TECHNICAL SERIES

SCIENCE IN ACTION

A new tool for flood management and runoff?

Multiple factors inform methane reduction targets

How much pasture and crop could potentially be eaten on your farm?
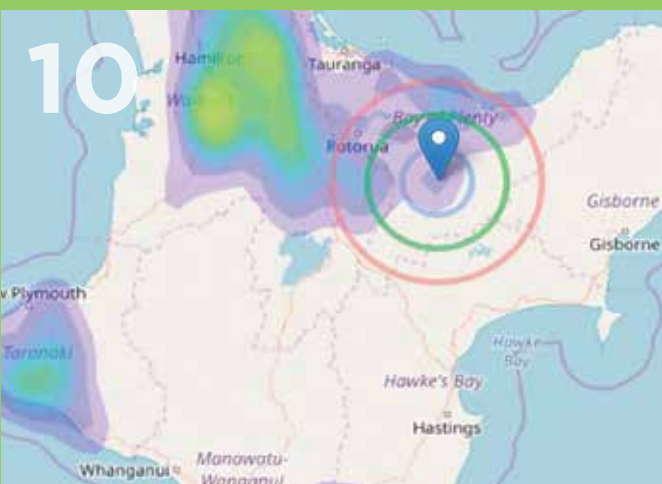
Pre-graze mowing: trial results

DairyNZ

CONTENTS

Channelling the right tools for flood management and runoff

DairyNZ has been working with the Canterbury Waterway Rehabilitation Experiment (CAREX) group to investigate the 'two-stage channel', a promising tool to reduce landscape flooding and nutrients coming off the farm.
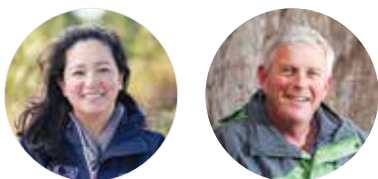
Catherine Febria and Jon Harding, CAREX Freshwater Ecology Research Group, School of Biological Sciences, University of Canterbury (Te Whare Wānanga o Waitaha)

Introduction

Nearly two decades ago, farmers and natural resource managers in the mid-western region of the United States of America (USA) were looking for solutions to address flooding and riverbank erosion issues on-farm. Over the previous 200 years, European settlers had dramatically altered the landscapes to move water off land through extensive drainage networks and into the Mississippi River and the Gulf of Mexico. In recent times, the scale of flooding problems on farms had become so severe that solutions needed to be developed. One of these solutions was the 'two-stage channel', which reduced flooding on paddocks and improved water quality.

In 2014, Prof. Jon Harding of the University of Canterbury visited some of the two-stage channel pioneers: Prof. Andy Ward and Dr Jessica D'Ambrosio from Ohio State University, and Prof. Jennifer Tank from Notre Dame University. Together, they viewed two-stage channels of varying ages and designs, and reflected on their usefulness in addressing similar issues on New Zealand farms. The University of Canterbury and DairyNZ are now carrying out a scoping study to trial the two-stage channel as a viable farm management tool for New Zealand. The findings of this study are outlined below.

What are two-stage channels?

Two-stage channels are artificially-created floodplains established on existing farm drains. We examined the traditional two-stage channel as designed and trialled in the mid-west USA and found their issues are similar to those experienced in New Zealand. For example, agricultural drainage channels have commonly become over-engineered (straightened, narrowed and deepened) with frequent dredging and mechanical clearance

KEY POINTS

- Two-stage channels deliver better management of farm waterways.

- Two-stage channels are artificially created floodplains within traditional agricultural drains. They increase flood capacity, absorb and transform nutrients, and trap fine sediment on their floodplain with minimal loss of land.

- Benefits seen overseas include reductions in turbidity of between 15-82% in flood events, increases in denitrification rates of between 35-49%, and N removal of 70% more than in unmodified channels.

- Exploring the potential for using two-stage channels requires an assessment of topography and soil types available for creating a floodplain on both sides of the channel.

- Additional environmental benefits are possible, including enhancing nutrient uptake through planting on the floodplains, trapping faecal microbes and intercepting tile drains and preferential flow paths.

- Further work is underway to determine regional rule requirements for constructing two-stage channels in New Zealand.

to preserve and maintain drainage function. However, drain maintenance can be costly for a farmer or regulatory agency, while also contributing to negative environmental impacts, such as poor water quality. They can also have potentially counter-productive outcomes for farm management (e.g. nuisance weeds that require ongoing management).

While there has been more emphasis on altering farm practices to help manage environmental impacts, there is a growing realisation that multiple actions and tools can be employed on farm and within waterway networks to improve water quality. Two-stage channels are one such innovative tool. They can offer

Photo 1: A two-stage channel in the USA, with grass on the floodplain and a grass riparian buffer zone protecting the drain from soil runoff from the neighbouring cropping land. In New Zealand, a two-stage ditch such as this on a dairy farm would require a fence at the top of the bank on either side. (Photo: J. Harding)
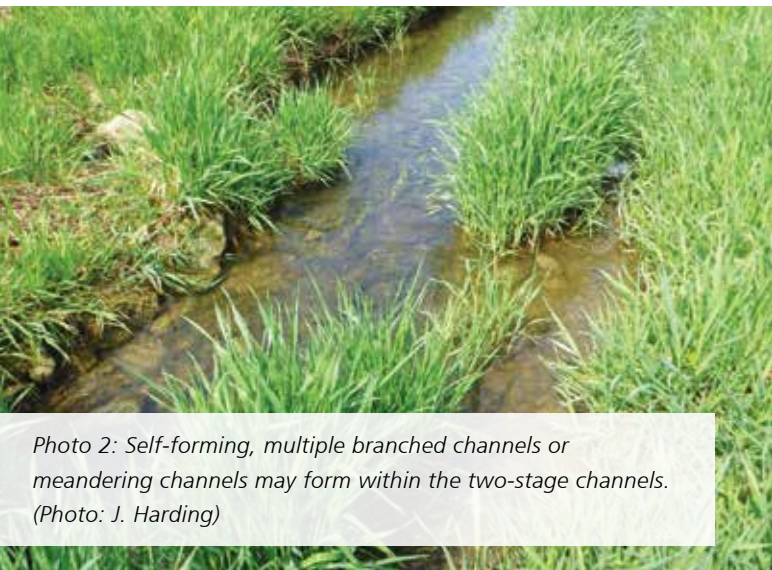

Photo 2: Self-forming, multiple branched channels or meandering channels may form within the two-stage channels. (Photo: J. Harding)

benefits for agriculture in terms of flood mitigation, and water quality and ecosystem outcomes[1].

What do two-stage channels look like?

Agricultural drains are often highly modified, straightened waterways and generally trapezoidal or U-shaped *(Figure 1a)*. In many parts of New Zealand, drains are also connected to subsurface tile drains. The two-stage channel design alters the shape of the channel to accommodate floodplains created on either side of the central channel[2, 3] *(see Figure 1b and Photos 1 and 2)*. Essentially, this creates a 'drain within a drain'.

In a two-stage channel design, the floodplain widths are about the same width as the drain on either side, banks are excavated slightly to reduce slope and bank collapse, and the exposed banks are simply grassed over. Hydrological data is used to inform the height of the bench and ensure floodwaters are effectively accommodated. As a result, the channel capacity is increased substantially.

Two-stage ditches can be created through self-forming channels. Despite the name, this is still an engineering option that involves excavating out a drain wide enough to establish initial conditions for floodplains, and then allowing other features to self-establish over subsequent flooding events[4] *(Photo 2)*. They offer similar benefits, require less excavation and are

designed to allow the natural creation of sediment bars and other physical features to form over time. With either of these options, subsurface tile drains can also be accommodated in the design, with flow from tile outlets being deposited on the floodplain benches. Please be aware that excavating out a drain may require resource consent.

How well do two-stage channels work?

The two-stage channel design increases channel cross-section (therefore holding more floodwaters), lowers the power of water to damage banks, and dissipates energy across a larger cross-sectional area. This reduces the flood's power and erosion potential[5, 6, 7].

Variable water velocities are also promoted in the channels with self-forming channels facilitating the creation of natural meanders and other structural features[8]. These help reduce bank erosion and create more habitat for fish and invertebrates. Over the longer-term, two-stage channels have been demonstrated to withstand high flows for more than 10 years after construction.

What are the water quality benefits?

Studies in the USA have shown a range of environmental benefits associated with two-stage channels. They can occur either in the main channel or upon the floodplain benches. The key mechanism behind this is ensuring floodwater overtops the benches during flood events or high flows. When that occurs, the speed of the water is reduced and sediment is deposited on the benches, whereas velocities in the main channel should be

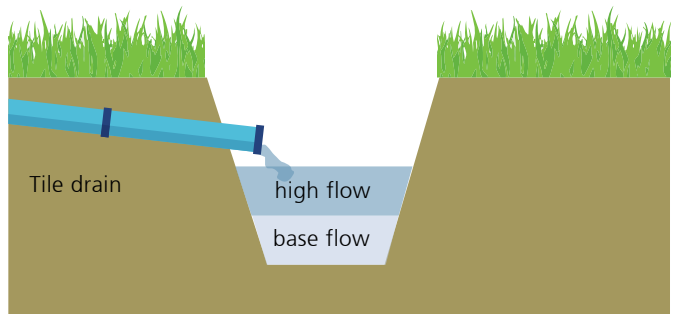### Conventional channelised channel

Figure 1a. Cross-section profile of a conventional channelised channel.

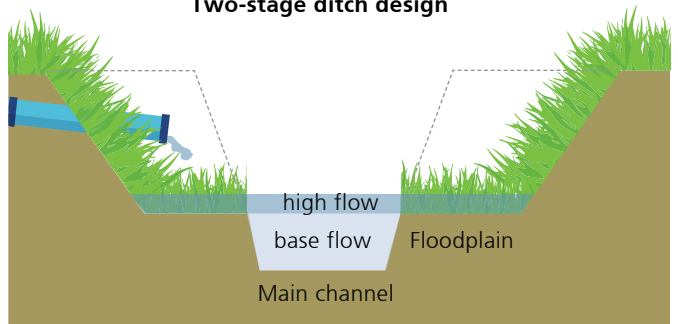### Two-stage ditch design

Figure 1b. Cross-section profile of a two-stage channel design[5].

higher.

As water levels drop, pools of standing water carrying sediments and other contaminants are trapped on the floodplains and nutrient removal can occur in the soils via denitrification. Published studies have shown a number of water quality improvements in two-stage channels, including for turbidity (sediment), phosphorus (P) and nitrogen (N).

Turbidity is a key measurement of fine sediments and particulates in the water column, and is an indicator of sediment loads. Studies have shown significant reductions in turbidity – a decrease of 15 to 82 percent during flood events[9]. Sites with the widest floodplains had the greatest turbidity reductions, with some suggestion that sediment retention may improve over time, and with further establishment of vegetation (e.g. plantings) on the floodplains.

There is growing evidence that two-stage channels are effective at reducing P export. Again, this is driven by floodwaters overtopping the benches and trapping P bound to fine sediment particles[7]. Like turbidity, reductions in sediment and P can be encouraged with vegetated benches[10], but further longer-term study is needed.

An additional benefit of the two-stage channel is its capacity for N removal. The primary mechanism for N removal is denitrification. Published studies indicate there is significant potential for this tool to increase N removal or uptake. Simply, denitrification occurs when floodwaters are trapped on the floodplain, and low-oxygen conditions are created in the floodplain soils, thus, supporting microbes to convert nitrate to N gas.

It follows then, that an increased floodplain area creates longer water residence time and enhanced denitrification[5]. Denitrification rates can be 35 to 49 percent higher in two-stage floodplains, compared to those without two-stage channels[11]. Another study demonstrated that most denitrification occurs when the floodplains are inundated during a storm event[9]. It found 70 percent more N was removed via denitrification compared to normal conditions.

A source of carbon is also needed to support and enhance denitrification, so vegetation and organic matter (grass, riparian plants) should be encouraged.

What about other contaminants?

Other potential benefits beyond flood mitigation, and nutrient and sediment reduction, have been hypothesised overseas[12]. These include reductions in faecal microbes, heavy metals, herbicides and pesticides. We're not aware of any published data on the ability of two-stage channels to reduce these contaminants, but we agree reductions are also likely for New Zealand waterways.

Cost effectiveness

An important factor to consider in constructing two-stage channels is their implementation cost and cost-effectiveness, relative to other mitigation tools (e.g. planted riparian buffers,
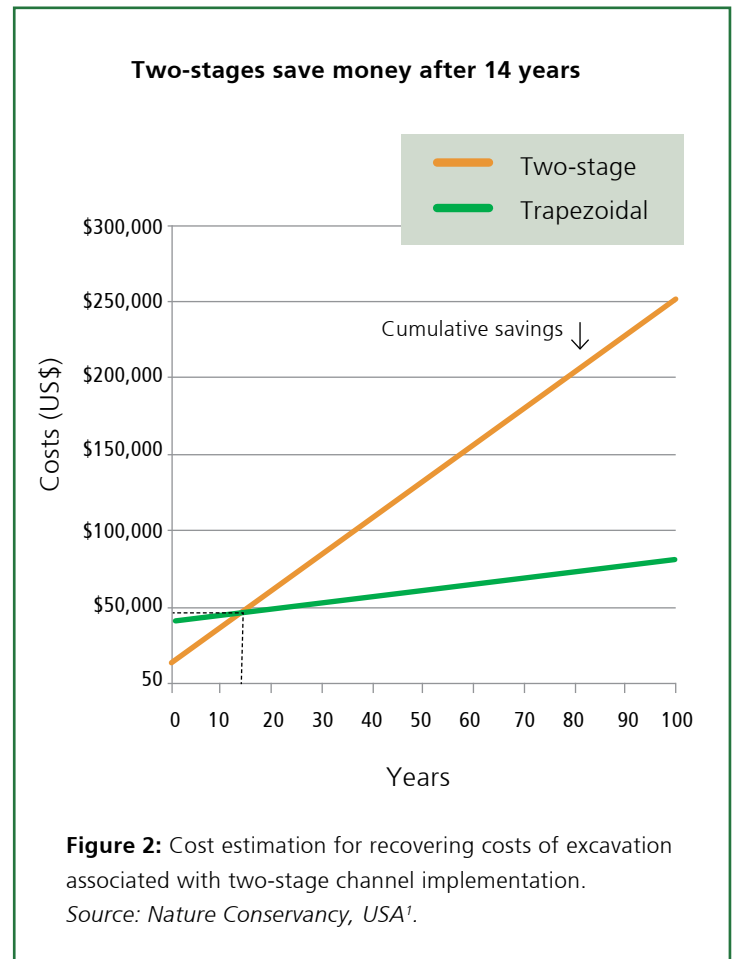
Figure 2: Cost estimation for recovering costs of excavation associated with two-stage channel implementation. *Source: Nature Conservancy, USA[1].*

constructed wetlands) used for improving water quality outcomes. While few cost-benefit analyses have been conducted, field trials have shown that once installed, several examples of two-stage channels in the mid-western USA have not required further maintenance, even 12 years after construction (A. Ward, personal communication).

A recent analysis compared two-stage channels' cost-effectiveness to other remedial actions on-farm (i.e. cover crop, wetlands) over 10- and 50-year timeframes[13]. It found the initial cost of building the two-stage channel was higher than protecting on-farm wetlands or using cover crops. However, in the long-term, the costs evened out due to minimal maintenance. This is supported by evidence from the Nature Conservancy, which suggests the payback period for excavation costs in the USA is about 14 years[1]. *(Figure 2).*

Some farmers may initially assume the two-stage implementation requires surrendering productive land to provide space to create the floodplain benches. This is not necessarily the case. In the mid-western USA, on farms where vegetated buffers were already present along drains, little to no additional land has been required or given up. Due to the excavation required, the upfront costs may be high, but overwhelmingly the data suggests two-stage channels offer an affordable, low-to-no-maintenance, long-term solution in the USA. Tests are still to be carried out in New Zealand. However, we anticipate similar

findings, particularly when existing in-stream work costs, such as erosion protection works and drain cleaning, are factored in.

Criteria for two-stage channels

Two-stage channels are seen as an exciting new opportunity in New Zealand with potential to help mitigate multiple water quality impacts faced by our farmers and communities. Internationally, two-stage channels have been shown to be highly successful. Indications are that many New Zealand farming landscapes would likely gain similar benefits. Working with DairyNZ water quality staff, our research team will install and monitor a range of two-stage channels, test their performance, identify locations that are appropriate for their installation and determine regional consenting requirements for implementation.

To provide measurable water quality outcomes, waterway reaches should generally be at least one kilometre in length. However, some studies suggest 500 metres is the minimum distance for a two-stage channel to measure a difference (Andy Ward, personal communication). Ward has indicated that only about 10 percent of the roughly 500 two-stage channels constructed to date have failed. However, almost all of these failed channels have occurred due to poor design and construction, and installing the channels in the wrong locations.

Appropriate location depends on a combination of factors, including sound understanding of the hydrological regime (e.g. frequency of flood and flood magnitude), soil type and

Notre Dame University's Prof. Jennifer Tank, an international pioneer of two-stage channels.

land availability (i.e. space on either side of channel to create floodplain benches). Other considerations for New Zealand catchments include accommodating pivot irrigation (i.e. potentially requiring bridges and other infrastructure to be modified), and that spring-fed waterways with stable flows (less prone to flooding events) may not gain the same benefits where flood events fail to overtop the floodplains. Opportunities that require further testing include integrating the two-stage channel with other tools such as wetlands, riparian planting and sediment traps.

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Multiple factors inform methane reduction targets

Identifying an acceptable target for New Zealand methane gas reduction levels is a complex decision which requires balancing a variety of considerations. Changing conditions also mean any target needs to be reviewed regularly.

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Research Centre

Methane

Methane (CH_4) is a powerful short-lived greenhouse gas with a lifetime in the atmosphere of just over 12 years[1]. Since the 1700s, the concentration of CH_4 in the atmosphere has risen from about 700 to 1850 parts per billion (ppb). Despite being present in the atmosphere at very low concentrations, CH_4 exerts a strong influence on global temperature because it is highly effective at absorbing infrared radiation. Most of the warming from CH_4 occurs within 50 years of its emission; however, some lingers beyond 100 years. Current estimates are that global anthropogenic CH_4 emissions have contributed about 40 percent (~40%) of the total warming the world has experienced since the industrial revolution[2].

Sources of methane

Global anthropogenic CH_4 emissions (i.e. those caused by human activity) come primarily from three major sources: agriculture (~40%); oil, gas, and coal (~30%); and waste (~20%)[1]. In the agricultural sector, livestock are the dominant source[3].

Rumen function diagram

95%
Methane

CH_4

CH_4 Methane

5%
Methane

CH_4
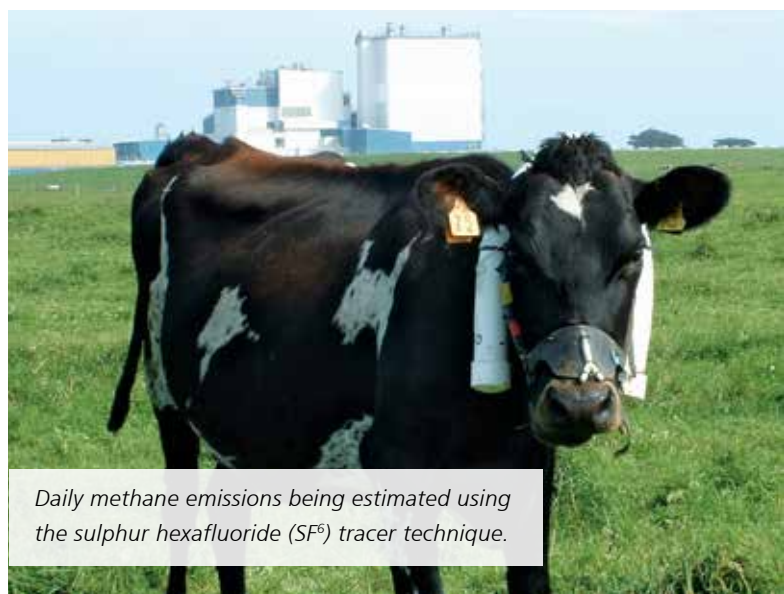
Daily methane emissions being estimated using the sulphur hexafluoride (SF_6) tracer technique.

KEY POINTS

- Worldwide methane emissions from ruminant animals have made a substantial contribution to current global warming.

- New Zealand's ruminant animals' methane emissions make a substantial contribution to total New Zealand greenhouse gases emissions and the global warming that our emissions have contributed to so far.

- Methane is a short-lived gas; because of this, its emissions don't have to be reduced to zero to meet the temperature goals of the Paris Agreement. This is in contrast to the long-lived gas carbon dioxide, which has to be reduced to zero.

- Setting national methane emissions reduction targets involves balancing social, economic, environmental and equity issues that science can only partly inform.
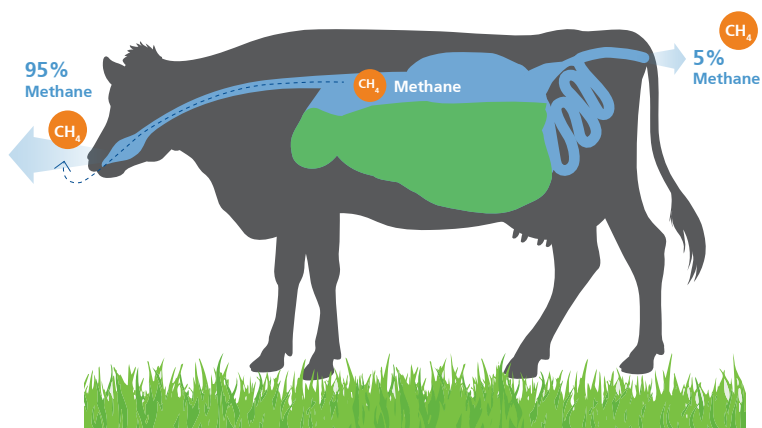
Methane is emitted continuously from the cow's mouth as part of its natural digestive process.

Estimates of the CH_4 currently produced globally by livestock are in the range of 90 to 120 million tonnes CH_4 per annum[4, 5, 6]. This is 30 percent of total anthropogenic CH_4 emissions. Livestock have been responsible for around 14 percent of the warming experienced by the Earth since the Nineteenth Century[7]. Enteric CH_4 emissions, those arising from the digestion of feed, comprise approximately 90 per cent of all livestock-derived emissions, with cattle (77 percent) being the dominant source globally[4].

Worldwide by 2030, CH_4 emissions are forecast to be 12 percent above current emissions[6].
In New Zealand, CH_4 emissions from agriculture livestock have risen from 1.1 million tonnes in 1990 to 1.16 million tonnes in 2016[7]. Dairy cattle emissions currently comprise 50 percent of New Zealand's agricultural CH_4 emissions. Methane emissions from New Zealand's agricultural sector peaked in 2006 and current forecasts are that they will remain relatively unchanged until at least 2030[8].

Breakdown in the atmosphere

Methane has a short life in the atmosphere, principally because of chemical reactions with hydroxyl radicles (OH) in the troposphere (between the Earth's surface and the stratosphere). These reactions break down CH_4 into water (H_2O) and carbon dioxide (CO_2)[2]. Given that enteric CH_4 arising from the digestion of plant material removes CO_2 from the atmosphere by photosynthesis, it is easy to think it's simply a case of CO_2 in and CO_2 out, and hence completely neutral with respect to global warming.

This is incorrect, because for a short time some of the CO_2 removed from the atmosphere by photosynthesis is present in the atmosphere as CH_4. This absorbs more infrared radiation than the CO_2 from which it was originally derived (see reference source[9] for a more detailed discussion).

How does methane compare with other greenhouse gases?

The three main anthropogenic greenhouse gases (GHG) are CO_2, CH_4 and nitrous oxide (N_2O). These differ in their longevity in the atmosphere and in their absorption of infrared radiation. International treaties designed to encourage the reduction of anthropogenic GHG, for example the United Framework Convention on Climate Change (UNFCCC), refer to GHG collectively. This raises the question: how should individual GHG be compared with each other?
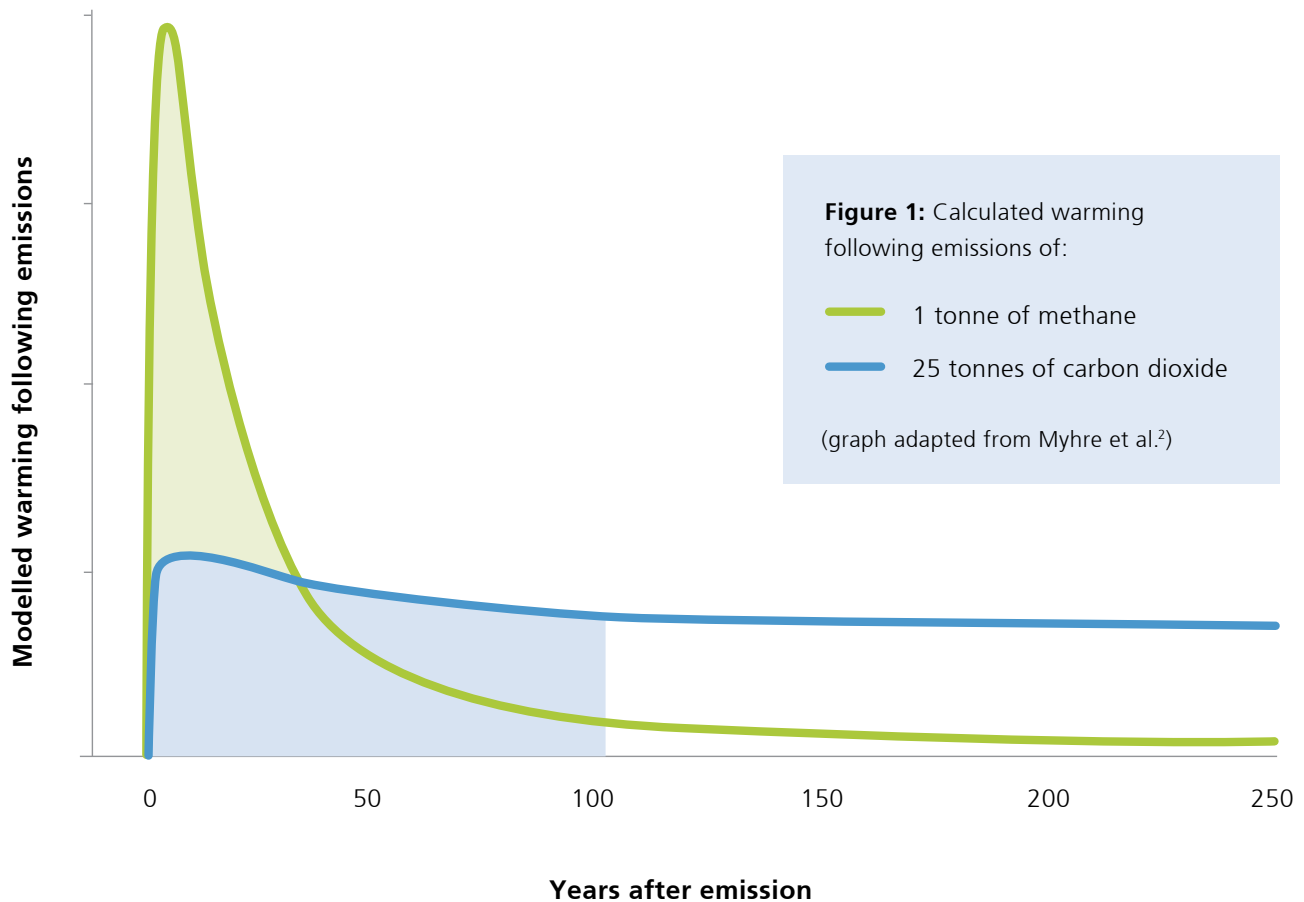
To answer this question, scientists have devised systems that allow all GHG to be expressed using common units. The most common of these systems is called Global Warming Potentials (GWP) in which CO_2 is given a value of one and other gases are compared with CO_2 based on their longevity in the atmosphere and their ability to absorb infrared radiation[10].

In international reporting to the UNFCCC, GHG are compared over a 100-year timeframe: CH_4 currently has a value of 25 and N_2O a value of 298. Using these values, GHG can be reported in a common currency known as carbon dioxide equivalents (CO_2-e). *Figure 1* explains graphically how CH_4 warms the atmosphere relative to CO_2. Basically, one tonne of CH_4 creates the same average warming as 25 tonnes of CO_2 over a 100-year period (i.e. the area under the curves are equal).

Figure 1 also shows that the GWP gives a good representation of the average warming over a given period of time relative to CO_2. However, it hides the fact that the time course of warming caused by CH_4 is very different to that of CO_2. Methane has a short life in the atmosphere and a much higher level of warming initially, but one that disappears relatively quickly. Carbon dioxide has less of an immediate impact but, because it decays much more slowly, the warming continues at a similar level for hundreds of years.

GWPs are the most commonly used method for comparing different GHG but they're not the only method. GWPs have also been criticised as being an inappropriate metric when considering how CH_4 should be treated relative to CO_2 under ambitious GHG mitigation, and when considering the impact of cumulative emissions year-on-year[11].

Atmospheric warming

Figure 1: Calculated warming following emissions of:

— 1 tonne of methane

— 25 tonnes of carbon dioxide

(graph adapted from Myhre et al.[2])

Modelled warming following emissions (y-axis)

Years after emission (x-axis)

Does New Zealand have a specific methane reduction target?

Under the 2015 Paris Agreement, 196 countries pledged to reduce GHG emissions with an aim of restricting global temperature rise to well below two degrees Celsius (2°C) and pursue efforts to keep the warming as low as 1.5°C. Parties to the Paris Agreement have submitted plans for reducing emissions up to the year 2030 – so-called Nationally Determined Contributions (NDC). New Zealand in its NDC has committed to reducing CO_2-e GHG emissions to 30 percent below 2005 levels by 2030.

Parties to the agreement are expected to strengthen their reduction commitment over time. New Zealand has not set a specific target for individual gases within its emissions reductions. However, since CH_4 from agriculture comprises more than 40 percent of all CO_2-e emissions, there is likely to be pressure on the livestock sector to reduce CH_4 emissions. In the longer term, the current government is working on a Zero Carbon Bill. In its consultation phase, that bill outlined options that could result in differential targets for the three principal GHGs out to 2050.

These options included a target to reduce CO_2 to 'net zero' by 2050 (emissions minus removals of CO_2 stored in things like trees). They also included a reduction in all gases to net zero (using the same approach) by 2050, and a differential treatment of the short-lived gas (CH_4) and the long-lived gases (CO_2 and N_2O). This latter option calls for 'stabilising' CH_4 at some level, with the other gases reduced to net zero.

Why should methane be treated differently to carbon dioxide and nitrous oxide?

The 2018 report[7], commissioned by the Parliamentary Commissioner for the Environment (PCE), lays out in detail the scientific basis for treating CH_4 differently to CO_2 when it comes to GHG mitigation. The following brief summary draws on this report.

As methane lives for only a short time in the atmosphere, stabilising or reducing emissions below their current levels would see the concentration in the atmosphere level off within a few decades. This in turn means that, eventually, no additional warming will occur in excess of that caused already by existing emissions, but this levelling off in warming will take some time.

Figure 1 shows that although CH_4 lasts for around 12 years in the atmosphere, the warming from an individual emission pulse continues for more than 100 years after the gas has disappeared from the atmosphere. So stabilising emissions at current levels still results in increased warming for several centuries (albeit at a declining rate).

In contrast, CO_2 can remain in the atmosphere for thousands of years, so the removal of previous emissions will not offset current emissions in the same way that CH_4 does. Each CO_2 unit emitted increases the concentration in the atmosphere. If CO_2 emissions are stabilised, the concentration in the atmosphere will continue to increase as the removal of past emissions will not balance the addition of emissions. Hence, temperatures will keep rising. The only way for CO_2 concentration in the atmosphere to stabilise, and hence make no further increased contribution to warming, is for the net emissions of CO_2 to be zero.

The different behaviour of CO_2 and CH_4 in the atmosphere leads to two very clear conclusions. First, for the world to stay within the below-2°C temperature limit, CO_2 emissions need to be reduced to zero as quickly as possible. Second, CH_4 emissions don't have to be reduced to zero but the less CH_4 is emitted, the less the Earth will warm overall. The more CH_4 is reduced below current levels, the more feasible it is for the world stay well below the 2°C limit *(see Figure 1).*

So is there an unambiguous methane reduction target for New Zealand?

Setting national targets for GHG reduction has to consider more than science. Science tells us that to meet the Paris Agreement temperature limit of well below 2°C, CH_4 does not have to go to zero. However, the lower future emissions go, the less New Zealand will contribute to climate change. Science alone doesn't tell us what a national reduction target should be, or the rate at which the target should be reached. Setting targets involves far wider consideration of social, economic, environmental and equity issues (both within New Zealand and between New Zealand and the rest of the world). These involve

judgements and trade-offs that science can only partially inform.

The recent PCE report[9] estimated that if New Zealand reduced its CH_4 emissions by 10 to 22 percent below 2016 levels by 2050 (the range reflects differing assumptions around atmospheric feedback processes and emissions from other countries), then our CH_4 emissions would contribute no further to global warming than they already are. This implies that if emissions could be reduced by more than 10 to 22 percent below 2016 levels, we would contribute to 'cooling' the planet, relative to the warming caused up to 2016.[*]

Press coverage has generally interpreted the 10 to 22 percent as an appropriate national target for New Zealand, a notion that the author of the report went to considerable effort to refute. Interpreting 10 to 22 percent as an appropriate target implicitly assumes that 'not adding any further to warming' is an appropriate way to frame a national target for CH_4 and, further, that 2016 is the correct reference year.

Choosing 'not adding any further to warming' as the benchmark by which to set a methane reduction target makes the tacit assumption that the warming caused to date is the acceptable level for New Zealand (i.e. that we have some sort of property right to the warming we have already caused) and that not causing any more warming fulfils our contribution to meeting the goals of the Paris Agreement. This is certainly not an issue that can be decided by science.

The choice of reference year is also problematic. The Paris Agreement doesn't set GHG emission targets relative to a reference year. It simply seeks to limit warming relative to the pre-industrial levels (loosely, since the mid-Nineteenth Century[12]). It's then up to each country to set emission targets they think will be consistent with that overall goal.

New Zealand's commitment under the Kyoto Protocol was not to increase GHG emissions above 1990 levels on average over the 2008 to 2012 period. For 2013 to 2020, New Zealand voluntarily agreed to reduce emissions to five percent below 1990 levels. Under the Paris Agreement, the emissions reduction target is 30 percent below 2005 levels. Science can inform the consequences of using a particular reference year but it doesn't

The amount of food a cow eats is the biggest determinant of how much methane it produces.

The type and quality of what a cow eats influences how much methane is produced.

Measuring methane emissions using the portable Greenfeed™ system

tell us the appropriate reference year to choose. So, science can't provide a definitive CH_4 reduction target for New Zealand. However, science can help ensure that any target takes into account CH_4's short-lived life in our atmosphere, alongside social, economic, environmental and equity issues. Any methane target needs to be regularly reviewed to ensure it takes account of changing circumstances.

*'Cooling' here refers to causing less warming than that caused relative to a reference point, e.g. a particular reference year. All emissions of methane will cause the earth to be warmer than if they had not been emitted. With a short-lived gas like methane, reductions in emissions against a fixed reference point can result in the absolute contribution to warming going down, compared with that reference point. Current methane emissions still warm the atmosphere, but not as much as previous emissions did. This is not the case for a long-lived gas like carbon dioxide.

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How much pasture and crop could potentially be eaten on your farm?

It's likely that many dairy farms can improve their performance by increasing the amount of pasture and crop eaten by their herds. Here, we profile a tool that's currently being developed and tested, to see if it can enable farmers to accurately estimate that potential on their own farms.

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New Zealand dairy farms vary widely in financial performance. Pasture management, soil fertility and drainage can all be improved[1]. However, a substantial proportion of any farm's financial performance is determined by the amount of pasture grown and eaten on-farm[2, 3].

Opportunities to improve profitability by increasing this factor do exist. For example, grazing management may not follow best practice. McCarthy et al.[4] found around 25 percent of farmers were overgrazing and 25 percent were undergrazing, relative to recommended post-grazing residuals. Clark et al.[5] found that, even on research farms with consistent management and measurement, the best paddocks had twice the yield of the poorest paddocks.

In real terms, increasing the amount of pasture and crop eaten on-farm by one tonne of dry matter per hectare (t DM/ha) could equate to around $300 of extra operating profit/ha. Neal et al.[3] estimated that doing this could be worth approximately $200 million per year to the dairy sector overall.

However, looking at increasing pasture and crop yields is only part of the picture. We need a tool that can give farmers a more accurate estimation of potential pasture and crop eaten, so they can see what closing the gap might mean.

Mind the (yield) gap

The difference between the potential harvest and the actual harvest is the 'yield gap'. Yield gaps have become an increasingly popular measurement for assessing the scope for improvement in farm practice and subsequent yield[6]. For example, for Australian wheat yields, Hochman et al.[7] estimated the difference between district yields and modelled maximum yields, when moisture was the only limiting factor, to highlight the opportunity for improvement.

Recognising the difficulty in achieving the moisture-limited maximum, Hochman et al. defined the 'exploitable yield gap' as the difference between actual yield and 80 percent of the moisture-limited maximum. This illustrates that a yield gap should also be considered in economic terms. Not only may it be difficult to achieve the maximum possible yield, there may be diminishing marginal returns, so achieving maximum yield may not be the most profitable target.

Measuring pasture vs crop eaten

In DairyBase (DairyNZ's online database) pasture and crop eaten is estimated from farm performance data. These estimates are based on the energy demand for animal maintenance and milk production, followed by subtracting the energy supplied by imported supplement.

Approximately 700 DairyBase farms

per year have the data necessary to calculate pasture and crop eaten, although this information takes several months to be collected and made available for analysis. While areas of crop are recorded, reliable measures of crop yields are not generally available. This means it's not possible to separate the contribution of pastures versus crops.

Regional benchmarks for pasture and crop eaten can be generated from this data, but other factors such as rainfall, soil, altitude, terrain and fertiliser use vary widely within most regions. This means a regional benchmark is likely to be of limited relevance to any given farm.

Pasture Potential Tool

Now for the good news: the improved availability of data and spatial estimation tools does allow many of the factors noted to be rolled into an interactive tool, which we call the 'Pasture Potential Tool'. This tool defines pasture potential for a specified location as the '90th percentile of pasture and crop eaten on nearby farm' (i.e. the level that only one out of ten farmers beat).

The prototype Pasture Potential Tool is available at **dairynz.co.nz/pasture-potential**

Using the tool

The tool allows farmers to select their region interactively or by entering an address (Figure 1). Coloured areas show the availability of data, with green representing the locations with the most data. The year of interest can be selected from a dropdown menu. This gives an indication of how many farms with pasture and crop eaten data are within a 60 kilometre (km) radius of the selected point (red circle). For reference, a 20km and 40km radius are also shown, in blue and green respectively.

The farmer can then filter the data further by selecting the most relevant characteristics. For example, in Figure 1, farms with
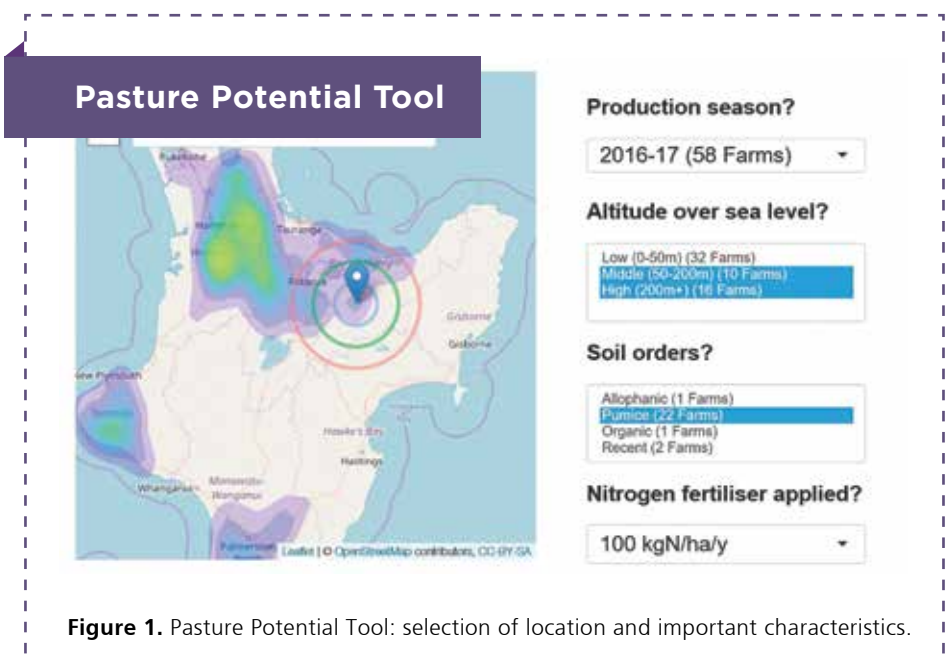

Figure 1. Pasture Potential Tool: selection of location and important characteristics.

mid to higher altitudes are selected, with the 'pumice' soil order. All observations can be adjusted to a particular level of nitrogen (N) fertiliser assuming a response rate of 10 kilograms (kg) of dry matter (DM) per kg N fertiliser applied.

Tool outputs

An example of tool outputs is shown in *Figure 2* below. This chart shows the distribution of DairyBase pasture and crop eaten within a 20km, 40km and 60km distance from the chosen location. The potential achievable (actually the 90th percentile) is shown as a dark blue line with a numerical value. The uncertainty band of this estimate is shown as a shaded area around this level.

Charts do not appear unless there are at least four farms in that group. In *Figure 2's* example, a farmer can choose to consider the small number of farms close by (within 20km) as the relevant peer group, or the larger number of farms in the 60km radius. Regardless, the indicative potential is around 12 to 13t DM/ha for that year.

When using the tool, take these points into consideration:

- Data is less available in some regions.

- Terrain (apart from elevation) is currently not taken into account.

- The farmer may be aware of factors that are not accounted for in the tool that could make a substantial difference.

- Environmental or other regulations may mean it is not possible to create an appropriate peer group.

Nonetheless, feedback from groups of farmers who have piloted the tool has been encouraging, reporting it to be a useful first step towards change and improvement.

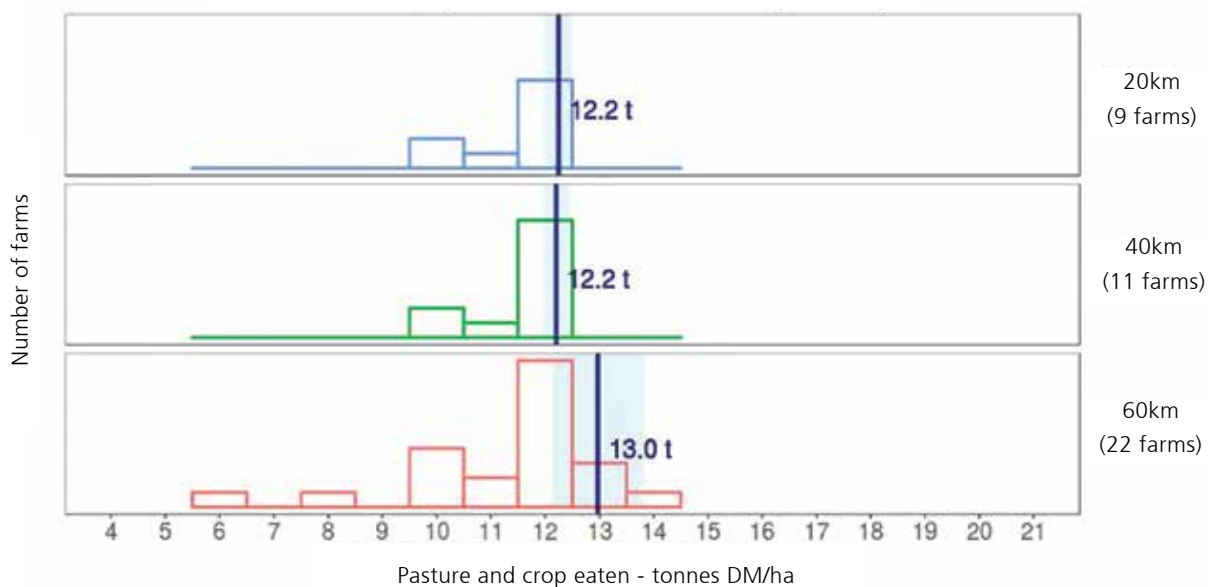**Pasture and crop eaten near your location (2016/17)**

Figure 2. Pasture Potential Tool: distribution of pasture and crop eaten, with estimated potential (90th percentile) indicated as a dark blue line, and light blue shading to indicate the 95% confidence interval of this estimate.

Capturing the pasture and crop eaten gap

The gap between a farm's potential for and its actual pasture and crop eaten can be determined using the Pasture Potential Tool in conjunction with the estimated pasture and crop eaten calculated by DairyBase (or from DairyNZ's online tool for pasture and crop eaten assessment – **dairynz.co.nz/pasture-eaten**).

DairyBase data presented on DairyNZ's website shows a one DM/ha increase in pasture and crop eaten has corresponded to an average increase in operating profit of approximately $300/ha in 2014/15. For example, the possible value of meeting a 12t DM potential for a 100ha farm with a current pasture and crop eaten of 10.5t DM, would have been 1.5t DM x $300 x 100ha = $45,000.

Capturing the opportunity to improve

Once the gap between potential and actual pasture and crop eaten has been identified, the pathway to capture the opportunity still needs to be determined. This is likely to require holistic consideration of the farm. Even though substituting higher-yielding crops for pasture (e.g. for harvest) should improve the overall amount of pasture and crop eaten and increase profitability, this will not necessarily lead to higher profit.

For example, using 12 years of DairyBase data for the Waikato, a regression analysis showed that farms with 10 percent of area in harvested crop would be expected to have approximately 0.6t DM/ha more pasture and crop eaten ($p < 0.05$). However, as there was no significant improvement in operating profit/ha from the increase in area allocated to high-yielding harvested crop, it is likely there was also an increase in costs related to the use of these crops.

Where to from here?

The future of the pasture potential concept may lie in more customised reporting (for example, in DairyBase), or via dashboard tools. New developments could see options for real-time comparisons across relevant peers for their pasture harvest in the year to date.

DairyNZ will also be improving the 'pasture journey' for farmers who are looking to improve their level of home-grown feed.

DairyNZ resources

DairyNZ has a number of resources that can help farmers to capture their pasture potential opportunity. Go online to find out about:

- **dairynz.co.nz/pasture-potential** – view the prototype of the Pasture Potential Tool.
- **dairynz.co.nz/pasture-eaten** – an online tool for assessing pasture and crop eaten.
- **dairynz.co.nz/feed** – feed management information (including more specific tools such as DairyNZ's Spring Rotation Planner or SRP).
- **dairynz.co.nz/farm-gauge** – Farm Gauge (specifically, its pasture component).

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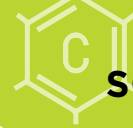
Cutting to the chase: the effects of pre-graze mowing

Mowing before grazing (pre-graze mowing) is a strategy sometimes used to achieve target pasture residuals with the belief that intake is increased and surplus pasture will be converted into milk. However, neither past nor recent research supports this belief, explains DairyNZ senior scientist Jane Kay.

Past research

Earlier research compared cows grazing mown pastures versus standing pastures and reported little or no benefit to cow production, and reduced pasture growth rates. However, these studies didn't investigate the longer-term effect of mowing pastures with higher-than-recommended pre-graze pasture covers.

Recent research

DairyNZ researchers joined up with farmers, rural professionals, and university professors, to compare the outcome from grazing mown versus standing pastures at two pre-grazing covers: moderate (MOD) – 2900 kilograms of dry matter per hectare (kg DM/ha) and high (HIGH) – 3500kg DM/ha.

The experiment was carried out at Lincoln University Research Dairy Farm from October 2016 to February 2017. There were four treatments *(see table on right)* and eight farmlets (two farmlets for each treatment), each with a stocking rate of 3.5 cows/ha. To achieve different pre-graze covers, rotation length was eight days longer (29 versus 21 days) in the HIGH compared with the MOD farmlets.
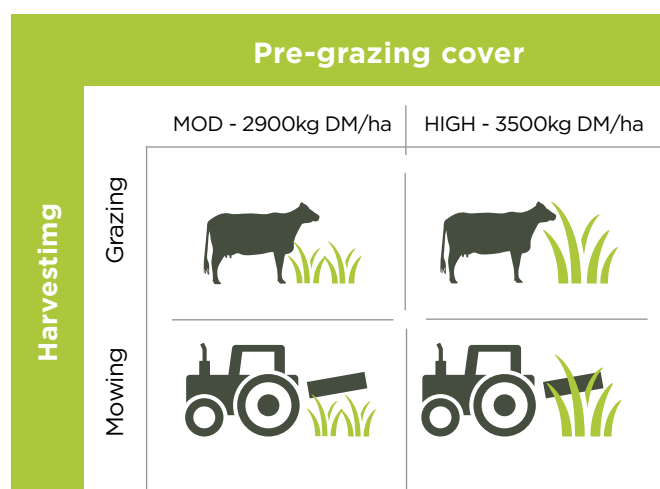
Results: cow performance

Pre-graze mowing had no effect on cow performance, with cows in both mown and grazed herds averaging 1.8kg milksolids per day (MS/d) and a 4.2 Body Condition Score (BCS) throughout the experiment.

Pasture disappearance (pre-graze less post-graze yield) was greater in mown versus grazing treatments (+2kg DM/cow/d) but substantial mown material (2kg DM/cow/d) was left behind in the paddocks. Combined with the lack of response in cow performance, this indicates there was no increase in cow intake with pre-graze mowing.

There was an effect of pre-graze pasture covers, with cows in the MOD farmlets producing six percent more milksolids than those in the HIGH farmlets.

Results: pasture and supplements

Pre-graze mowing had a negative effect on

Pre-grazing cover

| | MOD - 2900kg DM/ha | HIGH - 3500kg DM/ha |

pasture performance, reducing tiller numbers and pasture density. This means, for a given height, there was less pasture available in the mown farmlets. This resulted in less silage being made, and more silage fed out to cows in the mown farmlets to maintain intakes.

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