Dairy Council Northern Ireland
Shaftesbury House
Edgewater Office Park
Edgewater Road
Belfast BT3 9JQ

T +44(0)28 9077 0113
F +44(0)28 9078 1224
E info@dairycouncil.co.uk

www.dairycouncil.co.uk

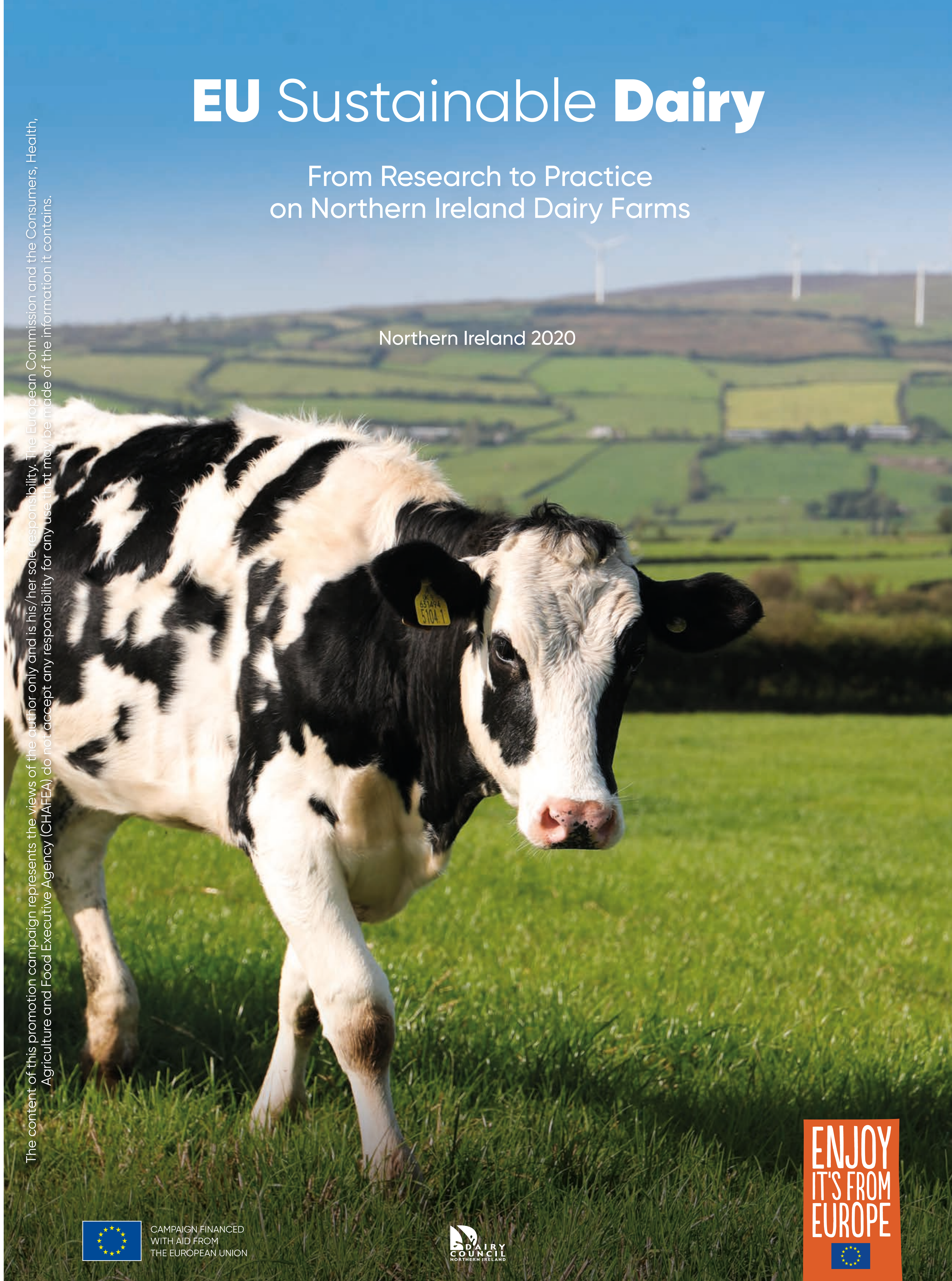
CAMPAIGN FINANCED WITH AID FROM THE EUROPEAN UNION

ENJOY IT'S FROM EUROPE

EU Sustainable Dairy

From Research to Practice on Northern Ireland Dairy Farms

Northern Ireland 2020



CAMPAIGN FINANCED WITH AID FROM THE EUROPEAN UNION

ENJOY IT'S FROM EUROPE

Foreword

This year I had the pleasure of addressing the third EU Sustainability Symposium organised by the Dairy Council Northern Ireland. The Northern Ireland Dairy industry continues as it always has, to produce high quality food but to remain viable it must be increasingly efficient and resilient to financial and physical pressures. However this efficiency must be achieved in balance with environmental sustainability.

Around 70% of land in Northern Ireland is devoted to agriculture so agriculture has a very significant impact on the environment, whether it be air quality, water quality, biodiversity, general land or soil management, and this impact can be both positive and negative.

I commend the efforts made to date by the dairy sector, in partnership with DAERA, through the Efficient Farming Cuts Green House Gases Strategy. The 34% reduction of carbon intensity per litre of milk since 1990 is a significant outcome indicator and a big step in the right direction. This initiative also clearly demonstrates the importance of industry and government working collaboratively.

Our economy is changing. There are many reasons for this, but perhaps the single most important of these is the commitment by the UK Government to achieve Net Zero Carbon by 2050. Overall we have reduced our emissions in Northern Ireland by 18% in recent years. We have gone down from emitting 24 mega tonnes of carbon dioxide equivalent in 1990 to 20 mega tonnes in 2017. While this is not enough, it proves that we can make progress when we work together.

In terms of the challenges that face us, Northern Ireland, in common with any region or country with large livestock numbers, is a significant contributor to Greenhouse Gas (GHG) emissions.

DAERA is leading in the development of a multi-decade Green Growth Strategy and delivery framework for Northern Ireland, in partnership with other Departments, Local Government and stakeholders from across the business and voluntary sectors. The outcome will be a framework of programmes which will help deliver a resilient recovery through a greener, low carbon and circular economy for Northern Ireland.

Northern Ireland's farmers and processors need to make use of the best research to deliver best practice in relation to environmental and conservation management. There is a need for continued investment in research to underpin sustainable agricultural policy development, and to facilitate practical environmental management knowledge transfer to farmers, land managers and processors. This fact book summarises some of the advances that have been led by effective local research.

The dairy sector will have to change and adapt to meet future environmental challenges. In order to achieve this change, the sector will need to be given the correct information and knowledge, on why it is being asked to change, how to achieve the change, and what the benefits are for it and for the environment. The presentations within this fact book and the associated Symposium support this need for information and knowledge. I am also pleased to highlight the investment by dairy processors to reduce their emissions and this demonstrates the positive impact that innovation and effective management is having in reducing the dairy sector's carbon footprint.

Minister Edwin Poots MLA
Agriculture, Environment, and Rural Affairs

Introduction

Our 2020 EU Sustainable Dairy Fact Book marks the completion of a three year campaign to promote the sustainability practices of the dairy sector in Northern Ireland.

Starting in 2018, the first fact book provided a solid introduction to the local greenhouse gas inventory and profiled some of the great work being done at AFBI and CAFRE to ensure evidence-based best practice is implemented on local dairy farms.

It quickly became clear that world-leading research was being done on our doorstep to better understand the unique role our dairy herds, hedgerows and grasslands play in carbon capture and we were able to include examples in our second fact book of how our local dairy processors are improving their efficiencies and supporting their suppliers to do the same.

We've also benefited from the expertise of global leaders in the field of dairy sustainability and it has been a great opportunity to strengthen the information exchange, inform government policy and deliver better environmental outcomes on Northern Ireland dairy farms.

Our local dairy sector is something to be proud of and I am grateful that some of Northern Ireland's dairy enterprises have allowed us to gain an insight into how they are putting research into practice.

The content of this year's fact book reflects our theme, "From Research to Practice", and looks at three research projects carried out at scale in Northern Ireland, namely youngstock and heifer rearing, soil and catchment modelling, and efficient concentrate use, and profiles three local dairy farms which are putting into practice the learning from the research.

A lot has changed since we published our previous fact book in December 2019. The UK has left the European Union, our lives have been dramatically changed by the arrival of a global pandemic and the impact on the dairy sector has been immense.

For the first time in three years, Northern Ireland has a functioning Executive and we are grateful to the DAERA Minister, Edwin Poots MLA, for writing the foreword for this year's fact book.

Northern Ireland falls under the remit of the UK Climate Change Act 2008 but the New Decade New Approach agreement committed to setting NI specific targets for reducing carbon emissions in line with the Paris Climate Change Accord. It also committed to a Climate Change Act, Energy Strategy and a sustainable Economic Strategy to ensure Northern Ireland plays its part in taking a coordinated and strategic approach to tackling climate change and we look forward to playing our part in contributing to each of those.

From a national and international perspective, climate change and sustainability remain high on the agenda.

Next year the UK will host the UN Climate Change Conference (COP26) in Glasgow and help shine a greater spotlight on the work being done locally and internationally to deliver a sustainable future.

In November 2020 the UK Government launched an ambitious Ten Point Plan for a Green Industrial Revolution outlining how it will stimulate economic growth and achieve net zero by 2050. In December 2020 the Committee for Climate Change published its latest report which included a recommendation that Northern Ireland reduce its carbon emissions by at least 82% by 2050 to help the UK achieve its net zero ambition and the DAERA Minister, Edwin Poots MLA recently launched a consultation on a Climate Change Bill for Northern Ireland.

Whilst all of these endeavours are honourable, it is essential that the dairy sector continues fulfilling its role in the transition towards net zero, and, therefore, we need to be mindful of the UN's four pillars of sustainability - climate, nutrition, economy and culture. Without sustainable local dairy farm enterprises, we cannot achieve the ambition of a sustainable future.

It is therefore imperative that future policy decisions and incentives are evidence-based and co-designed in partnership with the sector and subject matter experts who have been studying the sustainability of the dairy farms for decades.

One such example is the findings from an AFBI research project on soil nutrients which suggest improving the pH levels of Northern Ireland dairy grazing platforms, at a cost of £30 million, could yield an impressive sevenfold return on investment.

Throughout this programme we have had an insight into the work being undertaken at AFBI, CAFRE, the investment being made by dairy processors, and the adaptation of new technologies and practices at farm level to improve the environmental footprint of the Northern Ireland dairy sector.

The benefits are a reduction in emission intensity of one third from the NI dairy sector since 1990, an achievement that is all the more commendable given that the sector has grown by two thirds over the same time period.

I would like to extend my personal thanks to all of our speakers, contributors and programme participants over the past 3 years. It is a credit to our local DAERA, AFBI and CAFRE colleagues that the research and learnings highlighted in our campaign will help inform future Agricultural and Environmental policy decisions.

This fact book has been produced with support from the European Milk Forum (EMF) and financial assistance from the European Union. The EMF 'Sustainable Dairy' initiative is co-ordinating a new and informed dialogue with key stakeholders on the environmental actions being taken in six EU countries. We are grateful to the EMF and EU for their support as we highlight the positive contribution that the dairy sector is making towards the environmental sustainability agenda in Northern Ireland.

Mike Johnston

Dr Mike Johnston MBE, PhD
Chief Executive

Chapter 1.

Rethinking **Methane**

The **path** to **climate** neutrality

Dairy and the **Path** to **Climate** Neutrality

Q&A

With Frank Mitloehner, Ph.D.
Professor & Air Quality Specialist Department of Animal Science, University of California, Davis Director, CLEAR Center at UC Davis.

What Challenges does the Dairy Sector face in quantifying its Environmental Footprint?

I recently compared the emissions inventories for the City of Los Angeles, Europe's Largest Coal-fired power station Belchatow in Poland and the Republic of Ireland.

Most people would assume that with the lack of green space in Los Angeles and its population of 13 million, it must have the highest emissions, followed by the power plant and then Ireland. At least I initially did, because what I found surprised me.

Ireland emits 50% more CO_2e* per year than the power plant, and even the city of LA has a lower carbon footprint.

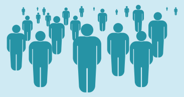
Ireland has three-times fewer people than the city of Los Angeles and has an abundance of carbon-sinking grasslands, so it doesn't really make sense that it has such a high carbon footprint. The problem lies in the way we quantify the climate impacts of one of the main gases from Irish agriculture, which is methane. This presents a major challenge – and opportunity – for the dairy sector.

Another area that needs further consideration, is the role that grasslands, bushes and trees play in carbon sequestration in Ireland. During photosynthesis they pull in large volumes of carbon which is absorbed and stored in their biomass in the soil.

A large proportion of the green space in Ireland is marginal land and used for grazing, making use of land that is otherwise unproductive from a food-producing point of view. Furthermore, that land is able to capture a lot of carbon and hold onto it in its soil.

This sequestration process isn't currently accounted for but is a very important sink of greenhouse gases.

Carbon Intensity of Los Angeles California, Belchatow Power Plant, Poland - The Largest Coal Fired Power in Europe, and the Republic of Ireland.



50MMT
of CO_2e* per year
L.A. – population of 13 million

40MMT
of CO_2e* per year
Belchatow Power Plant

60MMT
of CO_2e* per year
Republic of Ireland – population of almost 5 million

** Carbon dioxide equivalents per year*

Neither of these two topics matter for Los Angeles or the coal-fired power plant, as they only produce greenhouse gases, but they are very important for the carbon footprint of animal agriculture and in particular the dairy sector. It is important that we look at how greenhouse gasses actually warm our planet so we're not missing climate solutions right under our feet.

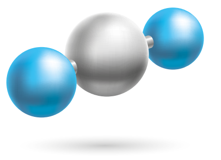
Are All Greenhouse Gases Equal?

We compare GHGs based on their global warming potential or GWP_{100} which is their relative strength in relation to CO_2.

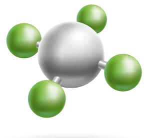
While this unit of measurement shows the potency of a greenhouse gas, it doesn't show how short-lived climate pollutants like methane actually warm the planet.

Global Warming Potential (GWP_{100}) of Main Greenhouse Gases

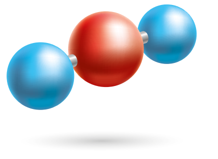
Carbon Dioxide **01**



Methane (CH_4) **28**



Nitrous Oxide (N_2O) **265**



Methane is 28 times more potent than CO_2. Nitrous Oxide is even stronger with a GWP_{100} 265 times stronger than CO_2. But that is only part of the picture.

Methane has a relatively short life of 10 years compared to the thousands of years that CO_2 hangs around. After about 10 years, most atmospheric methane is broken down and converted into CO_2 and water vapour. As a result of its short lifespan, methane is only significantly warming our atmosphere for those 10 years, which is why it is considered a short-lived climate pollutant (SLCP).

Its short lifespan is further relevant in regard to warming, because it means that as methane is being emitted it is also being *destroyed* in the atmosphere, making it a *flow gas*.

This illustrates that methane's warming impact isn't determined by how much is being emitted – since it's destroyed relatively quickly – but by how much more or less methane is being emitted over a period of time. This is a change in the rate of emission.

What is notable about methane, is that it's possible the amount being emitted can equal the amount being destroyed. For example, if a herd of cattle emits the same amount of methane over 10 years, they are contributing to warming for those 10 years. But afterward, roughly the same amount being emitted is the same that is being destroyed through oxidation, and thus warming is neutral.

It's clear that methane from livestock warms very differently than CO_2 from fossil fuels, and we need to consider that when accounting for climate impacts of various sectors.

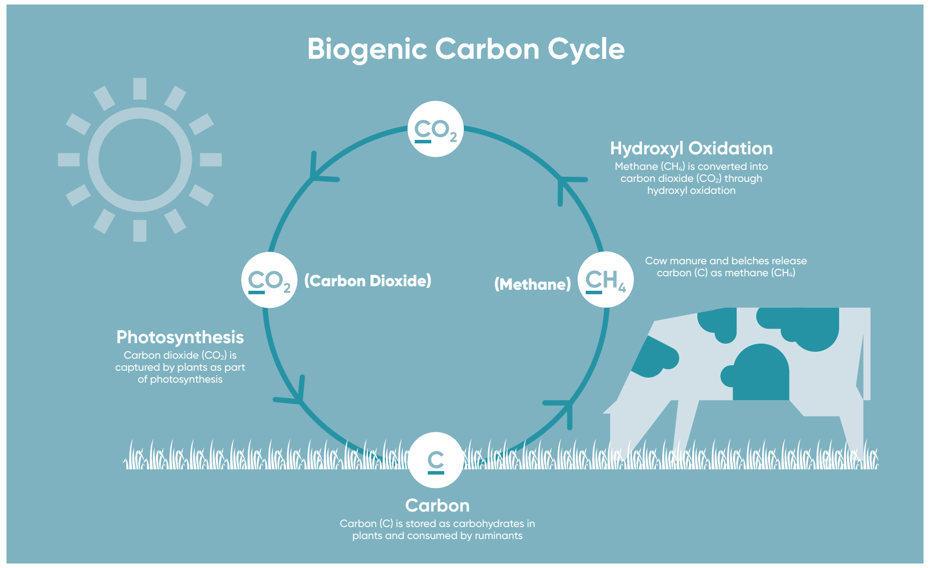
How does methane from livestock behave differently than other greenhouse gases?

Cattle belch methane, and methane is a potent greenhouse gas that we must not increase. But biogenic methane from cattle is part of an important natural cycle, which is called the biogenic carbon cycle.

The carbon component of the methane (CH_4) particles in the biogenic carbon cycle originates as atmospheric carbon dioxide (CO_2). During the photosynthesis process, plants require water, sunlight and carbon. They draw the carbon from the atmosphere to build carbon containing molecules such as cellulose and starch within their biomass. These carbohydrates, which humans cannot eat, are subsequently consumed by livestock and turned into food humans can eat.

As a by-product of eating that cellulose, cattle release methane and return that carbon sequestered by plants back into the atmosphere. After about ten years, that *methane is broken down* and converted back to CO_2. This is recycled carbon, that is not adding additional carbon to the atmosphere.

> *" It is vital that the biogenic carbon cycle is fully considered when calculating the impact of livestock on climate. "*



It is vital that the biogenic carbon cycle is fully considered when calculating the impact of livestock on the climate. It is a beautiful solar-powered process that requires very little input.

The resulting CO_2 from methane being oxidised is returned to the atmosphere. It's important to consider that this is not new or additional CO_2 in the atmosphere, as CO_2 from fossil fuels is. A fossil fuel (oil, coal and gas) is carbon that was originally plants and animals which have since been stored under great pressure for millions of years.

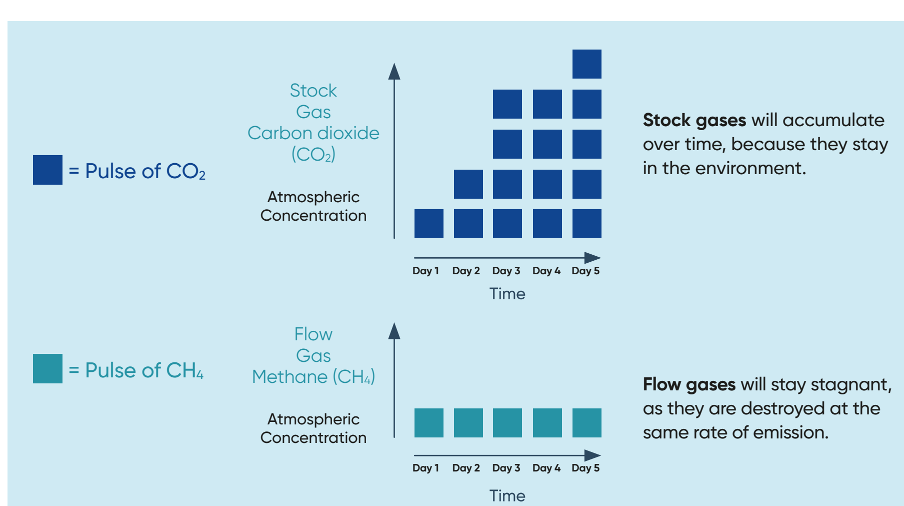
In the last 70 years we have extracted approximately 50 percent of known fossil fuels. We have reached peak oil, extracted it from the ground, burned it and relocated to our atmosphere where it is warming our planet at an alarming rate.

How should the impact of methane be calculated?

It is important to acknowledge that as a stock gas, CO_2 accumulates and builds up in the atmosphere over time. Every time you burn a fossil fuel, say by driving your car, new carbon is released and added to previous emissions.

Methane, as a flow gas, is emitted and destroyed in the atmosphere. If you have a constant source of methane for about 10 years, say from a herd of cattle that has stayed the same size, what is being emitted will equal what is being broken down in the atmosphere. So, unless you increase the emissions you are not adding any new or additional carbon to the atmosphere.

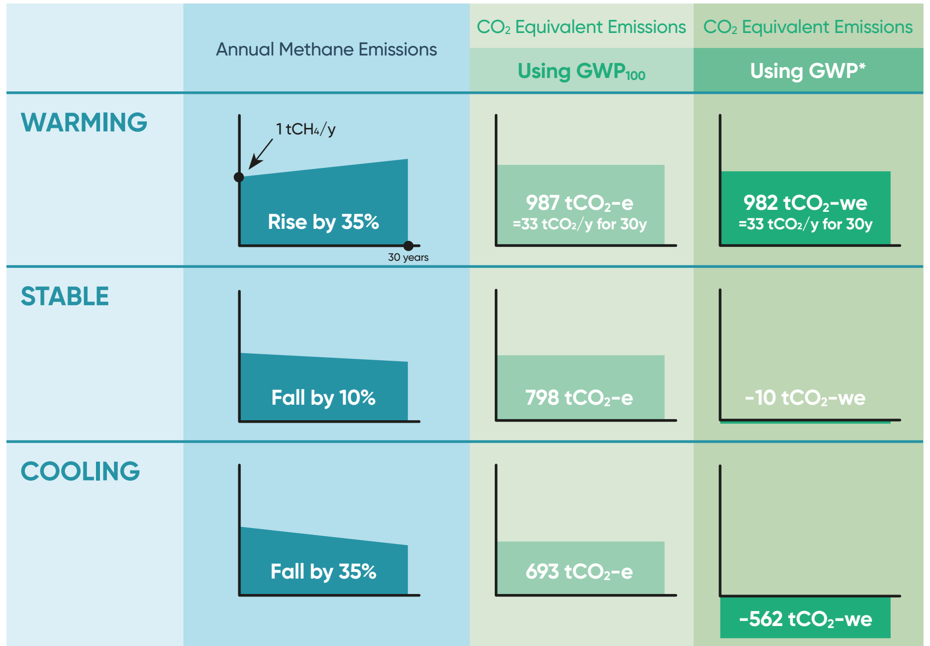
It is important to remember though, that for those first ten years, a source is adding warming to the atmosphere. And if we increase methane emissions, say by growing a herd, it will lead to a significant increase in warming.



Based on research by Myles R. Allen, Keith P. Shine, Jan S. Fuglestvedt, Richard J. Millar, Michelle Cain, David J. Frame & Adrian H. Macey

To show methane's impact on our climate, researchers at the University of Oxford strongly suggest an alternative to GWP_{100} for short-lived climate pollutants such as methane, in favour of a unit that actually predicts the warming of methane over time known as GWP*.

Using GWP* would better inform our understanding of the temperature impact our activities are having on warming. And if we're talking about global warming, we want to better understand how a pollutant impacts warming – not just it's CO_2 equivalence.



Cain, M., Allen, M. & Lynch, J. Oxford Martin Programme on Climate Pollutants 2019

If we are to realise the commitments contained the Paris Climate Accord to reduce warming by 1.5 degrees by 2050, it is important we measure the emissions in a suitable unit which measures the warming impact of our actions accurately.

The diagram above from the University of Oxford School of Martin programme on climate pollutants illustrates the impact of mistreating methane as a stock gas instead of a flow gas over a 30-year period.

The current GWP100 predicts an increase in CO_2 equivalent emissions regardless of what changes you make to methane emissions. This overstates methane's impact on our climate, while also overlooking valuable climate solutions.

GWP* on the other hand illustrates that methane has a big warming impact with increasing emissions, but neutral warming can occur with minimal changes (-10%) to annual methane emissions and a strong cooling effect can be achieved from a fall of 35%. These reductions are all possible with advancements in feed additives, manure management and animal health.

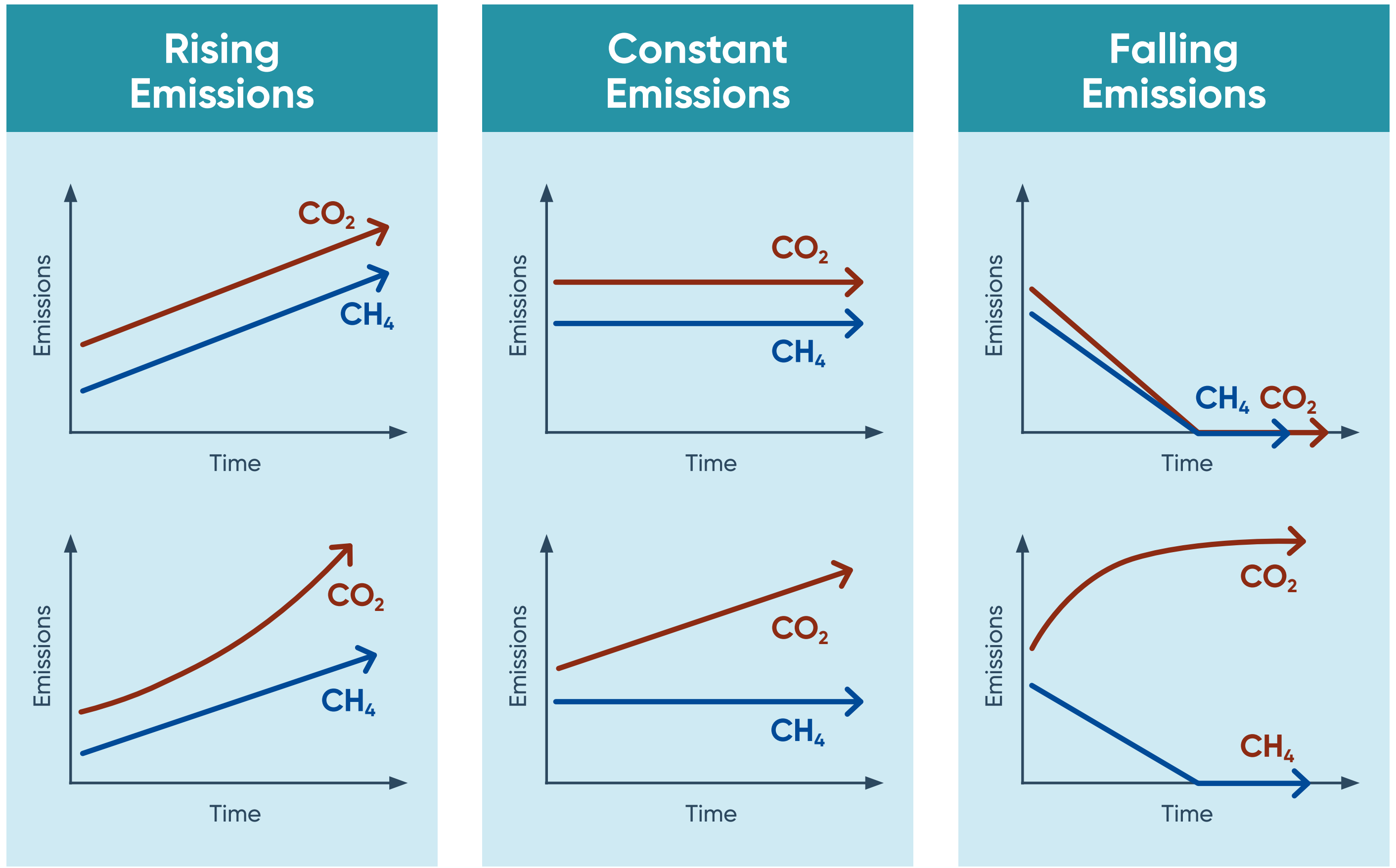
> *"Using GWP* would better inform our understanding of the temperature impact our activities are having on warming."*

What does this mean for the dairy industry?

The diagram below illustrates how CO_2 warms differently than methane, emphasizing the need for alternative metric to measure short-lived climate pollutants. Without considering how each gas warms our climate, we're exaggerating the impacts of sectors that may actually be part of a climate solution.

The temperature response to changing methane emissions are instantaneous and therefore present a real opportunity to use our livestock herds to improve temperatures.

The left panel shows how increasing emissions of carbon dioxide versus methane both increase warming. In the case of carbon dioxide, it occurs at a much faster rate, simply because we're creating an ever-larger stockpile of it over time. Today's emissions of carbon dioxide are being added to yesterday's emissions and those of the day before, and the day before, and the day before, ad infinitum. In other words, the stock gas CO_2 is accumulating, leading to an exponential increase in warming.



Oxford Martin, Climate Metrics for Ruminant Livestock, July 2018

It's a different story for methane. When methane increases, warming follows in a linear fashion. Though warming increases when additional methane is emitted, it does so at the rate of emission, because the methane of yesteryear is long gone, having been recycled. Warming is coming from the new, incremental methane in the air.

The center panel shows a scenario where emissions of both gases remain constant, but only carbon dioxide leads to increasing warming, while warming via methane is neutral. This is because methane is being destroyed at the same rate that it's being emitted. Thus, there is no additional warming.

On the other hand, carbon dioxide's warming continues to increase, because it's being added to the atmosphere without the earlier carbon dioxide being sequestered or destroyed. Again, that CO_2 is being added to atmospheric concentration of CO_2.

Finally, in the right panel, emissions of both gases are reduced to zero. Carbon dioxide's warming continues to rise, since even though a decreasing amount is being added, whatever is released into the atmosphere will join the atmospheric stock and further warm.

It eventually levels off, but without removing CO_2, that's the best we can hope for.

Methane, on the other hand, immediately creates a cooling effect. That's owed to the fact that methane is a flow gas and as it is emitted, it is also being destroyed. So, less methane in the atmosphere means more is being destroyed than is being emitted. In this methane reducing scenario, carbon is actively taken out of the atmosphere leading to negative warming, or better said "cooling".

Furthermore, plants continue to need carbon dioxide, and they will naturally draw from the surplus of carbon dioxide from other activities if methane isn't providing enough. While we grapple with how to reduce our global footprint, methane and the dairy sector can play a role in keeping climate warming at bay, providing we succeed in reducing it.

Chapter 2.

Soil and catchment modelling

Alex Higgins, Soil Scientist,
Agri-Food and Biosciences Institute (AFBI)

Soil and catchment **modelling**

During the autumn/winter seasons of 2018 and 2019 almost 20,000 fields were soil sampled across Northern Ireland using GPS technology to record field locations and sampling transects as part of the largest soil survey scheme ever to occur in the UK.

The scheme funded by the EU EAA fund had two components. The first component was a Northern Ireland-wide scheme, known as the ***"Open Scheme"****, to which all livestock farmers in Northern Ireland were eligible to apply. The second component, the* ***"Catchment Scheme"****, was targeted at farmers within specific geographical areas of the Upper Bann river catchment.*

All participating farms were provided with free whole-farm soil sampling, with analysis and results being provided through an accredited laboratory with reporting tailored to Northern Ireland requirements, allowing farmers to use the results for other purposes such as in relation to the Nitrates regulations.

Over 1000 farm businesses that were successful in applying to the scheme received their soil sample analysis reports by the first week in April 2018 and these were supported by scheme-specific training developed by CAFRE with input from AFBI, and delivered locally to farmers by AI Services Northern Ireland Ltd.

The free training provided by CAFRE included modules on soil report interpretation and nutrient management. This led AFBI to develop RAG (Red Amber Green) nutrient maps for individual farmers: red indicates fields over supplied by a particular nutrient, Amber indicates fields that are under supplied by a particular nutrient and green indicates optimum nutrient levels. LiDAR technology was used to map the catchment and produce nutrient loss risk maps.

LiDAR stands for **L**ight **D**etection **A**nd **R**anging; in this case a plane mounted Laser which captures a huge amount of data. There are tens of millions of points across the catchment, and it provides detailed height information associated with each one of those points.

This was flown in the autumn and winter when there were few leaves on the trees which allowed for the capture of information to the ground surface.

The generated surface allowed for the production of a water flow model for the catchment, which once integrated with soil data (infiltration capacities and the hydraulic conductivity of the soil), generates flow accumulation paths as water moves over the soil. The red areas on the map are hydrologically sensitive areas where water will accumulate on the surface.

Soil and catchment **modelling**

The Catchment Scheme

The Catchment scheme was focussed on the **11 sub-catchments of the Upper Bann**, from Banbridge in the north to Hilltown in the south; **513 farms participated encompassing 7,300 fields**. AFBI recruited farms from the catchment area, the distribution of enterprises is more representative of the types of farms in the area.

The analysis reports contained detailed information about soils (i.e. pH, Phosphorus (P) and Potassium (K) status) enabling participating farmers to target the application of slurry, manure and chemical fertiliser more accurately. This will help to maximise grass yields, improve soil fertility and increase farm profitability *(for example by reducing the need for expensive fertiliser nutrients in fields already well supplied with P or K)*, while also reducing the potential for negative impacts on water quality. The reports also contained recommendations for liming.

Taking a typical 100 acre (40ha) grassland farm, lime application costing £1,440 would result in an increased grass yield of 86 t DM (i.e. an extra 1 t DM/ha/year for 5 years on 43% of the grassland area, i.e. 17 ha), worth an estimated £10,750.

Results of these soil tests also demonstrated opportunities to save on fertiliser P inputs and to make better use of slurry P, minimising future loss to waterways. The results indicated that 40% of fields in both lowland and disadvantaged land areas (DA), and 30% of fields in severely disadvantaged areas (SDA), have soil P indices greater than 2+.

Agricultural fields with above optimum soil phosphorus (P) are considered to pose risks to water quality however the impact of this on water quality depend on the hydrological connectivity of those areas to the nearest watercourse. As part of this project, scientists are working with LiDAR digital elevation models of the local landscape and soil P data from 7693 fields in a 220km^2 catchment. By combining water flow pathways across the landscape and soil P concentrations, high and low risk areas of P loss are being identified to allow farms to alter the timing and location of nutrient applications to minimise this risk.

> A preliminary analysis of the results from the scheme indicates that 43% of farmed grassland (excluding rough grazing) across Northern Ireland is under-limed with a total lime requirement of 1.2 million tonnes, requiring an expenditure of £30 million. Correcting this soil acidity problem could potentially increase grass DM production in Northern Ireland by some 1.73 million tonnes over the next 5 years, with a feeding value worth up to £216m *(£125/t DM)*, and thus representing an almost 7 fold return on the lime investment.

11
sub-catchments of the Upper Bann

513
farms

7300
fields

Issues arising from crop excess soil P:

- P is a growth limiting nutrient in aquatic systems, any additional dissolved P in water can lead to increased algal growth, an increase in unwanted aquatic plant growth and a significant reduction in water quality.
- Soils found to be at or above Olsen index 3 have been shown to lose higher rates of P, primarily through surface processes like loss of dissolved P or erosion of particulate P through either organic or mineral material lost.
- The distribution excess soil P is spatially uneven throughout the catchment, more of an issue in areas farmed more intensely than other areas such as sheep farms for instance.
- To focus on the potential management of this issue LiDAR imagery was obtained for the catchment.

Areas in fields that are prone to waterlogging after rain events essentially are zones of prolonged saturation and ephemeral surface water accumulation, and these represent the primary route for surface delivery of dissolved and suspended nutrients to aquatic systems.

Once these Hydrologically Sensitive Areas have been identified, it allows AFBI to produce Nutrient loss risk maps. Each field would be identified along with the risk areas and purple dots identify the delivery points to the aquatic system. Identifying these areas allows mitigation strategies to be taken to stop or slow down the delivery of P to the river, such as placing sediment traps or buffer zones. The benefit of employing such mitigations could potentially avoid blanket measures like a ban of fertiliser or organic manures on some of these high-risk zones.

AFBI has a long established water chemistry sampling network within the Upper Bann sub catchments, which lends to the examination of the relationship of the water quality and these intensive soil measurements collected through the scheme.

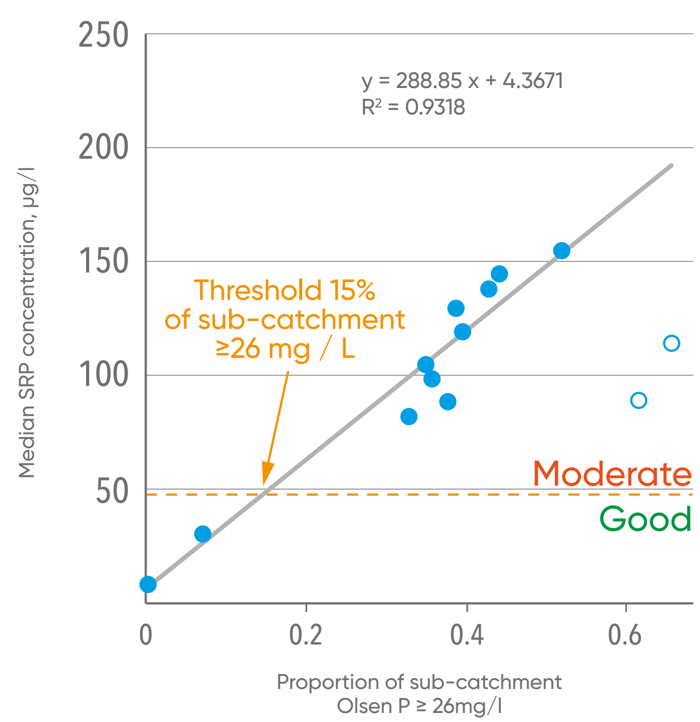
> *"The benefit of employing such mitigations could potentially avoid blanket measures like a ban on fertiliser or organic manure use on some of these high-risk zones."*

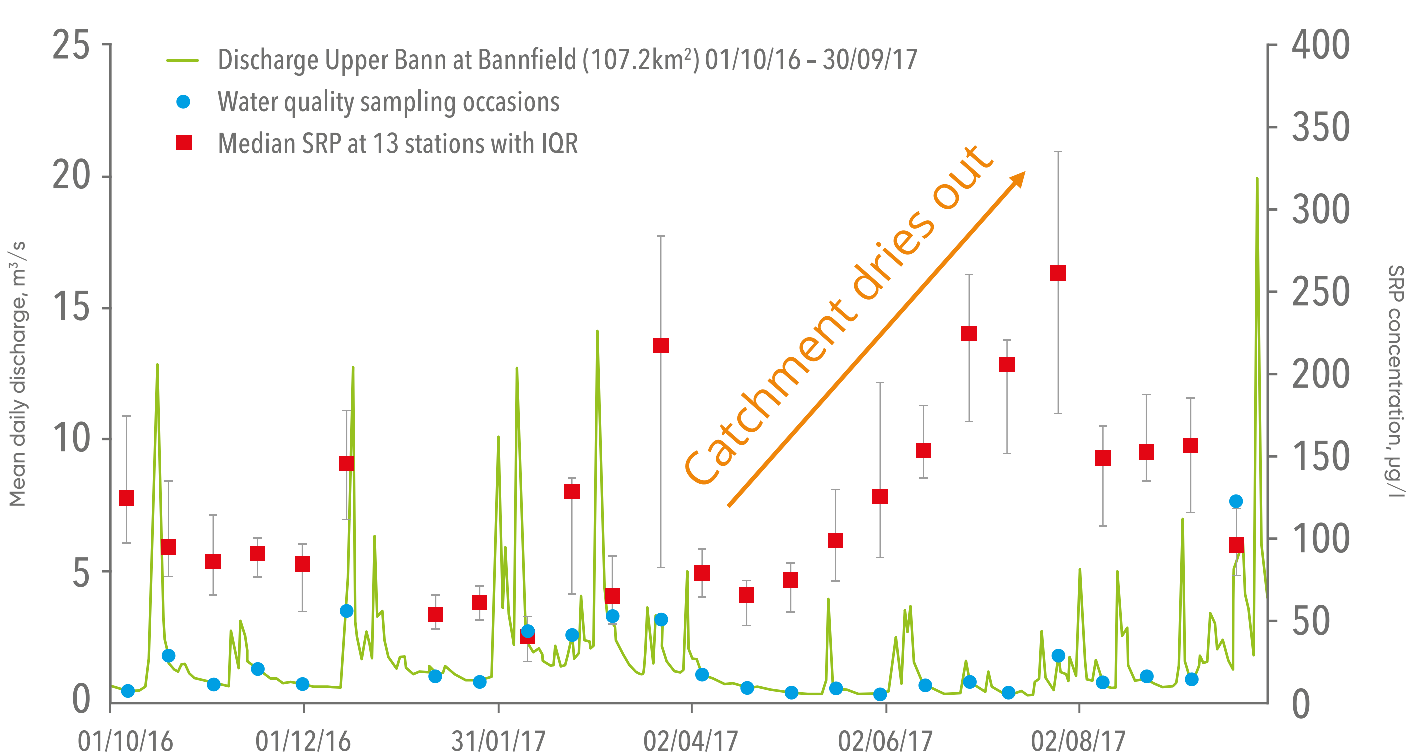
Results

These catchments are sampled on fortnightly intervals, there are 13 sub-catchments and 11 of those sub-catchments were involved in the scheme and 2 outside the scheme. This allowed AFBI to examine the relationship between the in-stream Phosphorus known as Soluble Reactive Phosphorus (SRP); this is the measurement the Water Framework Directive uses to categorise good, moderate and poor quality river waters.

The graph below demonstrates there's a wide spread between SRP values in the 11 sub-catchments, the two upland catchments are in the good to very good category but they move progressively down the moderate scale for some of the other sub-catchments, with a range from 8.5 to 145 micrograms. 48 micrograms represents the difference between good and moderate water quality in terms of SRP within the water framework directive. There's very strong seasonal variation in this value as well.

SRP v Above Olsen P Index 2





Soil and catchment **modelling**

The graph (left) shows the actual measured data collected by AFBI. The blue line is the volume of water being discharged and the pink square is the median SRP value as measured at the 13 sub-catchments. It illustrates that in the spring to summer period there is a gradual increase in the concentration of SRP of up to 250 micrograms which is classified as poor water quality. As this is a median value, some of the values are exceptionally high going up to 1200 micrograms which is exceptionally poor water quality.

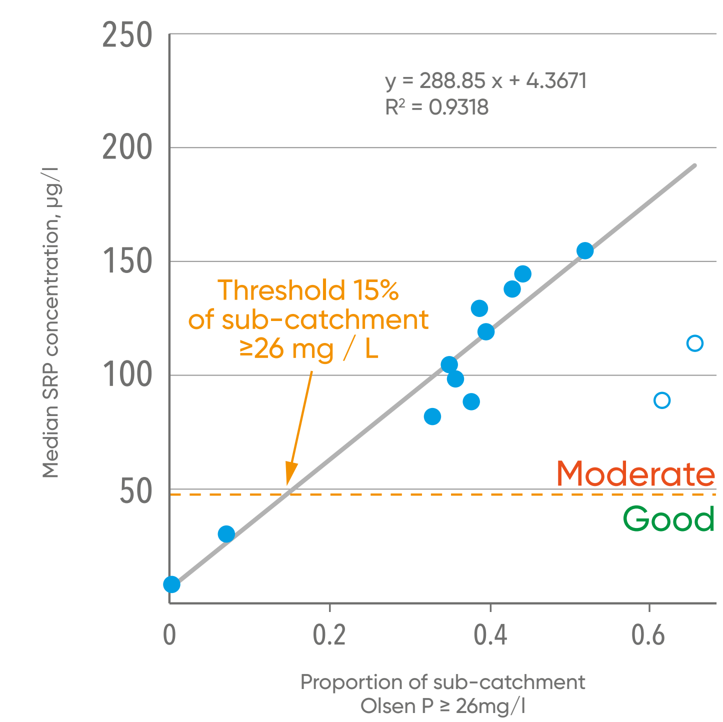
There's a very strong relationship between SRP concentration dissolved P in water and a proportion of the sub-catchment above index 2, and at the point on the graph where the division between moderate and good is, there is a value of about 15%. This is the threshold to avoid Eutrophication, and where you go from good to moderate quality so in essence the catchment can't have more than 15% of the fields above index 2 otherwise it slips into this moderate category.

Another way of looking at this data was to include the proportion of the Hydrologically Sensitive Areas (HSAs). If the proportion of soils which are above index 2 and which contain HSAs is examined, the proportion of the catchment containing both to maintain good water quality cannot exceed 1.5 percent.

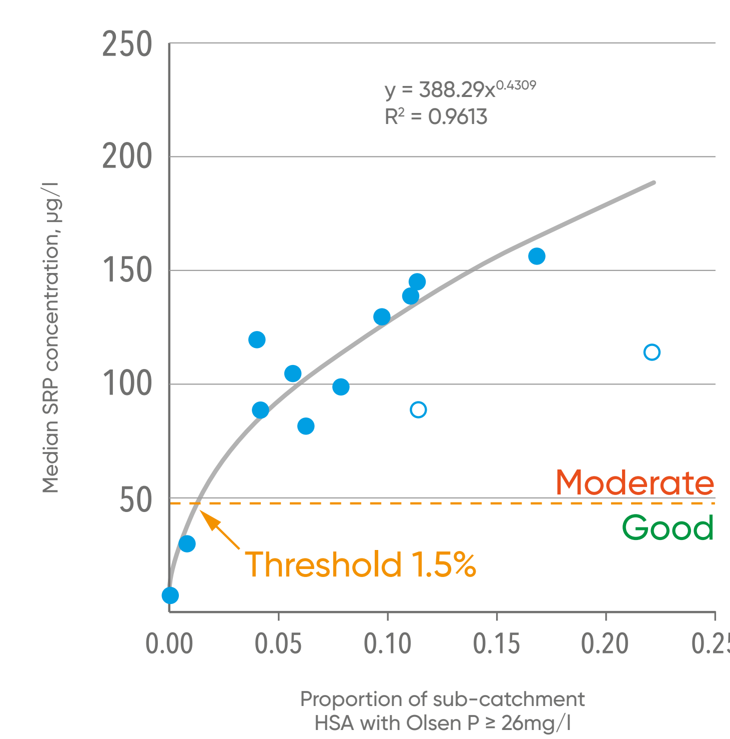
Taking the usual experimental error into account, the data suggests having any hydrologically sensitive area in soils above index 3 would prevent water quality improving to good.

> *"In essence the catchment can't have more than 15% of the fields above index 2 otherwise it slips into this moderate category."*

SRP v Above Olsen P Index 2



SRP v HSA & Above Olsen P Index 2



Conclusion

- This was a highly successful scheme with over 70% participation allowing AFBI to collect this highly useful data.
- A sustainable increase in quality and quantity of grass could be achieved through correcting sub-optimal soil pH (40% of grassland tested) and soil K status (42% of grassland tested).
- Soil P levels excessive to plant requirement are a concern because of their potential impact on aquatic systems (38% of grassland tested Olsen >Index 2).
- Water sampling indicates a strong relationship with the proportion of the catchment with excess soil P levels and HSAs in combination with excess soil P in relation to overall river water quality.
- Soil nutrient and runoff risk mapping can be a potentially useful tool to target and manage nutrients at farm scale, both to protect the environment and conserve a valuable nutrient.

Ian previously worked with his brother on the family farm at Katesbridge and in construction, before becoming the third generation to take over the running of Creevy House Farm in 2015, where he now lives with his wife and two young children.

Back then, Creevy House was a beef and youngstock farm but he has since installed a 12-point, swing over feed to yield dairy parlour and new accommodation block and it is now exclusively a dairy enterprise.

Ian currently manages a milking herd of 90 cattle and hopes to increase his headcount to 100 in the next couple of years.

Creevy House is situated in the Upper Bann catchment area which was the focus of the EEA soil and catchment modelling study. Ian took part to learn how to better target his nutrient application to make the most of the land available and maximise feed from forage.

He also acknowledges that any efficiency savings in nutrient application and forage also save his business money by reducing his artificial fertiliser and concentrate costs.

FARM DETAILS

Area Farmed	130 acres (20 of which are rented)
Cropping	All grass
Stock	150 90 milking
Soil Type	Medium loam
Rainfall	50 – 55 inches every year

FARM AVERAGE PHYSICAL PERFORMANCE (Year ending June 2020)

Milk Yield	10,000 litres
Concentrate fed	2.98t/cow
Feed rate	0.3kg/l
Milk from forage (grass & silage)	3,600 litres (targeting 4,000)
Replacement rate	<20%
Calving interval	13.7 months (targeting 12)

Farm Objectives

Having started his dairy enterprise in 2015, Ian has been conscious to introduce efficiencies from the outset and is constantly exploring new opportunities to improve his environmental footprint.

The farm operates on a low input high output model and he is currently achieving 10,000 litres. He also breeds the herd for fats and proteins to ensure he is producing nutrient-rich milk to meet customer demand.

Milk from forage has been rising year on year and the advice and recommendations from the soil and catchment modelling research programme will hopefully help him work towards achieving an average of 4,000 litres of milk from forage.

Improving Farm Sustainability Through Soil and Catchment Modelling

As part of the Upper Bann catchment area research Ian received soil and LiDAR analysis of his farm and surrounding areas which detailed where the most likely nutrient run-off areas are.

Ian says, *"The researchers came out to farms all along the Upper Bann catchment area and did the sampling themselves, so on my part I didn't have to do an awful lot. We have greatly benefited from the analysis and recommendations the programme produced and it has helped inform my fertiliser application and is enabling me to make the most of my soil testing, grass measurement and nutrient management."*

The soil analysis left Ian with information to use going forward on pH levels and P and K in the soil, "I now know my land has good Ps and good enough Ks for now. It just gets upkept with lime as and when required."

Nutrient Management

Ian has only been working in dairy for five years but has soil tested for four of them to help him understand his grassland performance and soil nutrient needs.

Due to good underground storage capacity Ian has the freedom to only apply slurry when required. This allows him to select times when it is drier to improve nutrient uptake and prevent ground damage.

In mid-February 2020 for example, 2,500 litres was spread by contractors using a dribble bar.

Ian says his grass yield has increased year on year since taking part in the soil and catchment modelling project and his milk from forage has increased by 1,000 litres in the last four years.

"My grass yield has increased year on year since taking part in the programme."

Ian McClelland

Ian also participates in AFBI and AgriSearch's GrassCheck project and has been monitoring grass growth and quality weekly for the last five years to further optimise his nutrient management and reseeding programme.

Last year he grew an average of 10.8t DM/ha across the grazing platform and any future improvement will help him achieve his target 4,000 litres of milk from forage.

The information provided as part of the study means Creevy House Farm can optimise its slurry application and no longer has to apply artificial Ps or Ks to optimise soil nutrient levels.

All of these savings have the added benefit of reducing the cost of production on the farm.

Youngstock Management

Youngstock are reared to a target first calving age of 22-24 months to reduce his heifer raising costs and maximise the potential of his milking herd. This involves getting them to a target weight and a programme of vaccinations to reduce the risk of poor health.

The farm operates autumn block calving and, once new-born calves have received their mother's colostrum, they are raised on whole milk from the milking herd until 12 weeks before being weaned onto haylage.

To minimise the number of bull calves, Ian is using sexed semen. Whilst it is more costly to breed this way, he believes it is worth the investment as it eliminates calves being born on the farm which aren't going to be introduced into the milking herd resulting in longer term financial and environmental benefits.

Environmental Sustainability

Hedge management has been an important part of Ian's sustainability effort. In a bid to increase cover he has undertaken a hedge repair and replacement programme where damaged or poorly performing hedging is either cut back to stimulate new growth or replaced entirely.

The hedges are improving continually and are trimmed back every two years with the aim of growing as thick a hedge as possible to create a safe habitat for wildlife and increasing carbon capture on the farm.

The farm already plays host to a number of ravens, buzzards, squirrels, foxes and rabbits and Ian hopes that situation improves as he continues to nurture his internal and external boundaries.

Ian recently introduced two beehives on the farm and he hopes the pollinators will improve biodiversity in the surrounding area further. He also enjoys the added benefit of having his own supply of honey on site.

The parlour and animal accommodation are fitted with LED lighting and rainwater recovery systems. A plate cooler next to the milk tank cools the milk and the heat recovered is used to heat the water used to clean the parlour which helps reduce refrigeration and heating costs.

Chapter 3.

Sustainable youngstock rearing

Martin Mulholland, Senior Dairying Technologist, CAFRE

Sustainable youngstock **rearing** at **Cafre**

Rearing dairy herd replacements represents a major investment by dairy producers in the future of the enterprise. In today's fast moving and competitive dairy industry it is crucial that heifers are reared cost effectively to calve at an age and body size which will maximise lifetime performance.

> *"Reducing the age at first calving from 27 to 24 months of age could reduce the overall dairy GHG footprint by 7%."*

Achieving this will also lower overall greenhouse gas emissions associated with the dairy enterprise on commercial farms.

Recent economic evaluations have estimated the cost of rearing a dairy heifer to the point of calving at between £1,453-£2,283 (CAFRE), equating to an average of £2.31/day (Boulton et al., 2017) or approximately 6 pence per litre of milk produced.

One of the most significant factors affecting rearing costs is age at first calving (AFC), with each extra day of AFC increasing average rearing costs by £2.87. Achieving a first calving age of 24 months, at the optimum weight, has been shown to deliver the highest level of lifetime performance.

Following an industry-wide programme in 2008, which involved research and knowledge exchange activity on commercial farms, a blueprint for heifer rearing was developed for Northern Ireland farms to achieve 24 month calving. Analysis of the Northern Ireland Animal and Public Health Identification System (APHIS) database of heifers calving suggest that by 2016, the average age at first calving for dairy heifers had fallen from 32.7 months to 27.5 months of age.

Continued reductions in age at first calving will have further benefits with modelling activity using the AFBI Greenhouse Gas Calculator suggesting that reducing the age at first calving from 27 to 24 months of age could reduce the overall dairy GHG footprint by 7%. This reduced footprint was a result of fewer heifers in total on the farm which also meant that less land, forage, fertiliser and concentrate was required.

Successful cost effective heifer rearing, to achieve 24 month calving and subsequently high levels of lifetime performance requires a good rearing environment leading to good calf health and good nutrition. To address this, a range of research activity is being undertaken jointly by CAFRE and ABFI to ensure that all three areas of health, nutrition and environment are met.

Cafre herd **case** study

Recently, CAFRE has invested in new calf housing facilities for the dairy herd at Greenmount and are part of a new research project, OptiHouse. OptiHouse is a large scale calf housing project which is currently being carried out on dairy farms across Northern Ireland by the Dairy Youngstock research team at AFBI Hillsborough in collaboration with CAFRE Dairy Advisors.

The project aims to provide a better understanding of calf rearing houses within Northern Ireland and the key factors linked to sub optimal environmental conditions within rearing accommodation as these can have a significant impact on calf health and performance. Another main objective is the development of blueprints for new modern calf-rearing housing and fixes for existing common calf house designs that would maximise delivery on both calf and producers considerations. Calf considerations include air quality, social interactions, growth performance, and space allowance.

The new facilities at CAFRE, commissioned in September 2019, include a completely open plan building with no gable or side walls to provide as much fresh air as possible to calves to minimise the transmission of disease organisms. It comprises 40 individual calf pens for baby calves to 7 days of age, mounted on wheels which allow easy removal of the used pens to the wash bay for cleaning after each calf has been in the pen for seven days.

After 7 days, calves are moved to one of 6 group rearing pens where they have a choice of environments. Calves can make an individual welfare choice to be in either the bedded igloo or the straw bedded pen in front of the igloo.

To demonstrate labour efficient calf rearing to CAFRE students, two automatic feeders each servicing three milk feeding and three concentrate feeding boxes have been installed. Each milk feeding box is equipped with half body weigh scales to allow the performance of the calves to be monitored on an ongoing basis.

Heifer rearing at CAFRE is managed to maximise lifetime performance using the following techniques:

- Calving at 24 months of age
- Feeding 10% by body weight of colostrum within 2 hours of birth
- Colostrum quality testing
- ZST blood sampling to check calf immunity
- Using weighbands to assess heifer weight
- Using the AFBI Bovine growth rate calculator
- Bedding young calves in a deep straw bed
- Using of calf jackets to maintain body temperature in cold weather
- Calf housing with adequate ventilation
- Automatic calf feeders
- Weaning calves by concentrate feed intake

A range of research findings have been published by AFBI on various components of heifer rearing including disease, colostrum quality, grazing and pre-wean nutrition.

Why calf heifers at 24 months?

Table 1. Impact of age at calving on replacement heifer numbers

	Age at first calving (months)		
Age Category	24	30	36
0-12 months	35	35	35
12-24 months	35	35	35
24-36 months	-	17	35
Total replacements	75	87	105

As shown in the table, earlier calving results in fewer of the older and therefore larger non-milk producing replacement heifers on the farm.

In the example of a 100 cow dairy farm with a replacement rate of 35%, this farm will have 30 fewer heifers over 24 months of age if calving heifers at 24 months compared to calving at 36 months. As a result there will be fewer animals emitting enteric methane, less land will be required, fewer heifer housing places will be required, which leads to reduced costs and workload.

Age at calving in practice

Table 2. Mean date of birth and age at first calving of heifers at CAFRE

Calving Season	Mean D.O.B.	Mean calving date	Mean age at first Calving date (months)
2016-17	24th October 2014	26th October 2016	24.1
2017-18	13th October 2015	5th October 2017	23.8
2018-19	25th October 2016	8th November 2018	24.5
2019-20	1st October 2017	*3rd November 2019	*25.1

** Start of Calving season deliberately moved back by 2 weeks for management reasons*

The table above shows the CAFRE calving statistics for the last five years, and the trends show that since 2016, heifer calves are generally born earlier and calving earlier in the season, and the average age on first calving is on target to achieve 24 months.

The earlier average date of birth has the further impact at CAFRE of reducing concentrate fed to calves in the first summer.

During the 2019-20 calving season, the calving age was increased at CAFRE by one month to 25 months of age, due to a deliberate movement in the start of the breeding season to delay the start of calving to make better use of autumn grass on the college farm.

Accelerated growth

CAFRE is trying to take advantage of the benefits of accelerated growth through milk replacer feeding protocols with milk replacer levels fed at up to nine litres per day or 1.35 kilograms of milk powder. The aim is to achieve accelerated growth to rates of over one kilo of daily live weight gain during the milk feeding period.

Research findings from a review of thirteen published worldwide studies (Soberon and Van Amburgh, 2013) indicate that accelerated growth in the early stages of a heifer's life will deliver:

- Improved lifetime production
- Earlier maturity and breeding
- Indications of improved fertility
- Indications of improved disease resistance
- Indications of improved longevity.

Management of the new-born calf

Hygiene management is critical to prevent the spread of disease, therefore calving takes place in individual pens, cleaned and disinfected between births. Hygiene management is imperative in stopping the spread of diseases such as Johne's, as the calf at this stage is particularly prone to infection from faeces contamination from Johne's shedding cows. The calf is removed from the cow at birth to minimise the Johne's disease risk.

The calves are fed colostrum at 10% of body weight within an hour of birth after milking the cow with a portable milking machine in the calving pen. This is standard practice at CAFRE. The calf is then fitted with a clean calf jacket and moved to a straw bedded individual pen in the calf house.

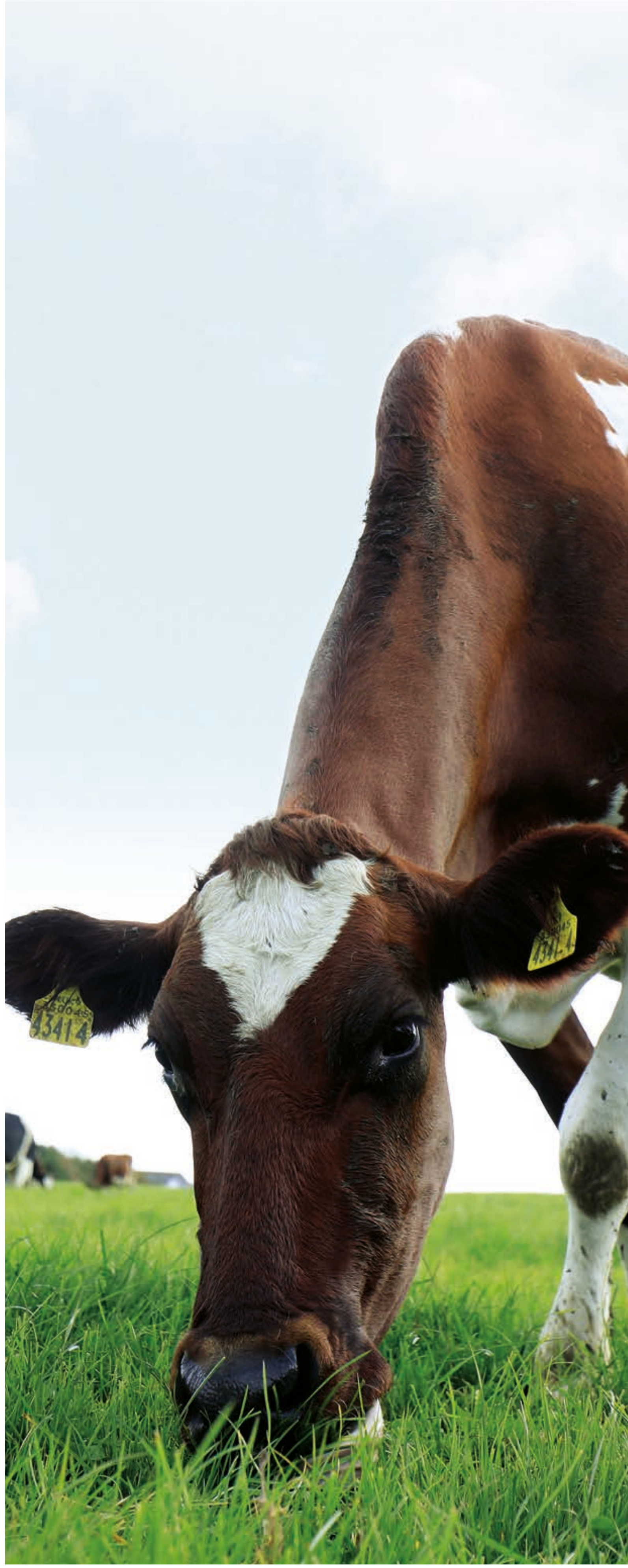
Surplus colostrum and transition milk is pasteurised or acidified and refrigerated in the calf house. The calves are then fed re-heated dams colostrum/transition milk for first 4-5 days and transitioned onto milk replacer on day 5 to 7 (26% protein; 16% fat) and moved to group pens and automatic feeders at 7 days of age.

Disease Prevention

Disease prevention is critical to allow the effective rearing of calves on dairy farms, both at the CAFRE dairy unit and on commercial farms. The new building has been deliberately located on the edge of the farm facing in to the prevailing wind, not closest to the dairy unit and this is to ensure that clean, fresh air is blown over the calf house, instead of the wind blowing pathogens in to the calf house from older stock in other buildings.

There are strict pneumonia vaccination protocols in place, isolation facilities for sick calves, and a strong cleanliness and hygiene focus through the provision of industrial dishwashers and washing machines in the milk preparation room for cleaning milk bottles and calf jackets respectively.

The automatic milk feeders also come equipped with automatic teat cleaning equipment to minimise the risk of disease transition via the milk teat and there are staff and student hand and boot cleaning facilities at the calf house to allow students and staff to protect both themselves and the calves from disease and infection.



Grazing and Housing Management

- Calves are turned out in April according to weather and ground conditions, when grazing and weather conditions are suitable. Grazing results in lower ammonia emissions per animal than housing so the aim is to graze for as long a season as possible
- A leader follower system is practised with the calves grazing ahead of the in-calf heifers
- Comprehensive parasite and fly control systems are practised
- September to November born cows are put out to grass and receive no concentrates
- December or January born calves are grazed separately and fed two kilos of concentrates during the grazing season with the aim of getting them to target service weights earlier so that they can be calved down at a younger age as early as possible in the calving season.
- During the second winter calves are housed in a purpose-built heifer house which incorporates ammonia emission reduction flooring to reduce the emission of ammonia from the building
- In their second summer at grazing, the heifers again receive no concentrates and are followers in the leader follower system.

Genomic testing

All female dairy cattle on the CAFRE dairy farm are genomically tested.

Table 3. Genetic merit of female dairy stock at CAFRE

Lactation	Cow £PLI	Cow PTA Milk (kg)	Cow PTA Fat (%)	Cow PTA Protein (%)	Sire £PLI	Sire PTA Milk (kg)	Sire PTA Fat (%)	Sire PTA PR%	Sire Fertility Index	Sire Lifespan (Lactations)	Sire SCC
Calves and maiden heifers	272	-81	0.15	0.10	419	0	0.22	0.13	8.7	0.3	-10
Lactation 1	214	-113	0.10	0.10	332	44	0.07	0.10	10.7	0.2	-3
Lactation 2	96	-156	0.07	0.06	207	-83	0.12	0.08	8.2	0.2	-2
Lactation 3	93	-212	0.10	0.09	179	-131	0.11	0.10	10.0	0.2	6
Lactation 4	74	-122	0.07	0.06	200	25	0.08	0.08	4.1	0.1	-1
Lactation 5	94	-266	0.11	0.07	236	-112	0.12	0.10	8.2	0.2	-7
Lactation 6	36	-371	0.19	0.11	174 -	117	0.12	0.10	3.1	0.1	-6
Lactation 7+	-4	-301	0.09	0.06	146	-133	0.10	0.07	3.9	0.1	-4

The breeding indices associated with dairy farming sustainability are constantly being improved within the CAFRE dairy herd. As shown in the above table, the overall Profitable Life Index (PLI) has increased over the last 8 years from -4 to up to 272. The fertility index (FI) is also improving, as is life span (LS) and the somatic cell count (SCC) is decreasing.

At CAFRE the individual genomic merit data is used to decide which females to breed replacements from, and if there is a surplus, which heifers to keep and which to sell. On commercial dairy farms breeding potential dairy sires, genomic analysis is also a highly effective tool to select potential sires for breeding.

Breeding with sexed semen

In order to increase the number of milking animals, sexed semen and genomic testing results are used with maiden heifers to breed most replacement heifers. CAFRE also breeds to beef sires to optimise the value of crossbred calves.

The sires chosen to breed replacements from are first selected from the top 25% of available sires by PLI.

PLI is continually being updated with recent dairy sustainability related indexes added, including a maintenance measure to ensure that over time the size of cows reduces and as a result this will reduce the maintenance energy requirements and hence enteric methane emissions.

Other indices added in recent years include TB resistance, dairy carcass index, calf survival and lameness resistance. Sires are also chosen from both the UK proven sire list and the genomic young sire list. After a first screen for PLI, secondary selection is then made based on fertility index, lifespan, and milk protein percentage.

James farms in Ballywalter with his wife Pamela. Seaview Farm was originally only 30 acres when James took over the farm. Now it spans over 170 acres with 115 acres making up the grazing block. 75 acres are 2.5 miles from the main block of land and is used for silage and young stock.

FARM DETAILS

Area Farmed	190 acres: 170 acres owned and 20 acres rented
Cropping	All grass
Dairy Stock	160 cows 22 in calf heifers 36 maiden heifers
Beef Stock	Beef is calf to store selling at 16-18 months sold in August Approximately 20 calves and 20 stores
Altitude	The farm starts at 40ft above sea level to no more than 100ft
Soil Type	Medium loam topsoil heavy red clay sub soil
Rainfall	Approximately 35 inches every year

FARM AVERAGE PHYSICAL PERFORMANCE (Year ending June 2020)

Milk Yield	6,000 litres
Concentrate fed	1.2 tonnes / cow / year
Feed rate	0.22 kg / litre
Feed/Cow	1.26 tonnes
Milk from forage (grass & silage)	3,000 litres
Replacement rate	21%
Calving interval	375 days

Farm Objectives

James takes a great interest in taking an evidence-based approach to farming and has taken part in a wide range of research projects to date. He was also a member of the DAERA expert working group which prepared the 'Sustainable Agricultural Land Management Strategy' in 2016.

James joined the sustainable youngstock study because he wanted to get his heifers to a heavier first calving weight so the youngstock would calve on target at 24 months of age and there would be fewer unproductive cows in the herd.

To improve grass from forage and increase the days that the cows are at grass, James breeds hardier, lighter Ayrshire animals which are able to go out earlier in the Spring and are aggressive grazers. Moving to Ayrshires, the average yield dropped slightly but butterfat rose and 20% less silage was needed to feed the cows over the winter period because of the lighter body weight at 550kgs average mature weight.

Approximately 15% of the milking herd are Norwegian Reds which were part of a previous research project.

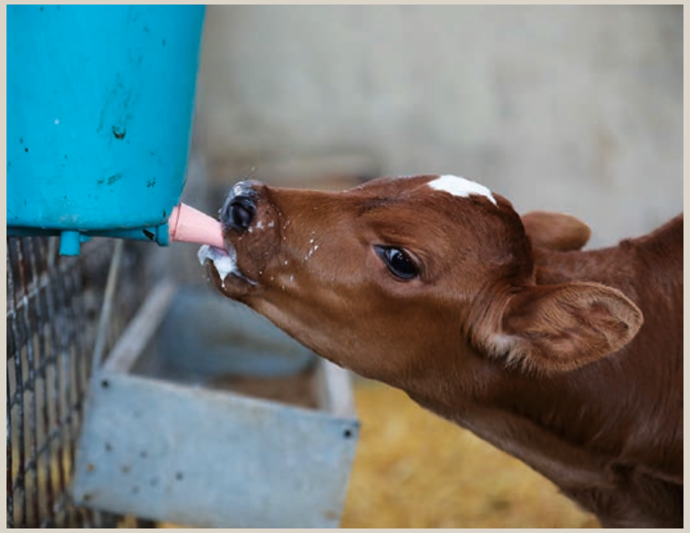
Sustainable Youngstock Rearing

To improve farm sustainability James has been involved in a programme which helps farmers take an holistic approach to calve rearing to reach a target weight and prepare them for a target first calving age of 24 months.

The programme involved weighing the calves from birth until the end of first lactation, body condition scoring, monitoring feed intakes and any health issues including a vaccination programme to improve health outcomes.

Getting it right in the first 100 days prepares them for better health and production outcomes throughout the rest of their lifetime and therefore has a significant impact on the future dairy herd and the environmental footprint of the farm.

> *"Getting it right in the first 100 days prepares them for better health and production throughout the rest of their lifetime."*
>
> *James Brown*



The feedback from the research project confirmed the farm was performing well in the care of its youngstock, but James made a number of changes to how colostrum is fed to the calves to better monitor consumption and make sure they get the right nutrients in those early days.

All calves are out at grass from 12 weeks old, there is no stock in the yard during the summer months, and replacements are reared on milk substitute and weaned on body condition and concentrate intake.

> For lifestyle reasons James splits his calving into two blocks with 20% of calves born in the Autumn and 80% in the spring. He has also improved his calving index in recent years, bringing it down to around 375 days.

Disease prevention is a priority for achieving good health in both the milking cows and the youngstock. James works closely with his local veterinary practice and the advice they give is followed for vaccinations and mastitis control and some adjustments are made to enable the two calving blocks.

The main changes coming out of the project were to the concentrate use and disease prevention steps to improve the overall health of the replacements entering the milking herd which in turn improves the overall efficiency of the farm.

Youngstock management starts long before the calf is born. It is important to get a lot of minerals into the dry cows which produces a healthier calf at birth. The calves have more immunity to scours and diseases, are stronger and more vigorous at birth and thrive from day one.

> *"Youngstock management starts long before the calf is born."*

Nutrient Management

To maximise nutrient uptake Slurry is applied via dribble bar where possible, including the first and second cuts of silage. Half the slurry is treated with additive to aid mixing which helps cut down on fuel costs.

All the farm is soil tested every four years to ensure that the pH balance is maintained. The phosphorus balance is consistently around three and soil tests have shown that very little phosphorus is needed. The two main plant nutrients used are potash and nitrogen.

Being a derogated farm under the nitrates directive, it is stocked at around 230kgs n/ha, below the 250kg limit. Efficient use of slurry on the grazing block can reduce the reliance on chemical nitrogen and over the past few years significant savings have been made from chemical applications to the silage ground with no loss in silage yield and resulting in longer lasting leys.

Land Management

Grass is routinely measured and compared with the other members of the development group to improve management and challenge James to set higher targets.

The soil type ranges from medium loam to heavy clays that can be quite wet especially in the spring, which is not suited for silage cutting in early May but can be high yielding.

Fertility Management

Due to targeting a first calving age of 24 months, there are fewer animals on Seaview Farm, which in turn has led to lower emissions and more lactations. Some of the herd are having as many as 11 lactations and 15% of the herd has a lifetime yield of over 50 tonnes of milk produced per cow.

The farm produces an average of 3,000 Litres from forage which is supplemented by approximately 1.2 tonnes of concentrate which means per million litres Seaview Farm is using around 100 tonnes less concentrates than on a high input system.

Reducing the use of concentrates has also helped reduce the phosphorous levels on the farm.

Environmental Sustainability

James made a conscious decision to let the hedges grow up to 9ft, which has doubled the sequestration capacity. In terms of wildlife and biodiversity, there are more grassland birds and hares and the canopy provides shelter for animals, and are invaluable for pollinators and other insects.

The lights on the farm are being replaced with LEDs to save on energy where possible and an energy efficient heat recovery system recovers heat from the Bulk tank cooling system. This hot water is used for washing the milk tank and the dairy milking equipment, and is sufficient to feed all the calves' milk substitute in the winter.

Chapter 4.

Improving farm **sustainability** through

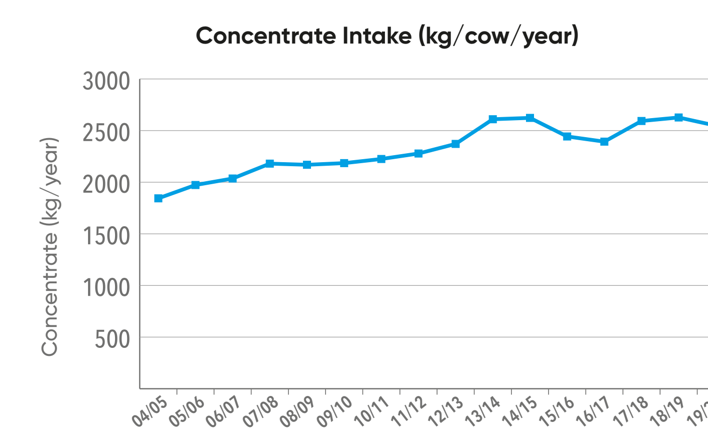
Efficient concentrate use

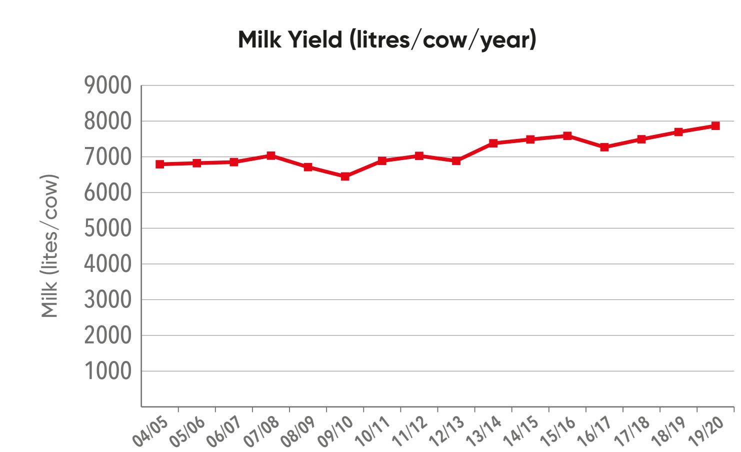
Improving farm **sustainability** through the **efficient** use of **concentrates***

Purchased concentrates currently represent between 60 - 70% of variable costs of milk production on Northern Ireland (NI) dairy farms. Concentrates are more expensive than either grazed grass or grass silage, while concentrate prices can vary considerably from year to year.

In addition, CAFRE Benchmarking data indicates increasing reliance on concentrate feedstuffs in NI, with average annual concentrate input per cow having increased from 1.8 tonnes in 2004/2005, to 2.6 tonnes in 2019/2020. This has been accompanied by an increase in annual milk yields, which are just under 8000 litres per cow at present in Benchmarked herds. These trends are presented in Figures 1 and 2, right.

Concentrate usage has increased for a number of reasons, including herd expansion on a limited land base, and an increase in the genetic merit of the NI dairy herd during the last two decades, with an associated increase in individual cow milk yields. These higher yielding cows require more nutrient dense diets to meet their greater energy requirements, and this can be achieved in part through increased concentrate feed levels. However, as concentrate feed levels increase, the efficiency with which concentrates are used tends to decrease, resulting in higher nutrient surpluses on-farm, and an increased risk of nutrient losses to the environment.

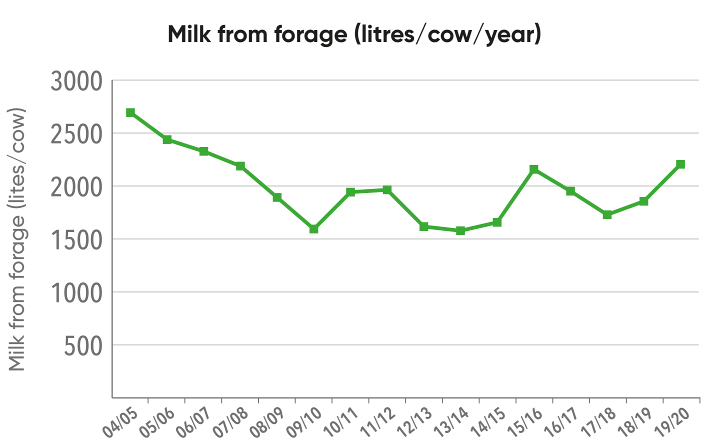


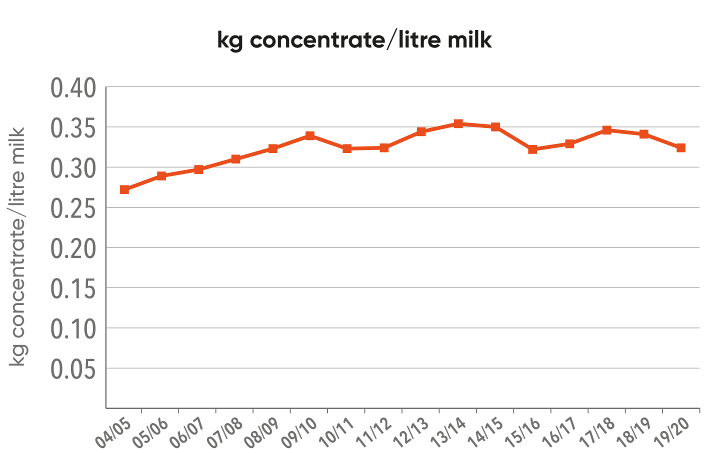


Figures 1 and 2: Changes in annual concentrate intakes and milk outputs (per cow) on Northern Ireland dairy farms over the last 15 years (CAFRE Benchmarking data)

Efficiency Indicators

Two indicators of the efficiency with which concentrates are used for milk production are presented in Figures 3 and 4. Milk from forage fell dramatically between 2004 and 2010, although there is some evidence that it has started to edge upwards in recent years, a positive trend. In addition, the number of kilos of concentrate required to produce each litre of milk provides another efficiency indicator, with Figure 4 highlighting that kilos of concentrates required to produce each litre of milk increased steadily until around 2014. Unfortunately, higher figures indicate poorer efficiencies. Nevertheless, during the last few years there has been some evidence that the quantity of concentrates required to produce each litre of milk has started to decline, which is a positive finding.





Figures 3 and 4: Changes in milk from forage, and concentrates required to produce each litre of milk on Northern Ireland dairy farms over the last 15 years (CAFRE Benchmarking data)

> *"As concentrate feed levels increase, the efficiency with which concentrates are used tends to decrease, resulting in higher nutrient surpluses on-farm, and an increased risk of nutrient losses to the environment."*

Figure 5 shows the relationship between average herd performance (annual milk production) and annual concentrate inputs, with each blue dot representing an individual farm (CAFRE Benchmarking data from 2018/2019). This figure demonstrates the wide range in concentrate use efficiencies on local dairy farms. For example, some farmers are able to produce 8,000 litres of milk when offering 1.7 tonnes of concentrate, while on other farms 4.0 tonnes of concentrate is required to produce this amount of milk.

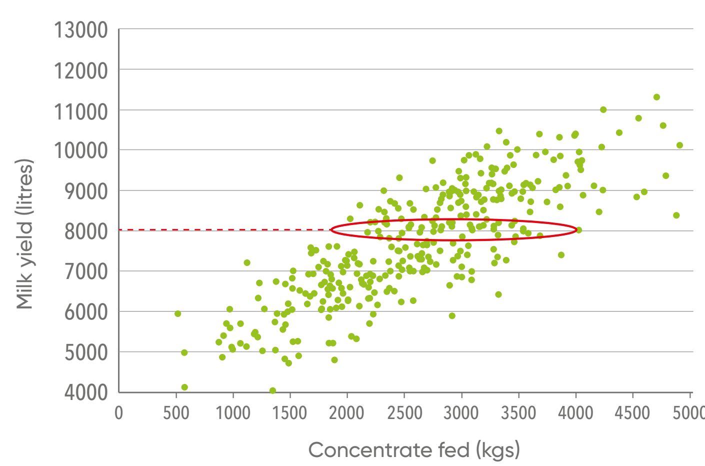


Figure 5: Relationship between annual milk productions and concentrate feed levels on Northern Ireland dairy farms (CAFRE Benchmarking, 2018/2019)

Efficient concentrate **use**

Potential Impacts of concentrate usage on environmental sustainability

Concentrate use can contribute to a number of environmental issues, including poor water quality, ammonia emissions and climate change. With regards water quality, concentrates represent one of the key inputs of phosphorus onto farms in NI. High concentrate feed levels often drive farms into a phosphorus surplus situation, whereby more phosphorus is brought onto farms than is removed in 'product'. If not properly managed, phosphorus levels in soils can increase, and there is an increased risk of phosphorus being lost to waterways. Similarly, concentrates represent a significant input of nitrogen to farms (as protein), and if diets are too high in protein, nitrogen use efficiency will be low. This increases the risk of nitrogen being lost as ammonia and nitrous oxide to the atmosphere, and as nitrates to waterways. When ammonia is deposited on sensitive habitats, it causes nutrient enrichment of these areas, and this can contribute to biodiversity loss. Nitrous oxide on the other hand is a greenhouse gas that can contribute to climate change.

Improving environmental sustainability through efficient concentrate use

1. Improving forage quality:

For many farmers, perhaps the most important step in improving concentrate use efficiency is to improve the quality of forage offered. Forage quality is one of the biggest determinants of how concentrates are used on our farms and is key to improving concentrate use efficiency. For example, for every 1% increase in silage D-value (digestibility), there will be a concentrate saving of approximately 0.47 kg per day (Keady et al. 2013). Thus, by improving silage quality, NI dairy farmers can achieve the same amount of milk with less concentrates.

Unfortunately, however, over the past 20 years the quality of silage made on local farms has shown only a moderate improvement. In an AFBI survey of over 180 dairy farmers, weather was identified by farmers as the predominant factor limiting improvements in silage quality. Other quality limiting factors included poor quality swards, delaying harvesting to reduce cost, unavailability of contractors when required, inadequate compaction, and the presence of slurry and soil residues on grass at ensiling. On farms where silage quality had improved over the past 10 years, the predominant reasons given were reseeding and earlier cutting.

2. Optimum feed levels and feeding approaches:

Getting concentrate feed levels correct is dependent on knowing the genetic potential of cows in a herd, and the quality of silage and other forages available. Once optimum concentrate feeding levels are identified, consideration needs to be given to how concentrates will be offered.

A number of recent AFBI studies have examined the impact concentrate feeding systems and concentrate allocation strategies can have on cow performance. Individual cow approaches involving feed-to-yield systems have been compared with group feeding approaches involving a complete diet. Results demonstrated that different feeding systems can be equally effective, provided each are managed correctly.

For example, while the cows on the AFBI study all calved within a period of 8 weeks, most herds have a much more spread calving pattern. In this case, if a complete diet is being offered, grouping cows according to milk yield is required to avoid overfeeding some cows. Similarly, with feed-to-yield systems, there is a risk that higher yielding cows offered high levels of concentrates will have reduced milk fat levels.

This was examined in a recent study involving 30 farms, with the results showing a reduction in milk fat levels with increasing concentrate levels. However, this study also demonstrated that this reduction in milk fat was in part genetic, the higher yielding cows having a lower PTA for milk fat content. Therefore, monitoring milk composition at high concentrate feed levels is extremely important within feed-to-yield systems.

However, this study also highlighted another very important point, namely the need to check the accuracy of concentrate feeding equipment on farms. When concentrate feeding equipment on the participating farms was examined, on many farms the concentrates were actually being overfed or underfed, by between 10 and 20 percent on some farms. Concentrate feeding equipment must be checked on a regular basis.

On-farm research: Concentrate feeding during the dry period

The period around calving (the transition period) is one of the most important periods in relation to overall cow productivity. This period can be highly stressful for the dairy cow given the stress of calving, an increased risk of injury and uterine infection, and large changes in diet. In addition, the cow's immune system becomes suppressed at this time making her more susceptible to infection.

Nutritional and management strategies during the dry period should be targeted at preparing the dairy cow to achieve high milk yields and high fertility levels during the following lactation, whilst minimising the risk of metabolic and infectious diseases.

While concentrate feeding during the dry period is often recommended as a strategy to improve body condition of cows prior to calving, and to 'prepare the rumen' to better cope with concentrate rich diets offered in early lactation, the scientific evidence to support this is limited. In a series of studies the effect of concentrate feeding during the dry period has been examined.

Results from research trials and on-farm studies from 9 commercial farms indicate that when cows have a condition score of 2.5 or above at drying off, and are offered good quality silage together with a high quality dry cow mineral supplement, offering concentrates during the dry period is unlikely to result in milk yield, health or fertility benefits. Again, this allows savings to be made in concentrate usage.

3. Feeding concentrates with lower phosphorus levels

High phosphorus levels in our rivers and lakes remains a major problem in NI. While phosphorus in our watercourses arises from a number of sources, agriculture has been demonstrated to be a significant contributor. Concentrates represent one of the main inputs of phosphorus to dairy farms.

Historically dairy cow concentrates contained excess phosphorus, and in 2001 that figure was around 6.2 g P/kg. However, the results of a 4 year research programme at AFBI clearly demonstrated that the quantity of phosphorus in dairy cow diets could be substantially reduced (to approximately 3.8 g P/kg DM) with no loss in performance, a 30% reduction compared to where the industry had been operating at. In the years following this research the NI feed sector made substantial progress in reducing the amount of phosphorus in dairy concentrates. However, given the adverse trends in phosphorus levels in waterways, concentrate phosphorus levels may need to be reduced further.

> *"Research at AFBI demonstrated that the amount of phosphorus in dairy cow diets can be substantially reduced, to 3.8 g P/kg DM, representing a 30% reduction."*

On-farm research: Delayed concentrate build-up strategies

Milk yields increase rapidly in the weeks following calving, and in many cases higher yielding cows are unable to consume enough feed to meet their nutrient requirements. In an attempt to keep pace with this rapid increase in milk production in early lactation, the quantity of concentrate offered may be increased rapidly following calving. However, this may further increase milk production and result in an even greater negative energy balance. A series of studies investigated the impact of delayed or slow build-up concentrate strategies in early lactation to negate these issues.

Results show that cows on the delayed strategy had a higher forage intake in early lactation and lower incidence of rumen health problems than those on higher concentrate feed rates. In addition, there was no negative effect on lactation performance. Adopting a delayed build-up strategy can result in savings in concentrates of approximately 100 – 150 kg/cow. These results have also been replicated on five local dairy farms.

4. Reducing diet Protein

If dairy cows are offered diets containing excess protein, the amount of nitrogen excreted in urine and faeces will be increased, with an increased risk of nitrogen being lost to the environment. Consequently, there is increasing pressure to reduce protein levels in dairy cow diets, with this the focus of a major new DAERA and industry co-funded research project at AFBI. This project aims to examine if diet protein levels can be reduced from 17.5% to approximately 15.5% in early lactation, with no loss in performance.

On-farm research: Precision feeding

The adoption of feeding systems in which concentrates are offered to individual cows according to their milk yield is now commonplace. The approach most often adopted on local farms involves offering a 'basal diet' of silage and concentrates, which is designed to support the energy requirements of the cow for maintenance, plus a certain milk yield (often referred to as the Maintenance plus, or M+ value). Additional concentrates are then offered to individual cows to support milk yields above those supported by the basal diet. In reality, a range of feed rates are adopted on-farm, hence studies were undertaken to identify the optimum feed rate for lactating dairy cows. A study examining three different feed rates (0.35, 0.45 and 0.55 kg per litre of milk) indicated that reducing feed rates to 0.35 kg per litre of milk had no significant impact on cow performance, but increased margin-over-feed-costs per cow. However, excellent quality forage is required to allow feed rates to be reduced.

5. Use of locally grown ingredients

The NI livestock feed sector has a high reliance on imported ingredients, with many protein ingredients (eg soya bean meal) imported from countries outside the European Union (EU). This reliance on imported ingredients leaves the dairy sector vulnerable to instability of supply, price volatility, and the limited availability of non-genetically modified protein sources. For these reasons there is increasing interest in the use of locally-grown protein crops.

Field bean (Vicia Faba) is a grain legume of particular interest locally, with yields of 5.5 - 8.5 t/ha reported in Ireland. While the crude protein content of field beans is lower (30%, DM basis) than that of soya-bean meal (55%, DM basis), field beans have a much higher starch content (40% of DM) compared to soya. However, until recently there was limited information on the impact of including field beans in dairy cow diets. In addition, the use of field beans in dairy cow rations is often restricted due to concerns about 'anti-nutritional factors' which can reduce intakes and performance. A series of recent AFBI studies examined the use of locally grown field beans in dairy cow diets.

Results show that field beans (at up to 3.5 – 4.0 kg per cow/day) can partially replace soya bean meal and rapeseed meal in dairy cow diets with no adverse impacts. Furthermore, the research demonstrated that when moist field beans were preserved with propionic acid and offered to dairy cows, cow performance was similar to that achieved when beans were dried and milled. Thus 'home preservation' approaches can be adopted if beans are grown on local farms.

** Based on a presentation given by Dr Conrad Ferris (AFBI) at the 2020 EU Sustainable Dairy Symposium.*

Drew and Val McConnell milk 160 cows on a 300 acre farm at Carrigans, just outside Omagh. Drew is the third generation to farm at Carrigans, and in addition to taking responsibility for the calves, Val also owns sheep and suckler cows.

One of the many research programmes the farm has been involved in explored how to improve farm efficiencies by altering the diet being fed to the cows.

FARM DETAILS

Area Farmed	300 acres
Cropping	0
Stock	160
Altitude	350 – 700 ft
Soil Type	Heavy clay
Rainfall	50 – 60 inches every year

FARM AVERAGE PHYSICAL PERFORMANCE (Year ending June 2020)

Milk Yield	9, 500 - 10,000 litres
Concentrate fed	3.02t/cow
Feed rate	0.31kg/l
Milk from forage (grass & silage)	2,983 litres
Replacement rate	<20%
Calving interval	13.7 months

Farm Objectives

The farm business is focussed on breeding high-producing animals that are efficient and will produce high quality milk for a long number of years. By targeting efficient animals with a long lifespan they achieve a better financial margin but a lower carbon footprint due to the lower number of both milking cows and youngstock required to maintain overall farm production.

Taking part in research trials to help improve youngstock rearing for long lifespan animals has been key to achieving the farm's environmental footprint.

Sustainable Youngstock Rearing

The modern dairy cow has the genetic potential to produce high volumes of milk in early lactation. However, to do this a cow has a huge daily energy requirement. To meet this energy demand a cow may have to break down body fat reserves.

Working in partnership with Thompsons Feeding Innovation and AFBI, the farm investigated the impact of feeding a lower protein diet to dairy cows as part of a two-year research trial with the aim of reducing the negative energy balance.

The protein element of the diet was reduced down to 15%.

This lower protein ration limited milk production in the first 40 days after calving, thus reducing the overall energy demand being placed on the cow at this important time.

> *"This lower protein ration limited milk production in the first 40 days after calving, thus reducing the overall energy demand being placed on the cow at this important time."*
>
> *Drew McConnell*

Although milk volume was reduced in those early days, the farm recorded no negative impact on overall milk performance because the cows maintained their peak for longer so, over 305 days, there was minimal difference in milk yield. There were also improvements in animal health and fertility.

Importantly, lowering protein in the diet has also helped improve the farm's environmental footprint by lowering enteric emissions and overheads have been reduced because protein is the most expensive part of the diet.

During the research programme they also achieved marginal benefits in milk quality.

Nutrient Management

Soil testing is carried out every 2-3 years allowing nutrient application to be tailored to meet the needs of the farm. This has reduced the nitrogen applied on the farm which has an environmental and financial benefit to the business.

The utilisation of dribble bar technology has reduced the fertiliser use by 25% and 10-15% of the land is reseeded each year.

Lime is applied after reseeding and depending on the soil analysis, it can be applied in subsequent years to optimize pH levels.

Grassland Management

The grasses selected for the farm contain a lot of sugar and provide a higher nutritional value for the cow to ensure the cow achieves maximum benefit from the forage provided. Silage is harvested during the summer months.

Youngstock Management

The farm was involved in an earlier project in relation to Sustainable Youngstock Rearing and now targets a first calving age of 24 months. This has led to cost savings, higher producing animals and fewer unproductive animals on farm. The replacement rate dropped and this all led to a reduction in emissions. Calving runs from September to April.

Environmental Sustainability

To maximise the carbon sequestration and the biodiversity credentials of the farm internal hedges are only cut every 3-4 years which allows for a better canopy for birds and other wildlife and creates more food for birds.

The farm also utilises a borewell for water and energy efficient LED lighting has been installed in the parlour and sheds.

Chapter 5.

Nutrition

Dr Stephan Peters, Nutrition Research and Food Legislation Manager,
the Dutch Dairy Association (NZO)

A **sustainable** diet is a **delicate** balance

A sustainable diet must be healthy, acceptable and affordable for all. This makes composing a sustainable diet a delicate balance. A switch of a few food items can affect nutritional value and environmental footprint significantly. Modelling tools such as the Dutch developed Optimeal® help understand the impact of food choices on the environment, health and food prices.

The European Milk Forum (EMF) is further developing the Optimeal® modelling tool to include dietary, environmental and price data from all the EMF member countries (Northern Ireland, Republic of Ireland, France, Netherlands, Austria, Belgium, Denmark and Norway).

Sometimes replacing certain foods leads to counter-intuitive results. For instance, replacing animal-based foods with plant-based foods does not necessarily lower the diet's carbon footprint.

These effects are shown in the modelling tool Optimeal® developed by the Netherlands Nutrition Centre and Blonk Consultants (Netherlands) using the data from life-cycle assessment methodology to calculate the environmental impact of the food we consume.

The Optimeal® model calculates nutritional, environmental and price impact when a category of food is omitted or replaced. The 'reference diet' is the recommended daily intake of nutrients and consumption of foods advised by the Dutch Health Council and the Netherlands Nutrition Centre.

"Essentially, Optimeal® calculates what food products you need to consume in order to replace the nutrients you exclude when omitting certain foods. Of course, it is a standardised model, but it gives insights for composing both more healthy and more sustainable diets," says Dr Stephan Peters.

"The nutrients from dairy have to be compensated for by other foods and not individual nutrients. This means that not only protein needs to be replaced, but also calcium, vitamin A, B12, B6 and more," he explains.

"For this reason, you have to consume large amounts of mainly beans, pulses and vegetables. Perhaps surprisingly, the CO_2-footprint of the alternative diet is approximately the same as diets with dairy," Dr Peters continues.

Healthy and sustainable – and affordable and acceptable too

Besides following the recommended diets and nutritional intake, Optimeal® has adopted the four dimensions of sustainable diet as defined by FAO, the UN's Food and Agriculture Organization – namely health, sustainability, affordability and cultural acceptability.

Therefore, the model is designed to put forward diets as close to the recommended diet as possible with respect to these four dimensions.

Dr Peters elaborates: "A diet could easily have a low emission but at the same time be unhealthy, expensive or unfamiliar. For instance, a very large amount of vegetables is more costly. Or sweets and snacks are cheap, but definitely unhealthy. That is why we strive to follow the recommendations of the Dutch food-based dietary guidelines."

Don't jump to conclusions

According to Dr Stephan Peters, the full potential of the modelling tool is yet to be fulfilled:

"We want to be able to give more nuances to the model. Expanding the food groups, we include and expanding the dimensions of the environmental impact to water use and land use." he explains.

While Optimeal® has been widely recognised in the European science community, according to Dr Peters, it has the potential of greater impact outside academia too.

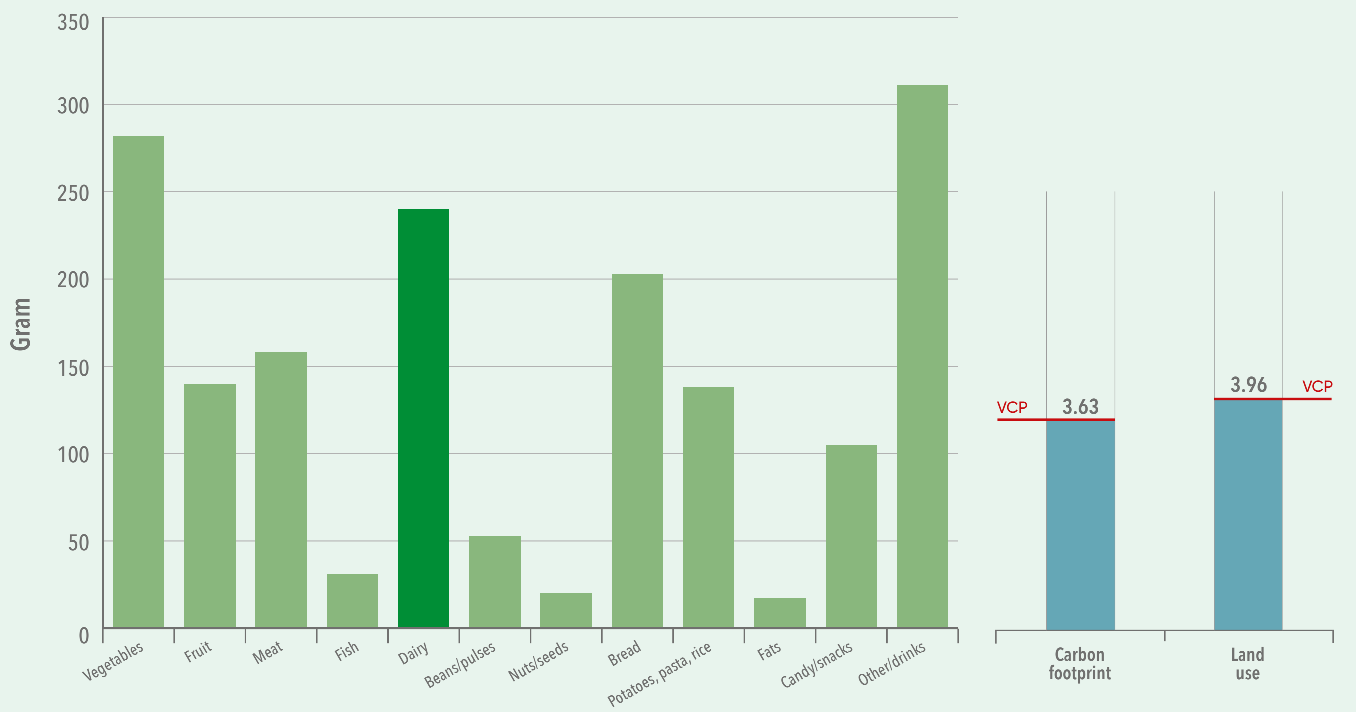
"Optimeal® and related linear programming tools could help inform the public debate. The common notion that animal-based foods always have a higher environmental impact than plant-based sometimes becomes too simplified. There are more consequences than what is usually presented by policy makers for instance. We need more nuances," he says.

Therefore, to Dr Peters, it is important that we treat the debate on sustainable food with respect and don't jump to conclusions. We will have to keep the good things of a healthy, nourishing, affordable food pattern within the need to create an even more sustainable production.

"When you change diet patterns, it sometimes comes with totally unexpected consequences. It is a delicate balance between economic, cultural, ecological and health aspects. When you want to change the food system or consumption, you should take into account all these four factors. When one is ignored, you are doomed to fail. In addition, you must monitor the consequences critically. We tend to forget this," Dr Stephan Peters concludes.

Optimeal® uses average Dutch diets based on the Dutch National Food Consumption Survey and from September 2020, EU data is a part of the reference data. The model has so far included a life-cycle assessment of 208 products across food groups.

As illustrated in the chart below, the model makes it possible to adjust the intake of various food groups like bread, fish, fruit, vegetables, dairy and so on.



About Dr Stephan Peters:

Dr Stephan Peters is manager of nutrition and health at the Dutch dairy association since 2015 and is specialised in the role of dairy in healthy and sustainable diets and food systems. Dr Peters has previously worked on the development of Dutch food-based dietary guidelines and was product developer of clinical nutrition for cancer patients. Dr Peters has a MSc in nutrition and toxicology and a PhD in clinical nutrition in cancer patients.