2022

afbi AGRI-FOOD & BIOSCIENCES INSTITUTE

Science Impacts 2022

Leading | Protecting | Enhancing

Contents

Dr Stanley McDowell
AFBI CEO

AFBI's innovation... helps the agri-food industry to drive growth in our economy whilst importantly helping to protect and sustain our environmental priorities

CEO FOREWORD

I am pleased to introduce the fifth in the series of AFBI Science Impacts Reports in which we highlight the key outcomes and impact of our science programmes. The Report highlights the excellence of our science and importantly the impact that this science is making for society, the economy and the environment.

Our people are critical to delivering our achievements and I am delighted that so many of our science teams have contributed to this report showcasing AFBI's breadth and depth of work. As an arms-length body of DAERA, AFBI scientists play a crucial role in providing the underpinning research and development, statutory and analytical testing, monitoring and surveillance science, emergency response capability and expert scientific advice required to support the important work programmes of DAERA and the wider requirements of the agri-food industry.

Innovation and new knowledge to address problems is a major driver of economic and societal progress and our people have contributed significantly to this aim through the many outcomes reported here. The creativity, ingenuity and hard work that AFBI staff continue to demonstrate is so necessary to further advance our state of knowledge and bring forward new solutions to address the challenges that society faces. AFBI's innovation for example, helps the agri-food industry to drive growth in our economy whilst importantly helping to protect and sustain our environmental priorities. This report demonstrates the excellence of our scientists through their ability to conduct highly relevant applied science, addressing societal needs whilst also making a scientific impact both nationally and on the global stage.

With our many challenges and opportunities demanding an ever increasing multi-disciplinary approach, partnership working has never been more important with a wide range of organisations working together. To deliver many of the achievements within this booklet, AFBI is delighted to work alongside DAERA, local industry, other government agencies and a range of academic colleagues to ensure that the work we do has direct relevance and maximises both the impact and reach of our science

Against the backdrop of current and emerging global and local challenges, the need for science has never been greater. I believe AFBI is very well placed to contribute to meeting these challenges through our three overarching scientific themes. For example, within **'Leading Improvements in the Agri-food Industry'**, we highlight 30 years of energy metabolism research which has underpinned the feeding requirement of livestock across the UK and is currently providing evidence to UK Government policy on Climate Change. In the area of **'Protecting Animal, Plant, and Human Health'** we feature our work on food safety in relation to the detection and control of chemical contaminants and other residues. This work is essential to enable the trade of NI livestock products and protect human health from the risk posed by potential contaminants. With regard to **Enhancing the Natural and Marine Environment**, our work on soil science is featured. Soil is the asset underpinning our agricultural industry and we are delighted that our work in this area will be further expanded and enhanced through the delivery of the world leading Soil Nutrient Health Scheme. The Scheme is a fantastic example of how AFBI science is being translated into practical knowledge for all farmers in NI with the aim of delivering economic and environmental benefits.

I would like to end by gratefully acknowledging DAERA and the various funding bodies who have supported our scientific achievements and my sincere thanks to all of our staff who have led and contributed to all of the various work programmes.

Dr Stanley McDowell

AFBi Chief Executive

Who we are and What we do

Key Metrics

AFBI science is helping **protect the economy,** delivering

3.3 MILLION

ANIMAL, PLANT & FOOD SAFETY TESTS
over the last 5 years

supporting sales from the agri-food industry to the value of

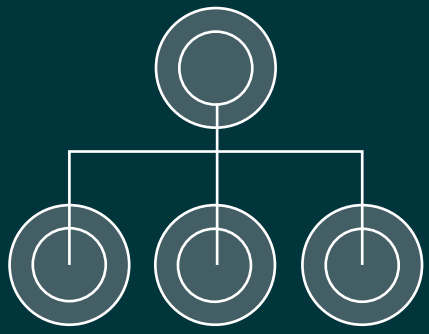
£4.2 BILLION Total Sales

£1.5 BILLION

£2.7 BILLION

Source: NI Food and Drinks Processing Report 2020

Knowledge Transfer activities from 01.01.17 to 07.11.22



2,008
Knowledge transfer events in total

Research publications from 01.01.17 to 07.11.22

766
Papers in total

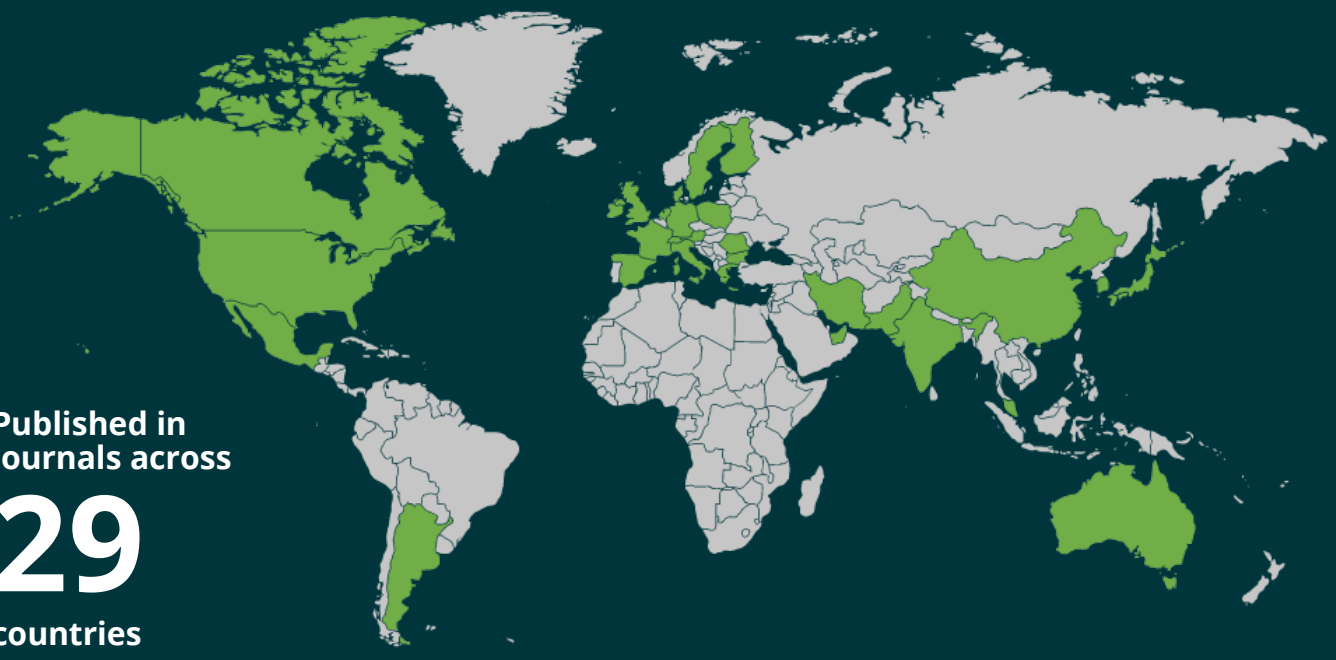
= 10 papers

619
Papers with at least one citation

= 10 papers

7,990
total citations

= 10 citations



Published in journals across
29
countries

AFBI Vision

Scientific excellence delivering impactful and sustainable outcomes for society, economy and the natural environment.

AFBI Purpose

To deliver trusted, independent research, statutory & surveillance science and expert advice that addresses local and global challenges, informs government policy and industry decision making, and underpins a sustainable agri-food industry and the natural and marine environments.

ENHANCING

the natural and marine environment

Measuring and Managing Ammonia Emissions from Northern Ireland Agriculture

Research Leads: Dr. John McIlroy, Dr. Tianhai Yan; Dr. Elizabeth Ball and Dr. Christina Mulvenna

Summary

Ammonia (NH_3) emissions from livestock production present a major challenge for the Northern Ireland (NI) agri-food industry. The Agri-Food and Biosciences Institute (AFBI) is conducting a major research programme to evaluate cost-effective mitigation strategies for ammonia emissions from NI agriculture. This work is funded by the Department of Agriculture, Environment and Rural Affairs (DAERA).

Background

Ammonia (NH_3) is an air pollutant that can damage ecosystems and negatively impact human and animal health. Ammonia is a gaseous form of nitrogen and the main ways in which it is lost from agriculture include the storage and application of livestock manure, chemical fertilizer application and manure deposited by grazing animals. Northern Ireland is responsible for 12% of the UK's total NH_3 emissions, despite having only 6% of the UK land area, but emissions are in line with the volume of meat and milk Northern Ireland produces for the UK food system. The NI cattle sector is responsible for 69% of agricultural ammonia emissions, followed by the poultry sector (14%) and the pig sector (8%). Nitrogen fertiliser accounts for 7% of ammonia emissions from NI agriculture (Figure 1). There is however work needed to continually update the emissions from livestock due to improvement in factors such as genetics and manure management.

For example, in the NI poultry sector, ammonia emissions were quantified at 34g/bird place/year. However, this figure was based on historic data and was potentially no longer applicable to modern poultry production systems and therefore it needed to be updated.

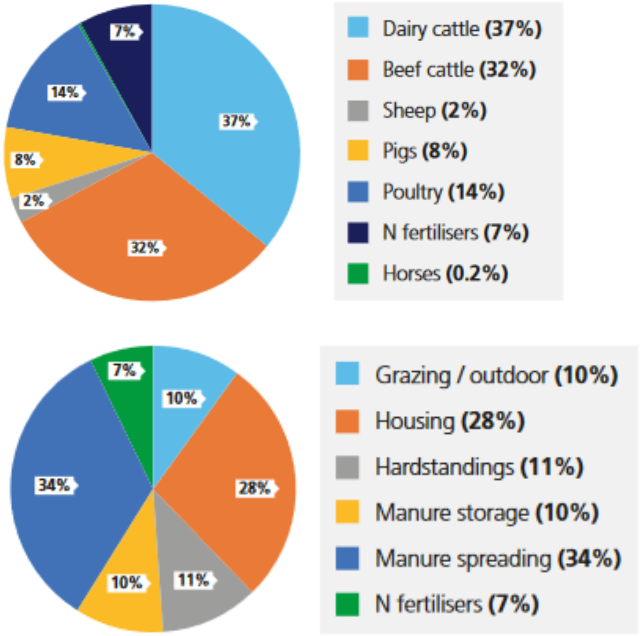


Figure 1. Sources of NH_3 emissions from NI agriculture (UK National Atmospheric Emissions Inventory, 2019)

EU Policy & Ammonia

Ammonia is an issue since approximately 98% of NI's designated sites exceed their critical nitrogen loading, as stipulated in the EU Habitats Directive and Biodiversity Strategy. Critical loads of nitrogen are defined as the nitrogen threshold above which significant harmful effects on sensitive elements of the environment occur. A significant proportion of this deposited nitrogen is understood to originate from local agricultural ammonia sources, mainly from livestock manure management.

Ammonia can adversely affect natural habitats on land. In many designated sites, such as Special Areas of Conservation (SAC) and Areas of Special Scientific Interest (ASSI), naturally occurring forms of nitrogen are scarce and local species of plants, bryophytes (e.g. liverworts, hornworts and mosses) and fungi have a low nitrogen tolerance. Excess nitrogen in these environments derived from agricultural ammonia emissions, encourages the growth of nitrogen-loving species such as grasses and nettles, which are often fast-growing and outcompete the more sensitive, slower-growing species such as lichens and mosses.

UK Policy & Ammonia

The UK is obliged to meet ammonia emission reduction targets set by the Gothenburg Protocol and National Emissions Ceilings Directive. To comply with UK and international agreements to improve air quality the aim is to reduce ammonia emissions by 16% by 2030, relative to the 2005 baseline. Northern Ireland has some 250 sites designated for protection, which are sensitive to the impacts of ammonia and nitrogen. Most of these sites are currently experiencing ammonia and nitrogen concentrations above the critical levels, which could lead to plant damage. DAERA is legally obliged to protect these designated sites and to enhance biodiversity.

AFBI Science

Driven by a multidisciplinary team of environmental scientists, animal scientists and agricultural economists, the AFBI Ammonia Research Programme is providing scientific evidence to better understand the sources and environmental impact of ammonia emissions from agricultural practices in NI and how to mitigate these cost-effectively, whilst updating emission factors for the National inventory. This important work will also underpin policy making decisions in relation to climate change from agricultural sources. The AFBI Ammonia Research Programme is a collaboration with Rothamsted Research and the UK Centre for Ecology and Hydrology who collectively are experts in ammonia accounting and atmospheric dispersion and deposition. As part of this programme, a new 28-site ammonia monitoring network was established across NI in March 2019, to measure atmospheric

ammonia concentrations and ground truth pollutant dispersion models. Sites chosen were representative of all major agricultural sectors, i.e. cattle, pigs, poultry, sheep and mixed farming as well as NI habitats as a whole. This research collaboration is addressing ammonia emissions in NI using range of strategies and disciplines including:

- Modelling a range of NH_3 mitigation strategies through the National Ammonia Reduction Strategy Evaluation System (NARSES) national ammonia inventory model and FRAME spatial model. This has allowed AFBI to determine ammonia mitigation strategies for NI, and the subsequent reduction in nitrogen deposition at NI's designated sites (SAC and ASSI) (Figure 2).
- Determining the potential for ammonia emission reduction strategies at farm level for typical NI dairy, beef, pig and poultry enterprises using the NARSES national ammonia inventory model.
- Determining the cost-effectiveness of modelled ammonia abatement strategies and the development of Marginal Abatement Cost Curves (MACC) for NI.
- Establishing a network of 28 new NH_3 monitoring sites across NI, in addition to 3 existing monitoring sites. This has provided data at farm level, facilitating an independent verification of ammonia concentrations from modelling outputs (Figure 3).
- Establishing a real-time ammonia monitoring site at AFBI, Hillsborough and modelling atmospheric concentrations of ammonia with local farm activities that result in ammonia emissions (Figure 4).
- Deriving emission factors for common NI livestock management practices, including reduced levels of crude protein in the diet, dry air heating poultry systems and increasing the time at grass for grazing ruminants, for inclusion in the national inventory on ammonia emissions.

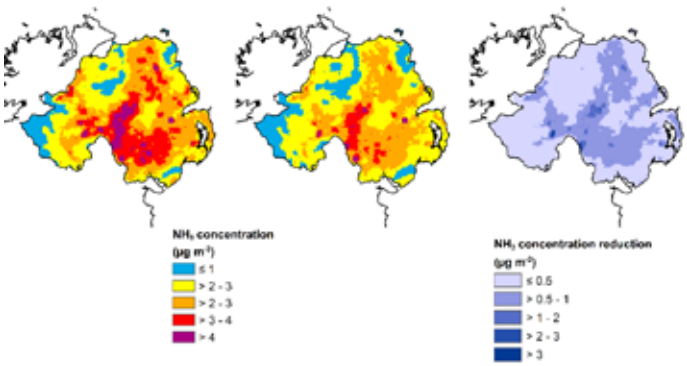


Figure 2. NH_3 reduction modelling scenarios for NI (modelled 25% reduction in NH_3). Left - 2019 Baseline NH_3 emissions. Centre - 25% reduction in NH_3. Right – Absolute difference.

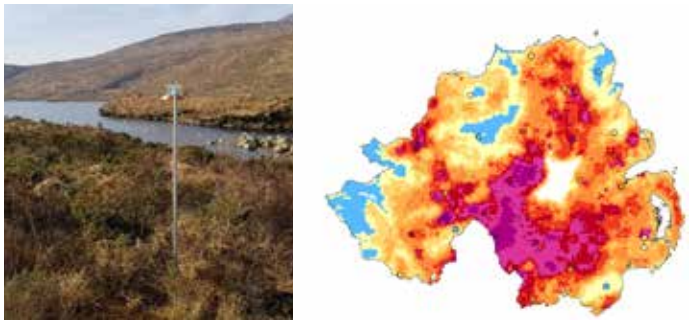


Figure 3. NH_3 monitoring systems at Bencrom (Mourne Mountains) (left) and measured (point) versus modelled NH_3 concentrations based on 1 year of measurements

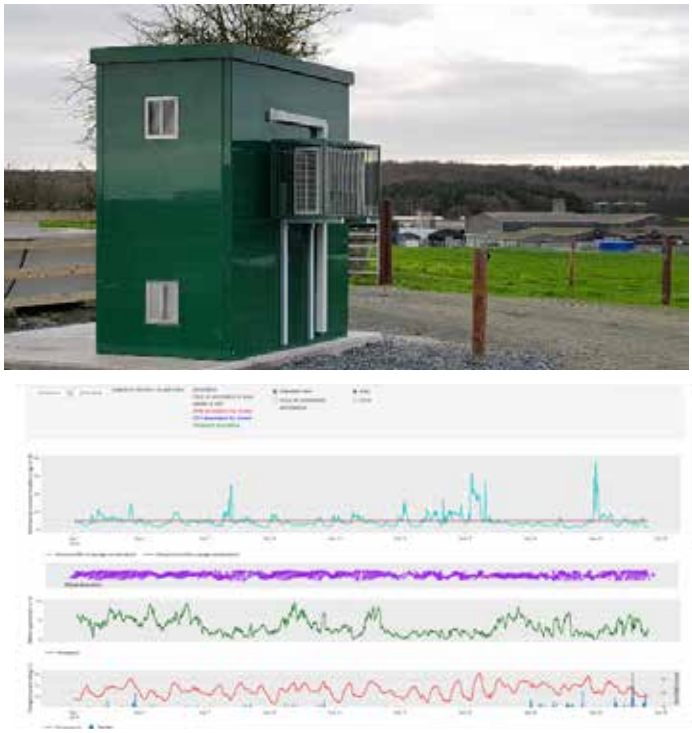


Figure 4. NH_3 monitoring at AFBI Hillsborough Research Farm

Impact of AFBI Science

Reducing NH_3 emissions

Results from the monitoring network established suggest that there is good agreement between actual and modelled estimates of atmospheric ammonia across NI. Ammonia reduction modelling also demonstrated that a 25% reduction in ammonia could be achieved by adopting a number of strategies on farm, which could be adopted over 5-10 years. Such measures to reduce ammonia emissions include lowering the level of crude protein (CP) in the animal's diet; genetic improvement in pigs and poultry; low emission livestock housing with novel flooring systems for cattle, pigs and poultry; roofing and scraping dairy cow collection yards; extending the grazing season; adjusting the pH of slurry; low emission slurry spreading; using stabilised urea fertiliser; and covering above ground slurry stores. These strategies, at appropriate uptake rates, would allow NI to fulfil its contribution to the UK Air Quality Strategy with an ammonia reduction target of 16% by 2030.

Economics

A modelling exercise in the form of a Marginal Abatement Cost Curve, demonstrated that by implementing the five most cost effective measures on farm gave an overall reduction of 21% in ammonia emissions across NI, at a cost of £6.6m/year. The five lowest cost ammonia reduction measures included extended grazing; lowering the level of CP in the animal's diet; using stabilised urea; low emission slurry spreading; and genetic improvement of cattle, pigs and poultry. These strategies would significantly contribute to the achievement of targets set by international protocols and national legislation.

Updating Emission Factors for GHG Inventory

In the broiler study conducted by AFBI for example, ammonia production was assessed for over one year's production across four broiler houses, with a level of 24g/bird place/year being recorded. This is 29% lower than the current standard of 34g/bird place/year (Figure 5), which can be attributed to advancements in genetics, nutrition and management practices that have improved feed efficiency, reduced overall nitrogen excretion and increased broiler litter dry matter. The adoption of this new emission factor will facilitate more accurate ammonia emission modelling, along with providing accurate information for poultry housing planning decisions in Northern Ireland.

Similar studies across pig and dairy systems are underway, with a major project currently underway with industry partners to design dairy diets with reduced protein levels. Such diets are being designed to reduce nitrogen excretion from the cow and therefore ammonia emissions from the resultant manure, but optimise dairy cow productivity, health and welfare.

Figure 5. Comparison of measured ammonia

emissions with the current standard value (g ammonia/bird place/year)

Underpinning Policy

Outputs from the AFBI Ammonia Research Programme were disseminated through the DAERA Ammonia Stakeholder Forum; and informed the Code of Good Agricultural Practice for the Reduction of ammonia Emissions, by the College of Agriculture, Food and Rural Enterprise (CAFRE). Outputs from this important research will continue to underpin DAERA's Ammonia Strategy and related Action Plans.

Dr Kate Semple DAERA:

The ammonia research programme led by AFBI and funded by DAERA was an excellent example of AFBI leading a UK-wide partnership of the key scientific providers in this area to deliver a world class evidence base on ammonia. Crucial to the success of the programme was the breadth of work it encompassed, from measuring ammonia concentrations in the air across Northern Ireland, to assessing the environmental benefit and economic impact of farm measures to reduce ammonia, as well as analysing the spatial impact of farming practices. The AFBI-led ammonia research programme has been an invaluable evidence base for policy development and has been communicated across the stakeholder community, including farmers, government, the environment sector and other research organisations within NI and further afield.

The study was funded by DAERA E&I

Walking trees and black rivers: impacts of a bogflow on carbon transport and water quality in the River Derg

Research Leads Dr. Phoebe Morton, Dr. Billy Hunter, Dr. Rachel Cassidy, Dr. Donnacha Doody

Summary

Bogflows, which are essentially landslides in which rafts of solid peat are displaced by a sudden evacuation of semi-liquid basal peat, are not uncommon on the island of Ireland but are poorly understood, largely due to their unpredictability and their occurrence in remote locations. On 13th November 2020, a section of peatland at Meenbog on the Tyrone-Donegal border, detached itself from the surrounding forested landscape and, complete with trees, walked down the hill and into the River Derg (Figures 1 and 2).

About 5 hours later, this bogflow forced the water treatment works (WTW), located 37 km downstream at Castlederg, to shut down as the intake waters turned black (Figure 3). Ongoing monitoring in the River Derg provided a unique opportunity to monitor the impact of this bogflow on carbon transport and water quality.

Figure 1: A tree moved downstream during the bogflow.

Figure 2: The impacts of the bogflow are clearly visible as peat on the river banks for over a kilometre downstream of the event location.

Background

In Northern Ireland, surface water provides over 99% of our drinking water. Whilst industry and agriculture are often implicated in dirtying rivers and lakes, organic carbon compounds that are released naturally from soil can also be difficult and costly to remove during water treatment. Peat contains the highest organic carbon concentration of all soils but, when intact, it also functions as a filter, removing impurities from water passing through. Intact peatlands are therefore crucial to both carbon storage and good water quality.

AFBI Science

Since 2018, AFBI scientists have been monitoring pesticide concentrations in the River Derg as part of the cross-border Source to Tap project. Water samples were collected every seven hours from the River Derg for three days before, and nearly four weeks after, the bogflow (Figure 3). Samples were analysed for dissolved organic carbon (DOC) and particulate organic carbon (POC).

Surprisingly, the bogflow did not affect the DOC concentrations, which were controlled by river flow rate alone (Figure 4a). However, POC concentrations (usually 0.5-2 mg/L in peaty rivers), reached 346 mg/L. Calculation of the daily POC loads, which incorporated the seven-hourly POC samples and the hourly river flow rates, and comparison to the samples taken before the bogflow, revealed that an additional 384 tonnes of POC passed the WTW in the first nine days after the bogflow occurred (Figure 4b). This equates to 612% more POC than that which would have been expected at a similar flow rate.

Impact of AFBI Science

Monitoring the River Derg has provided a unique insight into bogflows, being rarely recorded events with potentially devastating impacts. The finding that DOC concentrations were unaffected by the bogflow is of significant value to water companies, as DOC is much more complex to remove than POC, for which filters can be used.

Figure 3: Water samples from the River Derg before (bottles on the left) and after (bottles on the right).

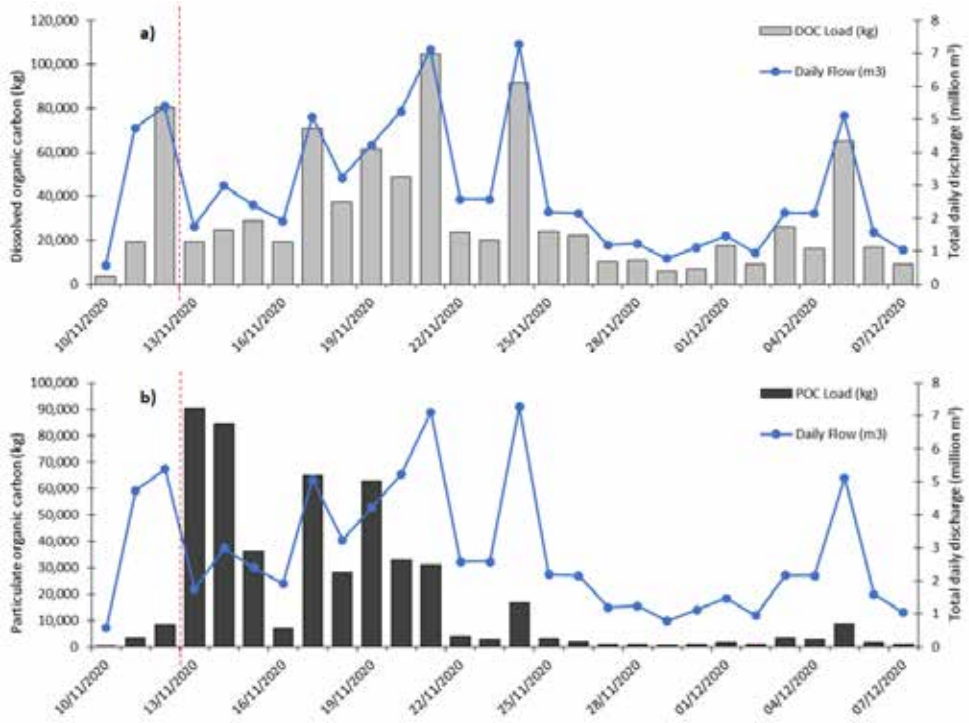


Figure 4: Daily a) dissolved organic carbon (DOC) and b) particulate organic carbon (POC) loads calculated from measured DOC and POC concentrations & river flow rates in the River Derg. The dashed red line indicates when the bogflow occurred

This means that WTWs may not need to shut down abstraction operations completely during future bogflow events, providing the water is filtered.

Up to 50% of the POC that entered the River Derg will ultimately decompose to carbon dioxide, which will be released into the atmosphere, contributing to climate change. As the likelihood of bogflows increases due to climate change drying the peat surface and creating more intense rainfall events, once published, these data could be used to help model the potential impacts of bogflows as a positive feedback mechanism to the climate.

The study was co-funded by Source to Tap- supported by the European Union's INTERREG VA Programme, managed by the Special EU Programmes Body (SEUPB

Connecting nature-based solutions within the Carlingford catchment: Potential solutions for improved water quality and the mitigation of flood and wildfire risk

Research Leads: Dr. Diane Burgess, Mr. Graham Finney, Dr. Catherine Glass, Ms.Rachel Reid-McCann and Mr. David Bannon.

Summary

Nature-based solutions, offer the potential to deliver both environmental and economic benefits to landowners and society, including water quality improvements and mitigating flood and wildfire risk. Such measures can include the creation of riparian zones (strips of vegetation that border rivers and streams), and planting wildflower margins. Benefits can be further enhanced by locating these features in a network across a landscape, forming connected nature-based solutions.

Background

Agri-environment schemes offer support measures to farmers to implement nature-based solutions on their farm. With individual farmers deciding how much they participate within such schemes (if at all), connected nature-based solutions in the Northern Ireland landscape are few and far between. The aim of this study was to model the potential impact of connected nature-based solutions in improving water quality and mitigating flood and wildfire risk.

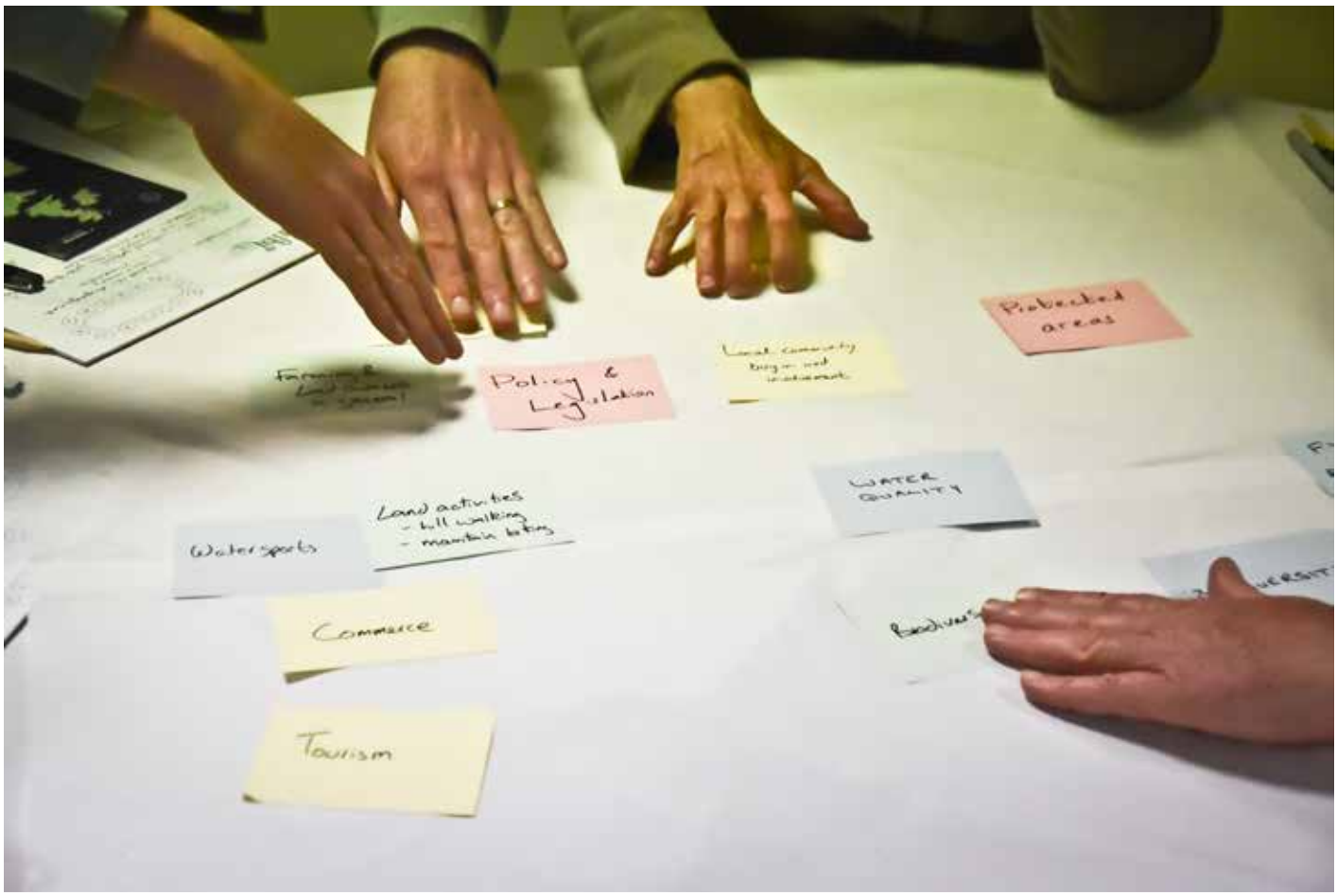
AFBI Science

The EU Interreg funded ALICE project modelled the impact of implementing connective nature-based solutions in the Carlingford catchment to improve water quality, and to mitigate flood and wildfire risk. The Carlingford catchment was chosen as one of four locations across Europe to benefit from the development of new, state-of-the-art digital map-based models.

These models were created to measure how changes in land and water management can benefit the catchment, particularly at a time when our climate is changing. AFBI economists delivered a series of stakeholder workshops and interviews with farmers and intermediary bodies, to explore barriers to the adoption and uptake of such nature-based solutions in this catchment. The study also examined the potential for farmers to work together to increase impacts.

Impact of AFBI Science

Investigating how farmers responded to previous and existing agri-environment schemes provided key insights into potential barriers to adoption of such schemes by farmers.



The major findings were:

(a). A requirement for further information, e.g.:

- Details of the measures
- Benefits of such measures for farmers and society (highlighting win-win potential)

This work prompted the development of a Nature-Friendly Farming Toolkit to help farmers implement nature-friendly solutions on farm.

(b). The benefits of engaging a trusted intermediary to break down barriers to farmer participation in such schemes, providing sound advice and encouragement for farmers to work together.

The study was co-funded by ALICE: Atlantic Area Interreg

Long-term retention of dummy acoustic (sound) transmitters in adult brown trout - The application of medical grade ultrasound technology to inform fisheries biology & management

Research Leads: Dr. Richard Kennedy, Dr. Derek Evans & Dr. Michelle Allen

Summary

Researchers use acoustic telemetry (sound transmitters) to collect information about fish movement (e.g., fish location, behaviour, migration patterns, habitat use, survival, etc.)

Modern and rapidly developing fish tagging technology offers new sensor capabilities, smaller tags, and improved battery life. The aim of this study was to examine the retention of dummy acoustic tags in fish using medical grade ultrasound technology.

Background

Studies often monitor fish movement using surgically inserted tags. It is often assumed that transmitters are retained for life in the fish.

Intraperitoneally implanted tags (i.e. surgically implanted into the body cavity) can be lost from the body of the fish over time, through transdermal shedding (when it is shed back through the body wall) or can be lost via

the intestine or at during spawning via the vent). Despite the widespread use of acoustic transmitters for tracking fish, few studies have monitored long-term tag retention rates in fish.

AFBI Science

AFBI researchers examined the retention and location of intraperitoneally implanted dummy acoustic tags in hatchery brown trout using a medical grade ultrasound system, followed by surgical examination of fish after the study was complete.

The ultrasound technology used linear (2.5-12 MHz) and curved (convex 2.5-7.5 MHz) transducers to detect the presence and location of tags in fish. A final examination determined the long term (1 year +) presence, location and status of the tag.

Results from this study demonstrated that more than one third (13 out of 36) of individually tagged fish shed their tags during a 370 day monitoring period.

Impact of AFBI Science

The use of medical grade ultrasound technology offers a non-invasive, repeatable and portable alternative to existing methods used to inform fish biology and management (e.g. X-ray or surgery).

This technology also reduces handling stress in fish, promoting good animal welfare. Significant opportunities also exist for further studies on salmon and other fish species.

Continuous temperature monitoring of the Irish Sea as an indicator of health in the Irish Sea ecosystem

Research Leads: Dr. Billy Hunter, Dr. Steven Beggs and Dr. Adam Mellor

Figure 1. AFBI's Irish Sea Oceanographic Mooring

Summary

AFBI scientists play an important role in monitoring change in the marine environment, to support the sustainable management of Irish Sea fisheries. The aim of this ongoing work, funded by the Department for Agriculture, the Environment and Rural Affairs (DAERA), is to assess the impact of a range of stressors, including climate change and man-made pollutants, on the health of the Irish Sea ecosystem.

Background

Through a long-term monitoring programme using AFBI's Irish Sea oceanographic mooring (i.e. a collection of interconnected scientific instruments, anchored at the sea floor and suspended by a surface marker buoy) (Latitude: 53.783; Longitude: -5.63), water temperature was recorded in the central Irish Sea (Figure 1).

The mooring has been in place since the 1990's, where water temperature at the sea surface and seabed have been continuously recorded (Figure 2).

AFBI Science

AFBI research has demonstrated some evidence of warming temperatures in the Irish Sea, with an increased number of days observed since 2010, where summer sea surface temperatures exceeded 15°C (Figure 3).

In July, 2021 a marine heatwave resulted in the highest sea surface temperature ever recorded in the Irish Sea. During this period, temperatures where higher than 18°C for 12 days, between 16-28 July 2021, reaching a maximum of 19.7°C on 23 July 2021 (Figures 4 and 5). This represents the highest temperature ever recorded in the western Irish Sea.

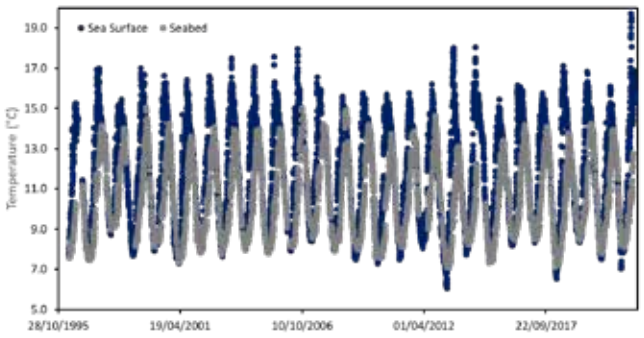


Figure 2. Daily sea surface and near sea bed water temperatures at the AFBI Irish Sea mooring (1996-2021)

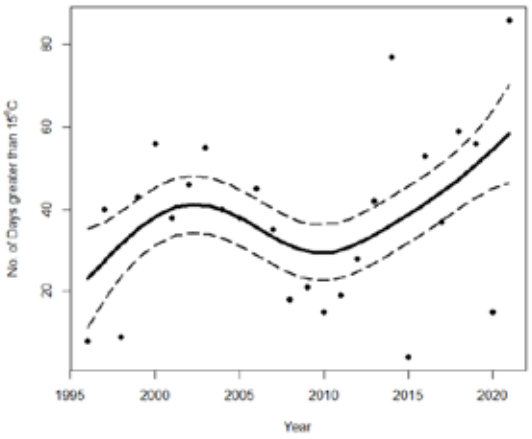


Figure 3. Annual number of days when Sea Surface Temperature at AFBI's Irish Sea mooring exceeded 15°C

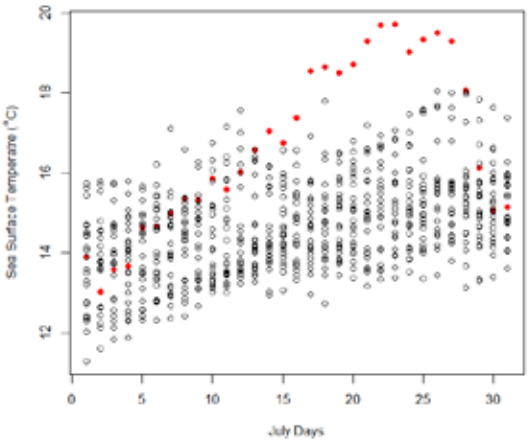


Figure 5. Maximum heatwave temperature anomalies (1997-2021), demonstrating the most intense heat event occurring in July 2021

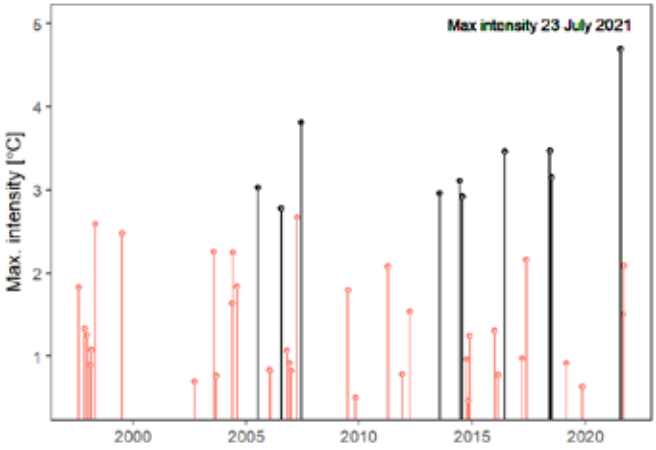


Figure 4. Daily July Sea Surface Temperature (1996-2021). Red Dots show 2021 temperatures, with a heatwave between 16-28 July 2021. Peak temperature was recorded on 23 July 2021 at 19.72°C.

Impact of AFBI Science

While the environmental drivers behind marine heatwaves are still poorly understood, it is widely expected that their frequency and intensity will increase over the next century, as the earth continues to warm.

The high sea surface temperatures recorded by AFBI in July 2021 may therefore represent a harbinger of future extreme weather events in the Irish Sea. It is imperative to continuously record data to predict the impact of climate change and man-made pollutants on the health of the Irish Sea ecosystem.

The early marine distribution of Atlantic salmon in the North-East Atlantic: Using data integration to understand salmon migratory behaviour at sea

Research Lead: Dr. Dennis Ensing

Summary

The survival of the iconic Atlantic salmon fish (*Salmo salar*) which spawn in rivers before migrating to sea to forage and mature, has reduced dramatically during the marine phase, with a disproportionate impact on the poorly understood early phase of the marine lifecycle. To advance understanding of Atlantic salmon distributional ecology in the North-East Atlantic, a comprehensive analysis of existing information and data was undertaken by scientists from a wide range of European institutes, including AFBI.

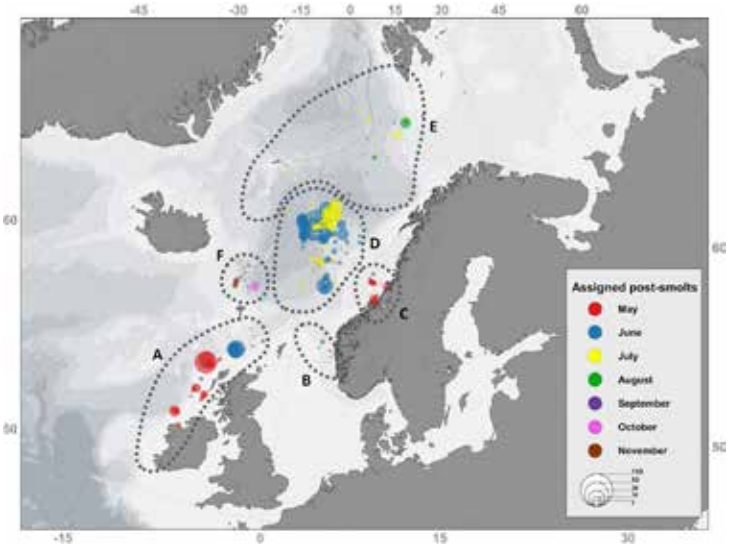
Background

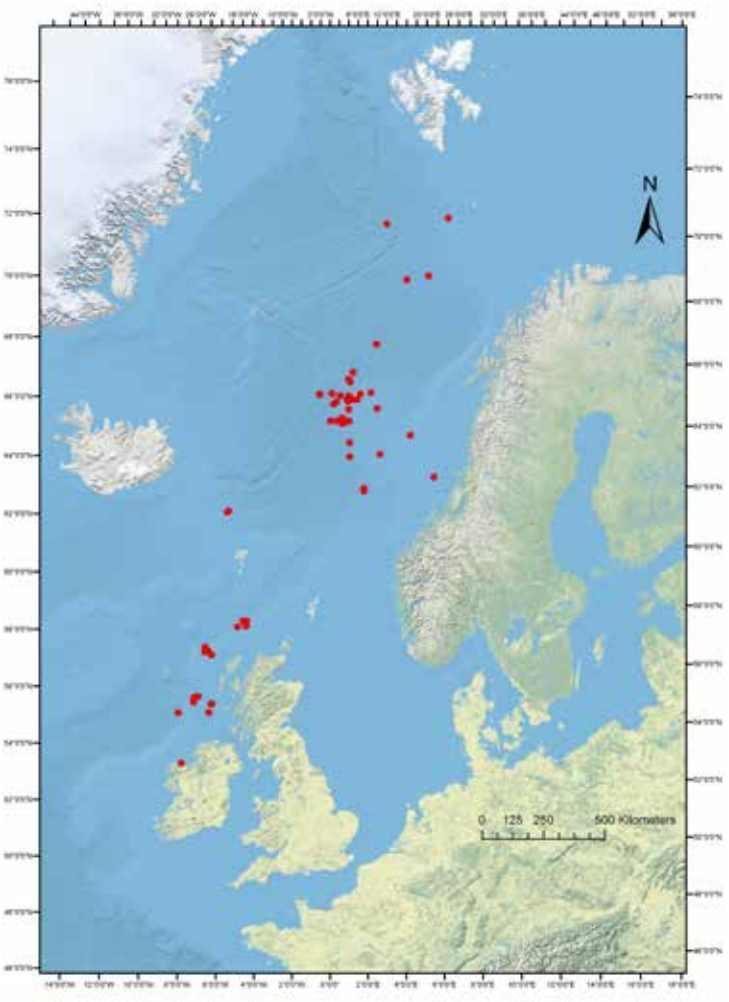
Data were synthesized from 385 marine cruises; 10,202 individual trawls; and 9,269 captured Atlantic salmon, spanning three decades and ~4.75 million km^2 of ocean, with 3,423 individuals genetically assigned to regional phylogeographic origin. Phylogeography refers to the study of the historical processes that may be responsible for past to present geographic distributions of bloodlines.

AFBI Science

Statistical analysis to geographical region or river of origin were conducted using a genetic baseline comprising >26,000 individual Atlantic salmon from 284 rivers across Europe, including all 19 primary salmon rivers in Northern Ireland.

The findings from this study confirm major migrational aggregations of salmon in the early marine phase on the continental shelf-edge off Ireland, Scotland and Norway, and





an important marine foraging area in the Norwegian Sea. Some Northern Irish fish from the River Foyle were located as far north as Bear Island off the coast of northern Norway, located roughly halfway between the North Cape and Spitsbergen.

This study also identified a key foraging habitat for southern European (including British and Irish) Atlantic salmon located in international waters immediately west of the Vøring Plateau escarpment (a volcanic margin remaining from the breakup of Greenland and Norway during the opening of the North Atlantic). This could potentially expose these salmon to a high by-catch mortality from extra-territorial fisheries for pelagic species such as Mackerel and Herring (i.e. the fish inhabit the water column (not near the bottom or the shore) of coasts, open oceans, and lakes).

Impact of AFBI Science

Evidence of the differential distribution of regional salmon stocks points to fundamental differences in their migration behaviour and this may lead to inter-stock variation in response to environmental change and marine survival. This study demonstrates the importance of understanding early-marine phase Atlantic salmon ecology in relation to stock-specific variation in habitat utilisation; biological performance; and exposure to mortality factors, which can be significantly advanced by data integration across studies and exploiting genetic approaches.

The study was co-funded by: EU 7th Framework Programme, (as part of a collaboration contributing to the SALSEA-MERGE- Adviancing understanding of Atlantic Salmon at Sea: Merging Genetics and Ecology to resolve Stock-specific Migration and Distribution patterns), DAERA INLAND FISHERIES GROUP, Loughs Agency, TOTAL Foundation

Long-term impacts of nutrient enrichment and non-native species in Lough Neagh and Lough Erne.

AFBI Research Lead(s) Dr. Robert Rosell , Dr. Richard Kennedy, Dr. Derek Evans, Dr. Kevin Gallagher, Dr. Yvonne McElarney, Dr. Michelle Allen

Background

AFBI have been collecting data on environmental conditions and surveying fish stocks in the UK's two largest lakes, Lough Neagh and Lough Erne for over 50 years. Both lakes have valuable commercial (Lough Neagh) and recreational (Lough Erne) fisheries. Both lakes have also been subject to human driven changes over the past century, including nutrient enrichment and multiple introductions of non-native species.

Lough Neagh Eel

From 1950 to 1980, high nutrient levels fuelled algal blooms, supporting growth of the high numbers of juvenile eels entering Lough Neagh from the sea, consequently yielding a peak in the number of adult eel harvested. After 1980 however, fewer juvenile eels, competition with introduced species, and decreasing nutrient levels all contributed to reduced eel catches. Future sustainable management of eels depends on our understanding of these drivers of change and their effects on sustainable fisheries.

Lough Erne Trout

Following the introduction and spread of the invasive Zebra mussel in the late 1990's and early 2000's, a steep decline was observed in the number of spawning trout. Numbers of juvenile trout in the streams feeding into Lough Erne by contrast, remained stable, suggesting that reduced lake trout numbers were due to changes in the lake ecosystem, rather than the streams. Zebra mussels remove plankton from the water, reducing the food available to young fish, and making the water clearer. Clear water and more weed beds provide habitat for visual predators such as perch which have replaced roach as the dominant fish species within the lake.

Impact of AFBI Science

Through maintaining important long-term data series, AFBI research is revealing the key drivers of change within these complex lake ecosystems.

The study was co-funded by DAERA INLAND FISHERIES GROUP

LEADING

improvements in the agri-food industry

30 years of AFBI Research Underpins Government Policy on Climate Change, Sharpens Greenhouse Gas Inventories, and improves Nutrient Requirement recommendations for Farm Animals

Research Leads: Dr. Tianhai Yan and Dr. Conrad Ferris

Summary

With a the world population now at 8 billion, along with a changing climate, sustainable farming is imperative. Data from research trials conducted at AFBI over the past 30 years is playing a key role in driving improvements in the environmental footprint of NI livestock farming. AFBI research has been conducted in the areas of energy metabolism and reducing methane (CH_4) emissions, via a more efficient use of nutrients on-farm. Research on the nitrogen use efficiency and excretion of phosphorus has also been of a key focus. Such research has underpinned the development of AFBI's Feed Into Milk, Feed Into Beef and Feed Into Lamb models, to maximise the efficiency of nutrient utilisation for sustainable animal production on-farm. It has also underpinned government policy making decisions on climate change and data have shaped and sharpened the UK's Greenhouse Gas (GHG) inventory.

AFBI Science

Feed Conversion Efficiency

Feed Conversion Efficiency (FCE) in dairy, beef and sheep production has a major influence on profitability and environmental sustainability on-farm. As such, it is important to fully understand the energy requirements of farm animals to optimise health and production. Considering concerns relating to enteric CH_4 production from ruminant animals and their impact on climate change, improving FCE could help mitigate CH_4 emissions. Equations to predict the energy requirement of dairy, beef and sheep according to the Agricultural and Food Research Council (AFRC) were outdated and required updating. Research at AFBI over the past 30 years has provided modern data to update these equations, so that they are representative of modern farming enterprises and systems. This work is important to improve nutrient requirement recommendations for farm animals.

Energy Metabolism & GHG Emissions

Energy metabolism is the process of generating energy from nutrients. Cells require energy for growth and maintenance and have evolved to have multiple pathways to produce energy. Energy metabolism data, including CH4CH_4 and Carbon Dioxide (CO2) emissions from cattle and sheep have been measured by AFBI over the past 30 years. Since 1992, some 1,200 dairy cows; >300 beef cattle; and >200 sheep (6 sheep respiration units were constructed in 2011) have been subject to evaluation using specially designed infrastructure (Figure 1) to scientifically measure the effect of dietary and animal factors on energy utilisation efficiency and CH_4 emissions in these animals.

With increasing concerns about the impact of agriculture on climate change, this has focused the attention of government and policy makers on the need to develop accurate estimates of GHG emissions from agriculture. This is particularly true in the UK, where the UK Climate Change Act requires

Figure 1. AFBI Cattle Respiration Calorimeter Unit

the UK to reach net zero by 2050, relative to 1990 levels. Achieving these ambitious GHG reduction targets is requiring a significant effort across all sectors.

Carbon Calculators

Underpinned by the outcomes from the research on the dietary impact on GHG's, AFBI has also developed sophisticated Dairy and Beef carbon footprint calculators to support government understand the carbon intensity of these sectors over periods of time and support the industry lower its carbon footprint, relative to other EU member states. The dairy calculator in particular has been independently verified against international standards, e.g. PAS 2050 and International Dairy Federation, and has therefore been validated to the highest standards.

Furthermore, AFBI compared GHG emissions generated by the AFBI BovIS calculator for nine NI farms, with those obtained from three other GHG calculators used in France and the Netherlands. Total GHG emissions and emissions/kg milk were relatively similar across the four calculators, with individual farm variation captured accurately and consistently across all calculators.
The verification and comparison provided confidence in the ability of the AFBI calculator to estimate GHG emissions for NI dairy

farms, and in its ability to be an important tool in the development of GHG mitigation strategies to reduce GHG emissions at farm level. Local dairy producers can use this calculator to estimate the quantity of GHG emissions/litre of milk produced. The easy-to-use calculator accounts for all activities within a farm that are sources of GHG emissions, e.g., emissions from rumen fermentation, manure management, fertiliser manufacture and application, concentrate production and transportation. The calculator use the latest research findings from AFBI and other national and international scientific studies.

Lastly Data from the AFBI respiration units were used to develop a range of mathematical models to predict and mitigate CH_4 emissions from cattle and sheep production in NI. These models have been widely adopted elsewhere to quantify CH_4 emissions in GHG inventories.

Ongoing studies

At present, AFBI Hillsborough has 7 ongoing research projects relating to the measurement and mitigation of enteric CH_4 emissions from cattle and sheep production. These projects are mainly funded by DAERA; the Department of Agriculture, Food and the Marine (DAFM); the Department of Environment, Food and Rural Affairs (DEFRA) (providing funds for EU ERA-NET projects); EU Horizon 2020 and the Biotechnology and Biological Sciences Research Council (BBSRC) Doctoral Training Partnership (DTP) programme. The majority of these projects are in collaboration with QUB through the AFBI-QUB Alliance and involve multi-partners from EU countries and other continents (e.g., Canada, New Zealand and South American countries).

These CH_4 projects are designed to investigate the effect of dietary manipulation on CH_4 production activities in the rumen of cattle and sheep and to identify the appropriate CH_4 mitigation strategies. The dietary factors that have/will be evaluated include:

- Alternative Forages (e.g., multispecies swards, white clover and willow silage)
- Microalgae and their derivatives; seaweeds and seaweed abstracts
- Feed Additives

Impact of AFBI Science

Feed input is the biggest source of expenditure in livestock farming, and it also plays a key role in delivering a reduced environmental footprint of cattle and sheep production (e.g., GHG emissions). AFBI research has made a significant contribution to cattle and sheep production industries, through its research to develop and update energy and feed intake models for precision rationing cattle and sheep.

Feed Into Milk

AFBI was a key player in the development Feed Into Milk models for precision rationing of dairy cows. These models have been widely adopted for rationing dairy cows in UK and used globally as a reference tool for calibration/evaluation of prediction of

local milk production and environmental footprint (e.g., GHG emissions and manure N excretion). The Feed into Milk models have been adopted by the UK expert group for prediction of feed intake, which is then used to update annual inventories of GHG, ammonia and manure N emissions in dairy production for the whole UK and each part of the UK.

Feed Into Beef

Accurate guidelines for rationing beef cattle are critical to ensure that nutritional requirements are met; and the desired levels of performance are achieved in an economically sustainable manner. This project delivers new guidelines for predicting beef cattle performance and feed requirements. It also benefits the red meat industry, as more accurate predictions of cattle flows to meat plants can be made; and carcases should meet market specification in terms of age at slaughter, carcass weight and fat classification. This research will support policy making decisions and industry stakeholders, as the outcomes will be available for future modelling to determine beef nutrition regimes or farm management practices with the lowest environmental footprint.

Feed Into Lamb

AFBI has researched the metabolisable energy requirements and carbon footprint of sheep production, whilst developing a robust energy feeding system for sustainable sheep production in NI and Great Britain. In identifying the key parameters influencing N excretion and enteric CH_4 emissions, prediction equations for manure N and enteric CH_4 emissions from sheep offered fresh grass and grass silage were developed. The equations developed in AFBI studies provide an approach for sheep producers to quantify N excretion and enteric CH_4 emissions against production and consequently to develop their own GHG mitigation strategies to reduce the environmental impact of sheep production systems.

Summary

This extensive research programme has provided and will continue to provide DAERA and the cattle/sheep sectors with evidence-based benchmarking information, to underpin the development of government policy for environmentally responsible cattle and sheep production systems that are economically sustainable. AFBI's research will continue to play a key role in assisting farmers and industry in meeting the requirements of the Nitrates Directive and Water Framework Directive. The development of new GHG emission factors will continue to sharpen the UK GHG inventory and data from these extensive studies in AFBI have and will continue to set nutrition requirements for farm animals in the UK.

THE STUDY WAS CO-FUNDED BY DAERA, DEFRA, DAFM, EU, AGRISEARCH AND COMMERCIAL COMPANIES

Farm fatalities in Northern Ireland: What 50 years of data tells us.

Research Leads: Dr. Claire Jack and Dr. Simone Angioloni

Summary & Background

Farming remains one of the most hazardous sectors to work in, due to the high number of accidents. The main causes of farm-related accidents in Northern Ireland are vehicles and equipment; falls; and animal handling. As part of a wider DAERA Evidence and Innovation farm safety project, the aim of this research was to analyse fifty years of Northern Ireland farm fatalities data from 1968–2017 to observe trends in the data, with a view to mitigating the occurrence of and preventing farm fatalities.

AFBI Science

Following a detailed analyses of 50 years of farm fatalities data, the following results were determined:

(a.) Although there has been a decreasing trend in farm fatalities caused by vehicles and equipment, this is still the main cause of accident-related deaths. Fatalities due to falls have remained constant, while livestock associated fatalities show an increasing trend.

(b.) Across all the main causes of fatal accidents on farm, the occurrence of same increases with age. (Figure 1).

(c.) Male fatalities are five times more likely than female fatalities, reflecting agriculture's predominantly male workforce.

(d.) For all fatality occurrences, there is an increased risk over spring/summertime (Figure 2), which is relatively more pronounced for children and younger adults (Figure 3).

For young children, there is an increased risk of accidents at weekends.

For farmers over 50 years of age, there is a higher rate of fatal accidents occurring between Thursday and Saturday.

Impact of AFBI Science

Farm fatalities have averaged ten deaths per year over the past 50 years, but they have decreased over time.

However, each fatality critically impacts on farm families and businesses and there is a need to continuously pursue improvements in safety at farm level.

Specifically, this study highlights that industry interventions focused on farm safety should be more targeted, i.e. specifically by identifying who is most likely to be impacted (children, younger farmers, older farmers); the time of year (an increased workload); and the nature of the accident occurrence.

Figure 1: Results by cause of accident and age

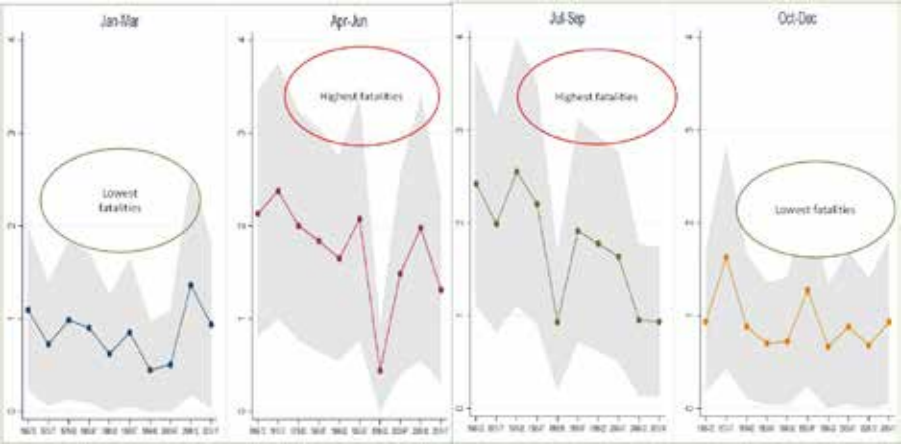


Figure 2: Results by season and period
Results by cause of accident and age

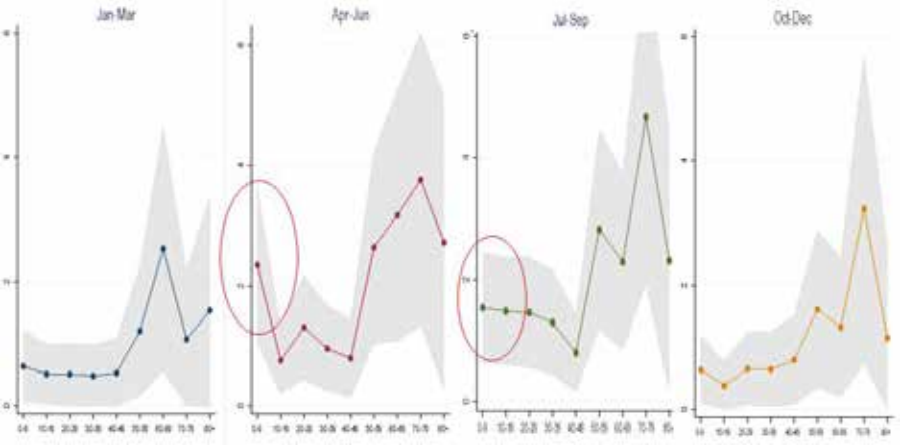


Figure 3: Results by season and age

A whole farm dairy systems model for Northern Ireland

Research Leads: Dr. Austen Ashfield & Dr. Claire Jack

Summary

The aim of this project was to establish a whole farm dairy model for Northern Ireland, providing an important framework to explore and guide decision making and resource use at farm level.

Background

Data from AFBI production research studies were used to set parameters within the model. Dietary components used in the model include grazed grass, grass silage, and concentrate. The model consists of four sub-models namely: farm system; animal nutrition; feed supply; and financial. Overall, this model allows for the evaluation of a wide range of technical and economic factors affecting dairy systems in Northern Ireland. Work is currently underway to develop and incorporate a model which reports on the environmental impact of the various systems and possible mitigation strategies.

AFBI Science

Following the development of the model, it was used to compare three dairy systems, Low (spring calving, 6,000l/cow), Medium (Autumn/spring calving, 8,000l/cow) and High (all year round calving, 10,000l/cow). The High system was found to have the highest concentrate requirement and carry the lowest number of cows (Table 1).

The Medium system was found to have the highest net profit followed by the High and then Low systems (Table 2). The effects of changing milk, concentrate and fertiliser price were examined, with milk price changes having the largest effect on profitability (Table 2). The High system was most affected by price changes (Table 2) and can result in the reranking of the profitability of the systems.

Figure 1 shows that increasing and decreasing milk price by 5ppl, resulted in the high system becoming the most and least profitable, respectively. Furthermore, the Low system became the most profitable when milk price decreased by 10ppl (Figure 1).

Figure 2 shows that decreasing concentrate price by £70/t resulted in the High system becoming the most profitable. However, when concentrate price increased by £60/t the High system became the least profitable.

Impact of AFBI Science

The impact of developing the AFBI Dairy Systems Model is significant, in that it will provide an important research tool for the Northern Ireland dairy industry and policy makers by providing an evidence base to inform decision making in the years ahead.

Table 1. Physical outputs of dairy systems studied using the AFBI Dairy Systems Model

	Low	Medium	High
Area farmed (ha)	70	70	70
Stocking rate (kg organic N/ha)	170	170	170
Milk yield (l/cow)	6,058	8,009	10,031
Average number cows	102	98	95
Concentrate fed (kg/cow)	1,032	2,008	3,313

Table 2. Financial outputs and effects of changing milk, concentrate and fertiliser price on the net profit of dairy systems using the AFBI Dairy Systems Model

	Low	Medium	High
Sales (£/farm)[1]	274,532	340,839	406,295
Variable costs (£/farm)[2]	125,665	176,763	246,003
Gross margin (£/farm)	148,867	164,076	160,293
Fixed costs	74,895	76,494	78,007
Net profit (£/farm)	73,972	87,583	82,285
Sensitivity (Impact on farm profit)			
Milk price (+/-5ppl)	30,929	39,053	47,682
Concentrate price (+/-£10/t)	1,326	2,005	2,859
Fertiliser price (+/-£20/t)	872	1,028	1,107

[1]Milk price 40ppl, [2]Concentrate price £400/t, Fertiliser price £650/t

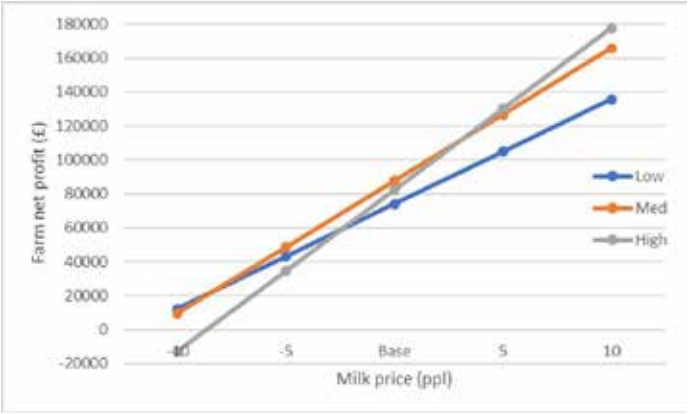


Figure 1. Effect of milk price change on farm net profit using the AFBI Dairy Systems Model

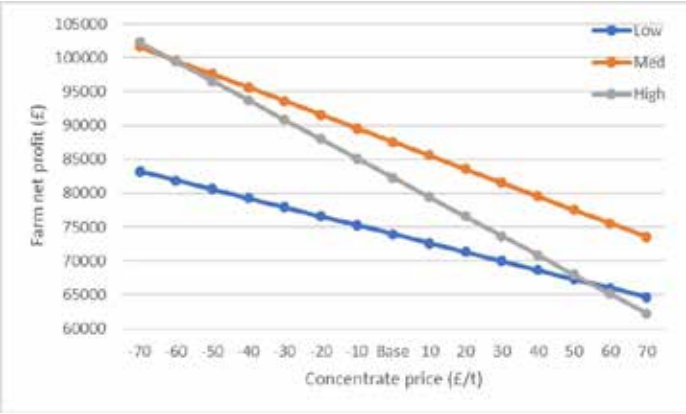


Figure 2. Effect of concentrate price change on farm net profit using the AFBI Dairy Systems Model

Virtual fencing – A breakthrough technology for livestock farmers?

Research Leads: Dr. Conor Holohan and Dr. Francis Lively

Summary

For centuries, cattle and sheep have grazed the pastures of Northern Ireland, contained within field boundaries by hedges, stone walls, wooden posts and wire, and in more recent decades, electric fences. Advancements in precision livestock technology have led to the development of a novel approach to containing and monitoring grazing animals known as 'virtual fencing'. The virtual fencing research programme at AFBI is currently funded through a DAERA E&I project, the HEA North-South Research Fund, and the EU HORIZON 2020 project SUPER-G. Within SUPER-G, AFBI is leading a working group to evaluate virtual fencing for livestock farming across Europe.

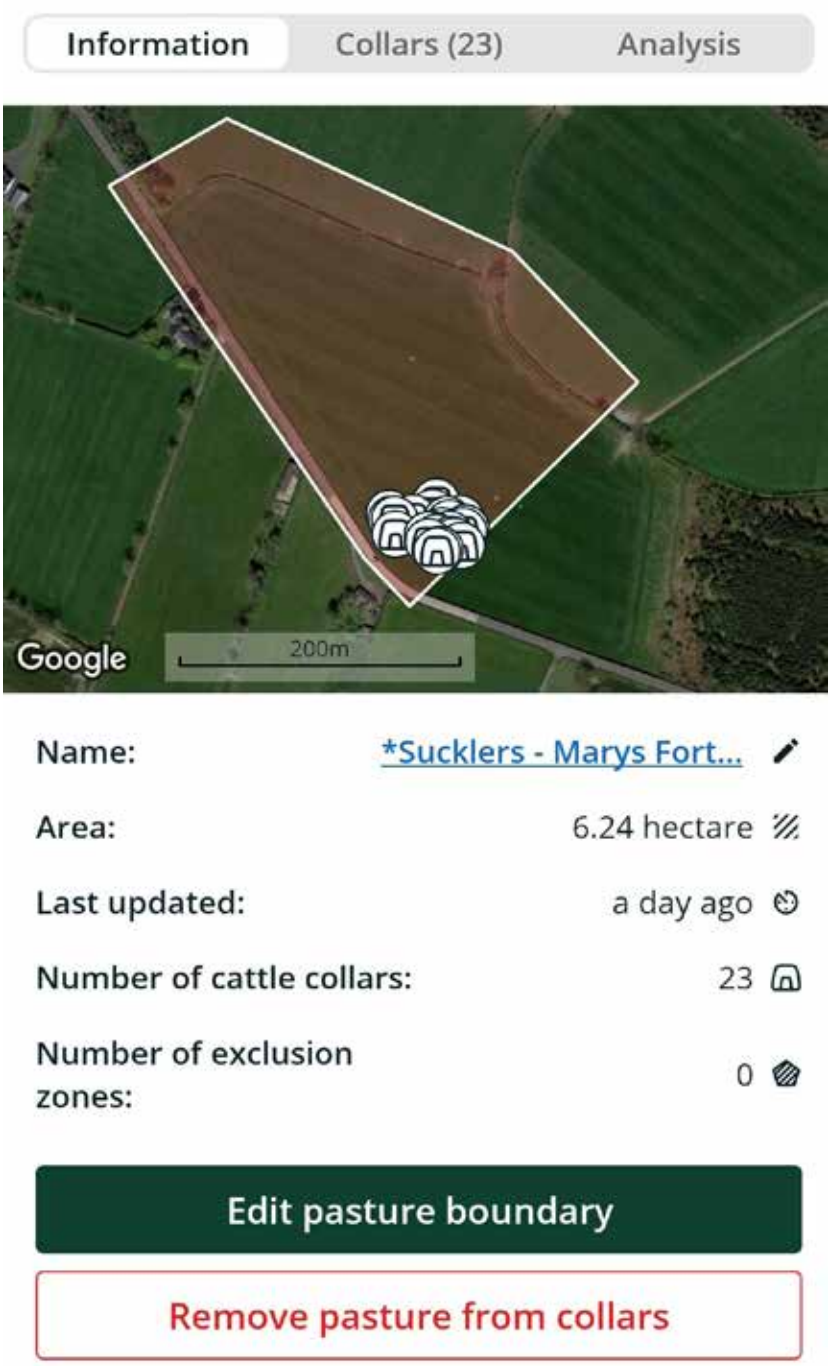
Background

Virtual fencing uses a combination of GPS technology and sensory cues to contain grazing livestock within a desired area, without the need for physical fences.

The system comprises a collar-mounted device and a mobile phone application that allows the user to remotely map a GPS boundary (virtual fence). When the animal

approaches this virtual fence, an audio cue alerts the animal to alter its direction away from the fence. This is followed by an electric pulse if the animal proceeds to pass beyond the virtual fence. Animals are trained on the principle of associative learning and initial results indicate that animals can rapidly learn to respond to the audio cue alone.

This technology could potentially offer an alternative to conventional fencing as well as benefits such as improved monitoring of livestock and better grazing management, particularly in sensitive ecological areas which are often impractical to fence off. There are, however, concerns around the efficacy of virtual fencing and its impact on animal welfare.



AFBI Science

Using world-leading expertise and cutting-edge technologies at AFBI our research seeks to determine if virtual fencing is effective at containing cattle and sheep in various grazing environments, and if animal welfare or behaviour are impacted by the use of such technology.

Impact of AFBI Science

Our studies to date have demonstrated that virtual fencing can effectively contain animals, with initial findings in cattle showing no adverse effects on behaviour and welfare. As one of the first virtual fencing research projects in Europe, findings from this AFBI research program are providing farmers, researchers, policy makers, and consumers with timely scientific knowledge on this new technological innovation and will play a pivotal role in its acceptance and adoption in the future.

The study was co-funded by the DAERA E&I and EU SUPER-G project which received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement no 774124

Economic and GHG modelling to inform sustainable agriculture and agri-food climate change policy

Research Lead: Dr. Ziping Wu

Summary

Climate Change Act (NI) requires that the Northern Ireland GHG emissions account for the year 2050 is at least 100% lower than the baseline in 1990. The aim of this project is to link the AFBI Systems Model (an economy wide model with a focus on agriculture) with greenhouse gas emissions by economic sector, to inform agri-food climate policy, by 2050.

Background

Northern Ireland has reduced its overall GHG emissions by 18% between 1990-2019. However, total emissions from agricultural activities, including those from land use and land use change in agricultural sectors, have continued to increase. In contrast, agricultural emissions in other UK nations have declined.

AFBI Science

The study encompassed three main components. First, an horizon scanning exercise reviewed the path of NI agricultural development and GHG emissions over the period 1990-2019, and established a baseline of decarbonisation, along with potential technical and socio-economic measures of GHG mitigation for NI agriculture sectors.

Second, the study is developing a modelling system that mimics interactions between the economic system and GHG emissions to show how changes in GHG mitigation measures will affect agricultural sectors and how agricultural activities will affect GHG emissions. This will be achieved through linking GHG accounting with the AFBI input-output tables that captures input-output linkages between different economic sectors.

Finally, the modelling system will be used to evaluate the economic and GHG effects of different mitigation scenarios. The analysis will help decision makers to select suitable GHG mitigation measures that balance environment and economy in NI.

Impact of AFBI Science

In the first year of the project, GHG emission intensity of 82 different economic sectors including 10 crop and livestock sectors in NI were calculated and the main drivers for the changes in emission intensity of agricultural sectors in last 30 years were analysed. This has provided an important baseline for monitoring and mitigating GHG emission in NI into the future.

By analysing the key categories of GHG emissions, benchmarking NI GHG emissions, mapping available technical and socio-economic measures and best practices of GHG mitigation in agricultural sectors, this study will now develop a potential GHG mitigation strategy for agricultural sectors.

This will provide an important evidence base in the development of the NI GHG mitigation action plan.

Very high concentrate levels do not always pay with feed-to-yield systems

Research Leads: Dr. Aimee Craig and Dr. Conrad Ferris

Summary

Concentrate feed levels are adjusted in response to milk yield within feed-to-yield systems, with the relationship linear. However, milk fat content decreased with increasing concentrate feed level. As a result, at a moderate milk price the benefit of increasing concentrate levels beyond 14 kg/cow/day was small.

Background

Feed-to-yield systems, in which concentrates are offered to individual cows according to their milk yield, are now common on Northern Ireland dairy farms. However, there is little information on the physical and economic performance of individual cows within feed-to-yield systems. Funded by DAERA via the Research Challenge Fund, and by AgriSearch, this study was designed to address this gap in knowledge.

AFBI Science

Thirty-one Northern Ireland dairy farms, all of which used a feed-to-yield approach, were visited regularly between August 2018 and May 2019. Silage and concentrates offered to dairy cows were sampled, and detailed information on feeding practices was recorded. Data on milk production and milk composition was obtained from milk recording organisations. Individual cow dry matter intakes were estimated using equations developed by AFBI.

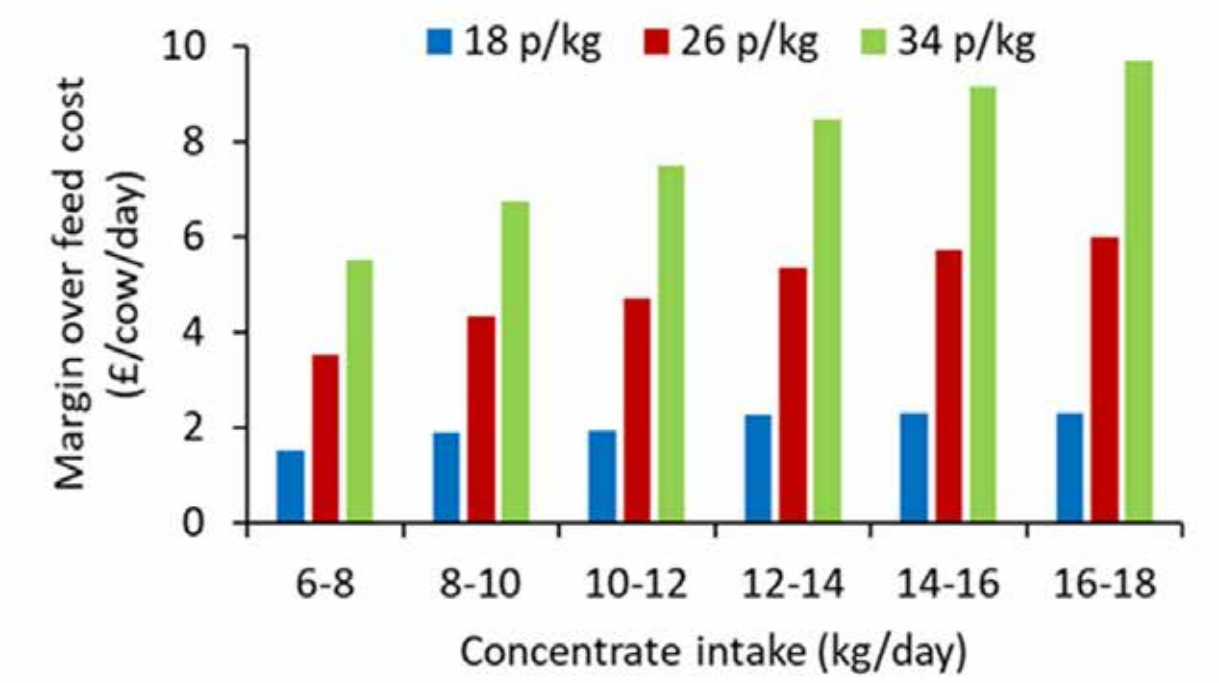


Figure 1. Relationship between margin-over-feed cost and concentrate intake, at three different milk prices, within a feed-to-yield system (concentrates costing £260/tonne)

Forage intake remained relatively unchanged across a wide range of concentrate levels, a reflection of higher yielding cows having a greater overall intake potential. There was a linear relationship between milk yield and concentrate level, a reflection of concentrate level being altered in response to milk yield. Milk fat content decreased with increasing concentrate feed level, partly due to dairy cow genetics (decreasing Predicted Transmitting Ability for milk fat) and partly due to dietary effects on rumen function.

As a result, the value of each kg of milk decreased by approximately 2 p/litre across the range of concentrate levels examined. Margin-over-feed cost showed a decreasing marginal response with increasing concentrate level across a range of milk prices (Figure 1), due to both a reduction in compositional bonuses, and the increasing cost of each kg of diet consumed.

At a milk price of 34 p/kg, margin/cow increased when the highest yielding cows were offered ≥17-18 kg concentrate/day. However, at these concentrate levels, it not only becomes difficult to satisfy environmental legislation, but cows are pushed close to a 'metabolic tipping point'. At moderate (26 p/kg milk) and exceptionally low milk prices (18 p/kg milk), the benefit of increasing concentrate levels beyond 14 kg/cow/day and 12-14 kg/cow/day, respectively, was small, even with the highest yielding cows in the herd.

Impact of AFBI Science

This research is important to support science-based decision making on dairy farms operating a feed-to-yield system, helping to deliver economic and environmental sustainability and meet environmental targets.

THIS PROJECT WAS CO-FUNDED BY DAERA AND AGRISEARCH THROUGH THE DAERA RESEARCH CHALLENGE FUND.

Ecosward - An investigation of the potential for Multispecies Swards to enhance ecosystem services within sustainable livestock systems

Research Lead: Dr. David Patterson

Summary

Multispecies swards (MSS) are swards comprised of species from a number of functional groups, namely grasses, legumes and herbs. In Northern Ireland (NI), there was a requirement to examine the potential positive effect of MSS on a range of nutritional, environmental, and animal health attributes in farming systems. The aim of this study was to address this gap in scientific knowledge, by researching the ability of MSS to deliver sustainable production systems on-farm.

Farmers attending a farm walk as part of the EIP project

Background

Multi species swards (MSS) have the potential to: mitigate Greenhouse Gas (GHG) emissions via a more efficient cycling of carbon and nitrogen; improve animal health and production efficiency; and improve the dynamics of above and below ground biomass. There are a range of published scientific and technical papers on MSS, covering aspects of agronomy, soil health, root dynamics and animal production.

AFBI Science

In the Ecosward Project, a comprehensive literature review was undertaken, with gaps in knowledge and future research priorities being identified.

Results demonstrated that:

GHG Emissions

MSS have potential to reduce methane and nitrous oxide emissions from ruminant production systems Grazing high proportions of individual swards species can positively influence the CH_4 emissions released from rumination however further research is needed to establish which sward mixtures and at what proportion are required for maximum benefit.

Herbage and Species diversity

The MSS plots showed evidence of over-yielding, where the dry matter yield of the mixture was greater than any of the constituent species when grown as separate monocultures.

MSS have the potential to improve above and below ground species diversity. Earthworm populations were higher with MSS than grass/clover swards under grazing, which can improve soil porosity and lead to improved soil health. When coupled with the enhanced rooting capacity this could enhance sward resilience to soil moisture extremes and climate adaptation.

Livestock systems

Although some studies have reported animal productivity gains with MSS, longer term studies are required to assess complete animal production cycles. With grazing, poor persistency of herb species such as Chicory have been identified and there are animal health concerns regarding bloat incidence in grazing cattle, along with challenges in making silage from MSS.

Impact of AFBI Science

These findings will inform follow-up experimental plans for a series of comprehensive field studies with MSS to further establish their ability to deliver sustainable production systems on-farm.

To date, findings from the Ecosward Project have fed into several industry webinars and farm walks. Links were also established with other research projects, such as: the EU SUPER-G Project (Sustainable Permanent Grassland) which aims to co-develop sustainable grassland systems and policies with farmers and policy makers across

Deep rooting Chicory within a multispecies sward at AFBI Hillsborough

Harvesting MSS plots under simulated grazing management at AFBI Loughgall

Europe that will be effective in optimising productivity whilst supporting biodiversity; the European Innovation Partnership (EIP) project which brings together researchers and farmers to investigate the feasibility and practicality of incorporating MSS on Northern Ireland commercial beef and sheep farms; and the all-island MSS researcher forum has been established to share early research findings and develop collaborative projects.

Future research priorities should address knowledge gaps such as:

- Quantification of GHG reduction potential of MSS
- Comprehensive assessment of ruminant production efficiency with MSS
- Persistency of herb and legume species in MSS
- Mitigation of bloat incidence in animals offered MSS
- Improvement of MSS constituent varieties aligned with animal requirements
- Development of robust management systems to facilitate a wider uptake and adoption of MSS as viable, sustainable grassland systems

THE STUDY WAS CO-FUNDED BY DAERA E & I & AGRISEARCH

PROTECTING

animal, plant and human health

Rapid response to Northern Ireland's first highly pathogenic Avian Influenza outbreak in 2021

Research Lead: Dr. Ken Lemon

Summary

Highly Pathogenic Avian Influenza (HPAI) represents an ever-increasing threat to the European poultry industry. The 2021-22 season was the largest ever recorded, with 2,467 outbreaks in poultry and 47.7 million birds culled across 37 European countries as of September 2022.

Between December 2021 and February 2022, scientists at AFBI VSD confirmed the presence of HPAI H5N1 in six poultry premises in Northern Ireland (NI), including four commercial flocks of chickens and ducks and two backyard flocks. Overall >80,000 birds were culled as a result. This year also witnessed unprecedented numbers of detections in wild bird species. Unusually, mass mortality events were recorded in colony-breeding seabird species throughout the summer months along the Atlantic coast of north-west Europe, leading to widespread conservation concerns.

AFBI Science

AFBI tests wild birds for HPAI as part of DAERA's wild bird surveillance and, similar to the situation elsewhere in Europe, detections were made in numerous seabird species such as Gannets, Guillemots and Razorbills around the NI coast between June and September 2022.

HPAI H5N1 has also been detected recently in multiple free living mammalian species, such as foxes, badgers, mink, polecats, porpoises, and seals. During 2021-22, three human cases of avian influenza were confirmed in Europe, associated with close contact with infected birds. However, bird-to-human transmission is very rare and the risk to the wider public is considered very low.

The situation with HPAI is therefore dynamic and rapidly changing.

Impact of AFBI Science

AFBI is working closely with DAERA and reference labs in GB and the EU to provide rapid diagnostic testing and emergency response capability. AFBI science has already had a major impact on helping the NI poultry industry manage this issue and minimise its negative effects in NI. AFBI's work continues in this area now on an ongoing basis to address the challenge of avian influenza.

Investigating a broiler breeder vaccine candidate to prevent chicken astrovirus transmission to embryos

Research Lead: Dr. Victoria Smyth

Summary

Chicken astrovirus (CAstV) is an enteric (intestinal) pathogen of young chicks. Infections usually occur within the first week of life. The earlier infections are contracted, especially vertically transmitted infections, the worse the outcome may be, because embryos are highly susceptible. As such, the aim of this study was to investigate a vaccine candidate for broiler breeders to (1) prevent transfer of CAstV infection to their embryos and (2) provide maternally derived antibodies to the embryos to protect against environmental CAstV infections once hatched.

Background

Chicken astrovirus is transmitted horizontally in young chicks via the faecal-oral route, or vertically from naïve, in-lay hens and so broiler chicks may hatch with high levels of CAstV. Embryonic infections often lead to the runting of chicks, along with deformities, resulting in embryo death or pale, weak chicks that fail to thrive and are unsaleable. A broiler breeder vaccine would provide anti-CAstV antibodies, stopping the transmission of CAstV to embryos from their parents. Such a vaccine would also provide antibodies to protect newly hatched chicks from environmentally acquired CAstV infections.

AFBI Science

AFBI research demonstrated that a patented strain of CAstV, examined as a broiler breeder vaccine candidate, was safe for hens, with a strong immune response generating statistically significant levels of antibodies against the virus.

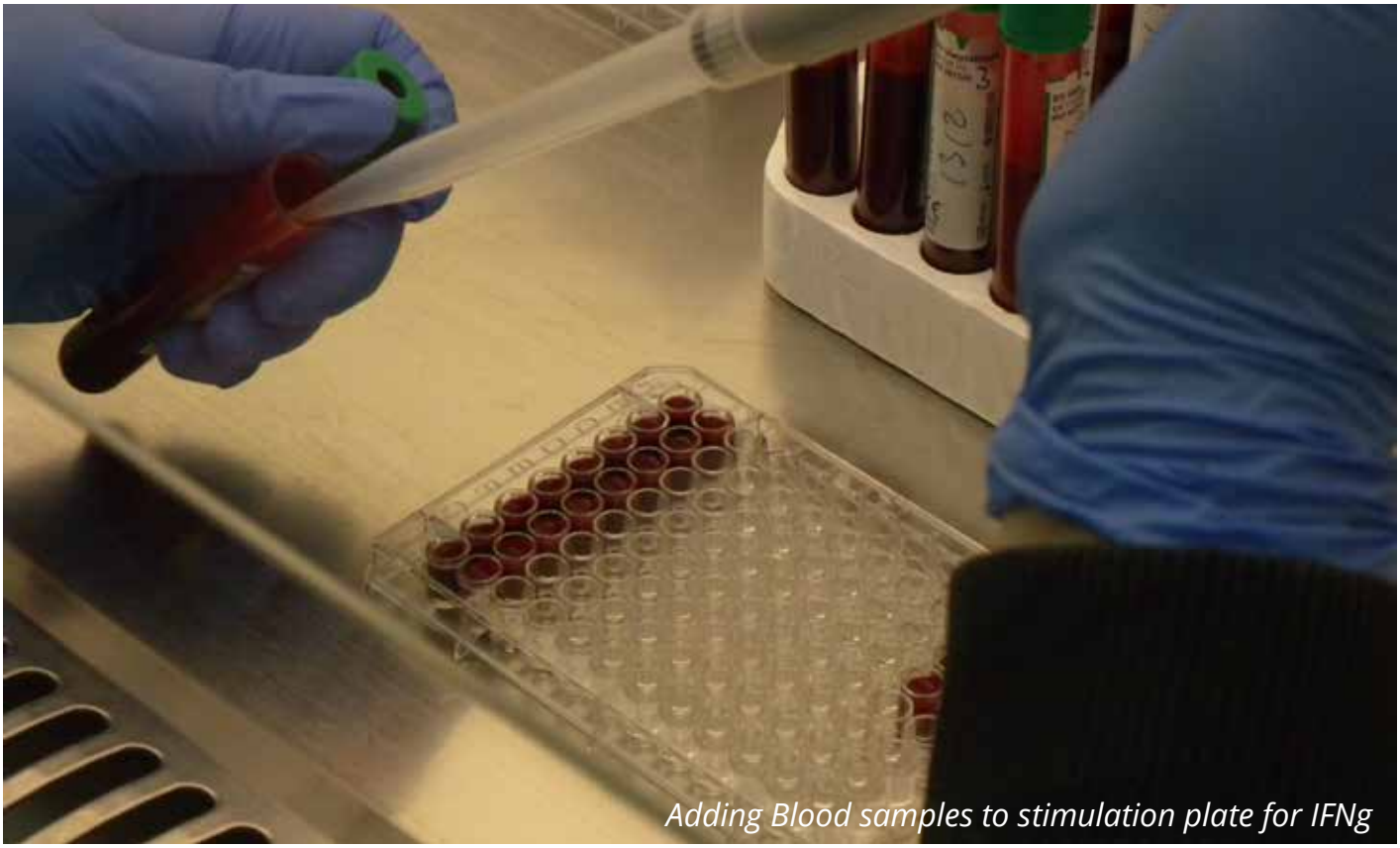
Research also demonstrated that the antibodies were subsequently deposited in the eggs, known as maternally derived antibodies. Moreover, chicks that hatched from these eggs were protected against harmful strains of CAstV, as demonstrated by significantly greater weight gains compared to chicks without the maternally derived antibodies, who were between 4.7-12.3% lighter.

Impact of AFBI Science

This important research demonstrates that vaccinating broiler breeder hens with AFBI's patented strain of CAstV, provides a safe and effective way to protect embryos and chicks from disease caused by harmful strains of CAstV.

THE STUDY WAS CO-FUNDED BY AVIAGEN UK LTD.

Bovine TB testing: Operational solutions for immunological problems



Adding Blood samples to stimulation plate for IFNg

Research Leads: Dr. Tom Ford, Dr. Fiona Young, Dr. Lyanne McCallan

Summary

Accurate and reproducible diagnostic tests are cornerstones of disease control and eradication strategies such as the programme implemented by the Department of Agriculture, Environment and Rural Affairs (DAERA) to reduce the burden of bovine Tuberculosis (bTB) in Northern Ireland (NI). AFBI support this programme with accredited diagnostic approaches, including the Interferon Gamma Release Assay (IGRA) which can deliver quick results for the early identification and control of disease. This study aimed to support expanded use of the IFGRA by evaluating operational enhancements that could ensure test quality and accuracy whilst overcoming biological issues associated with increased sample delivery times.

Background

IGRA utilises an animal's immune memory response, artificially induced in blood samples, to demonstrate exposure to the disease-causing organism. Fresh blood samples, however, have a limited viable period as the specialist immune cells can lose function if the time between sampling and analysis is too long and especially if transported at extremes of ambient temperature. To mitigate these issues a limit of 8 hours between sampling on farm and analysis in the lab has historically been implemented which restricts both the herd size and geographical reach of the test as all samples must be tested at a central AFBI laboratory.

Immunology / AHWI workshop discussing and establishing new sampling protocols

AFBI Science

To address the gap in knowledge relating to extended blood sample viability up to 24 hours, some 3,000 blood samples were taken from herds and delivered to the laboratory for IGRA testing with and without sample temperature control and at delays of 8 and 24 hours. The IGRA test data demonstrated how controlling the temperature of the samples between the farm and the laboratory, using active methods such as battery powered heat pads, was crucial to maintaining functional viability over 24 hour pre-analysis periods.

Impact of AFBI Science

This study has demonstrated how preserving sample viability beyond 8 hours can be achieved, an outcome that will inform DAERA's strategic expansion of the IGRA scheme as it will facilitate more cattle tests across a wider area. Whilst operational factors are clearly important to ensuring accuracy and quality of test outcomes other physiological factors can also play a role such as vitamin D deficiency and co-infection so AFBI immunologists are now undertaking further studies to investigate these factors.

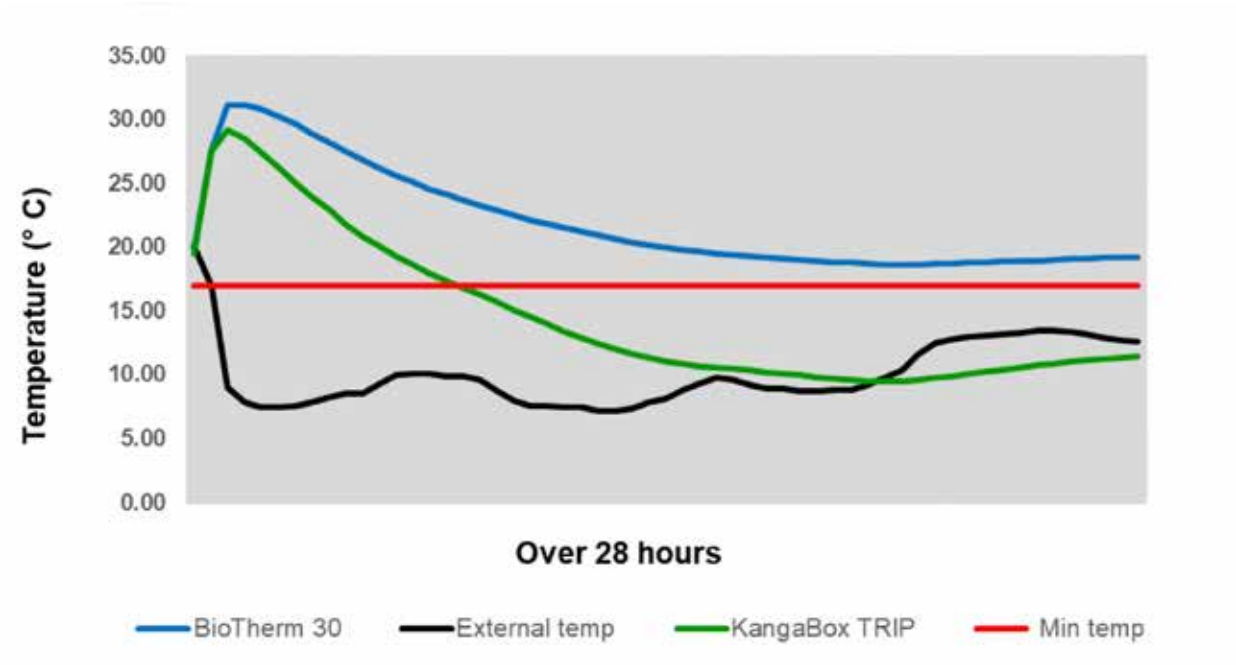
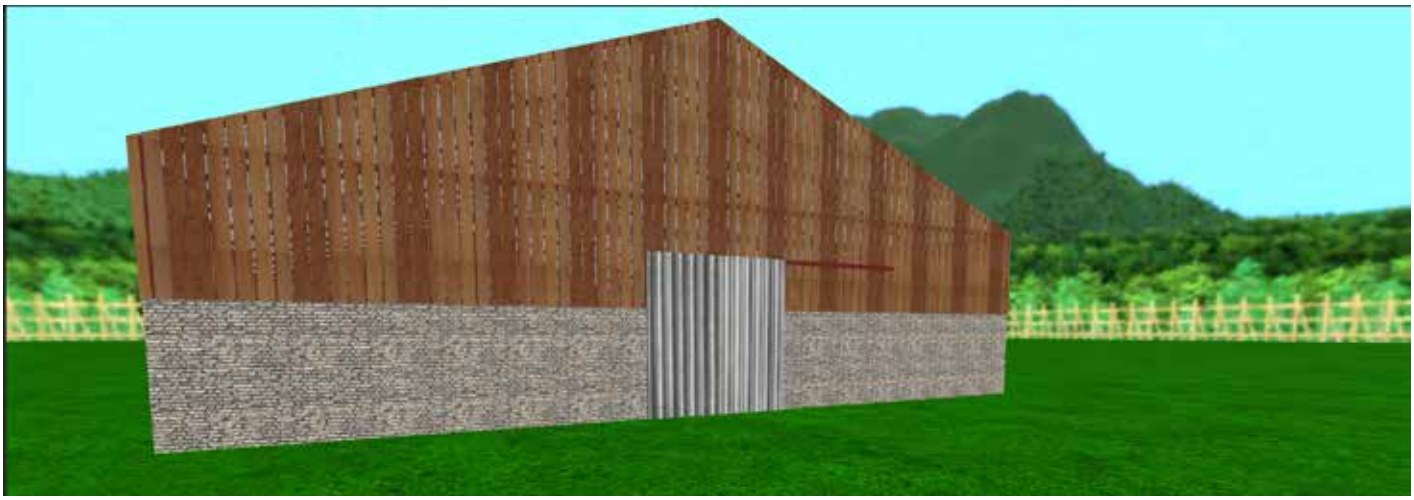


Figure 1: Temperature profiling data – evaluating different sample transit solutions

Optimising the housing environment for improved calf health and performance – The AFBI Optihouse project

Research Leads: Dr. Gillian Scoley, Dr. Steven Morrison, Aaron Brown (PhD Student)



Summary

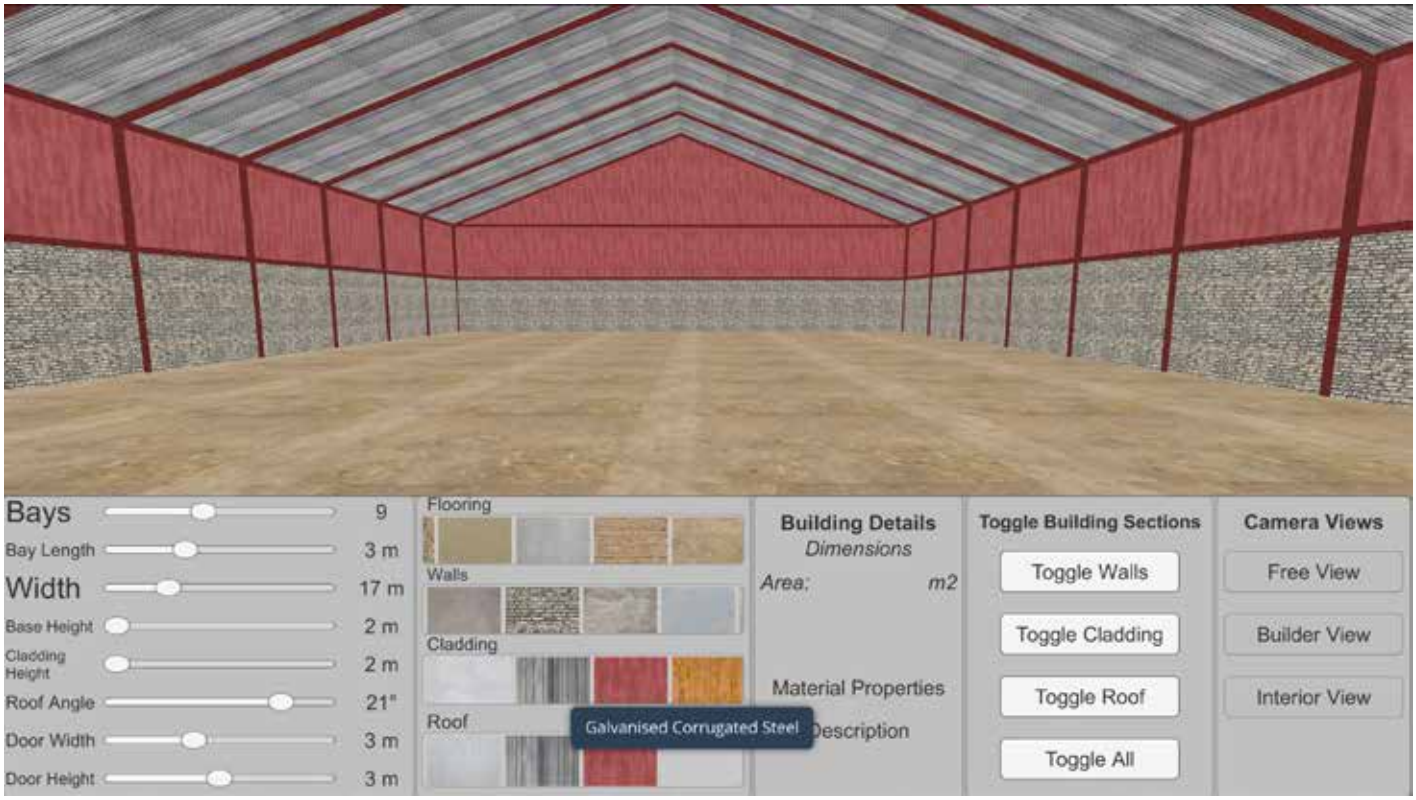
Calf rearing is one of the most labour-intensive activities on Northern Ireland (NI) dairy farms. Recent AFBI research has demonstrated high mortality rates in dairy calves during the first few weeks of life, being ≤6%. This mortality rate has not decreased over the past few decades across the UK. Calf mortality and morbidity rates are influenced by housing environment, animal husbandry and nutrition. However, little is understood about the true impact of the housed environment in the early life of the calf, and its interaction with nutrition, health, and genetics, something which the AFBI Optihouse project has addressed.

Background

The AFBI Optihouse project was a research project funded by the Department of Agriculture and Rural affairs (DAERA). The overall aim of Optihouse was to increase feed conversion efficiency and labour efficiency in NI calf rearing enterprises, via optimising the rearing environment and management of calves. Gaining a better understanding of conditions in NI calf rearing houses e.g. building design, hygiene practices and calf nutrition, will improve calf health and welfare.

AFBI Science

Sixty-six co-research farms across Northern Ireland were surveyed to gain an understanding of calf management practices and building design. Environmental and feed samples were also collected to allow an investigation into pathogen challenge within the rearing environment. A large degree of variation was found in nutrition, housing design and management and observations that may negatively impact calf performance and health included small space allowance for calves, suboptimal ventilation, and inadequate drainage. Variation in the practice of cleaning feeding equipment and pens also highlighted a lack of clear consensus as to the most effective practices amongst NI dairy farmers or differences in the availability of



time and labour to complete hygiene related tasks. An area of key concern identified was that bacterial counts in water samples were largely outside of target ranges and may indicate a common vector in the faecal-oral transmission of calf enteric pathogens.

As part of the ongoing work within the Optihouse project, AFBI is working with an external development team (Sentireal) to create an online, interactive calf housing system. The system will serve as an educational tool for farmers, advisers and students. Users will be able to develop blueprints for new calf accommodation, along with common fixes/solutions to improve existing calf houses.

Within the system, users will be guided through a process of identifying the best calf house design to suit their particular needs. Environmental and microbiological data collected on Optihouse co-research farms located across Northern Ireland will be incorporated into the system. This will facilitate users in gaining a greater understanding of how hygiene practices and ventilation can impact on calf health and performance.

Users will also be signposted to best practice guidelines to optimise calf health and management.

Impact of AFBI Science

The Optihouse project will have a number of positive impacts for both policy and industry, including the delivery of:

- Proven knowledge support material relevant for NI farms from which producers, advisers and policy makers can make informed decisions on calf housing.
- Reduced incidence of calf ill health, with a corresponding improvement in calf performance and welfare.
- Improved farmyard planning, which may have a positive impact on the performance of other livestock groups and overall labour efficiency on-farm.
- An enhanced marketability of livestock produce, by improving sustainability through a more efficient feed conversion ratio; higher welfare standards and better calf health.

THE STUDY WAS CO-FUNDED BY DAERA WITH IN-KIND CONTRIBUTION FROM AGRISEARCH

Monitoring Pesticide Use on Arable Farms in Northern Ireland from 1992–2020. Implications for Policy Development.

Research Lead: Dr. Stephen Jess

Summary

The AFBI Pesticide Usage Monitoring Group was initiated in 1989, primarily to fulfil a legal obligation under the Food and Environment Protection Act (1985), to monitor post-registration use of pesticides. The Group was designed to obtain impartial and accurate data on pesticide use in Northern Ireland. Monitoring is coordinated by a UK working party, comprising other survey groups in England, Wales and Scotland. Consequently, the UK is in a privileged position, having the most sophisticated and longest running pesticide use dataset in the world. The methodology used is highly respected across Europe, being proposed as a European Union (EU) and Organisation for Economic Cooperation and Development (OECD) standard. This work is funded by Department of Environment, Food and Rural Affairs (DEFRA).

Background

Since the 1960's, UK government policy and legislation on crop protection practices sought to minimise the impact of pesticide use in agriculture and horticulture on the wider environment. Subsequent EU policy and legislation has also embraced this objective, via a demanding approvals process and the promotion of integrated pest and disease management techniques. However, none of this substantive regulation refers to target reduction levels for pesticide use.

Since 1992, the number of arable farms in NI reduced by 65%, with a concomitant reduction of 38% in the area of arable crops grown. Despite this reduction in the area used to grow arable crops, the area treated by major pesticide groups increased by 29% due to intensification. However, the quantity of major pesticides applied to arable crops reduced by 42% (Figures 1 & 2). The intensity of application measured by the total quantity of all pesticides applied to the basic area

of arable crops treated, remained relatively constant at approximately 3.2 kg/ha (Figure 3).

AFBI Science

Trends in pesticide use and reduction policies in other geographic regions were examined by AFBI scientists. In Europe, pesticide reduction strategies were developed by several member states. In 1986, Denmark introduced the first in a series of action plans for to reduce pesticide use. The Netherlands, Belgium, Switzerland and Italy have been developing pesticide-reduction strategies, but without precise pesticide use monitoring data, it is difficult to critically assess impact. In France, it was demonstrated that a reduction in pesticide use rarely had a negative impact on productivity and profitably on arable farms.

Impact of AFBI Science

This work has demonstrated and underpinned a major improvement in NI water quality.

Commenting on AFBI's work, Roy Taylor, Catchment Manager, Northern Ireland Water, said, "Delivery of great tasting, clean and safe Drinking water is central to what we do. The water we use is taken from local rivers, lakes and a range of upland sources and treated to produce our high quality Drinking water. The expert pesticide work done by ABFI is very important to NI Water, in collating data on pesticide usage and helping to identify any future issues in our watercourses, so that we can proactively work together to ensure our Drinking water supplies are protected. We fully support the work of AFBI who provide the best possible scientific advice and we hope to continue to work closely together as we move ahead."

More recently, AFBI provided training and expertise to support the formation of a similar pesticide monitoring group in the Department of Agriculture, Food and the Marine in the Republic Of Ireland.

THE STUDY WAS CO-FUNDED BY DEFRA AND DAERA

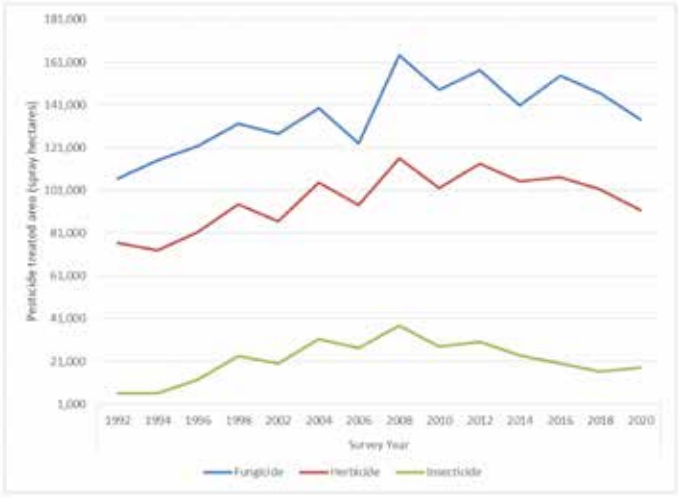


Figure 1. Area (spray hectares) of Northern Ireland arable crops treated with pesticides (1992–2020)

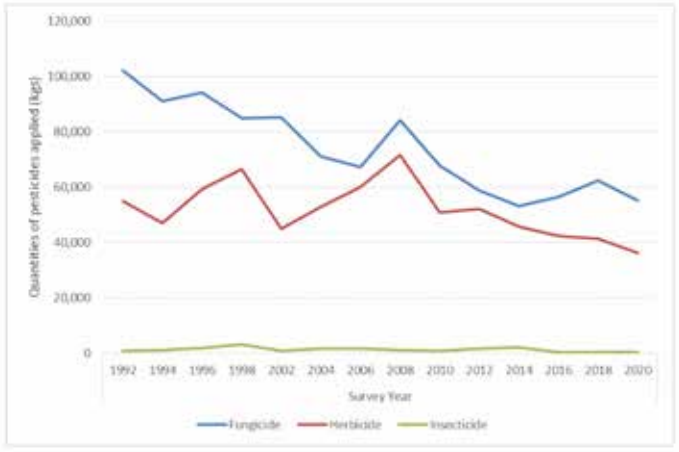


Figure 2. Quantity of pesticides (kg) applied to Northern Ireland arable crops (1992-2020)

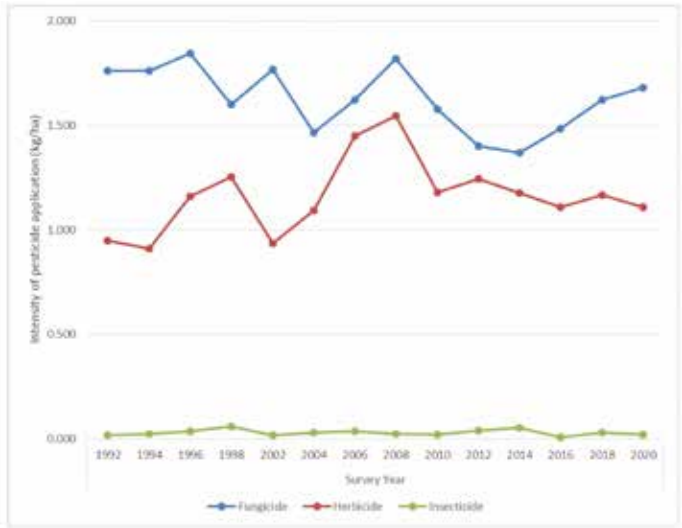


Figure 3. Level of pesticide application (kg/ha) to Norhern Ireland arable crops (1992-2020)

Addressing Faecal Pollution of Surface Waters in Northern Ireland: Public Health Implications

Research lead: Cathy Brooks

Summary

Faecal contamination of surface waters presents a risk to public health, not just from exposure to pathogenic organisms, but also from the spread of antimicrobial resistant organisms. Common sources of human faecal contamination include combined sewer overflows or septic tanks located close to watercourses. Rainfall may also cause run-off from land, leading to the contamination of waters by animal waste such as cattle slurry or chicken litter, or from human sludge used as a fertiliser on land. The direct contamination of water by livestock accessing rivers, or from dogs fouling on beaches can also have an adverse impact on bathing water quality, as can faecal contamination from wild animals, e.g. birds. The aim of these water quality projects is to measure and manage contamination of NI waters, in order to meet the requirements of the EU Water Framework Directive and protect public health.

Background

The European Union (EU) Water Framework Directive 2000/60/EC aims to improve surface water quality through an integrated catchment management approach. The directive was established in Northern Ireland (NI) in 2003 (SR 2003 No. 544) and the first river basin management plans were published in 2009. This umbrella piece of legislation covers all types of surface waters, including lakes, rivers and marine coastal waters. It aims to improve the ecological status of surface waters.

Poor ecological status of a water body is often an indication of pollution and the EU Bathing Water Directive (BWD) 2006/7/EC which is transposed into law in NI as the Quality of Bathing Water (Amendment) Regulations (NI) 2013 and its review (2021-2023), seeks to protect bathers from exposure to faecal contamination and the risk of exposure to viruses, pharmaceuticals and cyanobacteria in polluted waters. As part of the BWD, the Department of Agriculture Environment and Rural Affairs (DAERA) has published bathing

water profiles of each of the 26 designated bathing water locations in NI. These profiles document the potential sources of faecal contamination within the water catchment at each location and can give a good indication of the risks associated with bathing.

AFBI Science

AFBI's Food Hygiene Unit Laboratory at Stormont, comprising a team of technical and scientific staff, experienced in the fields of veterinary, food and environmental sciences, perform a range of activities centred around the detection of bacteria in food and the environment.

Faecal indicator bacteria *E. coli* and intestinal Enterococci are enumerated to assess contamination of shellfish and surface waters across NI (Figures 1, 2 & 3). A novel molecular technique called Microbial Source Tracking (MST), is employed to identify the source of pollution (Figure 4). Water microbiology and MST analysis is performed for a number of interdepartmental and INTERREG VA funded programmes, such as the Living with Water in Belfast Programme, which aims to deliver a long-term approach to drainage and wastewater management that will protect from flooding, provide a cleaner and greener environment and ensure Belfast is open for business and investment. Similarly, the AFBI laboratory also provides microbial and MST results of water samples for the EU INTERREG VA funded SWELL project which represents a cross-border partnership between NI Water, Irish Water, AFBI, the Loughs Agency and East Border Region, working to improve water quality within the shared waters of Carlingford Lough and Lough Foyle.

At the Better Beaches Forum (2022), DAERA announced nominations for 75 new bathing water sites in NI, some of which are freshwater locations. There are currently no authorised freshwater bathing locations in NI. Typically, the concentration of faecal indicator bacteria in freshwater is higher than in marine coastal waters and the introduction of freshwater bathing locations

Figure 1 Filtering water for culture of contaminating faecal bacteria.

Figure 2 Application of filter membrane to agar plate for growth of faecal bacteria.

Figure 3 Counting faecal bacterial growth on agar plates.

may increase the risk of illness associated with cold water swimming and increase the risk of exposure to antimicrobial resistant bacteria within the population. In a recent study by the Food Hygiene Laboratory at AFBI Stormont, six rivers which discharge into the bathing transects at Waterfoot, Carnlough,

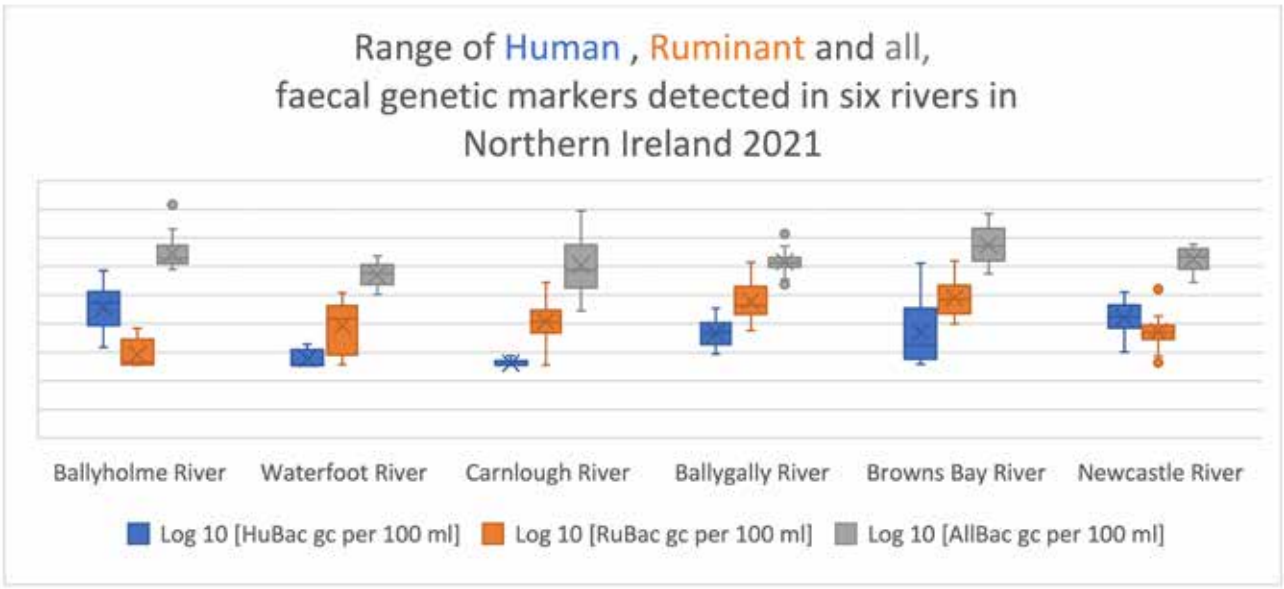


Figure 4 Sources of faecal bacteria at six rivers discharging on to bathing transects in NI in 2021

Ballygally, Brown's Bay, Ballyholme and Newcastle, it was found that the antimicrobial resistance Gene, OXA-48, was present in a greater number of samples from rivers with a dominant human source of faecal contamination, compared to those with a dominant source of ruminant (i.e. cattle and sheep) contamination.

Northern Ireland is fortunate to have 26 identified bathing waters, all of which meet the criteria for safe bathing under the EU Bathing Water Directive, with all but 7 classified as 'excellent'. Five beaches were classified as 'good' and two were classified as 'sufficient' in 2021. Part of the review of the BWD is to examine the length of the bathing season and regularity of testing. An improvement in bathing water quality not only reduces the risk to human health, it also helps to boost the local economy which is highly dependent on tourism. The 2021 bathing season in NI saw unprecedented numbers of people enjoying the stunning coastal resorts. This increase in outdoor activity has been seen in the popularity of cold-water swimming groups, often at un-designated bathing locations.

Interreg
EUROPEAN UNION
Northern Ireland - Ireland - Scotland
European Regional Development Fund

The Special European Programmes Body (SEUPB) and DAERA funded the INTERREG VA project 'SWIM', which developed a prediction model to determine when beaches are likely to exceed the safe concentration of faecal indicator bacteria at six bathing locations in NI and three bathing locations in the Republic of Ireland. This partnership between Keep Northern Ireland Beautiful (KNIB), University College Dublin (UCD) and AFBI installed signage at these locations and developed a mobile phone app. to inform the public when it is microbiologically safe to swim.

The SWIM project completed in December 2020 and DAERA is funding a legacy project called 'SWIM NI' to extend this model to a further six bathing locations in NI. The team at AFBI is working closely with Northern Ireland Water (NIW), DAERA and KNIB to continuously improve water quality in NI, with the primary goal of protecting public health.

Weaning pigs without Zinc Oxide, whilst improving economic and environmental sustainability

Research Leads: Dr. Christina Mulvenna, Dr. Ramon Muns

Summary

Zinc oxide (ZnO) has been used in the pig industry for many years to reduce the incidence of diarrhoea in post-weaned pigs. In June 2022 the ban of medicinal use of ZnO in pig diets came into effect in the EU though a two-year extension was granted in the UK. It was anticipated that, without medicinal use ZnO, Post-Weaning Diarrhoeal (PWD) disease would become more difficult to manage, resulting in an increased use of antibiotics. As such, the aim of this study was to research alternative strategies to reduce the incidence of PWD in pigs, without increasing the use of antibiotics.

Background

Antibiotic resistance occurs when bacteria develop the ability to survive or grow, despite being exposed to antibiotics. The guiding principle for antibiotic use in pig farming is still to use antibiotics as little as possible, but as often as necessary. Improving the health and welfare of pigs is important to reduce antibiotic use.

AFBI Science

Researchers at AFBI Hillsborough initiated a research project in 2019 to identify alternatives to ZnO. Within this project, AFBI investigated nutritional interventions to overcome the removal of ZnO from pig diets, where six different diets were offered to pigs after weaning T1: Conventional diet (20% Crude Protein (CP); 2.11% Crude Fibre (CF))

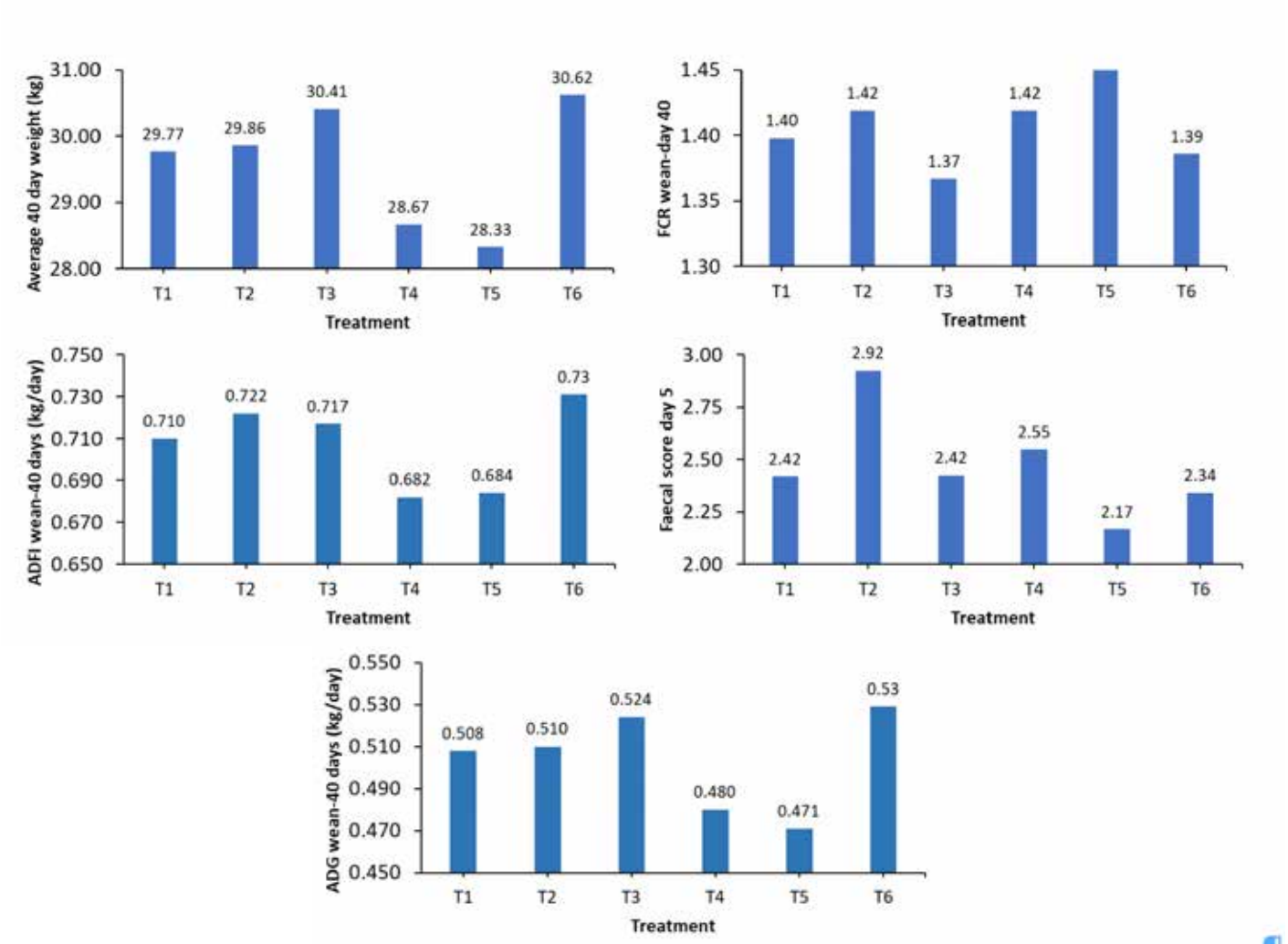


Figure 1. Effect of dietary treatment (T1-T6) on liveweight, Average Daily Gain (ADG), Average Daily Feed Intake (ADFI) and Feed Conversion Ratio (FCR) of post-weaning pigs

with ZnO added; T2: Conventional diet with no ZnO added; T3: Conventional diet with antibiotic added; T4: 18% CP diet (3.5% CF) without ZnO added; T5: 16% CP diet (3.5% CF) without ZnO added; T6: 18% CP diet (2.5% CF) and supplemental amino acids (commercial product) with no ZnO added.

All treatments were formulated at the same energy/lysine ratio and with an adequate and balanced ammino acid supply.

Results demonstrated that removing ZnO supplementation without changing dietary characteristics (T2) could result in a higher incidence of diarrhoea (as seen with a higher/ more watery faecal score).

Overall, reducing the CP level, while balancing amino acids, of pig starter diets to 18% improved faecal consistency, without a reduction in pig growth or negatively impacting on the Feed Conversion Ratio (FCR), compared to diets supplemented with ZnO.

Impact of AFBI Science

This research is important in informing the wider pig industry how to manage a change in legislation. Furthermore, as diets with a lower level of CP are associated with a lower nitrogen excretion rate to the environment, and they tend to be less expensive, this research is also important in improving animal health and welfare, economic and environmental sustainability.

Ongoing AFBI Science

making an impact

AFBI's INTERREG projects focusing on the environment

Summary

In 2018 AFBI secured major funding under the Interreg funding programme to take forward a suite of projects with a key focus on understanding and improving the health of our terrestrial, fresh water and marine environments. These projects are currently coming to an end. Some projects have already reported their main outcomes with others to report in 2023.

The projects were supported by the European Union's INTERREG VA Programme, managed by the Special EU Programmes Body (SEUPB). Match funding was provided by the Department of Agriculture, Environment and Rural Affairs in Northern Ireland. Various other funders contributed both in kind and in cash. The following provides a brief summary of the key focus of each of the projects AFBI was involved in.

MarPAMM

AFBI are the lead partner for MarPAMM, an environment project which aims to develop tools for monitoring and managing marine protected areas in Northern Ireland, south-eastern counties in the Republic of Ireland and Western Scotland (due to be completed in January 2023) and use this knowledge alongside stakeholder input

to create recommendations for future management plans of these protected areas to promote their sustainability in the face of climate change and health for both marine and human activities.

MarPAMM partners have been collecting data on the abundance, distribution and movement of key large mobile marine species and important seabed habitat features. This data will produce new habitat maps and develop models for a range of species, including connectivity assessment for species with mobile life stages. The project will produce a regional sea bird model, regional models for identified protected seabed-dwelling species and habitats, a seal distribution and underwater noise model, and a coastal processes model. Working closely with stakeholders and partner projects such as COMPASS and SeaMonitor, the project will culminate in the development of six comprehensive MPA management plans, including 3 which are cross border between NI, ROI and Scotland.

COMPASS

AFBI is also the lead project partner for COMPASS, which is delivering a network of monitoring buoys across the regional seas of the Republic of Ireland, Northern Ireland and West Scotland (due to be completed in December 2022). It aims to develop our marine observational and data management capacity across the region. It has been integrating a network of new monitoring buoys to the existing European oceanographic monitoring stations that are equipped with the latest oceanographic sensors, acoustic recorders and advanced fish tracking technology.

This innovative project has been building cross-border capacity for effective monitoring and management of Marine Protected Areas (MPAs), and is developing long-term monitoring strategies for highly mobile protected species such as marine mammals and salmonids. It is also providing essential infrastructure for baseline oceanographic and ambient noise monitoring. All of this is helping to deliver three truly regional scale environmental models, designed to support the management of a cross-border MPA network.

CatchmentCARE

AFBI is a project partner for CatchmentCARE, which aims to improve freshwater quality within the North Western and Neagh Bann international river basins. The project is focussed across three cross-border catchments, the Arney, Blackwater and Finn. The aims will be achieved through development of water quality improvement projects and installation of groundwater monitoring stations across the region. The project overall is grounded in the Water Framework Directive (WFD). The WFD takes an integrated approach to the protection, improvement and sustainable management of the water environment. It revolves around a River Basin Management Planning process of action and review to improve water quality and achieve 'good' status in water bodies (rivers, lakes, estuaries and coastal waters, and groundwaters) by 2027.

COMPASS
COLLABORATIVE OCEANOGRAPHY AND MONITORING FOR PROTECTED AREAS AND SPECIES

CatchmentCARE
Community Actions for Resilient Ecosystems

BioWILL

AFBI is a project partner for BioWILL, which is delivering a biorefinery model for Northwest Europe using Willow, by producing high value salicylates from willow bark for medical applications. The bark residue and bark-free willow pulp is converted into safe food quality packaging material to replace fossil derived plastics, and the end-of-life packaging is hyDr.olysed and used as a feedstock in an innovative bio-energy anaerobic digestion system producing biogas suitable for grid injection.

SWELL

AFBI is a project partner for SWELL, which is a cross-border partnership working collaboratively to improve water quality within the shared waters of Carlingford Lough and Lough Foyle. The partnership is utilising best practice, innovation and knowledge sharing to effectively achieve the outputs and results of the Interreg VA Programme. Through engineering excellence, strategic catchment investigation and modelling, SWELL is delivering sustainable upgrades to wastewater assets on both sides of the border and making a positive contribution towards 'Good' Water Framework Directive classification.

SeaMonitor

AFBI is a project partner for SeaMonitor, which is a unique marine research project studying the seas around Ireland, Western Scotland and Northern Ireland, using innovative marine species tracking technology to better understand and protect vulnerable marine life in our oceans.

The project is delivering five spatial models for basking shark, skate, salmonids, seals and cetaceans, and three Management Plans for three areas and two species: Loch Sunart to Sound of Jura (skate) and the Foyle and Clyde estuaries (salmon). The project is achieving this by extending the existing network of buoys with acoustic receivers, delivered by a sister project (COMPASS), from the east to north coast of the island of Ireland, establishing a physical connection of acoustic receivers between Ireland and Scotland which provide data to develop the models and management plans for selected species.

PROJECT WEBSITES

- https://www.mpa-management.eu
- https://compass-oceanscience.eu
- https://www.catchmentcare.eu
- https://swellproject.com
- https://www.nweurope.eu/projects/project-search/biowill/
- http://seamonitor.org

Veterinary Drug residue analysis – protecting consumers and facilitating trade

Summary

Veterinary Drugs are a critical component in food animal production. Their use, as well as being fundamental to animal health and wellbeing, is of extreme importance to the economics of the farming industry. The financial damage caused by the outbreak of disease under intensive animal production management systems can be devastating and as a result, the global farm animal Drugs market continues to grow. In 2021 this market was valued at around 16.1 billion US$ and is expected to reach 29.4 US$ by 2032.

In order to protect the health of consumers and to ensure animal products are safe for national and international trade, EU and domestic law requires the control of residues of veterinary medicines and illegal substances in products of animal origin (POAO). This control is implemented in Northern Ireland through the statutory residues testing programme which is performed almost exclusively by AFBI.

Background to residue testing

Residues can be defined as "pharmacologically active substances (whether active principles, recipients, or degradation products) and their metabolites which remain in foodstuffs obtained from animals to which the veterinary medicinal products in question have been administered."

Residue testing is widely accepted as a food safety programme which is designed to protect public health from potentially harmful contaminants. However, in addition to this, and less widely recognised is the role the analysis plays in protecting the NI agri-food industry from the potentially catastrophic damage that is often associated with a major

residue incident. For example, the financial losses stemming from the 2017 fipronil in eggs scandal are estimated to have cost the Dutch poultry industry more than €66 million. The programme also ensures that DAERA meets its legal obligations which, in turn, enables the continuation of agricultural trade in products of animal origin, within Northern Ireland and the United Kingdom, as well as across the European Union.

Testing in Northern Ireland takes place through statutory testing schemes

- The National Residues Control Plan (NRCP) - an extensive surveillance scheme which requires the testing of a percentage of all meat, milk, eggs, fish and honey produced.
- The Meat Inspection Scheme (MIS) – identifies and tests animals in abattoirs which are suspected of having been administered illegal substances or treated incorrectly with veterinary Drugs

EU law applies a uniform system for veterinary medicines residues surveillance in all Member States and in Northern Ireland. Revised regulations (Commission Delegated Regulation (EU) 2022/1644 and Commission Implementing Regulation (EU) 2022/1646) are due to be introduced across the EU during 2023 however these new regulations are expected to be broadly equivalent to the current surveillance programme. Prior to Brexit, DEFRA's Veterinary Medicines Directorate was the UK competent authority for residues testing however DAERA is now the designated competent authority for residues testing in NI and implementation of the NRCP and MIS is a statutory obligation for the department.

While the NRCP and MIS fulfil the core legislative requirement of residues testing, a considerable support structure is necessary to ensure the efficient operation of the testing schemes and that veterinary medicine residues in products of animal origin (POAO) are effectively controlled. Additional testing/surveys in response to findings or emerging problems must be performed; an

emergency capability must be maintained to allow a rapid response to emergency incidents involving residues and analytical methodology employed must meet legislative requirements.

AFBI Science

AFBI has, over many years, been responsible for almost all residue testing in NI. This analysis covers a percentage of animal production for the full range of veterinary medicinal products e.g., antimicrobials, antiparasitics, steroids etc. Analytically this presents quite a challenge given the range in sample type e.g., urine, serum, liver, muscle, and the differing demands in terms of detection limits for each Drug. For example, chloramphenicol, an antibiotic, is banned from use in veterinary medicine and, as such, must be detectable at concentrations of less than 0.15 parts per billion (ppb) in a kidney sample while chlortetracycline, also an antibiotic, must be detectable at 600 ppb in the same sample.

Changing demands in the scope of analysis, detection limits and the requirement for unequivocal identification and quantification has required AFBI scientists to continually develop and improve sample preparation techniques and to employ new or improved

methods of analysis enabling testing to continue to meet legislative requirements.

These drivers, alongside the need for increased efficiency have seen the 'AFBI' testing programme evolve over many years with the evolution continuing to this day. During the mid-1980's testing was centred around microbial growth inhibition techniques and radioimmunossay (RIA) with RIA then replaced with other immunochemical techniques such as enzyme immunoassay and immunobiosensor based analysis. Advancement in analytical methodology was matched by equally important progress in sample extraction and clean up procedures.

Until the early 2000's residue testing was very much performed using a two-tier approach were a rapid screening method, such as those listed above, was used to filter large sample numbers for those which were potentially non-compliant. These samples were then 'confirmed' as non-compliant using a chemical method. The introduction of techniques based on mass spectrometry into the residue testing arena over the past 20 years, and the introduction in particular of liquid chromatography coupled with mass spectrometry (LC-MS/MS) has revolutionised testing. This technology, coupled with appropriate extraction and clean up procedures, offered the ability, not only to provide unequivocal identification and quantification, but also to screen for hunDr.eds of Drug residues, from multiple classes, in a single run. As a result, AFBI scientists have, over recent years, replaced multiple 'conventional' screening methods with multiclass LC-MS/MS; the most recently developed, a multi class antimicrobial method in kidney samples which covers some ~70 different compounds. All methods are validated and accredited to ISO 17025 before application within the statutory residues testing programme.

In addition to the extensive testing and method development programme AFBI scientists are required to investigate residue problems either as part of an emergency response or with a view to reducing non-compliance within the industry. These investigations in recent years have helped to resolve issues caused by phenylbutazone residues in cattle, closantel residues in cattle and sheep and florfenicol residues in milk.

Scientists within the residue team provide advice to government and to industry and publish widely in the peer reviewed literature, currently having authorship of more than 300 manuscripts.

Impact of AFBI Science

In addition to protecting both trade and consumer health, controlling the challenges posed by contaminants such as veterinary Drug residues can contribute to the development of holistic approaches to underpin sustainable, healthy and productive environments and food systems. As such residue testing has the potential in the future to impact, not only on food safety and trade, but also on the One Health agenda where available data has a role to play in the investigation and understanding of antimicrobial resistance and the Green Growth where residue monitoring can advise on waste disposal and associated environmental contamination issues.

Soils Research in AFBI

Summary

AFBI has a long record of conducting high quality research and investigation on soil science in Northern Ireland (NI). It has been carried out over a range of scales such as the research on nutrient and carbon on the long-term slurry plots over the past 50 years to the large scale NI Soil Survey programme carried out over 10 years from 1987. The Soil Survey of NI provided vital information of on soil types and distribution throughout region. Since the completion of the soil survey in 1997 soil science in AFBI has focused on improving soil nutrient use efficiency, carbon sequestration and refining our understanding of soil hyDr.ology and losses to the environment.

In the past years this research has provided the evidence base to support the implementation of the Soil Nutrient Health Scheme (SNHS) which will provide farmers with detailed, accurate information on the status and management of their soil nutrients and farm level estimates of carbon stocks in both soil and above-ground biomass. The SNHS is therefore an excellent example of science with impact and being taken into practice.

The research programme in SHNS

Continuing the long tradition of conducting high quality innovative research, AFBI have incorporated a comprehensive research programme into the SNHS to further aid in our understanding of soil nutrients, water quality and carbon, which will further improve the advice and information provided to farmers and government.

For example one area of ongoing research relates to improving soil nutrient recommendations and ensuring these are optimised for crops on the diverse soil types identified in this region during the decade long Soil Survey of NI. This research is specifically related to the basaltic soils in the north east of the region which have high levels of iron and

aluminium which influences how well different soil tests provide an accurate measure of plant available phosphorus in soil. Reducing unnecessary inputs of phosphorus through soil-specific recommendations should deliver both cost savings to the farm business and reduce the risk of excess being lost to our rivers and lakes. Other research incorporated into the SNHS focuses on improving soil runoff risk predictions, estimates of soil carbon stocks and the role of the soil microbiome in carbon and nutrient cycling.

Soil sensing

In addition to the research embedded in SNHS, the project will act as a platform on which to build further research partnerships and collaborations, nationally and internationally. For example, AFBI are the only UK partner in the €80M Horizon 2020 European Joint Programme on agricultural Soil Management (EJP Soil - Towards climate-smart sustainable management of agricultural soils) has much synergy with the SNHS. Within EJP SOIL programme, the SensRes project is Soil new methods to downscale current large-extent soil maps to higher resolutions that will facilitate sub-field precision nutrient management by use of a combination of proximal (field-deployed) sensor systems and remote sensing. These systems will be applied to map key soil properties such as texture, soil organic matter, carbon and soil moisture across multiple field sites in NI and provide highly detailed soil information within individual fields. Validation will compare the sensor-derived estimates with laboratory and in-situ measurements being undertaken within SNHS. One sensor being tested within the project is Electromagnetic Induction (EMI), which measures apparent electrical conductivity (ECa) as a proxy for multiple physicochemical properties. If the technique proves effective it could be mounted on a vehicle and used for quick, non-invasive and inexpensive scanning of fields to provide rapid and sub-field scale information and guidance to farmers in precision nutrient and soil management.

SNHS, EJP Soil and a wide range of historical and ongoing soil research across AFBI will be instrumental in maintaining and improving soils health in NI. Soils are at the interface between land use and the environment. As such, good soil health is vital for achieving sustainable land use management that delivers multiple ecosystem services including food, clean air and clean water for society. Key to this is providing farmers with the knowledge and tools to manage their soils. As they put the data and knowledge provided by the SNHS into practice and see the benefits of improved soil health both for their farms and the environment it is expected that interest in technology and precision farming will also expand in the coming years. Going forward soils research in AFBI will focus on developing and validating new technologies and tools to support farmers with the sustainable management of soil in NI.

The EJP Soil project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 862695

Food Futures: A data-driven tool for SMART Sustainable Agriculture in Northern Ireland

Summary

Quantifying the sustainability of Northern Ireland's agri-food production is key to protecting existing markets and securing new markets. It also is fundamental to NI agri-food production reaching its ambition of being a globally leading industry in terms of sustainability. Economic, social and environmental sustainability has to be quantified, meaning a large set of varied data are required. As part of the Agri-Food Quest 'Food Futures' project, a holistic, data-driven tool has been developed and applied to Northern Ireland (NI) farms to measure, verify and report whole farm sustainability. This unique tool, co-created with numerous stakeholders, including scientists, policy and industry partners, can now bring NI to the forefront of sustainable agriculture, by supporting positive change and evidence-based policy development.

AFBI science

Scientifically robust indicators and metrics of sustainability were developed by the AFBI and QUB research teams to measure economic, social (i.e. farm family wellbeing) and environmental sustainability at farm level. Importantly, the latest research findings were incorporated into the Food Futures tool, to inform the selection of more than 100 indicators and the definition of the sustainability scoring system.

Specifically, responses to each indicator (eg slurry application methods, % of soils at optimum pH) were scored on a scale of 0 to 10, with 10 representing either best practice, the optimum status or the most efficient farms.

Data were then collected from 30 ambassador dairy, beef and sheep farms in NI in 2019 using a comprehensive questionnaire to inform the Food Futures tool.

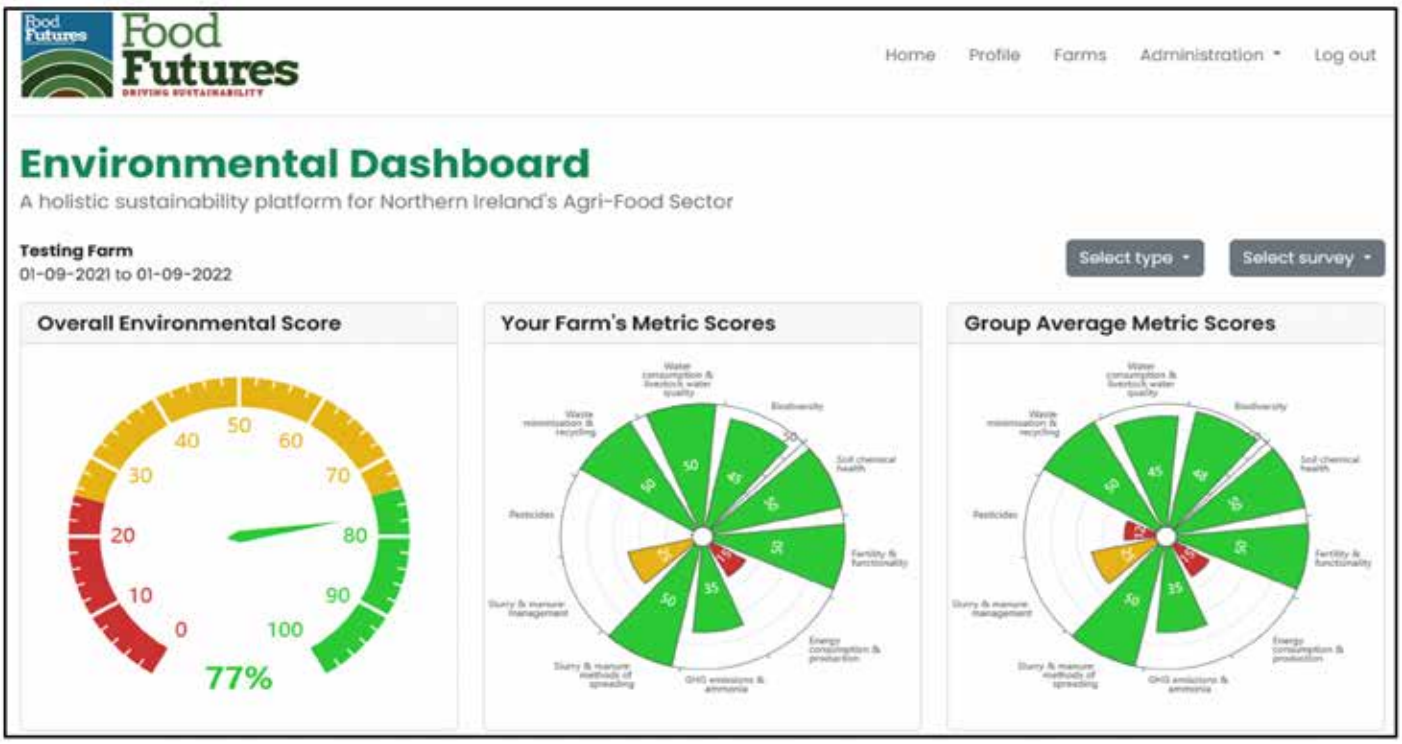


Figure 1. Screenshot taken from the dashboard illustrating the overall farm's performance for each of the nine environmental metrics. A similar approach and layout \ are used for the economic and social dashboards

A key feature of the tool is the provision of a SMART (Specific, Measurable, Achievable, Relevant and Time-based) feedback mechanism. This is targeted to adapt to each farm's individual circumstances and potential. In 2022, an interactive dashboard was created to facilitate the use of the tool by (a) optimising data capture; (b) providing quantified feedback on the level of performance using graphics and traffic light systems (Figure 1); and (c) providing targeted advice and practical options to improve on-farm sustainability. This transparent, evidence-based, multi actor and participatory approach was crucial to facilitate the dissemination of research findings and prompt uptake of new knowledge.

Results to date indicate that active participation in the development and use of this data driven tool has already resulted in positive behavioural change among the ambassador farms to further improve their sustainability credentials, e.g. via the planting of trees and hedgerows; using low emission slurry spreading techniques, along with a more frequent and extensive soil sampling regime to inform fertiliser application on-farm. In 2022, Food Futures worked with the Livestock and Meat Commission (LMC) to successfully test a bolt-on tool (shorter than the full Food Futures tool) on more than 160 Quality Assured beef and sheep farms in NI. This collaboration demonstrated how to enable wider industry 'buy-in'.

The Food Futures tool has also the capacity to satisfy and reflect changing policy, industry and societal demands. To achieve this, transparency and adaptability were crucial, as well as the effective streaming and automation of data required to calculate sustainability scores. Key potential dataflows have been identified such as CAFRE benchmarking figures or soil test results obtained directly from the labs. There is a need to further automate and minimise data entry requirements, by establishing further links with existing dataflows and schemes such as the Soil Nutrient Health

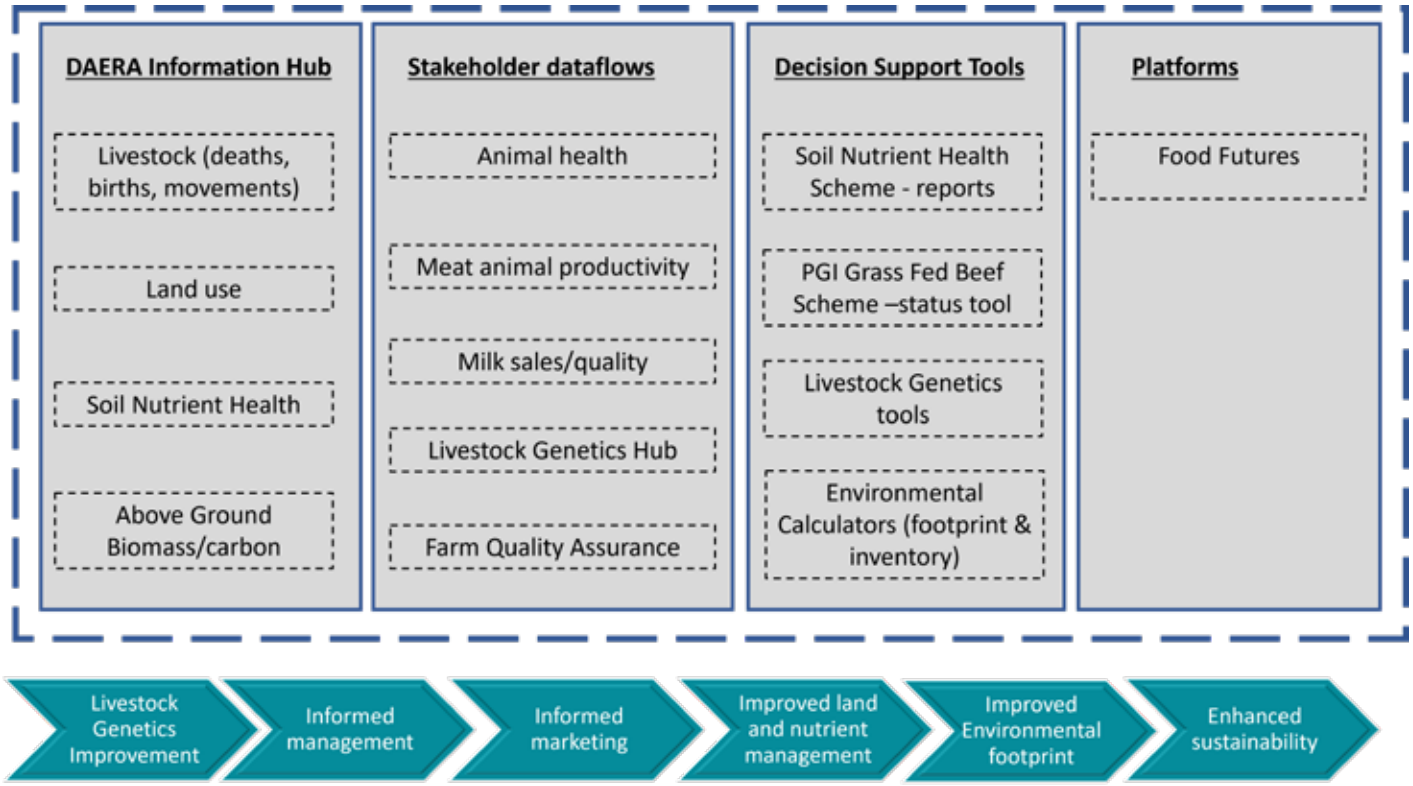


Figure 2. Example of dataflows that can inform the Food Futures tool, relating to improved animal and land management, marketing, environmental footprints and livestock genetics

Scheme (SNHS); Land Parcel Identification System (LPIS) and Animal and Public Health Information System (APHIS) via the DAERA Info Hub and outlets from other key stakeholders such as processors, soil laboratories, feed plants and veterinary practitioners (Figure 2).

Impact of AFBI Science

Building on the successful proof of concept developed as part of this project, a further commercial development of the Food Futures SMART tool will offer a mechanism to work in partnership with industry and government. This would facilitate a smarter use of on-farm data, enabling national sustainability measurements on-farm and delivering improved sustainability credentials. For further information, visit the Food Futures website Food Futures (food-futures.org).

Food Futures
DRIVING SUSTAINABILITY

RESEARCH HIGHLIGHTS

Publication Highlights

Dr. Adewale Adenuga

Adenuga, A.H., Jack, C., Ashfield, A., Wallace, M. (2021) Assessing the impact of participatory extension programme membership on farm business performance in Northern Ireland, **Agriculture, 11 (10), Article No. 949.**

In a bid to improve economic performance at the farm-level through fostering the competitiveness of agriculture and ensuring the sustainable management of resources, the Northern Ireland College of Agriculture, Food and Rural Enterprise (CAFRE) adopted, in March 2016, a new approach to advisory service provision for farmers namely, Business Development Groups (BDG's).

This study analysed the impact of BDG membership on economic performance for dairy and sheep groups using the conditional difference-in-differences approach.

The results of the analyses showed that membership of the BDG programme has a positive impact on the economic performance of participating farmers, indicating that organising farmers into participatory extension groups can increase the farm business income and contribute to the competitiveness of the farming sector

Dr. Mathieu Lundy

Bentley, J.W., Lundy, M.G., Howell, D., Beggs, S.E., Bundy, A., de Castro, F., Fox, C.J., Heymans, J.J., Lynam, C.P., PeDr.eschi, D., Schuchert, P., Serpetti, N., Woodlock, J., Reid, D.G. (2021) Refining Fisheries Advice With Stock-Specific Ecosystem Information, **Frontiers in Marine Science, 8, Article No. 602072.**

AFBI fisheries scientists, alongside international colleagues, have developed an innovative framework for 'Ecosystem Based Fishery Management' which will be implemented for the first time in the 2023 advice for Irish Sea cod. New fisheries management concepts have been defined, and the approach allows the incorporation of ecosystem information into the advice process whilst retaining current assessment models and underlying legislative requirements.

Our simulations show that the new technique is more precautionary when conditions are poor, whilst allowing higher catches when conditions are good.

Dr. Paul Cottney

Cottney, P., Black, L., White, E., Williams, P.N. (2021) The correct cover crop species integrated with slurry can increase biomass, quality and nitrogen cycling to positively affect yields in a subsequent spring barley rotation, **Agronomy, 10 (11) , Article No. 1760.**

The aim of this study was to identify species of cover crops which increase both biomass and total nutrient accumulation in response to manure/slurry. This could improve nutrient efficiency and intensify the benefits from over-winter cover crops.

Sixteen species of cover crops were grown in response to slurry, in pots. Biomass was measured then returned to the pots and spring barley then planted. The spring barley received no additional inorganic N to identify nutrient cycling from the cover crop residue. Significant interactions between species and the application of slurry were found in cover crop biomass, cover crop and spring barley nutrient uptake, as well as cover crop carbon accumulation, particularly in the brassica species used.

This study shows that slurry integration with the correct cover crops can be a promising sustainable farming practice to sequester N and other macro-nutrients whilst providing a range of synergistic benefits to spring barley production when compared to unplanted/ fallow land rotations.

Dr. Lyanne McCallan

McCallan, L., Brooks, C., Barry, C., Couzens, C., Young, F.J., McNair, J., Byrne, A.W. (2021) Serological test performance for bovine tuberculosis in cattle from herds with evidence of on-going infection in Northern Ireland, **PLoS ONE, 16 (4), Article No. e0245655.**

Despite a comprehensive eradication program, bovine tuberculosis (bTB) remains a persistent problem in Northern Ireland. Ongoing development of diagnostic tools is central to eradication efforts so this study examined the utility of commercial available serology tests when used alongside validated frontline methods – the tuberculin skin test (SICCT) and the interferon gamma test (IFNGRA), which are currently used together to maximise detection probability in high risk bTB settings.

The findings suggest that, where SICCT and IFNGRA are used together, there are limited opportunities to detect additional infected animals via the serological methods tested when samples were taken prior to skin testing.

Dr. Alastair Greig

McGregor, P.G., Liskenova, K., Roy, G., Swales, J., Greig, A. (2021) Growth Incentives and Devolved Fiscal Systems (Q1), **Regional Studies.**

Scotland has received new fiscal powers as part of a policy aimed at providing the Scottish Government with incentives to promote economic growth.

Part of this settlement was to replace part of the Barnett block grant with a novel per capita adjustment to the Scottish budget.

Using an intertemporal CGE model of Scotland, this article presents evidence that such mechanisms do not necessarily provide enhanced growth incentives when compared to a more conventional block grant.

Kerry McIlwaine

McIlwaine, K., Law, C.J., Lemon, K., Grant, I.R., Smyth, V.J. (2021) A review of the emerging white chick hatchery disease, **Viruses, 13 (12), Article No. 2435.**

Determining the pathogenicity of virus strains is key to understanding the role of particular strains of viruses in disease, whether benign or pathogenic; especially true for constantly evolving avian viruses that infect poultry with pathogenicities that vary from mild to severe in order to develop effective treatment options. Key to this is the development of phylogenetic trees based on genetic sequence, which groups strains according to how related they are.

AFBI developed a strain classification system for chicken astrovirus that was recently used to group strains that cause stunting, kidney disease and hatchery disease in the above publication

Dr. Aaron McKenna

McKenna, A., Ijaz, U.Z., Kelly, C., Linton, M., Sloan, W.T., Green, B.D., Lavery, U., Dorrell, N., Wren, B.W., Richmond, A., Corcionivoschi, N., Gundogdu, O, (2021) Impact of industrial production system parameters on chicken microbiomes: mechanisms to improve performance and reduce Campylobacter, **Microbiome , 8 (1) pp. 128.**

Our findings demonstrate a relative role of different production system parameters in shaping the bacterial communities' impact on the chicken microbiome, with stocking

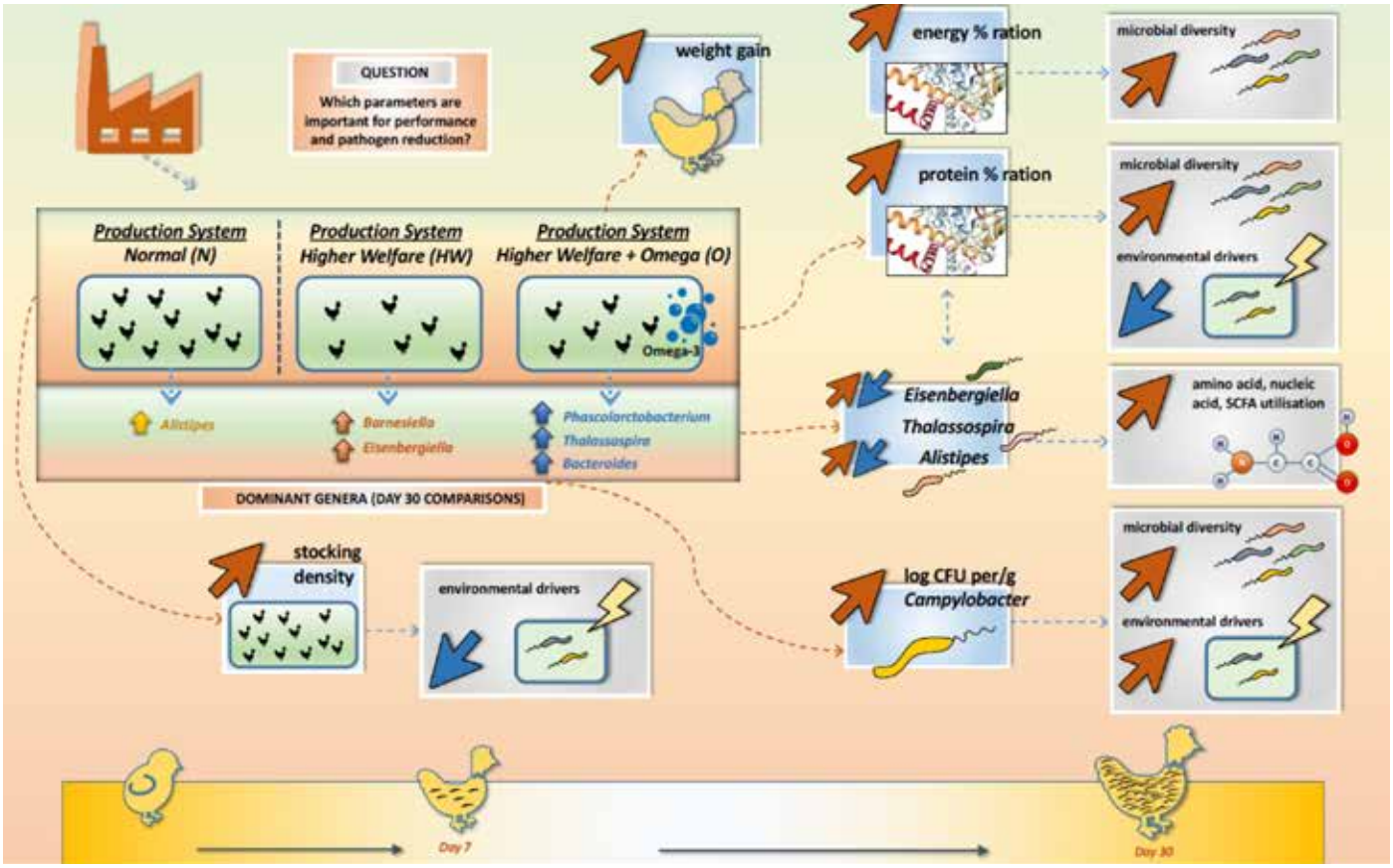


Figure 1: The relative role different production system parameters play in shaping bacterial communities' impact on the chicken microbiome

density playing a major role influencing microbial dynamics. Bacterial diversity was significantly different when conventional production systems were compared to high-welfare and omega supplemented systems. Increased stocking density led to a decrease in environmental pressure influencing the microbial community structure. Thus, an association exists between consistent and differentiating parameters of the production systems that affect feed utilisation, leading to competitive exclusion of genera based on competition for nutrients and other factors. *Campylobacter* was identified within specific production system and presence was linked with the increased diversity and increased environmental pressure on microbial community structure.

Dr. Naomi Rutherford

Rutherford, N.H., Lively, F.O., Arnott, G. (2021) A Review of Beef Production Systems for the Sustainable Use of Surplus Male Dairy-Origin Calves Within the UK. **Frontiers in Veterinary Science, 8, Article No. 635497.**

The UK dairy herd is predominantly of the Holstein-Friesian (HF) breed, with a major emphasis placed on milk yield. Following years of continued single-trait selection, the beef production potential of dairy bred calves has declined. Thus, male HF calves are commonly seen as a by-product of the dairy industry. With limited markets, perceived low economic value and high rearing costs means that these surplus calves are often euthanised shortly after birth or exported to the EU for further production. Welfare concerns have been raised regarding both euthanasia and long distance transportation of these calves.

Furthermore, total UK beef consumption increased by 8.5% from 2009 to 2019. Thus, in light to meet this growing demand, beef from the dairy herd could be better utilised within the UK.

A literature review was conducted to evaluate both steer and bull beef production systems, examining the impact on performance, health, welfare and economic potential to enable a sustainable farming practice, while meeting the market requirements of the UK beef industry. The literature provided several options for rearing and finishing such animals, however, a sensitivity analysis did show that profitability is highly subject to fluctuations in calf, concentrate and beef price and therefore such analysis and sourcing a market for the product is critical at the outset to determine the optimal production system adapted. Consequently, UK production systems could offer an opportunity to reduce welfare concerns over exporting or euthanising these surplus calves.

Dr. Donnacha Doody

Vero, S.E., Doody, D**.** (2021) Applying the nutrient transfer continuum framework to phosphorus and nitrogen losses from livestock farmyards to watercourses, Journal of Environmental Quality, 50 (6), 1290-1302.

Farmyards are commonly conceptualized as point sources of nutrient pollution nested within the wider agricultural landscape. However, within farmyards there are individual sources and delivery pathways, each of which is affected by a range of management practices and infrastructure. Rainfall mobilizes these nutrients, which may then be delivered to a receptor or to the wider Dr.ainage network. As such, the nutrient transfer continuum (NTC), which has been established as a framework to understand and mitigate nutrient loss at a landscape scale, can be similarly applied to disentangle the stages of nutrient transfer from farmyards.

This review paper applies the NTC template to farmyard nitrogen and phosphorus transport to conceptualize causative factors and to identify mitigation options.

Dr. Chuntao Yang

Yang, C.T., Wang, C.M., Zhao, Y.G., Chen, T.B., Aubry, A., Gordon, A.W., Yan, T. (2021) Effects of feeding level on enteric methane emissions and utilisation of energy and nitrogen in Dr.y ewes of two genotypes offered fresh ryegrass, **Small Ruminant Research, 199, Article No. 106381.**

A considerable change in production structure and genetics in sheep industry has resulted in increased meat and milk production during the last decades. However, a range of previous publications suggested that sheep production was associated with an undesirable increase in greenhouse gas (e.g., methane) emissions, and air (e.g., ammonia) and water (e.g., nitrate) pollution.

The objective of the present study was to evaluate the effect of feeding levels on enteric methane emissions and nitrogen (N) and energy utilisation efficiencies of ewe sheep offered fresh ryegrass. This was achieved in a factorial design study with 24 Dr.y ewes of 2 genotypes (12 Belclare vs. 12 Lleyn) offered fresh grass at 3 feeding levels (maintenance level vs. ad libitum vs. intermediate level).

There was no significant interaction between genotype and feeding level on any variable evaluated, except for methane emissions with which the interaction was significant. Sheep offered diets at the maintenance level had significantly higher digestibilities of Dr.y matter, organic matter, neutral detergent fibre, acid detergent fibre and energy than those given at intermediate level or ad libitum. However, increasing feeding level significantly decreased methane emissions as a proportion of nutrient intake or energy intake, and N loss in urine and manure as a proportion of N intake. Belclare ewes had greater energy metabolisability and lower

methane energy/metabolisable energy intake, urine N/N intake and manure N/N intake than Lleyn ewes.

The present data were also used to develop a range of prediction equations for methane and manure N emissions using feed intake.

The present result indicates that optimizing grazed grass intake is an effective mitigation strategy to reduce the environmental footprint of grazing sheep production in term of per unit of feed intake.

Dr. Erin Sherry

Martin-Ortega, J., Rothwell, S., Anderson, A., Okumah, M., Lyon, C., Sherry, E., Withers, P., Johnston, C., Doody, D. (2022). Are stakeholders ready to transform phosphorus use in food systems? A transdisciplinary study in a livestock intensive system. Environmental Science and Policy, 131: 177-187

The research applied a transdisciplinary process, bringing together physical and social scientists, to explore the potential for transformative thinking around how phosphorus is used within the food system. A substance flow analysis, illustrating the

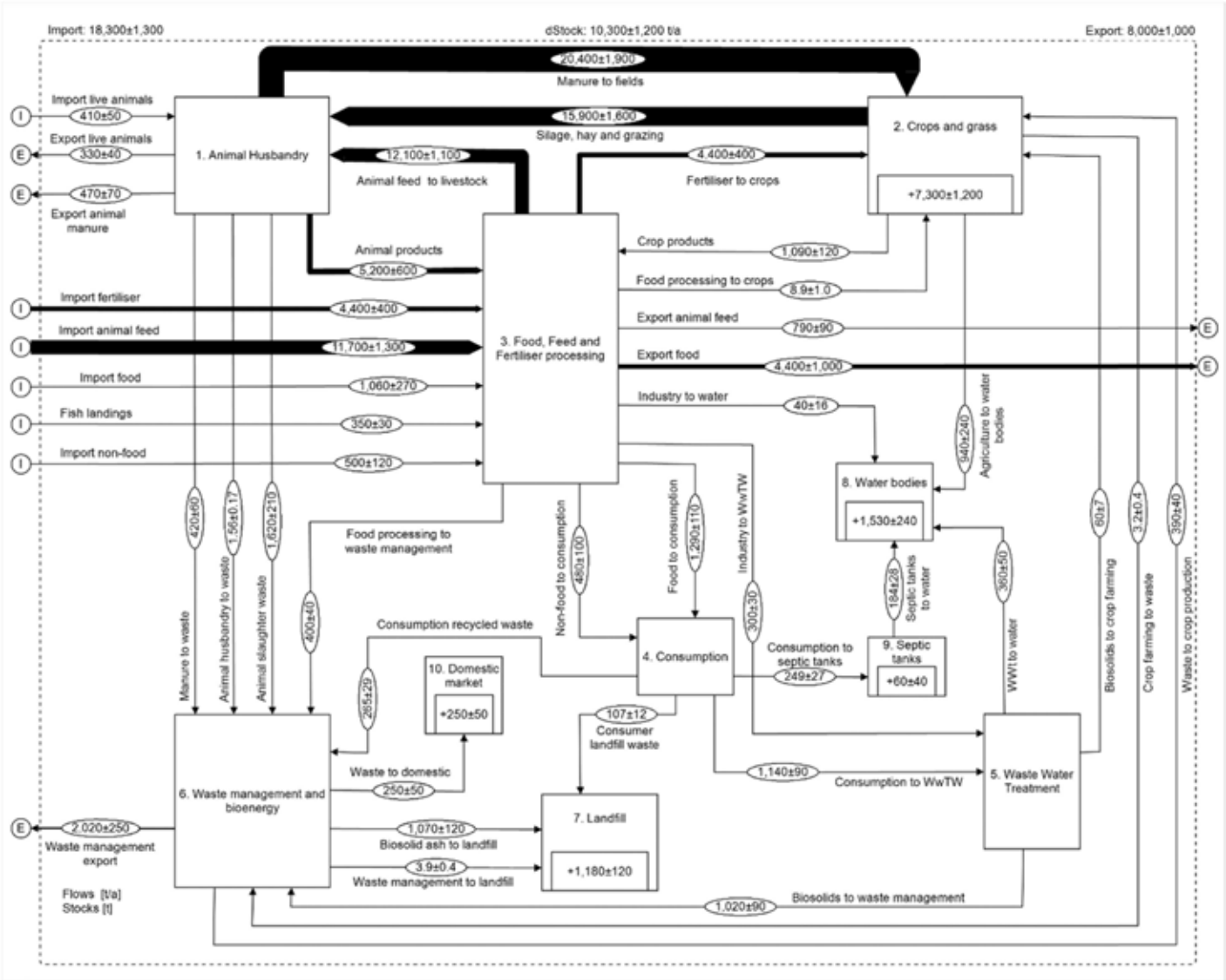


Figure 1. An example substance flow analysis illustrating the movement if phosphorus in and out of Northern Ireland via the food system

movement of phosphorus in and out of Northern Ireland *via* the food system, was presented to private and public sector stakeholders (Figure 1).

Alternative hypothetical food systems, to achieve a more circular and efficient use of phosphorus, were used to spark discussion and gather data on how stakeholders envision potential changes. The analysis (framed using triple-loop social learning) showed in most cases, relatively 'shallow' incremental or transitional changes were favoured over 'deeper' changes with greater potential to transform the system to be more phosphorus efficient.

The transformative changes that were raised included adjustments to existing food markets, creating new markets for phosphorus, re-examining stocking rates and production systems, as well as land use change. The findings from this Northern Ireland case study provide insight as to how stakeholders within livestock intensive food systems more widely are thinking about phosphorus, highlighting barriers and opportunities, as we progress towards a global scale transformation.

Dr. Frances Titterington

Titterington, F.M., Knox, R., Buijs, S., Lowe, D., Morrison, S.J., Lively, F.O., Shirali, M. (2022). Human–Animal Interactions with Bos taurus Cattle and Their Impacts on On-Farm Safety: A Systematic Review. Animals , 12(6):776

Cattle have the potential to cause serious injuries to humans. People can encounter cattle through working on farms, living on a farm, or traversing fields with cattle. A literature search was carried out to assess the factors which may lead to a dangerous interaction with cattle. Six themes which impact human safety were identified: actions of humans; human demographics, attitude, and experience; facilities and the environment; the animal involved; under-reporting and poor records; and mitigation of dangerous interactions.

It was found that many cattle-induced injuries could be prevented with targeted, tailored education for those who encounter cattle. In order to better understand the risk factors when dealing with cattle, more accurate recording of interactions leading up to injurious encounters is required. These findings can be employed by policy makers to improve safety on farm.

JOURNAL ARTICLES

Journal Articles

January to December 2021

Adebiyi, A.I., Mcilwaine, K., Oluwayelu, D.O., Smyth, V.J. (2021) Detection and characterization of chicken astrovirus associated with hatchery disease in commercial day-old turkeys in southwestern Nigeria, Archives of Virology, 166: 1607–1614.

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