Reducing nitrogen loss

A guide to good management practices

DairyNZ

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Introduction

The dairy industry is committed to a responsible growth in milk production involving maintaining and improving water quality to meet community agreed freshwater objectives. On all farms this means that farmers need to use their nitrogen (N) inputs efficiently and to meet catchment limits. On some farms suitable mitigation options will need to be found to reduce N leaching further.

The key is for farmers to convert N inputs into product efficiently and profitably while ensuring that N leaching from their farm is reasonable for their soil and climate.

This booklet is designed to provide farmers and their advisers with a way firstly to evaluate if the farm system is performing well (i.e. is it optimised?). It then looks at the key factors influencing N loss and describes the likely effects on the farm system and N loss if changes are made. It provides management guidelines for these key factors.

A key principle is to focus on improving farm performance or efficiency first as this will help improve farm profitability, thereby providing a way to offset any financial implications if making changes to reduce N surplus and leaching.

How to use this booklet

Before reading this booklet identify your goals and values, i.e. what are the important factors which influence your farming? What drives this particular farm business? Where may changes be possible?

Section One

In this section some of the key performance ratios for assessing overall farm performance are identified. It is best to work with an adviser. As regional farm data becomes available, regional benchmarks will be able to be drawn from DairyBase (the financial and physical data recording and analysis service provided by DairyNZ).

Sections Two and Three look at reducing N surplus and leaching as well as mitigation options.

Section Two

In this section the key factors involved in N management are summarised and the impact areas for reducing N surplus, and therefore the N available for leaching, are identified.

Section Three

This section provides additional information around the key impact areas and a brief summary you may like to read before your adviser visits. It also provides additional detailed information to aid in making decisions about mitigation options you might like to implement.

The information for each mitigation option is divided into four parts as follows:

- Summary points
- Likely impact on N leached
- Key considerations
- Details.

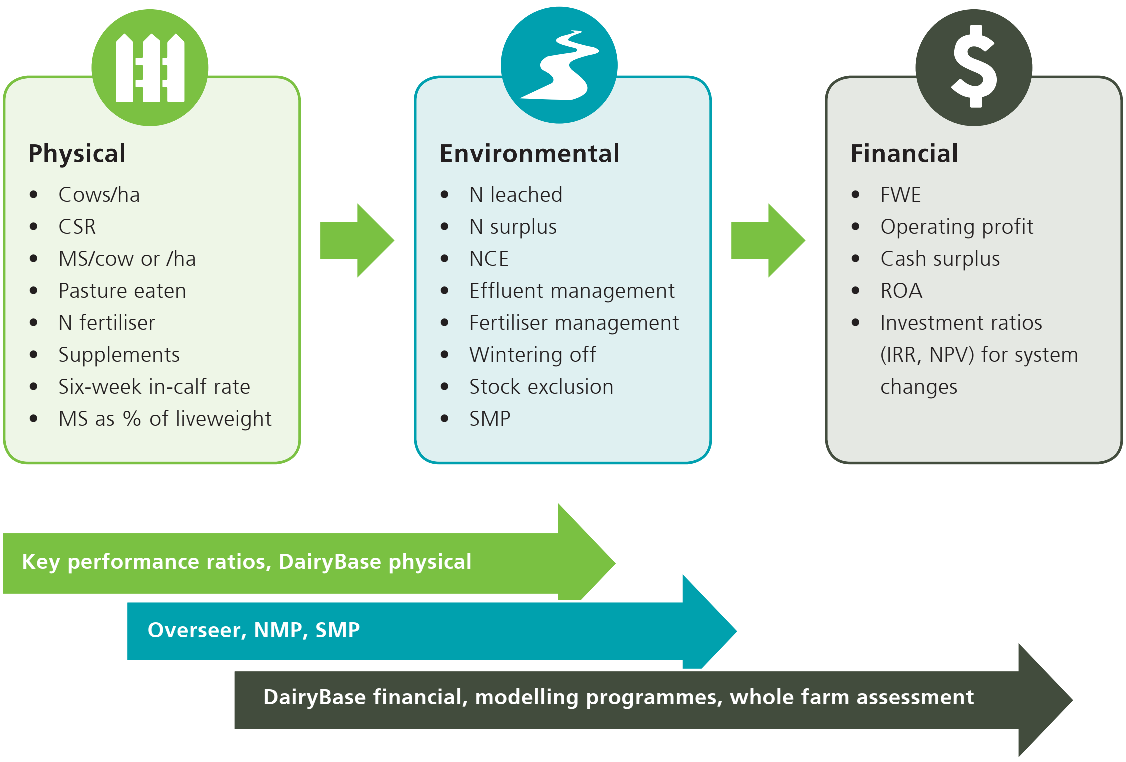
Whole farm assessment

The diagram below indicates the importance of assessing performance using all aspects of the farm system and available data. Although the ratios in Figure 2 are a starting point, a whole farm assessment process should be considered if farm system changes are being considered. This whole farm assessment process would include looking at personal and business goals, physical, environmental and financial key performance indicators (KPIs), as outlined in Figure 1 below.

A view of historical financial and physical performance is provided by DairyBase analysis (levels 1, 2 and 3). Environmental indicators such as N surplus, N conversion efficiency and N leached are provided by an OVERSEER® analysis. The effects of changes made can then be compared against the base data. Using farm system modelling programs is a useful way to evaluate the full effects of any changes.

Investment ratios, such as internal rate of return (IRR) or net present value (NPV) take the time value of money and depreciation into account and are a better way of assessing capital investments; e.g. an investment into some form of off-paddock facilities or feeding systems (barns, feedpads, in-shed feeders etc.).

Figure 1. Assessing your farm's performance



***CSR:** comparative stocking rate, **MS:** milksolids, **NCE:** nitrogen conversion efficiency, **FWE:** farm working expenses, **ROA:** return on assets, **IRR:** internal rate of return, **NPV:** net present value, **SMP:** sustainable milk plan*

By taking this approach to assessing overall farm performance, the process of adjusting to N loss limits may in fact become a positive exercise for the farm business by improving efficiency of resources (feed, fertiliser, water) and profitability.

DairyNZ consulting officers provide a whole farm assessment process as part of the discussion group process.

Assessing farm performance

In this section you will calculate some key performance ratios.

Figure 2 is designed to provide an overview of the farm without using DairyBase or OVERSEER®. It provides an opportunity to compare your current farm performance against other farms in your region and identify any areas that need further investigation for improved performance and profitability.

Step 1: Determine your farm performance

- Calculate the key performance ratios on page 7 for your farm. Your adviser can help with this
- Compare the results with regional averages either provided by your adviser or from the DairyNZ DairyBase system. There is space provided to fill in your farms targets
- This will help you decide if the current resources (i.e. cows, grass, supplements, effluent and fertiliser N, etc.) are being used efficiently
- The key performance ratios in Figure 2 are the ones that will have most influence on N loss. Other key performance ratios such as labour productivity and financial KPI's that are also important to your business are not covered here.

Step 2: Assess farm system impacts

Follow Step 1 with a detailed analysis examining the farm system impacts of changing any ratios that fall outside the expected ranges for your system type, climate and soil types. Can changes to these ratios improve overall farm performance?

Farm system models like Farmax, Udder and GSL can help do this effectively across the whole farm system.

Step 3: Assess environmental impact

The environmental impacts of any changes will also need to be assessed in OVERSEER® Nutrient Budgets.

Figure 2. Assessing key performance ratios for your farm.

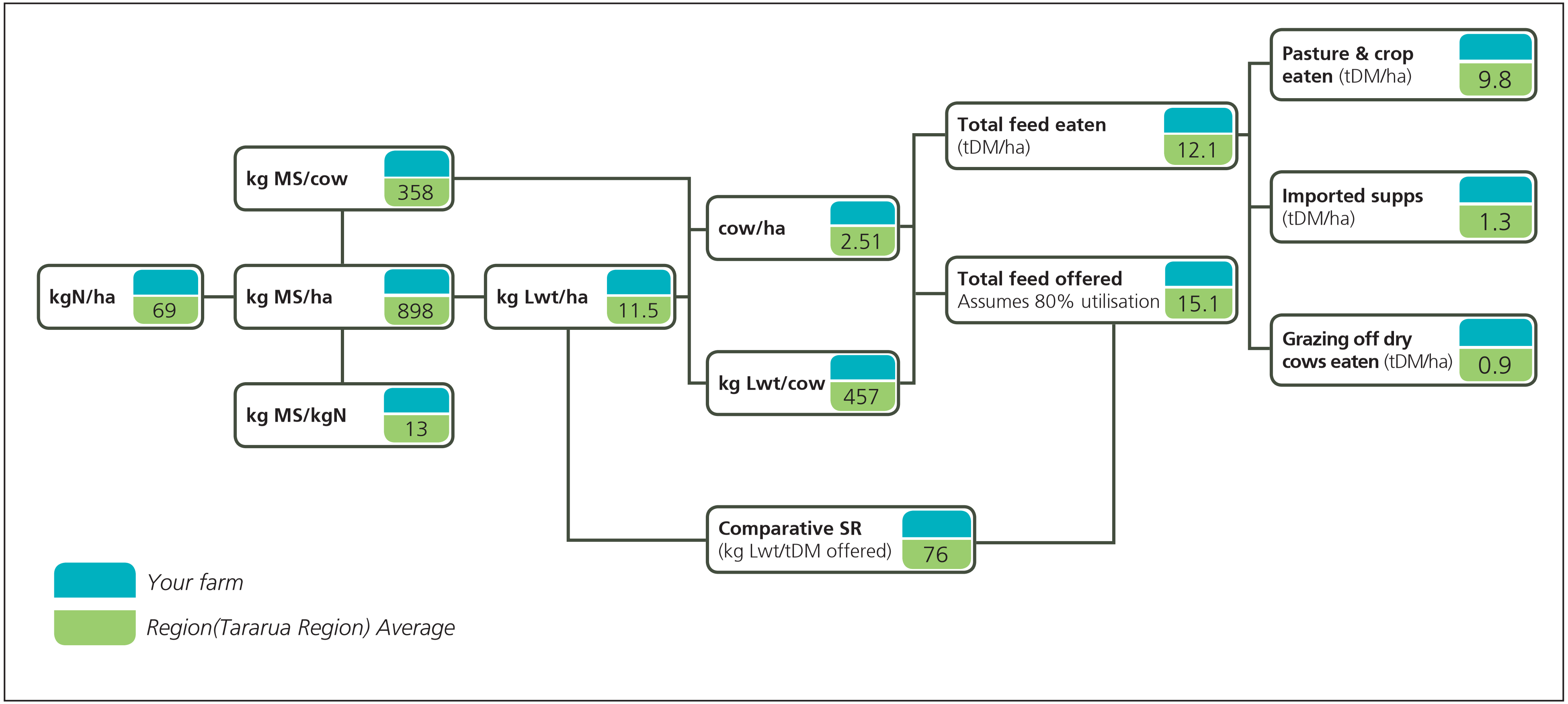


Figure 2 is designed to provide an overview of the farm without using data from either Dairybase or OVERSEER®. The above ratios have an impact on N loss. Dairybase and OVERSEER® data will provide more information and should be used if available.

Some useful guidelines:

Comparative stocking rate (CSR) should be in the range 75-80kg Lwt/tDM

kg MS/kgN – In this case a higher figure (more than 10) indicates more efficient use of N fertiliser. A figure of less than 6 indicates low MS output per kg N applied.

Comparative stocking rate: matching feed supply and demand

The comparative stocking rate (CSR), measured as kg liveweight/tonne dry matter (kg Lwt/t DM) offered, is a method of assessing the balance between feed demand and supply on farm and it provides an alternative to the traditional measure of cows per hectare (cows/ha). Farms now import significant amounts of supplements, or have different breeds (e.g. Holstein Friesian versus Jersey), and cows/ha is an inadequate description of this balance, and can be misleading when comparing farms.

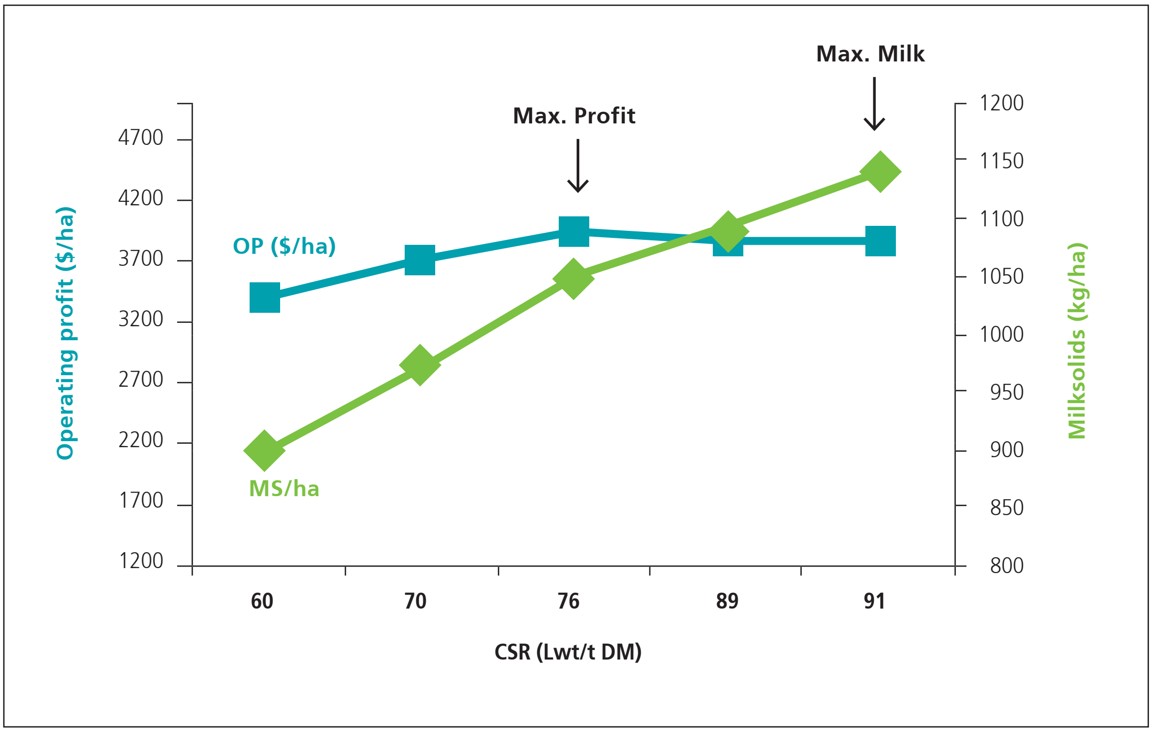
Calculating the CSR is an essential step in determining the feed balance of your farm (see p.35). It will need to be recalculated every time changes are made to the farm system.

A research farmlet trial identified the CSR to maximise operating profit/ha. It is less than the CSR required to maximise milksolids/ha (see Figure 3). Five herds were compared over a range of CSR from 60 to 91kg Lwt/t DM for three years. Operating profit was maximised at a CSR of 76, while MS/ha was maximised when CSR was 91. Figure 3 shows that the drop in profitability was not large for CSR on either side of the optimum.

Milksolids production per cow is very responsive to reduced CSR and research farmlet trials confirm the likelihood of maintaining total production levels with fewer cows. This will depend on the skills of the farmer. The impact of CSR on profit is less clear because it depends on how CSR is changed, and on the farmer's ability to take costs out of the system when reducing CSR.

Aiming to get close to the optimum CSR of 75-80 will help to improve profitability.

Figure 3. The relationship between CSR, operating profit /ha and MS production /ha from farmlet trials near Hamilton, 1998-2001



Understanding nitrogen (N)

N conversion efficiency, N leaching and N surplus, are measures of how well nutrients are used on farm and they highlight where improvements can be made.

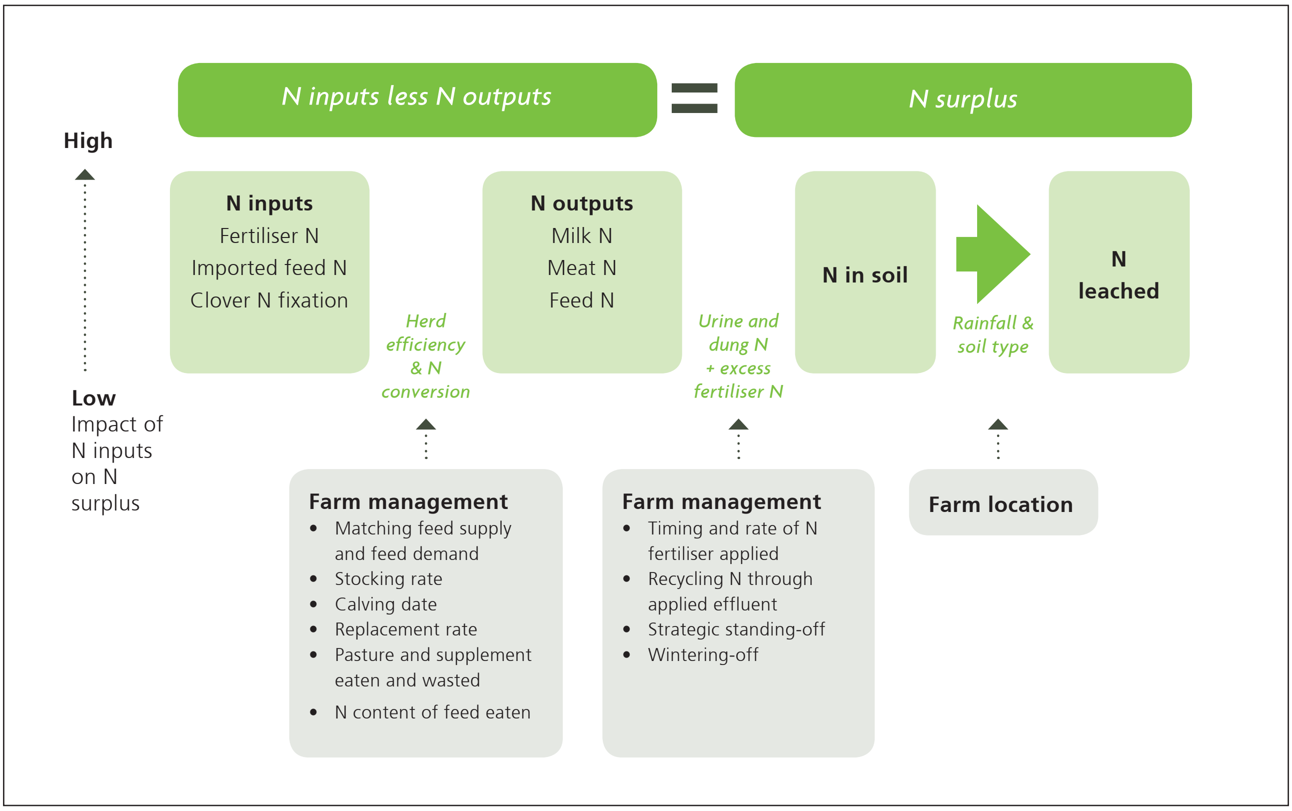
N conversion efficiency (NCE) describes the percentage of N going into a farm (N inputs) that is converted to N in saleable product (N outputs). NCE equals N output divided by N input and is expressed as a percentage[1].

N surplus is the nitrogen that remains after the conversion of N inputs to saleable product, such as milk, meat, and supplements sold off the farm, (N inputs - N outputs = N surplus) . The N surplus is mostly what is excreted by animals in urine and dung.

N leaching[2] is related to the N surplus. The amount of N leached is influenced by both farm management and non-management factors such as the volume of rain and some soil characteristics.

Every dairy farm has unique characteristics that will influence its N leaching risk. These can be physical factors, such as soil types and climate, or farm management factors, such as stocking rate, N fertiliser use, pasture and imported feed use, and pasture types. Figure 4 illustrates where management and physical factors can make a difference.

Figure 4. Relationship between N conversion efficiency, N surplus and N leaching



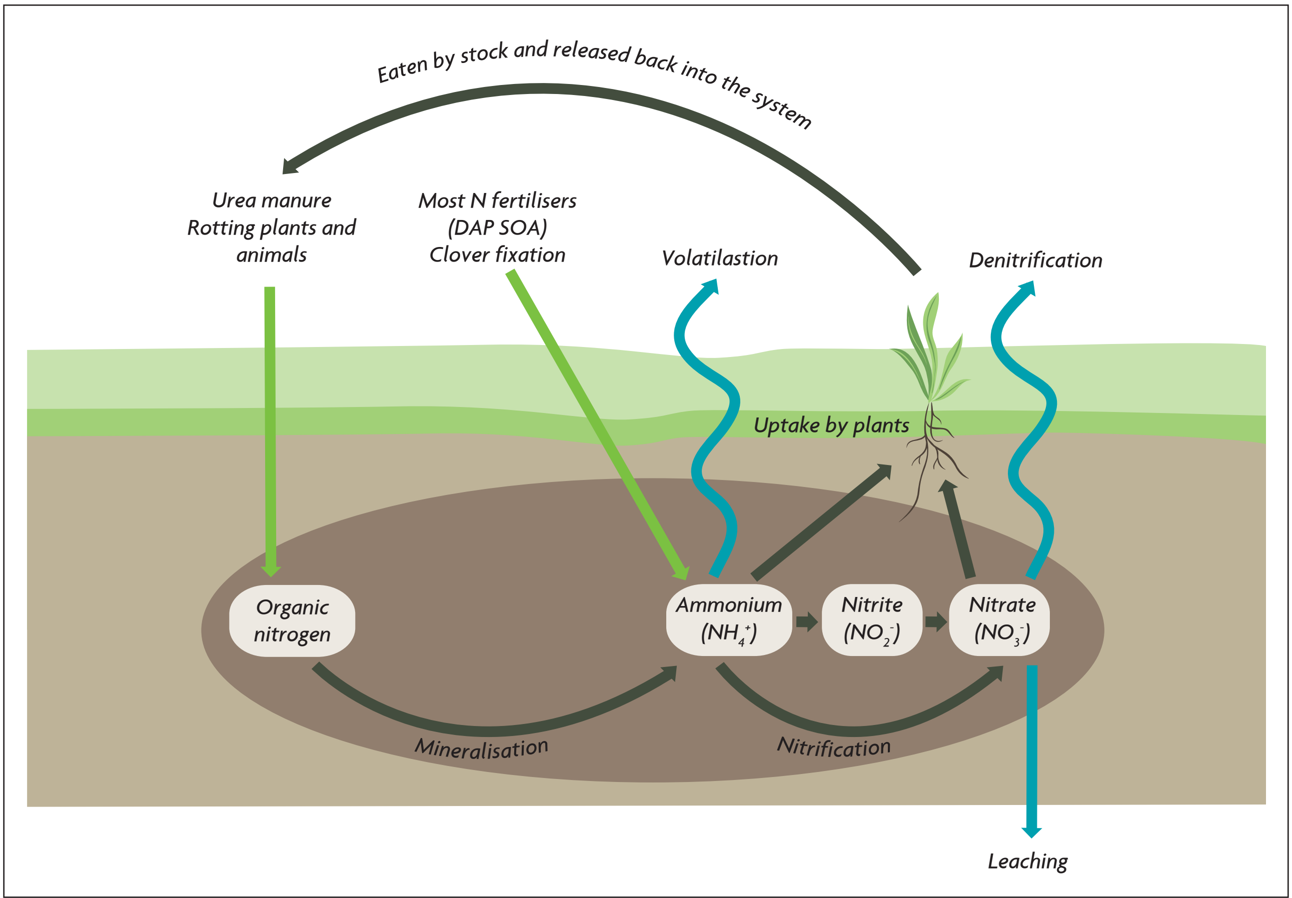
[1] $\text{NCE} = \dfrac{\text{N outputs in saleable products}}{\text{Sum of N inputs}} \times 100\%$

[2] N is leached from soil in the nitrate form so is also called nitrate leaching

How N is converted to nitrate

The diagram below illustrates the nitrogen cycle, the processes by which N is converted from one form to another; from organic N to inorganic forms of N (ammonia, nitrate). Nitrate N is the form of N that causes the issues when leached.

Figure 5. The nitrogen cycle



Mineralisation (organic N to ammonium)

Organic N is the N contained within organic matter such as animals, plants, dung and urine. Plants cannot use organic N until it has been broken down into a mineral form of N (ammonium). This is done by microbes in the soil and the process is called mineralisation.

Nitrification (ammonium to nitrate)

Nitrification is the process by which bacteria in the soil transform ammonium to nitrate through the addition of oxygen (oxidisation). Nitrification occurs all year round in most New Zealand soils. This generally means that N does not stay in the soil in large quantities as ammonium or nitrite before being converted to nitrate.

Nitrate leaching

Nitrate is mobile and highly soluble. It can be readily leached if there is too much available in the soil for the plants to take up. Leaching is the downward movement of soluble nitrate through the soil with water (drainage). If this happens, during conditions favourable to leaching, nitrate may be lost below the plants root system, through the soil profile to groundwater.

Volatilisation and denitrification

Volatilisation and denitrification are the processes by which N is lost to the atmosphere as a gas (ammonia, nitrous oxide or N gas). Denitrification occurs in wet or waterlogged soils (e.g. in winter) and volatilisation tends to occur during drier warmer conditions (e.g. spring, summer and autumn). These pathways are a minor component of N losses.

Improving N conversion efficiency

A number of factors can result in low N conversion efficiency. These include:

- Low N output in milk relative to N input
- High N fertiliser use or feed input per ha for the kg MS produced per ha
- High proportion of N fertiliser applied in months with low pasture growth response and high rainfall
- Low feed conversion into milk by the herd
- N from the effluent system is used poorly to replace fertiliser N and to grow feed on the farm.

Low cost solutions

Improved feed conversion

Common reasons for low feed conversion are a high proportion of:

1. Feed being used for maintenance of cows – either too many cows or too few lactation days relative to days dry.
2. Feeding too many replacements.

Improving feed allocation means that more of the right feed is fed in the right amounts, at the correct time, to the most efficient cows. This is achieved by:

- Reviewing stocking rates, and calving (and drying off) dates (see section on CSR, p.7)
- Reducing the time that cows are on the farm but not producing milk going into the vat, e. g. cows being treated for mastitis, late calving cows or cows dried off early.

Better N fertiliser management

See "Reducing total N fertiliser applied annually" p.15.

Time off pasture to manage recycling of dung and urine

See "Using off paddock facilities to reduce N loss" p.26.

Better effluent management

See "Managing effluent systems" p.32.

Relative significance of factors that influence NCE

Table 1 below outlines the expected impact of a number of factors on NCE. It is not always possible to accurately predict the response to changing one of these factors as there are a number of interconnected parts. It is therefore extremely critical that any farm changes are considered across the whole farm system and evaluated for impacts on profit as well as impacts on NCE and N leaching.

A high MS/ha, or MS/cow, does not always mean more profit. Before targeting these to improve NCE, impacts on profitability for the whole farm system should be considered. Likewise high producing farm systems with high N inputs and high N outputs can have a high NCE but also still have high values for N leaching.

Research and various farm reviews have, however, shown that in general these responses in Table 1 are the most likely responses.

For all farmers the focus should be on improving NCE without excessive N leaching while maintaining and/or enhancing profit. This can be achieved by optimising the efficiency of the farmer's chosen system.

Table 1. Ranking of factors that influence N conversion efficiency (NCE).

Ranking	Factors	Input	Likely change	Application on farms
1	Annual N fertiliser rate applied (kg/ha)	High	Increased N fertiliser usually reduces NCE.	On many farms increased N fertiliser is likely to increase N leaching.
2	MS/ha or MS/cow	Medium	Increased MS/ha or MS/cow usually increases NCE.	Increased MS/ha is also likely to increase N leaching per ha unless done without increasing total N inputs.
3	Cows/ha	Medium	Increased cows/ha slightly increases NCE.	Where farms are still developing and increasing pasture production, stocking rate increases accompanied by MS/cow increases should improve NCE. However N leaching may also increase unless total N inputs are kept constant.
4	Wintering-off	Low	More wintering off has slight beneficial effects on NCE.	This only applies to the milking platform, and may not reduce the N leached/ha if the land area where the cows are wintered is also included in the assessment.
5	N content in feed	Low	Lower feed N in imported feed can improve NCE.	Requires a significant substitution of a high protein supplement with a lower protein supplement such as maize silage to reduce the surplus N intake of cows.

Where catchment limits are in place the focus will be on meeting the farm's N leaching limit, and being profitable within that limit. The suggested first step is to review factors that can affect NCE and that can reduce the N surplus; then mitigate the amount of loss from any remaining N surplus (see p.9 Figure 4).

Good management practices for influencing N loss

This section outlines the key strategies which will impact on N loss (nitrate leaching).

The main points from each of these strategies are summarised below.

Reducing total N fertiliser applied annually (page 15)

- Reducing annual N fertiliser use per ha potentially reduces a farm's N surplus and therefore N leaching. Annual pasture production per ha will also be reduced
- Research results show a diminishing DM response to N fertiliser at annual rates above 200kg N/ha. The research also demonstrated that annual rates above 200kg N/ha could not be justified economically due to the high cost associated with harvesting the extra grass grown
- At annual rates of less than 200kg N/ha research shows that MS production will drop by approximately 1kg for every kg of N fertiliser not applied
- To manage reductions in N fertiliser where less than 200kg N/ha is used requires appropriate farm system changes to ensure profit is maintained
- Reduced N leaching will be greater on farms where applied N use is high relative to milksolids production (i.e. less than 6kg of MS/kg N)
- There is a wide range in efficiency of N fertiliser use on dairy farms, as indicated by the ratio kg MS produced per kg N applied.

Getting the best response to N fertiliser (page 18)

- Avoid direct leaching associated with applying in winter and to waterlogged soils
- Optimise response rates and pasture utilisation
- Ensure other nutrients are not limiting
- N is a cost effective way of increasing feed supply.

Grazing cows off in winter (page 21)

- Grazing cows off the farm during winter will reduce the N leached on the milking platform and can have positive physical effects on soils and pasture grown
- Wintering-off will mean there is more feed on farm at the planned start of calving (PSC) unless the calving and/or drying off dates change, or changes are made to the amount of supplements or N used
- If pasture covers are higher at the PSC then it will be possible to feed cows better through the early stages of lactation and/or reduce supplement use
- Grazing-off during winter should be evaluated by comparing the milk price and extra production versus grazing costs.

Using off paddock facilities (page 26)

- Off paddock facilities, such as feed pads and stand-off pads, can be used to reduce N loss by intercepting the N from dung and urine
- The mitigation opportunity is greatest over autumn, where N deposited will be at risk of leaching over the coming winter months
- Restricting grazing to 8 hours a day over the autumn/winter period, without supplementary feeding, has been shown to have no impact on production, but has the potential to reduce N leaching by 15-20%
- Use of off pasture facilities may cause animal health and welfare issues, in particular where existing structures were not designed to hold cows for extended periods. If off pasture facilities result in intensification (i.e. more feed is used), then more N may be introduced into the system and undo the environmental benefit
- Off pasture facility construction is a capital intensive process and appropriate long term budgeting techniques are required to ensure that the cost benefit ratio is positive.

Winter crop management (page 29)

- Mineral N leaching can be reduced by minimal or no tillage establishment methods
- Urine N leaching can be reduced through paddock selection, forage crop selection, grazing timing and regime
- Timing and placement of fertiliser applications can affect leaching. The use of crop calculators and precision application can ensure appropriate timing and application
- Winter fallow leaching can be reduced though the use of a cover crop or cultivating as late as possible.

Managing effluent systems (page 32)

- Application rates (depth of applied effluent) should be low enough to prevent losses of nutrients below the root zone
- Storage ponds/tanks should be of sufficient size to prevent the necessity of irrigating onto wet soils and to allow for easier management of farm dairy effluent (FDE) systems during busy times of the year. Storage ponds/tanks must be sealed (i.e. not leak)
- Efficient water use and rainwater diversions can significantly reduce the FDE storage requirement
- Effluent blocks should be sized correctly to ensure efficient use of nutrients.

Culling cows early in autumn (page 34)

- This will remove some urinary N from pasture during a risk period
- It will also reduce feed demand
- This may allow a reduction in fertiliser application or imported feed
- Before introducing you need to compare the lost milk production and revenue against saved costs.

Calculating Comparative Stocking Rate (page 36)

- Comparative stocking rate (CSR) calculated as the kilogram liveweight per tonne of dry matter (kg Lwt/t DM) offered, is a method of assessing the balance between feed demand and supply on farm
- Getting CSR as close to optimum as possible increases feed conversion efficiency and helps reduce N surplus
- Getting as close as possible to the optimum of 75-80 will help improve profitability.

Reducing total N fertiliser applied annually

- Reducing annual N fertiliser use per ha potentially reduces a farm's N surplus and therefore N leaching. Annual pasture production per ha will also be reduced
- Research results show a diminishing DM response to N fertiliser at annual rates above 200kg N/ha. The research also demonstrated that annual rates above 200kg N/ha could not be justified economically due the high cost associated with harvesting the extra grass grown
- At annual rates of less than 200kg N/ha research shows that MS production will drop by approximately 1kg for every kg of N fertiliser not applied
- To manage reductions in N fertiliser where less than 200kg N/ha is used requires appropriate farm system changes to ensure profit is maintained
- Reduced N leaching will be greater on farms where applied N use is high relative to milksolids production (i.e. less than 6kg of MS/kg N)
- There is a wide range in efficiency of N fertiliser use on dairy farms, as indicated by the ratio kg MS produced per kg N applied.

Likely impact on N leached

The direct impact of fertiliser N applications on N leaching is low unless N is applied to wet soils or when heavy rain is imminent. Most N leaching occurs from urine patches during winter drainage events, not from applied N fertiliser.

Data from dairy farms in the lower North Island area however showed that for every kg of N fertiliser added per ha, the N surplus increased by 0.9kg/ha. This is because the indirect impacts from applying N fertiliser are significant. The use of N fertiliser typically results in increased stocking rates, more feed eaten per ha, and more urine patches with higher concentrations of N in urine.

A reduction in N fertiliser application will therefore indirectly decrease a farm's N surplus and therefore N leaching, provided efficient milksolids production (kg MS/kg N applied, kg MS/kg DM) is maintained from the reduced N input. A 10 year farmlet trial near Hamilton measured a reduction in N leaching from 35 to 20kg N/ha/year (40% reduction) by reducing N applications from 180kg N/ha/year to none.

Key considerations

Modelling of appropriate farm system changes when N fertiliser is reduced is needed to ensure profit is maintained.

Ratio of milk price to the cost of N

The ratio between milk price and the cost of applying N is an important indicator of the likely profitability of N use. Building a farming system dependent on high levels of N fertiliser use does not guarantee high profitability. In the past decade there have been times when a low milk price and high N cost (milk price less than $5.50/kg MS, and N applied $2.20/kg) has meant that the ratio was unfavourable for the profitable use of N. When the ratio is favourable, good management practices are needed to ensure N fertiliser is used effectively, and applied so that the extra feed generated is eaten by the herd and converted efficiently into milksolids.

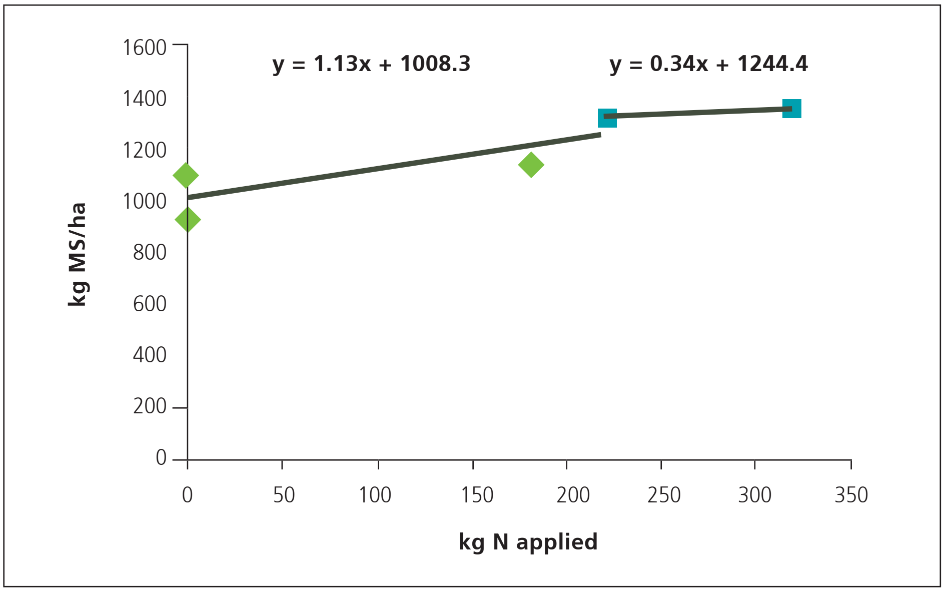
Use of extra feed

Applying N to provide additional pasture growth that remains uneaten, or has to be converted to hay or silage through more expensive harvesting and feeding out processes, is undesirable if these surpluses are not part of the normal farm system.

Research results show a diminishing DM response to N fertiliser at annual rates above 200kg N/ha. The research also demonstrated that annual rates above 200kg N/ha could not be justified economically due the high cost associated with harvesting the extra grass grown.

Figure 6 illustrates the diminishing response of MS/ha as N application increased. This graph indicates that 1.13kg MS was added per kg N applied up to 219kg N applied. Between 219 and 319 kg N applied only 0.34kg MS was added per kgN.

Figure 6: The relationship between annual N applications /ha and kg MS/ha



Comparing the ratio of kg MS per ha and kg N applied per ha with other similar farms will provide a guide to how well applied N is contributing to the production system. If there is a low ratio of kg MS produced per kg N/ha for your farm (less than 6kg MS/kgN) it is more likely that N fertiliser can be reduced without impacting negatively on profit.

Timing

The timing of fertiliser N applications can influence the amount of N leached. Winter applications of N, when pasture growth is low and drainage of water through the soil is high, will result in increased N leaching from applied fertiliser. The discontinuation of N applications in winter, when compared with any other time of the year, will most likely improve the efficiency of use of applied N and reduce N leaching, while having minimal impact on pasture production.

Details

Less annual pasture grown

Annual pasture production per ha will most likely be reduced with less N applied so adjustments need to be made to feed demand and feed supply to keep the CSR within the 75-80kg Lwt/t DM range and also adjusting calving date so that calving is no earlier than 60 days prior to spring balance date.

The reduction in annual pasture yield will depend on the N response achieved (extra kg DM grown per kg N applied). At a response rate of 10kg DM/kg N applied using 100kg N/ha less will result in 1 tonne DM/ha less feed, which requires a reduction in 0.18 cows/ha (450kg liveweight).

Be sure you understand the N response rates and time of application for your region. For example in a 10 year farmlet trial the response was an extra 16kg DM/kg N applied. Removing 180kg N/ha of fertiliser reduced pasture production by 2.8 tonnes DM/ha/year .

Changes to feed demand/supply balance and comparative stocking rate

The adjustment to the feed demand/supply balance in the farm system because of a 1 tonne DM/ha reduction in pasture yield can be estimated using the comparative stocking rate (CSR). A calculator is available on the DairyNZ website to assist with this process (dairynz.co.nz/csrcalc) and an example calculation is provided on page 36.

Buying imported supplement to replace N fertiliser

When reducing N, farmers could choose to replace the feed not grown by purchasing the equivalent amount as supplement, e.g. 1 tonne DM/ha reduction in pasture grown could be replaced by 1 tonne DM/ha of maize silage. The impact of doing this on the farm's N surplus needs to be considered. While maize silage is considered a low N content feed, it still contains 10kg N in every tonne DM. 100 tonnes of maize silage DM is equivalent to adding 1000kg N to the farm's N input.

The use of supplementary feed also requires a whole farm financial analysis as there are costs related to its purchase, storage and feeding. You also need to be sure that milk production levels can be maintained by using a supplement instead of N boosted pasture, as key components of a supplement, such as energy values and protein content, will differ from pasture. For example 1 tonne DM of maize silage contains approximately 1000 MJME less than one tonne of N boosted spring pasture. The timing of supplement use in relation to seasonal feed supply will also influence the production response and its economics.

Supporting information/tools

See Comparative Stocking Rate p.8 and p.36

Comparative Stocking Rate calculator – dairynz.co.nz/csrcalc

Getting the best response from N fertiliser

- Avoid direct leaching associated with applying in winter and to waterlogged soils
- Optimise response rates and pasture utilisation
- Ensure other nutrients are not limiting
- N fertiliser is a cost effective way of increasing feed supply.

Likely impact on N leached

The application of N fertiliser results in an increase in feed grown which can be converted into milk, but more feed going through the cow will increase the N leached relative to using no N. Optimising the response rates to N fertiliser will reduce N leaching by requiring less fertiliser per kg DM produced. Also if the extra pasture grown can fill feed deficits (thereby improving animal/farm efficiency) and when N is utilised well, the efficiency of N will be maximised.

Avoid direct leaching by minimising or eliminating late autumn/winter use when drainage occurs more often and responses are lower. Also, avoid applications prior to heavy rainfall or irrigation as the more water flowing through the soil profile the greater the risk of leaching.

Late autumn/winter use can also increase cow grazing days in this period which also increases N loss.

Key considerations

Make sure your N fertiliser is used efficiently by ensuring high response rates and utilisation of extra feed such as during a feed deficit period. However as N fertiliser increases the feed grown per ha it also increases the amount of N processed by the cow if eaten. This increases the N surplus per ha as N is not used with 100% efficiency in the animal.

If considering reducing N fertiliser, and hence the feed supply, ensure you quantify the impact and alter the feed demand as required.

Table 2. Impact of pasture growth on response rates to N fertiliser (N applied at optimum rates)

Pasture growth rate	Pasture growth (kg DM/ha/day)	Response (kg DM/kg N)	Time for full response (weeks)
Slow	10	5	10-14
Moderate	20-40	10	6-8
Fast	50-70	15	5-6
Rapid	80	20	3-4

See *DairyNZ Farmfact 7-10 Nitrogen fertiliser*

Details

Response rates are governed by a number of factors including: timing and rate of application, availability of other nutrients, pasture condition and rainfall. These factors are outlined in detail below.

Table 3. Factors which will affect the response to N fertiliser

	Likely responses	
Factor	**High**	**Low**
Prevailing growing conditions	good	poor
Season	spring	winter
Weather conditions	rain	freezing/drought
Soil water	adequate	waterlogged
Soil temperature	6°C to 17°C	less than 6°C or greater than 17°C
Application rate	20 to 40kg/ha	greater than 60kg/ha
Other nutrients (P,K,S)	optimal levels	less than optimum
pH	5.8-6.0 (mineral soils) 5.0-5.5 (peat soils)	less than 5.8 or greater than 6.0 (mineral soils) less than 5.0 or greater than 5.5 (peat soils)
N available from other sources	inadequate	adequate
Feed supply and interval to next grazing (round length)	inadequate	adequate
Sward conditions and composition	ryegrass	weed grasses, pugged
Product used	correct for weather conditions	

N fertiliser is a growth multiplier; when pasture growth rates are high the response to N will be higher, with greatest response rates achieved in spring. There are lower response rates in autumn nevertheless fertiliser N may still provide the lowest cost feed source. Early winter applications give the lowest growth responses and are most likely to lead to direct leaching of fertiliser N. During a dry summer N may be lost through volatilisation before it can be utilised and plant growth restricted. All forms of N produce the same amount of dry matter per kg N, if applied correctly.

It is important to avoid application to waterlogged soils or before heavy rainfall. Ensure adequate soil moisture and optimal temperatures (6-17°C).

Efficiency begins to decrease at rates about 60kg N/ha hence application rates of 20-40kg N/ha are recommended for grazing. All other nutrients need to be at optimum levels to allow optimal pasture growth and therefore response rates. Remember, for every 1kg N applied as urea, about 1kg lime is required to neutralise acidity. Avoid grazing between 4 and 14 days post application as this leads to high N intake and excretion by grazing animals. When using N, canopy closure will typically occur at a lower leaf stage. Ideal pre-gazing yields of 2600-3200 are recommended with grazing residuals of 7-8 clicks on a rising plate meter.

Ensure feed demand and supply is aligned to ensure high utilisation of pasture is achieved. Use the following monitoring and management methods:

- Strategic: feed budgeting, stocking rate
- Tactical: monitoring – farm walks, pasture wedge
- Operational: pre-gazing covers, residuals, pasture utilisation.

Nitrogen responses will be greater in ryegrass dominant swards. Spring and autumn applications promote increased tillering and vegetative growth. For more information see the pasture renewal guide (search: pasture renewal guide on the DairyNZ website dairynz.co.nz) and the Forage Value Index (dairynzfvi.co.nz)

Growth promoters such as Gibberellic acid promote leaf and sheath elongation but are not substitutes for fertiliser. Generally, the response when used with N is additive and it should be used in spring to fill a feed deficit and in autumn to stimulate growth before winter which will utilise some N.

Clover contributes 170 to 220kg N/ha/yr at 30-40% content in the sward. N fertiliser reduces N fixation by clover by about 1kg N/ha/yr for every 3kg N fertiliser applied. Although spring applications of N fertiliser affect clover N fixation less than other times of the year, high growth rates at this time of year also means that clover can be out competed resulting in less clover in the sward.

Response rates achieved on farm could be assessed with simple trials such as covering an area of the paddock with a canopy when fertiliser is being applied, or applying N fertiliser to half of the paddock and assessing the difference in dry matter production at grazing time.

Supporting information

DairyNZ Nutrient management on your dairy farm.

DairyNZ Technical Series: Issue 12, October 2012, p.2. Fertiliser use: response to nitrogen and phosphorous

DairyNZ Farmfacts

7-1: Plant nutrition

7-2: Determining fertiliser nutrient requirements

7-5: Critical nutrient levels for pasture

7-10: Nitrogen fertiliser

7-11: Seasonal nitrogen use

7-16: Nitrogen use going into summer

7-17: Nitrogen use after a dry summer

7-23: Minimising nitrogen loss

Grazing cows off in winter

- Grazing cows off the farm during winter will reduce the N leached on the milking platform and can have positive physical effects on soils and pasture grown
- Wintering-off will mean there is more feed on farm at the planned start of calving (PSC) unless the calving and/or drying off dates change, or changes are made to the amount of supplements or N used
- If pasture covers are higher at the PSC then it will be possible to feed cows better through the early stages of lactation and/or reduce supplement use
- Grazing-off during winter should be evaluated by comparing the milk price and extra production versus grazing costs.

Likely impact on N leached

Wintering cows off will reduce the N leached from the milking platform because one of the key contributors to N entering the soil (and therefore becoming susceptible to leaching) is urine deposited by cows.

There may be a reduction in the effectiveness of this strategy due to feed saved on farm being used in some other way. For example, wintering-off also allows a change to milking later in autumn or calving earlier in spring. These options will both mean more N leached at these times, offsetting some of the gains made from wintering-off.

If by wintering-off, less N is used and less feed is grown and used on the milking platform, then this will reduce N leached; however the overall impact on profitability will also need to considered.

Grazing-off is not a solution at a catchment level unless winter grazing is in a different catchment.

Key considerations

Grazing cows off in winter is a major change to the farm system which can bring a number of potential benefits. It means feed that otherwise would be needed during this period can be used in other ways potentially increasing farm income, particularly if it is used to increase milk production.

There are, however, risks (see p. 24 other considerations) to manage and the effects on the overall farm system needs to be considered. The net benefit from a financial perspective will depend on the cost of grazing versus the return from the extra feed available on the milking platform for milking cows (see worked example in Table 4).

Table 4. Value of feed saved at different milk prices

Number cows grazed off	100
Feed saved/cow/day	10 kg DM
Number of days	61
Feed saved (available for extra days in milk)	61,000 kg DM

	Addition revenue		
Milk price ($/kgMS)	$6.00	$7.00	$8.00
Utilisation of saved feed			
100%	$28,154	$32,846	$37,538
90%	$25,338	$29,562	$33,785
80%	$22,523	$26,277	$30,031

Assumes a conversion factor of 13kg DM/kgMS or approx. 80g MS/kg DM

Excludes costs of wintering-off.

Details

On farm options if utilising grazing-off

Milk longer in autumn

If all of the feed saved by grazing-off is used for milk production then there will be little reduction in N leached as the total feed, and therefore N going through the cow has not changed.

Milking longer into the autumn increases the urine N loading in the soil prior to the winter period which is the higher risk period for leaching. There is also more risk attached to milking longer in autumn as dry years could reduce your ability to continue milking.

Calve earlier

Farm modelling shows that the impact on profit of moving your calving date a few days either way, either earlier or later than currently, does not change profit that much.

However, especially in summer dry areas, the more production gained before the onset of summer the better, as it will reduce the influence of summer/autumn dry spells on total production. Calving earlier to utilise extra feed will generally be a better option and will have less negative implications for N loss than milking longer in the autumn.

Reduce N fertiliser

Applying less N will have the biggest impact on N leached although this is an indirect effect of feed grown and used.

Assuming 30kg N/ha is normally applied in April and August to build feed for winter and spring and average response rates of 10kg DM/kg N and 15kg DM/kg N respectively, grazing off 100 cows as in Table 4 could mean it is possible to reduce the area N is applied to by 80ha. This is calculated as follows:

80ha × 30kg N/ha × 10kg DM/kg N = 24000kg DM plus 80ha × 30kg N/ha × 15kg DM/kg N = 36000kg equals 60,000kg DM in total removed (the same amount "saved" by grazing-off). In this case, a total of 4.8 tonne less N can be used.

Fewer supplements used

There may be opportunities to decrease the bought in supplements. For example, an extra 300kg DM/ha at PSC is equivalent to needing 2.2 to 2.3 less bales per ha (150kg DM/bale) when differences in quality and utilisation are factored in. The impact of this on N surplus will depend on a number of factors:

- Is the baleage still made but sold off the farm instead?
- Does this mean less N is used?
- What type of supplement is being used and will its nitrogen content be different from pasture?

Usually changes in feed N content will only have a small impact unless large amounts of supplement are used and/or the feed crude protein levels are very different. The cost effectiveness of the supplement on an energy basis is the most important criteria for selecting supplements.

Increase cow numbers

If winter grazing is being used to reduce the N leached then increasing the number of cows milked may increase the N leached. This will need to be checked in OVERSEER®.

Other considerations when grazing-off

Reduced pasture damage and wastage

Grazing-off can increase the amount of pasture grown during winter. If you don't have to feed out or graze pastures in very wet conditions then wastage will be reduced and the soil compaction and pugging from stock or machinery (feeding out) will also be reduced.

It is important to ensure that when cows leave the farm pasture covers are low enough to prevent pasture losses from death/decay before the cows return.

Grazing contract terms

Experience has shown that wintering off works best when there is a written agreement that covers at least the following points and there is good communication and regular farm visits along the way, especially when the arrangement is a new one. It takes time to ensure everyone is clear on expectations.

1. Duration and type of contract
    - Will the agreement be based on a feeding rate (e.g. cents per kg DM/cow/day) or a flat rate (e.g. $/cow/week)? How will performance be checked or measured?
    - How much will be paid, due date, recourse if not performing?
    - What happens if there is a flood, snowfall or other event that impacts on feed supply? What is the grazier responsible for?

2. Feed/supplements
    - What type, quantity and quality? When will they be fed and at what rates? (this includes saved pasture).
    - How will dry matter percentage (DM%) and energy (MJME/kg DM) be assessed and allocated? Does the grazier pasture score/understand kg DM?
    - Will there be sufficient feed to meet your winter grazing requirements as well as the pasture cover required by the grazier at the end of the contract period? (see p.40 for an example feed budget).
    - Can the grazier feed different mobs different amounts, meaning you will achieve minimum body condition score targets? Who will monitor stock condition and determine if feeding rates are adequate?

      NB: the feed quality will impact on the amount needed and the live weight gain achieved. For instance, stock requiring 10kg DM of good quality pasture (11 MJME/kgDM) will need 10% more pasture DM fed if half their diet is poor quality silage (at 9.0 MJME/kgDM).

3. Stock health
    - What things should the grazier be concerned about, avoid doing and do?
    - What drenches or animal health treatments are required? Who will supply, pay for them and do the work?
    - If stock are ill, what process does the grazier follow? Do they need to check with the owner first before acting and what happens if the owner cannot be contacted?
    - How are abortions to be noted and verified?
    - The TB, BVD and Theileria status of the farm need to be checked before entering an agreement. How will you ensure the status is maintained while stock are there (movement control, records, exclusion zone)?

4. Yarding
    - How often is this required and what for?
    - How much notice is required, or are the dates set?
    - Who does the work?
    - What are the labour costs for weighing or other stock work?
    - Who meets these costs (owner or grazier)?

5. Stock losses
    - What losses is the grazier responsible for?
    - Is a percentage allowed before any cost is imposed on the grazier or does the grazier pay for all losses?
    - What price is paid for dead animals (or how is it calculated)?
    - How and when are losses or adjustments accounted for?

Supporting information/tools

Table 5. Cost of grazing – ready reckoner

	kg DM eaten/cow/day			
	10	**11**	**12**	**13**
$/cow/wk	**Grazing fee (cents/kg DM)**			
20	29	26	24	22
22	31	29	26	24
24	34	31	29	26
26	37	34	31	29
28	40	36	33	31
30	43	39	36	33
32	46	42	38	35
34	49	44	40	37

Using off paddock facilities

- Off paddock facilities, such as feed pads and stand-off pads, can be used to reduce N loss by intercepting the N from dung and urine
- The mitigation opportunity is greatest over autumn, where N deposited will be at risk of leaching over the coming winter months
- Restricting grazing to 8 hours a day over the autumn/winter period, without supplementary feeding, has been shown to have no impact on production, but has the potential to reduce N leaching by 15-20%
- Use of off pasture facilities may cause animal health and welfare issues, in particular where existing structures that were not designed to hold cows for extended periods are adapted for this purpose
- If off pasture facilities result in intensification more N can be introduced into the system and undo the environmental benefit
- Off pasture facility construction is a capital intensive process and appropriate long term budgeting techniques are required to ensure that the cost benefit ratio is optimised.

Likely impact on N leached

Where off paddock facilities, such as a feed pad, stand-off area or barn are used on farm they intercept the dung and urine that would otherwise fall on the paddock. It can then be collected and the effluent system utilised to spread the N across the farm uniformly rather than it falling in concentrated patches that are more susceptible to leaching. If sufficient storage is available, effluent irrigation can also be delayed until ground conditions are most suitable and plants are actively growing. In these situations plant take up more of the N applied and N leaching can be reduced further.

Where such facilities are already part of the farm system, adapting them to extend the amount of time that the cows are off-pasture can contribute to reduced leaching. This is especially true in autumn, as N deposited over this period is particularly susceptible to leaching because:

- N builds up in the soil over dry months
- Pastures are growing more slowly and are less able to utilise the N deposited
- The onset of winter tends to bring more rainfall (i.e. more drainage events) which will wash surplus N through the soil profile resulting in leaching.

Key considerations

Because a significant investment is required to construct an off-pasture facility financial implications must be carefully considered. Risks that may arise through adopting this strategy include:

- The risk of over-capitalising the business, which can occur because of high initial build costs and the cost of additional equipment purchased over time to operate the new system. It can be hard to recoup the cost of this additional investment meaning that the return on the investment as a whole can be lower than expected.
- Reliance on milk revenue less feed price as a marginal indicator of profitability. This marginal approach underestimates costs, especially the cost of capital. A full system analysis should be carried out considering the impact on all aspects of the business.
- Underestimating how operating costs, especially R&M, will change with intensification.

Such financial outcomes generally occur over the long term and need to be clearly understood. Appropriate budgeting techniques that account for the long term nature of the investment, such as net present value or internal rate of return, need to be used.

Details

Impact of time off pasture on N leaching and production

A dairy cow typically excretes 65-75% of the N consumed as surplus in urine and dung. The average cow will excrete 25 litres of urine per day over 8-12 urinations, with the resulting N application at the urine patch being equivalent to 700-1000kg N/ha. Restricting the number of urinations occurring on pasture during "at risk" times of the year can significantly reduce N leaching.

A DairyNZ study investigated the impact of restricted grazing practices on production in late lactation using three grazing duration treatments:

1. 1x8hr, one continuous eight hour period of grazing.
2. 2x4hr, eight hours of grazing split between two periods of four hours following each milking.
3. Control, normal 24 hour grazing practice.

When not on pasture the cows were stood off on a lined loafing area to capture urine and dung. While they were on the stand-off facility they had access to water but were not fed.

The trial found that 4-5 urinations occurred on the stand-off facility which captured 40-50% of the urine excreted during the period of the restricted grazing treatments. This was estimated to reduce N leaching over the following drainage period (winter) by 15-20% on both the 1 x 8hr and 2 x 4hr treatments.

The impact on production of this extended time off-pasture was minimal provided:

- The cows were eased into the grazing regime over 3-5 days (ie length of time gradually increased to this 8 hours
- No significant increase in the distance walked during the day occurred
- If used outside of late lactation e.g. when cows are producing close to peak MS/cow the grazing needs to be offered in 2x4hr grazing periods.

This research showed that it's possible for cows to consume all their daily intake requirements during restricted grazing without the need for additional supplements. Cows will readily adapt their grazing time and rate of pasture intake to a change in grazing routine. This means farms relying mostly on grazed pasture can also use standing off to help reduce the urinary N output to pasture in autumn.

However, if additional feed is added into the system this introduces more N to the system, some of which will be excreted and be at risk of leaching, potentially undoing the benefit of stand-off.

Impact on pasture

In addition to the potential benefits from reduced N leaching, restricting grazing time in autumn is useful for grazing management in drier, non-irrigated dairy areas. Standing off paddock can prevent cows grazing below the recommended pasture residuals during dry periods. The stand-off facility can also be used over winter to protect soils from damage, contributing to overall pasture production. The overall impact on pasture is likely to differ regionally and will be dependent on both rainfall and soil types. The DairyNZ trial reported above was unable to detect any difference in pasture eaten between treatments in the Waikato.

Animal welfare

Adapting existing facilities that are not designed to hold animals for long periods of time for stand-off purposes (e.g concrete yards) can result in animal husbandry concerns. Where cows are off pasture for long periods they need sufficient area to lie down. The surface of the facility needs to be wood chip or similar and managed to encourage cows to lie down and prevent lameness. Redesign of the facility may be necessary before a standing off area can be used for extended holding times.

Shade

The provision of shade in the stand-off area may help alleviate heat stress, so long as it does not restrict air movement and increase relative humidity. Water (e.g. using a sprinkler in the holding yard of the dairy) is more effective in reducing respiration rate and core body temperature but cannot be used in typical stand-off areas.

Animal health

As the length of time cows spend in a stand-off facility increases extra vigilance will be required to ensure animal health problems do not become an issue, for example, mastitis. The close proximity of cows for extended periods will also increase the risk of disease transfer.

Effluent system design

Stand-off facilities intercept dung and urine, which needs to be contained and dealt with by an effective effluent system. The capacity of the system to deal with extended periods off pasture must be evaluated to ensure it remains compliant.

Covering the facility

Covering the stand-off facility is a means of reducing the amount of rain falling on the surface and therefore maintaining the stand-off surface in better condition for longer. It has the added benefits of reducing the need to upgrade the effluent system but will add to construction costs of the stand-off area.

Supporting information/tools

DairyNZ Farmfacts

- 7-25: Standing cows off pasture – a potential mitigation strategy to reduce nitrate leaching
- 1-9a: Standing cows off – how cows change grazing behaviour
- 1-9b: Standing cows off – impact on pasture intake and milk production
- 8-2: Feed pad design and construction
- 8-3: Feed pad management and maintenance

Stand-off pads dairynz.co.nz/publications/farm/stand-off-pads/

Winter crop management

- Mineral N leaching can be reduced by minimal or no tillage establishment methods
- Urine N leaching can be reduced through paddock selection, forage crop selection, grazing timing and regime
- Timing and placement of fertiliser applications can affect leaching. The use of crop calculators and precision application can ensure appropriate timing and application
- Winter fallow leaching can be reduced though the use of a cover crop or cultivating as late as possible.

Likely impact on N leached

Winter crops are used because they provide large quantities of standing feed on a relatively small area at a time when pasture is in short supply. However, they present a significant challenge to the management of N leaching.

A literature review carried out by AgResearch has shown that the main causes of nitrate leaching from winter crops are caused by:

- **Mineral N leaching**
  When mineral N concentrations are too high to be taken up by the crop as it grows. High concentrations can come from the decomposition of the preceding pasture sward, crop residues or where excessive fertiliser remains in the soil in late autumn following cultivation and forage crop establishment in the preceding spring.
- **Urine N leaching**
  The deposition of large amounts of urine N onto bare soil when a forage crop is grazed over winter, a period when plant uptake is low and drainage likely.
- **Timing and placement of fertiliser applications**
  If fertiliser is applied in large amounts, or when and where the plant is unable to make use of the N.

Key considerations

Reducing the risk of mineralised N leaching

In order to reduce the risk of mineral N leaching, farmers need to avoid creating the conditions which stimulate N mineralisation, mainly cultivation. There is evidence to suggest that minimal or no tillage crop establishment techniques can substantially reduce the N leaching generated from soil mineral N. As an added benefit, minimum or no tillage following a pasture can benefit soil quality, nitrous oxide emissions and crop performance.

Reducing urine patch leaching

A cow will excrete high proportions of the N it consumes from feed (approximately 65-75% in urine and faeces); the majority being in urine. Urine has such high concentrations of N that plants are unable to use the available N before it is leached out of the soil.

The high density of stock which can graze on a winter crop (around 400 cows/ha/day), results in a greater density of urine patches and an increased risk of N loss to water over winter from this area. While this is N leaching to groundwater in the majority of cases, on sloping land or in the event of flooding, overland flow can also occur which is the main pathway for phosphorous, sediment and E.coli losses.

N loss from winter forage grazing can be significant and should not be underestimated. A trial at Woodlands in Southland estimated that the losses from the area used for winter forage grazing, which constituted only approximately 15% of the whole system area, represented approximately 44% of the whole farm system's N leaching losses.

Details

Research has shown that there are several measures that can be used to mitigate nitrate leaching from urine patches in crops.

Paddock selection

To avoid the risk of nutrient loss paddocks should not be selected for cropping if they have:

- Any waterways, temporary streams or natural drainage channels (running in times of high rain)
- Significant artificial drainage, such as mole or tile drains
- Significant slopes with risk of run-off/overland flow.

Timing of crop grazing and resowing

The later a crop can be grazed in winter the less time the soil will lie bare and nutrients at risk of leaching before another crop or pasture is established. Consider using other supplements first and graze winter crops as late as possible.

The results from a Central Plateau study indicated how important an influence the timing of forage crop grazing is on N leaching loss. Very high losses were measured from crops that were grazed in mid-June. These represented a "worst case scenario" due to the timing at the wettest part of the year (670-800mm drainage) and the extended period that the grazed paddock remained bare (site cultivated and drilled in late August).

Grazing management

Using controlled grazing regimes on winter crops (back-fencing and on-off grazing) reduces the risk of N leaching, run off, soil loss and compaction.

Forage crop selection and its effect on N in the urine patch

Grazing a winter crop with a lower crude protein percentage (CP%) can lower the amount of N excreted in urine and therefore the amount leached during a drainage event. Dry cows require approximately 12% CP.

Results from the Pastoral 21 trial at Lincoln University Research Dairy Farm have shown that N leaching from fodder beet crops is lower than kale. This is mainly due to lower N concentrations in the urine of stock grazing fodder beet (3g N/L versus 4g N/L) leading to less N per urine patch (300 versus 400 kg N/ha).

These differences in N leached need to be assessed against the whole farm N losses, total yields and cost per kg DM of feed grown, i.e. the benefits and costs need to be considered from a total farm systems perspective.

Table 6. CP% of different crops

Winter crop	CP%*
Kale soft stem and leaves	20
Green feed oats	13
Fodder beet	14

**Highest listed CP value*

Use of a "mop up" crop

Research from the Pastoral 21 trial at Lincoln University Dairy Research Farm showed that N left sitting in the soil after cows move off a crop is highly prone to leaching since a lot of drainage occurs in spring as well as winter.

'Mop-up' crops (also known as catch crops), such as annuals or summer crops, could be used to follow the winter crop and mop up the available N. Whether this is a feasible option will depend on the region (climate), if the crop is being grown on a support block or the milking platform and the sowing date of the subsequent crop. For example, if the next winter crop needs to be sown in the spring to make use of spring soil moisture, there is a limited window of opportunity to grow a mop-up crop.

Reducing fertiliser related leaching

Applications of N fertiliser to winter crops when the plant is unable to take up the fertiliser due to the plant not being established, environmental conditions or placement out of reach of the plant roots can result in direct N leaching.

Therefore, ensure the timing and placement of fertiliser applications enables N to be used by the plant. This can be facilitated by using crop, which calculate specific crop requirements, and where possible, precision fertiliser applications.

Supporting information/tools

DairyNZ Farmfacts

1-50: Feed values of NZ forages.

1-73: Fodder beet - feeding to dairy cows.

1-74: Kale - growing a high yielding crop.

1-75: Winter crops - feeding to dairy cows.

1-76: Swedes - growing a high yielding crop.

1-77: Fodder beet - growing a high yielding crop.

Southern Wintering Initiative Fact Sheet: Crop paddock selection www.dairynz.co.nz/sws

Ballance Agri-Nutrients crop calculators: available from Ballance.

Managing effluent systems

- Application rates (depth of applied effluent) should be low enough to prevent losses of nutrients below the root zone
- Storage ponds/tanks should be of sufficient size to prevent the necessity of irrigating onto wet soils and to allow for easier management of farm dairy effluent (FDE) systems during busy times of the year. Storage ponds/tanks must be sealed (not leak)
- Efficient water use and rainwater diversions can significantly reduce the FDE storage requirement
- Effluent blocks should be sized correctly to ensure efficient use of nutrients.

Likely impact on N leached

Storing effluent in an appropriately sized and sealed storage pond will significantly reduce the amount of N lost from the farm. If farms have insufficient storage they will be forced to irrigate when soils are actively draining creating direct losses of nutrients - particularly N.

Correctly storing effluent alongside reducing application depths will prevent the loss of nutrients below the root zone. Correctly sized effluent blocks will keep N losses from these blocks to a minimum due to the N application from effluent being better matched to the pasture N uptake.

Key considerations

Utilising the N provided by effluent can make it possible to reduce or eliminate the use of N fertiliser on the effluent area. Approximately 50% of the N in effluent is in a readily available form and each effluent application can supply around 30-50kg N/ha, but this should be measured on farm (to check the concentration of effluent nutrients and application rates).

Use an accredited effluent designer when making any changes or upgrades to your effluent system. An accredited designer will ensure your system is fit for purpose so that all legal requirements are met, with correctly sized ponds, irrigators that meet designed specifications for applied depths and correctly sized effluent blocks.

If installing a green water yard washing system remember to check out the rules prior to installation. Talk to your milk supply company or shed assessor about this too.

Details

The depth of applied effluent (measured in mm) should always be less than the soil moisture deficit at the time of application. If effluent irrigation occurs on soils that are too wet, then run off to surface water bodies or drainage below the root zone will occur, with valuable nutrients being lost from the farm and contaminating the environment.

Storage ponds and tanks

Storage ponds and tanks need to be sized correctly to allow for periods when the soil is too wet to allow irrigation and for when staffing issues make effluent irrigation difficult. The Dairy Effluent Storage Calculator (DESC) is used to size ponds. It looks at many variables including: climatic conditions (rainfall and evapotranspiration), soil type, water use, herd size, catchment areas (including yards, feed pads, silage bunkers etc.), storm water diversions, effluent irrigation depths and pump rates. To ensure accurate and realistic input data is used it is important to get a suitably experienced person to do the calculation for you. DairyNZ encourages the use of accredited companies to design effluent systems which includes the sizing of storage ponds and tanks. For a list of accredited design companies go to effluentaccreditation.co.nz.

Water use

Efficient water use in the shed can dramatically reduce the amount of FDE storage a farm needs and reduce the labour required for effluent irrigation. Water use minimisation can be achieved by scraping the yard prior to hosing, hosing with the correct pressure and flow rate (high flow and low pressure gives best results) and being conscious of poor water use practices. Stationary sprinklers and jets can often add thousands of litres per day to the effluent system, so either turn them off or keep their use to a minimum.

One way to reduce effluent volumes is to use recycled effluent (green water) to wash the dairy yard; this can reduce storage volumes by up to 50%. Before installing a green-water wash system there are some NZFSA rules to check (see the DairyNZ website, dairynz.co.nz - search: recycled farm dairy effluent).

Size of effluent block

You can use OVERSEER® to determine the right size for your farm's effluent block. Also check the rules and guidelines with your local regional council.

This is particularly important if you are utilising purchased supplements, feed pads or stand-off facilities, as supplements fed on feed pads can greatly increase the amount of nutrients captured by the effluent system.

It is important to:

- exclude all buffer zones from the size of the effluent block in OVERSEER®
- spread your effluent evenly across the entire effluent block each year
- spread any captured effluent solids outside the effluent block
- have samples of your solids analysed for nutrient value annually
- size the effluent block according to potassium (K) requirements.

Often blocks are sized to meet a compliance standard for N (150-200 kg N/ha/year from effluent). However potassium is an expensive nutrient to purchase, so ensuring the effluent block area is sized to use all the K being applied in the effluent, thereby preventing losses of this nutrient from your farm is cost effective.

Supporting information/tools

DairyNZ Farmfacts

5-18: Farm dairy water use.

6-15: Dairy effluent storage calculator.

6-41: Travelling irrigators measuring application depth.

Culling cows as early as practical in autumn

- This will remove some urinary N from pasture during a risk period
- It will also reduce feed demand
- This may allow a reduction in fertiliser application or imported feed
- Before introducing you need to compare the lost milk production and revenue against saved costs.

Likely impact on N leached

If animals are predominantly grazing pasture reducing the number of animals on the farm over the autumn period is likely to lower N loss. This is due to the reduced urinary N excretion onto pasture over a period where the N excreted is vulnerable to leaching as a result of the high risk of drainage occurring in the following winter period.

Key considerations

Reducing the feed demand in autumn may allow a reduction in the N fertiliser applied over a risky period (drainage season coming up), or reduce the amount of supplementary feeding. These changes may further reduce N leaching losses. It may also result in higher average pasture covers moving into winter which needs to be considered alongside the farm's wintering practices in determining the pasture management strategy in winter/early spring.

These changes need to be weighed up against the lost milk production and revenue from removing cull cows earlier than normal.

If the remaining cows are able to harvest the additional pasture, milk production may not fall by the full amount that the culls would have produced, as per cow production for the remainder of the herd could increase. In this situation it is unlikely that N leaching will fall by as much as if N fertiliser or supplementary feeding was reduced, yet this scenario may be financially beneficial.

Details

Removing culls early requires confirmed culling decisions (e.g. pregnancy testing, SCC decisions, low producers). What criteria will be used for these culling decisions and will all the necessary information be available at the right time?

Financial impacts need to be considered. Culling cows early could potentially reduce milk production (unless feed is used by other milkers). By culling low producers first it is sometime possible to maintain production because the feed from these culled cows allows others remaining in the herd to produce more.

Culling early could reduce expenditure. Supplementary feed imported, N fertiliser applied, and variable costs associated with milking (e.g. electricity/labour?) may all be reduced but will vary from farm to farm.

If short on feed due to a drought then culling early may be a sensible option, but if culling early becomes a permanent strategy then this removes an option for dealing with a feed shortage in a drought.

The following factors will also need to be considered in assessing the overall financial effect of culling cows earlier.

- Management of feed supply in response to decrease in feed demand. What was the daily allowance for these cows that is no longer needed? How will the pasture be managed to ensure that target residuals are still met?
- If the response is to feed the remaining cows more, what is the production response and additional revenue that you expect?
- What is the likely reduction in N leaching? Other factors need to be considered in this assessment, for example if the cows are off pasture in autumn for periods of time anyway, then the potential reductions in N leaching are not likely to be as large since only a portion of the urine N will be hitting the soil.
- Price received for cull stock. Is there likely to be a material difference in the price received for cull stock between months or not?

Only then can culling cows early be correctly costed and an assessment made of whether this is a more cost effective way of reducing N loss than other options?

Supporting information

DairyNZ Farmfacts

1-33b: Dry summer management – culling cows

2-2: Culling – selecting your future herd

1-2: Principles of grazing management

1-56: Return from feeding supplements in the autumn

1-37: Surplus management – identifying a surplus

1-38: Surplus management – options to manage a surplus

InCalf – The InCalf Book

Chapter 17: Choosing a pregnancy testing strategy

Chapter 18: Making culling decisions

Calculating comparative stocking rate (CSR)

- CSR calculated as the kilogram liveweight (Lwt) per tonne of dry matter (kg Lwt/t DM) offered, is a method of assessing the balance between feed demand and supply on farm
- Getting CSR as close to optimum as possible increases feed conversion efficiency and helps reduce N surplus
- Getting as close as possible to the optimum of 75-80 will help improve profitability.

The CSR calculation is a check for the appropriate balance between annual feed supply and feed demand on farm.

To calculate CSR (kg Lwt/tonne dry matter offered) for your farm you will require:

1. **An estimate of pasture grown (tonnes DM per ha) for your farm.**

   Annual pasture growth will ideally have been estimated from farm walks on your farm or a similar farm in your district. If not, then estimates for your farm can be obtained from the pasture eaten calculation in DairyBase or other similar estimates of pasture eaten based on energy requirements for production and maintenance (see DairyNZ Facts and Figures, Cow feed requirements, page 7), and an assumed utilisation factor.

2. **Actual or estimated average Lwt per cow for your herd.**

   Either weigh a sample of your herd or use default values based on your cow breed. The recommended times of year for weighing stock for this calculation are either two months before the start of calving, or mid-lactation, usually early December.

   To obtain an estimated or default Lwt value see NZ Dairy Statistics: Liveweight by age and breed of cow.

3. **An estimate of the kg DM supplied in supplements or cow grazing supplied from off the milking platform.**

The example over page shows how CSR is calculated and how the result is interpreted.

Example farm

100ha milking platform, 383 Cows, 3.83 cows per ha, 350kg MS/cow, 1344kg MS/ha, 500kg cow Lwt. Due to low production/kg Lwt (350/500 = 0.7) and evidence of continual underfeeding the suspicion is that CSR is too high.

Step 1: Calculate kg Lwt/ha		
Cow Lwt/ha	1915	Cows/ha x cow Lwt = 3.83 x 500
Step 2: Calculate total feed supply (t DM available/ha)		
Total feed required	19.9	Total feed = cows/ha x feed required/cow See cow feed requirements Facts and Figures page 7. From there, a 500 kg cow producing 350 kgMS needs to eat 5.2 t DM. = 3.83 x 5.2 = 19.9 tonne DM/ha
Feed from outside the milking platform (tonne DM/ha)		
Imported feed	1.3	
Winter grazing	2.5	
Pasture eaten	16.1	Total feed required minus total feed from outside milking platform = 19.9 - 3.8 = 16.1 tonne DM/ha
Pasture utilisation	90%	Assumed utilisation. For most farms this will be 80-90%
Estimate of pasture grown	17.9	Pasture eaten divided by pasture utilisation = 16.1 ÷ 0.9 = 17.9 tonne DM/ha
Total feed supply	21.7	Estimate of pasture grown plus imported feed plus winter grazing feed = 17.9 + 1.3 + 2.5
Step 3: Calculate CSR		
CSR	88	Cow Lwt/ha divided by total feed supply/ha = 1915/21.7

Achieving the optimum CSR

As noted earlier, the optimum CSR is between 75 - 80 kg Lwt/t DM. The following examples show how to calculate either the reductions in herd size or additions in feed required to achieve an optimum CSR of 80.

Option 1: Reduce herd size

Target kg Lwt/ha = total feed supply x desired CSR

= 21.7t DM/ha x 80kg Lwt/t DM = 1736kg Lwt/ha

New cows/ha = target kg Lwt/ha ÷ cow Lwt

= 1736/500 = 3.47 cows /ha

New herd size = hectares x new cows/ha

= 100ha x 3.47 = 347 cows.

Option 2: Buy more feed

Feed required = current Lwt/ha divided by the target CSR

= 1915/80 = 23.9t DM/ha, an increase from 21.7 tonne DM/ha

Additional feed required = feed required minus total feed supply

= 23.9 minus 21.7 = 2.2 tonne DM/ha

Overall farm impact

The profitability and farm performance resulting from both of these scenarios needs to be predicted to help determine which option will match the farm's circumstances and objectives.

This can be done by using the relationships between CSR and farm performance as determined by an analysis of 20 years of farmlet studies at DairyNZ.

- Annual pasture utilisation: a reduction in CSR of 1 unit resulting in 0.47% reduction in pasture utilisation
- Milksolids per cow: a reduction in CSR of 1 unit resulting in an increase in MS/cow of 4.5kg
- Milksolids production per kg Lwt: a reduction in CSR of 1 unit resulting in an increase in MS as % of Lwt of 0.75%.

From this it can be predicted that reducing CSR by 8 units (from 88 to 80) will result in:

- Decreased pasture utilisation of 3.8 % (from 90% to 86.2%)
  = 8 × 0.47%
- Increased kg MS/cow of 36 (from 350 to 386kg MS/cow)
  = 8 × 4.5kg
- Increased MS as a percentage of Lwt of 6% (from 70% to 76%)
  = 8 × 0.75%

A reduction in CSR with no change in feed supply (see Option 1 in Table 7), would enable MS/ha to be maintained at current levels. Where CSR is reduced by importing additional feed (Option 2) the prediction is an increase of 134kg MS/ha. To determine the consequences of choosing either alternative, you will also require information on how the economics and environmental indicators will perform.

Table 7. Predicted outcomes of farm performance for the example farm, where CSR is lowered by 8 units, from 88kg Lwt/t DM to 80kg Lwt/t DM

	Current situation	Option 1 Reduce herd size	Option 2 Buy more feed same herd size
CSR	88	80	80
Cows/ha	3.83	3.47	3.83
kg Lwt/ha	1915	1736	1915
t DM/ha more feed			2.2
kg MS/cow	350	386	386
kg MS/ha	1344	1339	1478
Pasture utilisation %	90	86	86

Environment

Option 1

Not expected to change N loss/ha significantly when compared with the current situation. A slight reduction in pasture eaten/ha may occur.

Option 2

More feed/ha is required, so N loss/ha will increase compared with the current situation unless there is investment in N loss reduction strategies.

Profitability

Option 1

Any increase in profitability will depend on the magnitude of savings derived from having fewer cows on the farm. For example, on a 350ha farm, the reduction of 0.36 cows/ha would equate to a 126 cow reduction in herd size and an associated reduction in per cow costs e.g. less labour units.

Option 2

This would incur the extra costs of purchasing and feeding additional feed, possibly some infrastructure costs, and the variable and capital costs of retaining cows.

Supporting information

DairyNZ Farmfacts

1-4a: Comparative stocking rate (CSR)

1-4b: Calculating comparative stocking rate

CSR calculator dairynz.co.nz/csrcalc

Winter grazing budget

Example feed budget calculation for a grazier (Figure 7)

- 200 cows grazed off from June 1 to July 31 (61 days)
- The grazier has set aside 65ha for stock
- The average cover is 2200kg DM/ha on May 1
- Pasture growth in May, June and July is expected to be 20, 10 and 6kg DM/ha/day respectively
- Required cover at end of July (the end of 61 day grazing period) is 1700kg DM/ha
- Feed required is 10kg DM/cow/day
- 50 cows need to gain one condition score which require additional feed
- The grazier will apply 30kg N to 30 hectares and expects a response of 10kg DM/kg N
- There are 250 bales of silage (180kg DM/bale) which will be fed in the paddock.

Will there be sufficient feed to meet these requirements and maintain the required pasture cover (e.g. an average of 1700kg DM/ha) on the grazing block at the end of the grazing period?

A blank feed budget form is also provided (Figure 8) and additional information to use when putting a feed budget together (Figure 9). This is also available on the DairyNZ website as an Excel calculator.

Figure 7. Example feed budget for a grazier

Winter Grazing Feed Budget

Name

Starting date for feed budget / /

Cows grazed off: 200

Effective Hectares on Grazing Block: 65

Feed Supply

Start Pasture Cover kg DM/ha V 2,200

1. Pasture Growth

Month	Days		Growth kg DM/ha/day		kg DM
May	30	x	20	=	39,000
June	30	x	10	=	19,500
July	31	x	6	=	12,090
		x		=	
		x		=	
		x		=	
Total DM/ha from growth (kg DM)				A =	70,590

2. Nitrogen No longer needed

No. ha nitrogen applied to	Appl'n Rate kg N/ha		Response kg DM/kgN		kg DM
30	30	x	10	=	9,000
		x		=	
		x		=	
N boosted pasture grown (kg DM)				B =	9,000

3. Pasture Utilisation (%) C = 90%

4. Total Pasture Supply (kg DM)=(A+B) x C = D 71,631

5. Supplement feed available over budget period

Type	kg DM		Wastage (%)		kg DM
250 bales baleage	45,000	x	80%	=	36,000
		x		=	
		x		=	
		x		=	
		x		=	
		x		=	
Total supplements (kg DM)				E =	36,000

4. Change in Pasture Cover Allowed

Start Cover	End Cover	Difference		kg DM
2,200	1,700	500	=	32500
		0	=	0
Change in Feed supply			F =	32,500

Total feed supply (kg DM) D+E+F = K 140,131

Feed Demand

Target pasture cover at end of grazing kg DM/ha Y 1,700

1. Total Stock on Grazing Block

Month	Number	kg DM/ cow/day		Days		kg DM
May	0	0	x		=	
June	200	10	x	30	=	60,000
July	200	10	x	31	=	62,000
			x		=	
			x		=	
			x		=	
Total DM Required for Stock (kg DM)					G =	122,000

2. Required by other stock on grazing block

Month	Number	kg DM/ cow/day		Days in month		kg DM
			x		=	
			x		=	
			x		=	
			x		=	
Total DM required (kg DM)					H =	0

3. Body Condition Score Gain (use DM/BCS) from table below)

No. of Cows		CS gain per cow		Total CS needed		DM/CS		kg DM
50	x	1	=	50	x	160	=	8,000
	x		=		x		=	
	x		=		x		=	
Total DM required (kg DM)							I =	8,000

Approximate amounts (kg DM) of commonly used feeds required for a 1.0 unit increase in BCS

		MJ ME/kg DM						
		Aut Past	Past Silage	Maize Silage	PKE	Kale	Swedes	Fodder Beet
Breed	Weight	11.5	10.5	10.5	11	11	12	12.5
J	400	165	130	130	100	175	145	125
JF	450	185	145	145	110	195	160	140
Fr	500	205	160	160	125	215	180	155
Fr	550	225	180	180	135	235	195	170

The requirements are above maintenance and pregnancy requirements and do not include any wastage.

Refer to DairyNZ body condition scoring the reference guide for NZ farmers, page 49 for the latest figures

Total Demand = (kg DM) G+H+I = L 130,000

Feed surplus/deficit of (K-L) 10,131 kg DM or 156 kg DM/ha (M)

Pasture Cover at End of Grazing Period 1,856 kg DM/ha

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Figure 8. Blank feed budget

Winter Grazing Feed Budget

Name

Starting date for feed budget / /

Cows grazed off

Effective Hectares on Grazing Block

Feed Supply

Start Pasture Cover kg DM/ha V

1. Pasture Growth

Month	Days		Growth kg DM/ha/day		kg DM
		x		=	
		x		=	
		x		=	
		x		=	
		x		=	
		x		=	
Total DM/ha from growth (kg DM)				A =	

2. Nitrogen No longer needed

No. ha nitrogen applied to	Appl'n Rate kg N/ha		Response kg DM/kgN		kg DM
		x		=	
		x		=	
		x		=	
N boosted pasture grown (kg DM)				B =	

3. Pasture Utilisation (%) C =

4. Total Pasture Supply (kg DM)=(A+B) x C = D

5. Supplement feed available over budget period

Type	kg DM		Wastage (%)		kg DM
		x		=	
		x		=	
		x		=	
		x		=	
		x		=	
		x		=	
Total supplements (kg DM)				E =	

4. Change in Pasture Cover Allowed

Start Cover	End Cover	Difference		kg DM
			=	
			=	
Change in Feed supply			F =	

Total feed supply (kg DM) D+E+F = K

Feed Demand

Target pasture cover at end of grazing kg DM/ha Y

1. Total Stock on Grazing Block

Month	Number	kg DM/ cow/day		Days		kg DM
			x		=	
			x		=	
			x		=	
			x		=	
			x		=	
			x		=	
Total DM Required for Stock (kg DM)					G =	

2. Required by other stock on grazing block

Month	Number	kg DM/ cow/day		Days in month		kg DM
			x		=	
			x		=	
			x		=	
			x		=	
Total DM required (kg DM)					H =	

3. Body Condition Score Gain (use DM/BCS) from table below)

No. of Cows		CS gain per cow		Total CS needed		DM/CS		kg DM
	x		=		x		=	
	x		=		x		=	
	x		=		x		=	
Total DM required (kg DM)							I =	

Approximate amounts (kg DM) of commonly used feeds required for a 1.0 unit increase in BCS

		MJ ME/kg DM						
		Aut Past	Past Silage	Maize Silage	PKE	Kale	Swedes	Fodder Beet
Breed	Weight	11.5	10.5	10.5	11	11	12	12.5
J	400	165	130	130	100	175	145	125
JF	450	185	145	145	110	195	160	140
Fr	500	205	160	160	125	215	180	155
Fr	550	225	180	180	135	235	195	170

The requirements are above maintenance and pregnancy requirements and do not include any wastage.

Refer to DairyNZ body condition scoring the reference guide for NZ farmers, page 49 for the latest figures

Total Demand = (kg DM) G+H+I = L

Feed surplus/deficit of (K-L) **kg DM or** **kg DM/ha** (M)

Pasture Cover at End of Grazing Period (M + Y) **kg DM/ha**

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Figure 9. Additional information to use for calculating a feed budget *(see DairyNZ Facts and Figures for further information).*

Feed Requirements *Refer to Facts and Figures page 11 for more information*

Autumn pasture @ 11 MJME/kgDM

Maintenance, pregnancy requirements, no body condition score gain

kg DM/cow		weeks pre calving			
		12	8	4	2
Jersay	350 kg Lwt	5	5.7	6.8	7.7
Jersey	400 kg Lwt	5.5	6.3	7.6	8.5
Cross	450 kg Lwt	6	6.8	8.3	9.3
Friesian	500 kg Lwt	6.5	7.4	9	10.1
Friesian	550 kg Lwt	7	8	9.6	10.8

Maintenance, pregnancy and gaining one body condition score in 60 days

kg DM/cow		weeks pre calving			
		12	8	4	2
Jersay	350 kg Lwt	5	5.7	6.8	7.7
Jersey	400 kg Lwt	11.5	12.9	14.3	15.7
Cross	450 kg Lwt	12.2	13.7	15.2	16.6
Friesian	500 kg Lwt	12.8	14.3	15.8	17.3
Friesian	550 kg Lwt	13.3	14.8	16.3	17.8

Maintenance and Pregancy Requirements (Average)

Maitenance and pregnancy requirements, no body condition score gain (kg DM/c/d) 11 MJME/kg DM autumn pasture, averaged across 8-0 weeks pre calving

		8-0 weeks calving
Jersey	350	8.0
Jersey	400	9.0
Cross	450	10.0
Friesian	500	10.5
Friesian	550	10.8

Supplements *DairyNZ Facts and Figures 19-27)*

Type	kgDM paqsture equivalent	kgDM in wagon
Grass silage		
Direct cut	150-200 kg per cubic metre	
wilted grass	160-180 kg per cubic metre	45-60 kg per cubic metere
Baleage	130-180 per 500kg bale	
Maize silage		
maize stack	170-250 kg per cubic metre (avg 200)	80-120 kg per cubic metre
maize bunker	200-270 kg per cubic metre(avg 220)	
Hay		
small bales	15-20 kg per 18-25kg bale	
round bales	150-250 kg per 180-300 kg bale	

Dry Matter Requirements

Dry matter Feed Requirements are based on pasture fed under good grazing conditions and allowances need to be increased to allow for wastage.

Nitrogen Response Rates

Pasture Growth rate will affect the response and duration of response to nitrogen.

PGR	PGR kgDM/ha/d	Response kgDM/kg N	Time for full response (weeks)
slow	10		
moderate	20-40		
fast	50-70		
rapid	80		

Young Stock Requirements

DairyNZ Farm Facts page 16

Autumn Winter feed budgets

	Rising 1 year	R 2 year Incalf Heifers
Jersey	5.0	8.0
Cross	6.0	9.0
Friesian	7.0	10.0

Increase R 2yr feed requirements if underweight and not on target for BCS 5.5

Typical DM%

PKE	90%
Concentrates	97-90%
Kale	11-15%
Turnips	9-11%
Fodder Beet	14-20%
Chicory	8-19%

Notes:

1. As research on wastage of supplements is limited, figures are based on best estimates from scientists and industry experts.

2. Includes losses at the stack face and when loading the wagon.

3. Bins = Feed trough for PKE fed in the paddock or feed pad for forages or in-shed feeding for concentrates.

4. Excludes refusal in the bin for rotten silage.

5. There can be additional losses feeding concentrates. 30-50% of starch (energy) can be lost if grain is not cracked. This can occur if whole grains are fed or if high level of small grains in mix.

Supplements - estimates of % wasted in storage and feeding out (1)

	Supplement	Storage		Feeding Out Paddock(2)			Feeding Out Bins(3)		
Supplement		**Excellent**	**Average**	**Poor**	**Excellent**	**Average**	**Poor**	**Very Good**	**Poor(4)**
Grass Silage	5%	5%	10-15%	20-40%	10%	20%	40%	5-10%	25%
Maize & Cereal Silage	6%	6%	10-15%	20-40%	15%	20-25%	40%	5-10%	25%
Palm Kernel	0	0%	10-15%	20%	25%	30%	50%	10%	25%
Concentrates(5)	0	0%	5%	15%				5%	25%

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