Important drivers of a lower footprint are reducing nitrogen fertiliser and imported feed.

Farming for a lower footprint – what should we focus on?

Find out about the latest research, co-funded by DairyNZ's levy, on mitigating greenhouse gases and nitrogen leaching. Do they reduce farms' environmental footprints and improve profitability?



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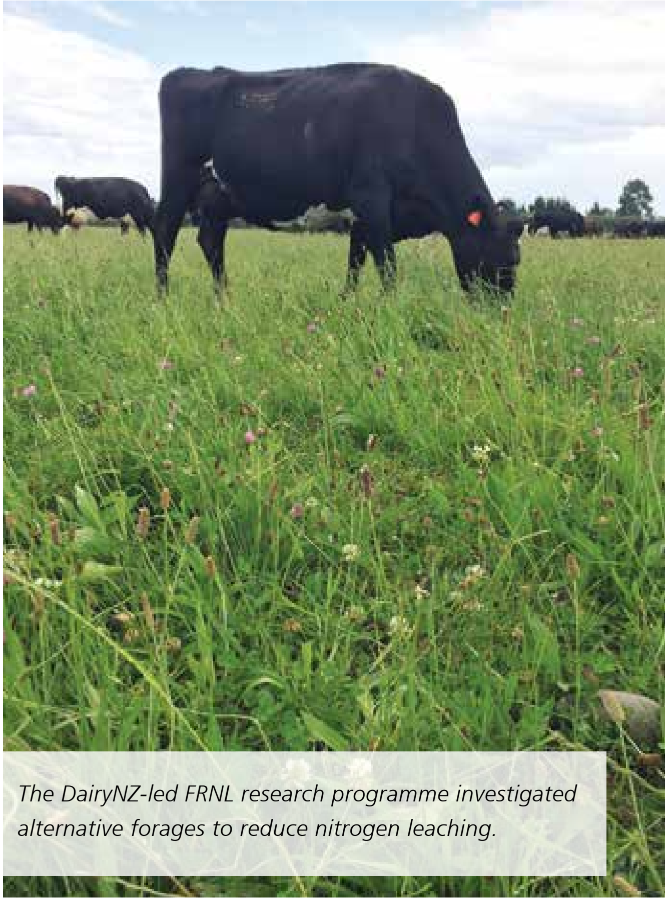
Farming businesses are facing growing pressures to reduce their nitrogen (N) leaching and greenhouse gas (GHG) footprints, driven by society and national/international water quality and GHG targets.

The challenge is to alter the farm system with a focus on sustainability while maintaining profitability. This requires planning and management to ensure the altered business's success[1]. Several studies have looked at production systems that maintain or increase profitability, while reducing impacts on receiving environments, including water and air. In some, the focus was on GHG[2] and in others, on N leaching[3].

A sustainable system must achieve multiple objectives: lifestyle for the farmer, welfare for the animals, quality product for the dairy processor, responsibility towards the environment, contribution to the community, goodwill from the public and

KEY POINTS

- Whether you focus on GHGs or N leaching, reducing one generally reduces the other.
- Important drivers of a lower footprint are reducing nitrogen fertiliser and imported feed. This reduces nitrogen surplus and feed flow through the herd and drives down both GHG emissions and N leaching.
- Systems with off-paddock infrastructure, e.g. barns, feed pads etc., are likely to reduce N leaching, but they also generate more effluent storage and handling, which may increase GHGs.
- Opportunities currently exist on many farms to reduce imported feed and N fertiliser and to achieve a five to 10 percent reduction in GHG emissions, with no or minimal negative impact on profitability.
- Targets beyond a 10 percent reduction in GHG emissions that do not reduce profit will require new technologies, such as different animal and/or plant genetics, different feeds or feed additives, or ruminal methane inhibitors.



The DairyNZ-led FRNL research programme investigated alternative forages to reduce nitrogen leaching.

profitability of the business.

This article summarises three of these DairyNZ levy-funded studies to answer the question: 'If I focus on mitigating GHG or N leaching, are there co-benefits to the total environmental footprint, and what is the impact on profitability?'

Focus on GHG emissions

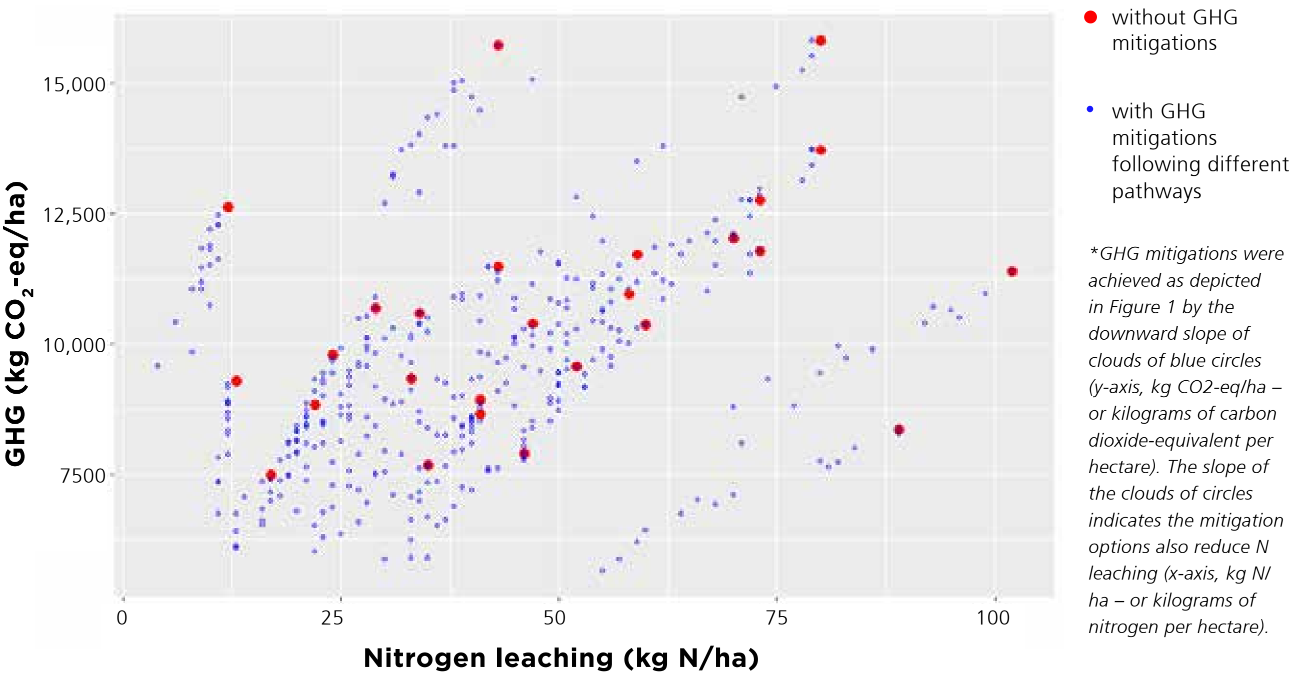
A DairyNZ modelling study[4], using Farmax and Overseer, identified 27 typical dairy farms across New Zealand. The outputs of the models for these farms were regarded as the baselines.

Farm system changes were made to mitigate GHG emissions by changing input combinations (e.g. fertiliser, amount and type of imported feed), with stock numbers altered to match feed supply.

In *Figure 1* below, the baseline farms cover a range of N leaching and GHG emissions due to the range of environmental conditions across the regions (e.g. soils and rainfall), and the range of farm systems (low to high input) modelled. The relationship between the pathways of the blue circles indicates that mitigation options to reduce GHG emissions also reduce N leaching.

Figure 2 on page seven shows for the same dataset that, in general, more GHG reductions means less profit, but there are a number of situations where mitigations had minimal negative impact on profit or increased profit (dots close to or above the horizontal line).

Figure 1. Predicted greenhouse gas emissions versus nitrogen leaching for typical regional dairy farms[4*]



**GHG mitigations were achieved as depicted in Figure 1 by the downward slope of clouds of blue circles (y-axis, kg CO2-eq/ha – or kilograms of carbon dioxide-equivalent per hectare). The slope of the clouds of circles indicates the mitigation options also reduce N leaching (x-axis, kg N/ha – or kilograms of nitrogen per hectare).*

Focus on N leaching

Farmlet trials co-funded by DairyNZ (Pastoral 21, or 'P21') were conducted in Waikato, Canterbury and South Otago over five seasons from 2011 to 2016, with the aim of developing system-level solutions to lower N leaching in a profitable manner[3] (see **dairynz.co.nz/P21**). Data from these trials were used to determine the impacts of N leaching mitigations on total GHG emissions ('Future' systems; Control = 'Current' – see *Table 1* below, right). Methodologies varied across the regions, but N leaching was measured using either soil suction cups, soil mineral N, or lysimeters (large barrels with undisturbed soil and sward to collect and measure drainage).

Annual average GHG emissions were calculated based on New Zealand's Greenhouse Gas Inventory methodology and included off-platform feeding and imported supplements. Milk production was determined from daily volumes and weekly milk compositions. Actual milk prices and actual or regional average costs of inputs (fertiliser, feed, etc.) were used for estimating profitability for those years.

In the Waikato, the Future system had lower N inputs (fertiliser and imported supplements), a lower stocking rate with higher genetic merit cows, and used a stand-off pad in autumn and winter. The Future system reduced GHG emissions by 16 percent, i.e. 2.2t (tonnes) of CO_2-eq/ha. However, averaged over five farming seasons, milk production was reduced by four percent, i.e. 50 kilograms of milksolids per hectare (kg MS/ha) and profitability by 13 percent – $280/ha compared with the Current system.

In Canterbury, the Future system with lower N inputs and stocking rate reduced GHG by five t CO_2-eq/ha (24 percent), milk production by 542kg MS/ha (24 percent) and profit by $358/ha (nine percent), compared with a high-input system (Current).

Figure 2. Predicted change in operating profit (%) versus change in GHG emissions (%) for typical dairy farms. The curved line is the best-fit local regression line with error margins. The dots above the horizontal line indicate situations where profit increased when reducing GHG emissions.

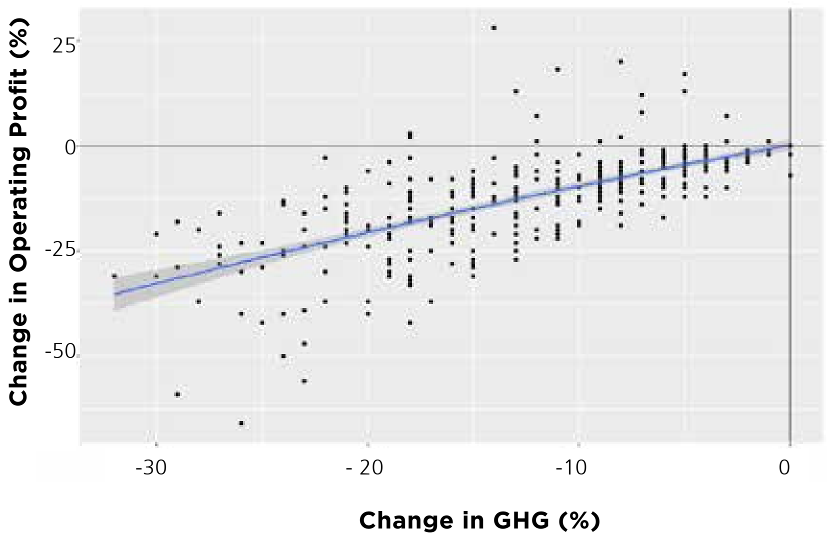


Table 1. Average performance (production, profit and environmental footprint) of three regional farm system trials

Region	Farm system	Milk production (kg MS/ha)	Operating profit ($/ha)	N leaching (kg N/ha)	GHG emissions (t CO2-eq/ha)
Waikato	Current	1200	2086	62	13.6
Waikato	Future	1153	1807	46	11.4
Canterbury	Current	2242	3893	Kale 114 FB 75	20.6
Canterbury	Future	1700	3535	Kale 80 FB 53	15.6
South Otago	Current	964	715	29	11.9
South Otago	Future-barn	949	20	16	11.6
South Otago	Future-opt	931	777	22	10.8

**All metrics are presented as 'per hectare of the milking platform', averaged over all farming seasons. In the Canterbury region, wintering of non-lactating cows can be either on kale followed by an oat catch crop (Kale), or fodder beet (FB).*

At Telford in Otago, there were two low-N leaching systems, one using a barn to house cows during winter and wet days in spring and autumn (Future-barn), and one attempting to optimise feed intake by changing calving date and type of home- grown feed (Future-opt). GHG emissions were reduced in the Future systems by between 0.3 and 1.1t CO -eq/ha (three to nine percent), compared with Current.

However, the profitability of the system that included the barn was significantly lower (NZ$700/ha or 97 percent), mainly due to capital and maintenance costs.

In summary, N mitigations in the farmlet systems achieved leaching reductions of 22 to 30 percent. In addition, these lower-input (less imported feed and N fertiliser) systems also reduced GHG emissions by between nine and 24 percent.

The exception was the Future-barn system in South Otago, where N leaching was reduced by 45 percent but GHG emissions were not reduced due to greater manure storage and handling. GHG reductions in the lower input systems of Waikato and Canterbury came at an average loss of profit of approximately NZ$100t CO_2-eq.

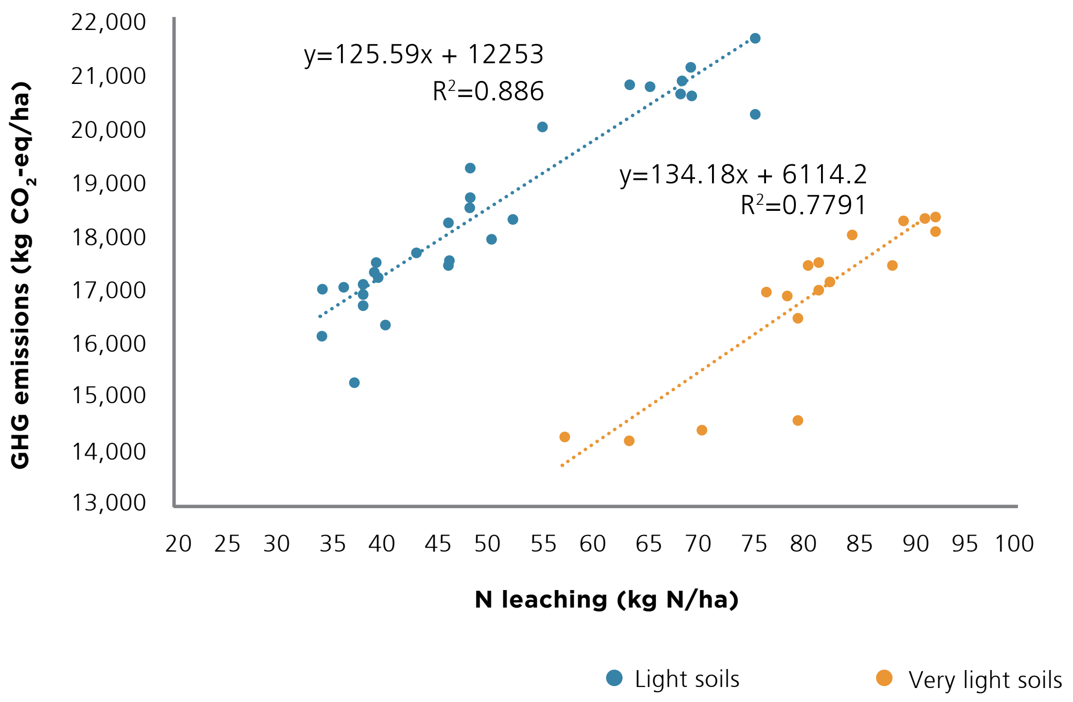
Focus on forages

The DairyNZ-led Forages for Reduced Nitrate Leaching programme (FRNL; 2013 to 2019) focused on N leaching by using alternative forages, e.g. plantain-mixed pastures, fodder beet (for wintering and shoulders of the season), and catch crops following forage crops.

The programme involved five monitor dairy farms in the Canterbury region (joining in 2014), and featured experiments with forage-based mitigations over the next years[5]. Data from the farms were used to estimate N leaching and GHG reductions using the Overseer model. Alternative scenarios proposed by the monitor farmers (e.g. using a feed pad, changing stocking rates and/or fertiliser rates) were also modelled. Results for the five FRNL monitor farms are presented in *Figure 3* below.

As N leaching decreased, so did GHG emissions, with N leaching accounting for 89 and 78 percent of GHG variability for light and very light soils, respectively. This is similar to the results in *Figure 1* on page six. In *Figure 1*, the focus was on GHG emissions with N leaching following, but in *Figure 3*, the focus is on N leaching with GHG following.

Figure 3. Predicted greenhouse gas emissions versus nitrate leaching for five dairy monitor farms (part of the Forages for Reduced Nitrate Leaching (FRNL) programme[5])*



**The focus was N leaching reduction. The results were clustered based on soils: three farms on light soils and two on very light soils.*

Telford's 'Future-opt' system focussed on better feeding and optimised grazing management of winter brassica crops.

Conclusion

Farm system mitigations that focus on lowering GHG emissions/ha or on N leaching/ha can result in a reduced overall farm environmental footprint. Key drivers for GHG emissions and N leaching are the same: feed eaten/ha, and N surplus (from N fertiliser and imported feed). Systems with off-paddock facilities (e.g. a wintering barn) may be the exception, these can reduce N leaching, but not necessarily GHG emissions. Depending on the current status of the farm, mitigation options that reduce imported feed and N fertiliser can achieve reasonable reductions (e.g. up to 10 percent) in GHG and N leaching. This can be achieved while maintaining or improving profitability. However, larger reductions that do not reduce profit will require technological solutions such as different animal and/or plant genetics, different feeds or feed additives, or ruminal methane inhibitors.

The Forages for Reduced Nitrate Leaching programme (FRNL) had principal funding from the Ministry of Business, Innovation and Employment (MBIE). The programme was a partnership between DairyNZ, AgResearch, Plant & Food Research, Lincoln University, the Foundation for Arable Research and Manaaki Whenua. Learn more at **dairynz.co.nz/frnl**

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