an alternative proxy based on farm nitrogen surplus;

(f) Review and comment on Environment Canterbury's section 42a report as it relates to the fertiliser nitrogen modelling proxy, and

(g) Conclusions.

4. HIGHER LEVEL PRINCIPLES RELATED TO GOOD MANAGEMENT PRACTICE

4.1 Plan Change 5 to the CLWRP describes the principles related to GMP for various topic areas including nutrient management. For nutrient management, it notes a target that "the amount and rate of fertiliser applied does not exceed the agronomic requirements of the crop". More specifically, it states that the GMP is to "manage the amount and timing of fertiliser inputs, taking account of all sources of nutrients, to match plant requirements and minimise risk of losses". For pastures and N fertiliser, this is noted as applying to areas of a paddock that are “not under urine patches”. The rules associated with applying this GMP for pastures are that there is a maximum of 50 kg N/ha/month, no N fertiliser is applied in May, June or July, and that N fertiliser is applied in accordance with the pastoral fertiliser nitrogen modelling proxy (Snow et al.. 2016).

4.2 The purpose of this evidence is to review and comment on aspects relating to GMP for N fertiliser use, the current proposed fertiliser N modelling proxy and an alternative farm N surplus approach.

4.3 It is relevant to firstly consider what research (internationally and in New Zealand) has shown on pasture responses to added N fertiliser in relation to the total amount of N application, particularly at high rates of application, in order to consider the implications of the GMP emphasis on not exceeding agronomic requirements. The following section gives a brief review of relevant research.

5. SUMMARY OF RESEARCH ON PASTURE RESPONSES TO NITROGEN FERTILISER, PARTICULARLY AT HIGH RATES OF APPLICATION

5.1 New Zealand grass/clover pastures do not have an inherent N deficiency in that they do not require N fertiliser to achieve and maintain a moderate level of production in the long-term. This is due to the ability of legumes, predominantly white clover, to fix atmospheric N_2 into a form that is used by them and is cycled to associated grasses (e.g. Ledgard 2001). This fixed N essentially replaces N losses and provides an equilibrium level of production. However, at this production level for mixed clover/grass pasture, the grasses are limited by N availability relative to their maximum potential production under high levels of available N in soil.

5.2 Grasses in grass-only or grass/clover pastures will respond to added N fertiliser, unless there are other major growth limitations, e.g. drought, temperatures below about 5°C or non-N nutrient deficiencies.

5.3 Summaries of mowing trials in western Europe on ryegrass have shown increased growth at rates up to about 600 kg N/ha/year (with split applications throughout the year) (Prins and Arnold 1980; Whitehead 1995). Similarly, European grazing trials showed animal responses up to and above 400 kg N/ha/year (Whitehead 1995). These trials generally showed a “diminishing returns” increase in grass growth eventually reaching a near-plateau.

5.4 In New Zealand, a long-term mowing trial in Southland showed average yields of 11,430, 12,470 and 14,930 kg DM/ha/year with N rates of 0, 100 and 400 kg N/ha/year (Risk 1982). Thus, the pasture response continued up to the higher N rate, with a small decrease in responsiveness. The response equated to 10.4 and 8.8 kg dry-matter/kg N for the 100 and 400 N rates, respectively.

5.5 In New Zealand, there has only been one main dairy grazing trial that compared different rates of N fertiliser application. This was in Waikato and during the first two years it compared 0, 213 and 379 kg N/ha/year. It resulted in increased pasture growth of 3350 and 4650 kg dry-matter/ha/year to the 213 and 379 kg N/ha/year treatments, respectively (Penno et al.. 1996). This trial continued for a further two years and showed increased pasture production up to the high N rate and average increases in milksolids production/ha of 141 and 219 for the 204 and 426 kg N/ha/year treatments, respectively (McGrath et al.. 1998).

5.6 European research has shown very low N leaching losses from pasture under a mowing system with relatively high rates of N fertiliser, e.g. up to 400 kg N/ha/year, but that N leaching increased significantly at much higher rates (Prins et al.. 1988).

5.7 Detailed modelling, using the validated model APSIM, of irrigated ryegrass pastures in Canterbury for responsiveness to N fertiliser applications indicated responses up to 600 kg N/ha/year and identified annual application of approximately 350 kg N/ha/year as optimal, in terms of achieving high responses with little direct leaching from fertiliser-N (Vogeler and Cichota 2015).

5.8 Research in Canterbury used an isotope (^{15}N)labelled N fertiliser applied at 200 kg N/ha/year in four split applications through the year (excluding during winter) to cut pasture on a shallow stoney soil and showed no significant direct leaching of fertiliser-N (Di and Cameron 2002). Other research in Waikato with ^{15}N-labelled N fertiliser showed that direct leaching of fertiliser-N can occur when it is applied during winter but that when applied in seasons with good pasture growth there was negligible direct leaching (e.g. Ledgard et al.. 1988).

5.9 In grazed pastures, the extra production and pasture-N associated with N fertilisation is consumed by grazing animals and much of it is recycled via excreta. Thus, studies have shown higher N leaching under grazing compared to under mowing (e.g. Wachendorf et al.. 2004) and have also shown an exponential increase in N leaching at high annual N rates as pasture responses diminished (e.g. summarised by Ledgard 2001; Whitehead 1995).

5.10 Thus, grazed pasture systems have shown increases in pasture and animal production in New Zealand at up to about 400 kg N/ha/year, although the increases in production had not reached a maximum at this N rate. This brief summary illustrates that if N fertiliser is used to match plant requirements in terms of achieving high yields, then most pastures will respond to N fertiliser up to high rates. It has also shown that by using multiple split applications and avoiding application in winter there is little direct leaching of fertiliser-N but that it increases exponentially at very high N rates and as the response by grasses are approaching maximum growth.

6 REVIEW AND COMMENTS ON TECHNICAL DOCUMENTS RELATING TO DEVELOPMENT OF THE PASTORAL FERTILISER NITROGEN MODELLING PROXY

6.1 The main technical basis for the pastoral fertiliser N modelling proxy is in the "Sheep, beef and deer modelling for the Matrix of Good Management- a technical summary" (Snow et al.. 2016). This notes that the calculation of the N requirements of pasture refer to the "amount of N that the pasture needs to support the existing farm system".

6.2 This approach selected was a logical follow on from the arable/horticultural model, where it is best suited, since for the latter the crop is harvested and N yield aligns directly to N offtake. However, with grazed pasture, this is complicated by most of the plant N in 'harvested' pasture being recycled back in excreta. In recognition of the variability associated with excreta return, they note that the proxy refers only to areas of a paddock that have not received animal urine.

6.3 The proxy is based on a mass N balance, whereby the fertiliser N requirement is calculated from an estimate of pasture N uptake, with other external N inputs subtracted and N losses added to it. In this case, external N inputs refer to those from effluent and irrigation, while N losses refer to the sum of the losses of N from gaseous forms and from N leaching. However, it cannot account for the latter directly and a modified approach is used.

6.4 In practice, this fertiliser N modelling proxy is calculated from the amount of pasture production, which is determined by the amount of pasture dry matter (DM) intake by animals using the OVERSEER® Nutrient Budgets model (hereafter called OVERSEER). This is multiplied by a constant pasture N concentration (from OVERSEER) based on no N fertiliser use to get total pasture N yield. This will be an underestimation since the pasture N concentration increases with increasing rate of N fertiliser use (which is also recognised in OVERSEER). It is unclear whether this would have much effect without doing a sensitivity analysis of it.

6.5 The estimate of total pasture N yield has the N in pasture residues subtracted from it to get net pasture N uptake. The pasture residue-N is taken from OVERSEER and refers to the pasture N not utilised by grazing animals assuming 85% or 70% utilisation of pasture by dairy cattle or sheep, beef and deer, respectively. In reality, the actual utilisation of pasture on farm will vary between farms. Values for irrigation-N and effluent-N are then subtracted from the net pasture uptake at a block level, if relevant.

6.6 The N fertiliser "requirement" is calculated from the net pasture N uptake after subtracting a constant value for non-fertiliser N ($N_{NonFert}$ from N_2 fixation and net soil N mineralisation, with the latter generally being considered as zero) of 250 kg N/ha/year (for grass/legume pastures; or 125 kg N/ha/year for grass-only and 2000 kg N/ha/year for lucerne). This is also multiplied by a constant factor ($F_{Fert\&InEff}$) of 1.4 to account for inefficiencies of N fertiliser use. Thus, the $N_{NonFert}$ and $F_{Fert\&InEff}$ constants are critical in estimation of the fertiliser N modelling proxy.

6.7 The net effect of this calculation for a block receiving no added N in effluent or irrigation is that the main factor in calculation of fertiliser-N requirement is the net pasture N uptake. In practice, since the pasture N concentration in the absence of fertiliser-N is constant and the utilisation factor for calculating residue-N is constant, it simplifies down to being determined by pasture growth (dry matter [DM] production). Thus, the point at which N fertiliser requirement is zero for grass/legume pastures corresponds with pasture growth for a dairy farm of near 8 tonnes DM/ha/year. Above this level of pasture growth, $N_{NonFert}$ would be exceeded and fertiliser-N would be required, while below it there would be a "negative fertiliser-N requirement" and that is set to zero.

6.8 The GMP $N_{NonFert}$ term of 250 kg N/ha/year was noted as being a "fitted parameter", although the process for this was not specified. In practice, a review of long-term grazed productive pasture systems (predominantly dairying) for a wide range of studies internationally, showed an upper value of about 250 kg N/ha/year (Ledgard 2001). However, it is a relatively high value for less productive sheep and beef pastures and as noted by Snow et al. (2016) a value of about 125 kg N/ha/year may be more appropriate. Their sensitivity analysis of this showed that it increased the GMP N fertiliser requirements for pasture, particularly in lower N input farm systems. However, it had little apparent effect on calculated N leaching, when the higher GMP fertiliser value was used. Following this sensitivity analysis, Snow et al. indicated that a differential value "does not seem necessary at present".

6.9 The GMP $F_{Fert\&InEff}$ constant factor of 1.4 is a factor that lumps together several factors, including 'F_{Uptake}', '$F_{NonFert}$', and 'F_{Losses}', adjusting for effects of N fertiliser rate on plant N uptake, non-fertiliser N uptake (primarily N_2 fixation), and N losses, respectively. Some of these factors will be non-linear with N rate. However, the decrease in F_{Uptake} with high N rates will be countered by an increase in F_{Losses}, and so this factor is likely to be relatively constant with N rate. Therefore the simplification of using a single $F_{Fert\&InEff}$ value is reasonable. Sensitivity analysis in the report by Snow et al.. (2016) illustrated that changing this factor between 1.2 and 1.6 changed

N fertiliser rate by up to about ± 50 kg N/ha with moderate-high N fertiliser rates. However, it only had a small effect on calculated N leaching.

7. STRENGTHS AND WEAKNESS OF THE PROPOSED FERTILISER NITROGEN MODELLING PROXY

7.1 The strengths of the fertiliser N modelling proxy are:

- It aligns with the cropping approach and is consistent with the OVERSEER model, which is used in calculating N leaching.

- The underlying basis for the model is driven by an N balance approach in that it adjusts for N inputs in farm dairy effluent (FDE) and irrigation.

- It can be applied at a block level, thereby adjusting for variation in practices such as FDE blocks.

- A limited number of case study analyses in the report of Snow et al.. (2016) indicated “general sensibility” in the results for dairy farms, and in particular in identifying a reduction in N fertiliser rate on blocks receiving a high rate of FDE-N.

7.2 Weaknesses of the fertiliser N modelling proxy are:

- The N balance model was modified to enable it to be used, which makes its calculations somewhat different from other internationally-used methods and more difficult to explain to end-users.

- Its major weakness is that it is a simplified approach using various constants such that the fertiliser N requirement is largely determined by the estimate of pasture growth. Since it uses a difference method, it means that it sets a critical threshold value of pasture growth that must be exceeded before a GMP amount of N fertiliser is identified (e.g. about 7.5 t DM/ha/year for dairy pasture).

- It is a difference method and therefore is also highly dependent on the $N_{NonFert}$ value. This value is essentially an estimate of the level of legume N_2 fixation. It was obtained using fitted data and is a reasonable value for the upper end of the range for long-term grazed pasture. However, it is relatively high for non-intensive non-irrigated sheep and beef pasture systems. A sensitivity analysis in the Snow et al.. (2016) report showed that halving this value would increase the GMP rate of N fertiliser, but with little effect on calculated N leaching.

- Estimates are also determined by the constant value set for $F_{Fert\&InEff}$ of 1.4. This factor attempts to account for inherent inefficiency in fertiliser use and in practice it will vary with site and management practices. However, it was not as sensitive to fertiliser N rate as other main factors of pasture growth and $N_{NonFert}$.

- A nil N fertiliser rate is estimated using the proxy on most sheep and beef farms due to their lower pasture production and the dominant effect in this proxy of calculated pasture growth relative to the $N_{NonFert}$ term. In practice, sheep and beef farms may have a strategic requirement for extra feed (which can be supplied using N fertiliser) in certain seasons or periods of feed shortage within a year. They may also have a valid reason for using N fertiliser annually to provide extra pasture for wintering and be able to use it to achieve good pasture growth increases with negligible direct fertiliser-N leaching. While this proxy does not stop N fertiliser use for these purposes, it could limit their calculated Baseline GMP N Loss Rate and GMP N Loss Rate, since N fertiliser use would have to be excluded from the N leaching calculation if this proxy deemed it not to be a GMP. However, sensitivity analysis in the Snow et al.. (2016) report indicated that this would have little effect on calculated N leaching.

- It does not recognise some situations where long-term legume growth is limited (e.g. by clover root weevil) or in a development situation where high N removal by immobilisation into soil organic matter is occurring. However, most modelling or recommendation methods would struggle to account for these factors without developing special modifications.

8. STRENGTHS AND WEAKNESS OF AN ALTERNATIVE PROXY BASED ON FARM NITORGEN SURPLUS

8.1 Farm N surplus (i.e. sum of external N inputs minus N output in products) is one alternative approach being proposed by the dairy sector with simplification to exclude inputs from legume N_2 fixation and atmospheric N deposition. Strengths of this approach are:

- This approach is well-recognised internationally and has been used elsewhere to restrict farm N losses (e.g. in the Dutch N accounting system).

- It is based on a simple N balance approach and uses a limited amount of farm data that is readily obtainable (i.e. fertiliser and feed inputs and milk and live-weight sold outputs). Thus, it is easily calculated.

- It does not try to account for legume N_2 fixation, which is variable and difficult to accurately quantify.

8.2 Weaknesses of the farm N surplus method are:

- Use of a farm-only approach means that it does not explicitly recognise variation between farm blocks, such as on FDE blocks that might already be receiving sufficient N from the FDE. However, potentially, it could be adapted to work at a block level.

- Its use for estimating N fertiliser requirement is an indirect method that doesn't explicitly relate to factors referring to N fertiliser use by pasture.

- Its major weakness is that it needs to be related to an appropriate threshold level (in a similar way as for $N_{NonFert}$ with the current N modelling proxy).

- On sheep and beef farms it will invariably result in low farm N surplus values, since N inputs in feed and N outputs in products are generally low (e.g. less than about 10 kg N/ha/year for each). Thus, it may have a relatively large N fertiliser value depending on the defined threshold level.

9. REVIEW AND COMMENT ON ENVIRONMENT CANTERBURY'S SECTION 42A REPORT AS IT RELATES TO THE FERTILISER NITROGEN MODELLING PROXY

9.1 The most relevant part of the section42A report that dealt with the fertiliser N modelling proxy and an alternative farm N surplus approach was covered in Appendix E. That Appendix included some results of analyses using both fertiliser N approaches in the section entitled "Implications of the N surplus cap for N losses compared with current MGM proxy" (pages 67-68).

9.2 In a "coarse comparison of 22 Fonterra files" the report noted that the relativity of the two methods depended on the choice of the threshold for the farm N surplus method in terms of giving the most N loss reduction. The farm N surplus method was apparently better with a lower threshold value of 250 kg N/ha/year than with 300 kg N/ha/year, depending on whether farms below the cap increased their N inputs [note that this was using OVERSEER N surplus, which included legume N_2 fixation].

9.3 A similar comparison with sheep and beef farms noted negative estimates from the farm N surplus (excluding legume N_2 fixation) and indicated that it was likely that it would lead to higher N losses compared to using the N modelling proxy method, if farms moved up to their calculated N threshold.

9.4 This broad assessment requires more detailed analysis. However, it suggests that a farm N surplus approach could potentially also be used effectively, but it rightly notes that it will depend on what would be done in a policy context on the many sheep and beef farms where current N fertiliser use is well below the threshold.

9.3 The results from Appendix E were summarised under points 6.110 and 6.111 in the section 42A report by indicating that there would be no substantial difference in the N leaching quantum depending on which N fertiliser method was applied.

9.4 The report noted the importance of forage cropping blocks within sheep and beef farms in their large contribution to overall N leaching. This is not unexpected in view of the high grazing intensity and lack of plant uptake after grazing. However, while aspects of this were addressed in the crop report of Hume et al.. (2015), there have been no analyses presented on results for a sheep and beef winter-crop system that I am aware of. Presumably the crop model of the fertiliser N modelling proxy could be applied to it. Potentially, an N surplus approach could also be used based on N inputs from fertiliser minus N outputs in harvested crop, as a guide to fertiliser N requirements. Analyses using both of these options for case study sheep and beef farms that graze winter forage crops is warranted.

10. CONCLUSIONS

10.1 PC 5 covers aspects relating to nutrient management and GMP of fertiliser so as not to exceed the agronomic requirements of the crop. More specifically, it aims to "manage the amount and timing of fertiliser inputs, taking account of all sources of nutrients, to match plant requirements and minimise risk of losses".

10.2 A review of research on N fertiliser use on pastures illustrated that under cutting management the pastures will respond through increased growth and N uptake up to very high annual rates of application, e.g. >600 kg N/ha/year. Maximum responses are less under grazing but New Zealand farmlet trials were still responding strongly to N fertiliser at 400 kg N/ha/year. In Canterbury, lysimeter studies showed that 200 kg N/ha/year in split applications showed no significant increase in N leaching relative to no N fertiliser. Thus, pasture growth responds up to high annual inputs (with regular split applications) of N fertiliser, and direct N leaching losses only become significant as responses approach near-maximum, or if poor management (high single rates or application in winter).

10.3 A pastoral fertiliser N modelling proxy has been developed for use in Plan Change 5 to estimate fertiliser N requirements of pasture to support an existing farm system. It is based on an N balance approach but has been simplified for ease of use. Plant N uptake is estimated from pasture production via OVERSEER and assuming an N concentration based on no N fertiliser use. For grass/clover pastures, the proxy is calculated from; pasture N uptake *minus* 250 kg N/ha/year (based largely on clover N_2 fixation). This defines an N deficit, which is multiplied by an inefficiency factor of 1.4 to estimate fertiliser N requirement. It can operate at a farm block level and so can identify where inappropriately high levels of N are being used after accounting for N inputs such as from farm dairy effluent.

10.4 Strengths of the pastoral fertiliser N modelling proxy are that it: aligns with OVERSEER (which is also used for estimating N leaching); can be applied at a farm block level; and in preliminary testing showed "sensible' results, including identifying a reduction in N fertiliser rate on blocks receiving a high rate of FDE-N.

10.5 The main weakness of the pastoral fertiliser N modelling proxy is that its simplification means that the GMP fertiliser N amount is largely determined by the estimate of pasture growth. Since for grass/clover pastures it is based on a difference relative to a constant of 250 kg N/ha, it means that it sets a critical threshold value of pasture growth (e.g. about 7.5 t DM/ha/year for dairy pasture) above which an N fertiliser rate will be identified. Below this the difference is negative but is set to nil N fertiliser. One effect of this is that it often results in nil N fertiliser for sheep and beef farms due to their lower pasture growth, despite their potential to respond to N fertiliser with negligible direct N leaching.

10.6 A possible alternative is to use a simple farm N surplus (N inputs minus N output in products). Strengths of this method are that it: is based on a well-recognised N balance approach; uses a limited amount of farm data that is readily obtainable; and excludes estimation of legume N_2 fixation, which is variable and difficult to accurately quantify

10.7 The simple farm N surplus method is an indirect farm-only approach (not proposed for use at block level), and its main limitation is in the need to define a threshold value, in a similar way as for $N_{NonFert}$ with the current N modelling proxy.

10.8 The section 42A report included a preliminary comparison of these methods, which requires much more comprehensive assessment, but concluded that that there would be no substantial difference in the N leaching from either N fertiliser method.

10.9 Both methods for estimating a GMP fertiliser N value for sheep and beef farms need greater consideration. The fertiliser N modelling proxy estimates no N fertiliser for most sheep and beef farms, which may be overly restrictive, whereas the farm N surplus method may give a moderately high N fertiliser value depending on how the threshold is defined.

Dr Stewart Ledgard

22 July 2016

REFERENCES

Di, H. J. and Cameron, K. C. (2002) Nitrate leaching and pasture production from different nitrogen sources on a shallow stoney soil under flood-irrigated dairy pasture, Australian Journal of Soil Research 40: 317-334.

Hume, E., Brown, H., Sinton, S. and Meenken, E. (2015) Arable and horticultural crop modelling for the Matrix of Good Management – a technical summary. Report 272-15/16 by Plant and Food Research for Environment Canterbury, 175p.

Ledgard, S. F. (2001) Nitrogen cycling in low input legume-based agriculture, with emphasis on legume/grass pastures. Plant and Soil 228: 43-59.

Ledgard, S. F., Steele, K. W. and Feyter, C. (1988) Influence of time of application on the fate of ^{15}N-labelled urea applied to dairy pasture. New Zealand Journal of Agricultural Research 31: 87-91.

McGrath, J. M., Penno, J. W., Macdonald, K. A., and Carter, W. A. (1998) Using nitrogen fertiliser to increase dairy farm profitability: Proceedings of the New Zealand Society of Animal Production 58: 117-120.

Penno, J. W., Bryant, A. M., and Macdonald, K. A. (1996) Effect of nitrogen fertiliser and supplements on pasture production and milksolids yield from dairy farm systems. Proceedings of the New Zealand Society of Animal Production 56: 236-238.

Prins, W. H., and Arnold, G. H., (1980) The role of nitrogen in intensive grassland production: Proceedings of an International Symposium of the European Grassland Federation, Wageningen, the Netherlands. 171p.

Prins W. H., Dilz, K., and Neetsen, J. J. (1988) Current recommendation for nitrogen fertilisation within the EEC in relation to nitrate leaching: Proceedings of the Fertiliser Society, London. Number 276.

Snow, V., McAuliffe, R. J., Taylor, A. L., DeVantier, B. P., and Robson, M. C., (2016) Sheep, beef and deer modelling for the Matrix of Good Management – a technical summary. Report RE500/2016/009 by AgResearch for Environment Canterbury. 191p.

Vogeler, I., and Cichota, R., (2015) Deriving seasonally optimal nitrogen fertilization rates for a ryegrass pasture based on APSIM modelling with a refined AgPasture model. Grass and Forage Science DOI: 10.1111/gfs.12181.

Wachendorf, M., Buchter, H. T. and Taube, F., (2004) Performance and environmental effects of foliage production on sandy soils. II. Impact of defoliation system and nitrogen input on nitrate leaching losses. Grass and Forage Science 59: 56-68.

Whitehead, D. C., (1995) Grassland nitrogen, CAB International, Wallingford, United Kingdom. 397p.