

TResearch

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SWARD STUDY

Sward type shown to affect sheep performance



FARM EFFICIENCY

Labour time study offers ideas to ease workloads



HEALTHY EATING

What does a sustainable diet look like?



BACK IN TIME:
How BurrenLIFE set the standard for farming best practice to support nature maintenance
p.24

Putting the pieces together

A look at the Agricultural Catchments Programme's research into the relationship between soil, water, carbon, climate and farming

Welcome

The Agricultural Catchments Programme (ACP) is an integrated research and advisory programme sharing science-based solutions to meet Ireland's environmental targets on water quality, greenhouse gas and ammonia emissions.

The ACP works across six catchments, which were selected following a rigorous scientific process to ensure they were representative of Irish farming systems.

Each catchment is a 'living lab' with an extensive range of laboratory equipment measuring environmental indicators such as water quality and gaseous emissions. This is only possible with the ongoing cooperation of the farmers in the programme, which also facilitates the assessment of socio-economic implications of reaching these environmental targets.

In this issue, we place a spotlight on the programme and on p12 we meet some of the ACP team, who tell us that the ACP is building a comprehensive understanding of how agronomic and climate drivers influence nutrient loss and gaseous emissions.

We meet the head of water quality research for the ACP on p17 in a one-to-one interview; Per-Erik Mellander is advancing vital knowledge in how water quality is impacted by agriculture and a changing climate.

Our colleagues at the South East Technological University give us their view on the ongoing value the ACP has for their students in our External Insight column on p36.

Meanwhile, Edward Burgess, ACP Specialist, gives us an overview of the ACP, and the continuing importance of its research in our Look Ahead column on p38.

We look forward to the fourth international Catchment Science conference hosted by the ACP, which will take place this November in Wexford – find out more about the conference on p37.

Catriona Boyle

Editor, *TResearch* magazine, Teagasc



Catriona Boyle

Eagarthóir, iris *TResearch*, Teagasc

Is clár comhtháite taighde agus comhairleach é an Clár Ceantar Talmhaíochta (ACP) trína gcomhroinntear réitigh bunaithe ar eolaíocht d'fhonn spriocanna na hÉireann i leith an gcomhshaoil a chomhlíonadh maidir le cáilíocht uisce, astaíochtaí gás ceaptha teasa agus astaíochtaí amóniam.

Oibrítear an ACP ar fud sé cheantar, a roghnaíodh tar éis próiseas eolaíochta mionchúiseach chun a chinntiú go raibh siad ionadaíoch do chórais feirmeoireachta na hÉireann.

Is 'saotharlann bheo' é gach ceantar ina bhfuil raon leathan de threalamh saotharlainne lena ndéantar táscairí comhshaoil a thomhas amhail cáilíocht uisce agus astaíochtaí gásacha. Ní féidir sin a dhéanamh ach amháin le comhoibriú leanúnach na bhfeirmeoirí sa chlár, rud lena n-éascaítear measúnú freisin ar na himpleachtaí socheacnamaíochta a bhaineann le baint amach na spriocanna comhshaoil sin.

San eagrán seo, dírimid aird ar an gclár agus ar leathanach 12 buailimid le roinnt ball den fhoireann ACP, a chuireann in iúl dúinn go bhfuil tuiscint chuimsitheach á forbairt ag an ACP ar an dóigh a n-imrítear tionchar ar chailteanas cothaitheach agus ar astaíochtaí gásacha ag spreagthóirí agramamaíochta agus comhshaoil.

Buailimid le ceannasaí taighde ar cháilíocht uisce don ACP ar leathanach 17 in agallamh duine le duine; tá eolas ríthábhachtach á fhorbairt ag Per-Erik Mellander ar an dóigh a bhfuil tionchar á imirt ag talmhaíocht agus ag aeráid atá ag athrú ar cháilíocht uisce.

Tugann ár gcomhghleacaithe ag Ollscoil Teicneolaíochta an Oirdheiscirt a gcuid tuairimí dúinn maidir leis an luach leanúnach a chuirtear ar fáil dá mic léinn ag an ACP inár gcolún External Insight ar leathanach 36.

Lena linn sin, tugann Edward Burgess, Speisialtóir ACP, léargas ginearálta dúinn ar an ACP, agus ar thábhacht leanúnach a chuid taighde inár gcolún Look Ahead ar leathanach 38.

Táimid ag súil leis an gceathrú comhdháil idirmáisiúnta maidir le hEolaíocht Ceantair a bheidh á hóstáil ag an ACP, agus a bheidh ar siúl i Mí na Samhna seo chugainn i Loch Garman – faigh faisnéis bhreise faoin gcomhdháil ar leathanach 37.



TResearch is an official science publication of Teagasc. It aims to disseminate the results of the organisation's research to a broad audience. The opinions expressed in the magazine are, however, those of the authors and cannot be construed as reflecting Teagasc's views. The Editor reserves the right to edit all copy submitted to the publication.

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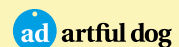
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Thanks to Tom O'Connell, Communications Officer, for his editorial and photography input to ACP articles.

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Throughout TResearch, we include icons alongside articles where there is a clear link to the urgent actions in our Climate Action Strategy. These actions are: Reduce Nitrogen Emissions, Reduce Methane Emissions, Increase Carbon Capture, Enhance Biodiversity, Increase Diversification, Enhance Adaptation, Circular Food System, and Supporting Policy.



Making a big IMPRESSion

Building zero-waste, sustainable, aquatic food value chains is the main goal of the recently launched EU-funded IMPRESS project.

To tackle growing demand for aquatic food in the face of overfishing, and growing concern about waste production and environmental damage, innovative solutions that address the entire value chain are necessary.

IMPRESS aims to unlock opportunities that entice the business community to adopt more circularity and zero-waste approaches, and educate consumers to adopt new eating habits.

The project will dive into two key areas: the potential of underused and low trophic species; and solid and liquid waste streams from fish processing.

Brijesh Tiwari, project coordinator from Teagasc, says: "The IMPRESS project presents an unprecedented opportunity to drive sustainable practices and create value across



Brijesh Tiwari, Declan Troy and Ciara McDonagh, Teagasc, at the launch.

the marine and freshwater sector, while addressing pressing environmental and societal challenges."

IMPRESS will unlock the potential of low trophic species (those at the bottom of the food chain), such as roach, sprat and lumpfish, to create new food products and non-food products (biopesticides, biofertilisers, fish feed).

The project will go even further to enhance the zero-waste approach by using waste water streams and solid by-products of commercial processing to extract

high-value ingredients and test the potential of these nutrient-rich waters to support duckweed and microalgae growth.

Conventional extraction methods along with emerging technologies will be studied to enhance the extraction process while increasing the yield and quality of isolated compounds (proteins, glycogen, PUFA-rich oil). The project will also develop and pilot biopolymer blends and composites for producing compostable polymer films for food packaging applications and coatings to increase shelf life.

The Agricultural Catchments Programme

What is the Agricultural Catchments Programme?

An integrated research and advisory programme sharing science-based solutions to meet Ireland's environmental targets on water quality, greenhouse gas and ammonia emissions.

What is a catchment?

- An area where rainfall, collected by the natural landscape, moves by gravity to a common outlet such as a stream or spring. The ACP works across six catchments (representative of Irish farming systems).
- These 'living labs' include an extensive range of laboratory equipment measuring environmental indicators (e.g. water quality, gaseous emissions).

How is the ACP supported?

- Operated by Teagasc since 2008.
- Funded by the Department of Agriculture, Food and the Marine.
- Ongoing cooperation of the farmers in the programme.



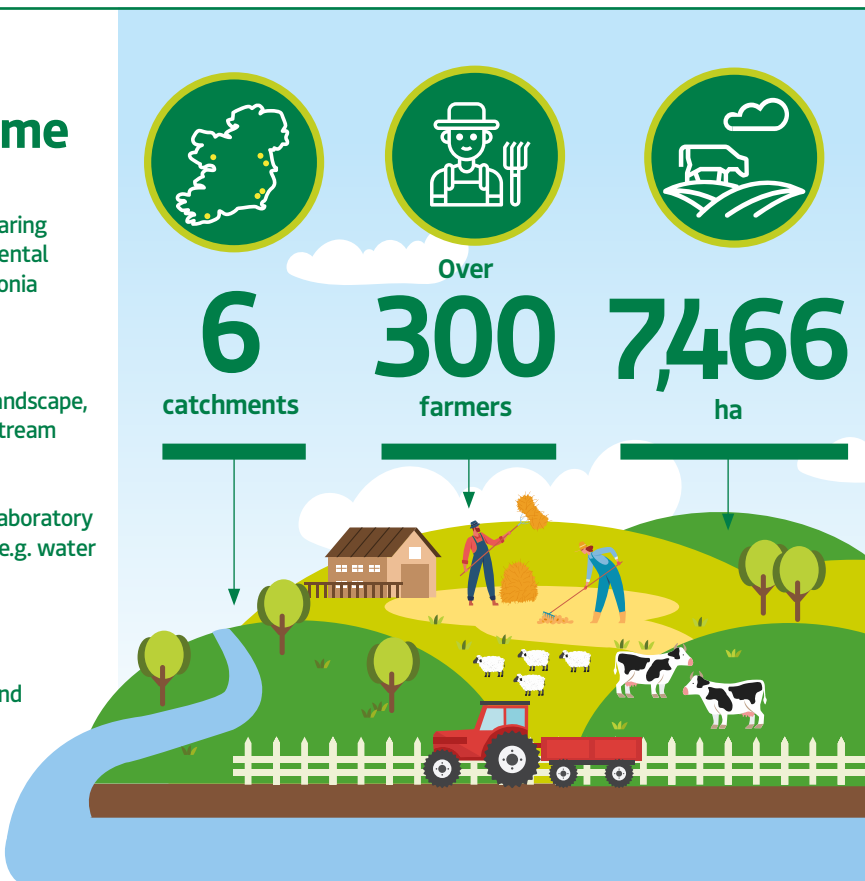
6
catchments



Over
300
farmers



7,466
ha



And the Oscar goes to...

Teagasc has been recognised for many achievements over the years, but the latest throws a spotlight on some new skills.

Our research and advisory teams were represented by Anne Kinsella and Barry Caslin at the fourth EIP-AGRI Support Facility steering committee and team meetings of the EU CAP Network, held at Novi Vinodolski, Croatia.

Participants took part in a team-building exercise that involved each team writing a script for a five-minute movie and then, equipped with a box of props, directing, producing and acting in it.

Anne was joined in her team by colleagues from France, Belgium, the Netherlands, Estonia and Hungary. Anne directed the movie while Barry played the lead actor. At the event's Oscar awards ceremony, their movie titled *The Great Eggsby* won the 'Best Picture' Oscar. The 'Director' brought this EU CAP Network Oscar prize back to Teagasc.



An Oscar-worthy performance: the winning team, including Teagasc's Barry Caslin and Anne Kinsella (back row, second and third from left).

BeSafe on the farm

Teagasc held an International Farm Health and Safety Conference at Teagasc Grange and Ashtown, sponsored by the Department of Agriculture Food and the Marine.

The BeSafe Conference included participants from Australia, North America and Europe, along with Ireland, reflecting on the international challenge of farm safety improvement.

Conference organiser David Meredith, Senior Research Officer at Teagasc, says: "Influencing behavioural safety is incredibly important to reduce farm workplace accidents. Behaviour is a factor in the vast majority of farm accidents and we must work with farmers on behaviour-change along with improving the physical farm environment to cut accident levels."

Mohammad Mohammadrezaei, Teagasc Research Officer, adds that 6% of farmers adopted safe behaviours measured as a part of Be Safe by using a novel 'vignette' approach that employed short stories to elicit actual behaviour. He explains: "A key approach to improve safety through expediting the transition from 'intention' to 'action' is to devise approaches to identify farmers implementing safe behaviours and have them actively influence other farmers, particularly those ready to adopt improved behaviours."

John McNamara, Health and Safety Specialist at Teagasc, concludes: "The findings of the BeSafe project are being published in international peer-reviewed journals. These are leading to novel behavioural approaches implemented through knowledge transfer, communications, training and advisory practices."

News in brief



Pictured (l-r): Dheeraj Rathore, Jonathan McCrea and Oliver Sheridan

Teagasc advises on things you need to know

In the next series of the TV show *10 Things to Know About...*, presenter Jonathan McCrea checks out Irish research for growing healthy and sustainable birch and alder trees with Teagasc scientists Oliver Sheridan and Dheeraj Rathore. We look forward to seeing our colleagues in this episode on Ireland's native trees this autumn.

Teagasc will also feature in an episode on eating well for healthy aging and another episode on fungi – namely mushrooms – Ireland's most successful export crop.

Virtual reality food

Emily Crofton and Cristina Botinestean, scientists at Teagasc Ashtown, have written a chapter on using virtual reality as a context-enhancing technology in sensory science for food development.

The chapter appears in the newly released book *Digital Sensory Science - Applications in New Product Development*, which is now published and available to purchase online from Elsevier.

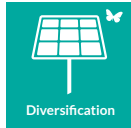


Pig staff induction module

Teagasc's Pig Department has launched the first ever online training module for the Irish pig sector that allows new and existing farm staff to undertake learning on their own farm. It allows users to interactively learn about pig production best practice and safe farming health and safety protocols. It was co-developed in conjunction with the Health and Safety Authority and FBD Insurance.



Pictured at the launch are representatives from FBD, Teagasc, a pig producer and the HSA.



The power of plant protein

Teagasc researchers are leading a project to create and demonstrate improved supply chain opportunities for the European plant protein industry.



The plant protein industry in Europe is poised for improvement, and Teagasc researchers are leading the charge. Current

production systems focus heavily on the production of feedstock for direct transfer into animal sectors in an attempt to counter the EU's over-dependency on imported feed.

Head of Teagasc's Crop Science department Ewen Mullins explains: "This direct transfer of crops into these lower-value markets and the lack of large-scale

processing facilities to transform these products into high-value food ingredients mean that farmers are not gaining maximum value for what they already produce very well. There is also a need to increase resilience in farming systems to mitigate against increasingly volatile climate patterns and to support farming systems to meet EU strategic objectives."

With this in mind, Teagasc researchers are leading a



Horizon-funded project, VALPRO Path, with the objective of co-creating and demonstrating premium supply chain opportunities for the plant protein industry across Europe.

A focus on high-yield crops

VALPRO Path will focus on high-yielding protein crops in five European pedo-climatic regions across Ireland, Italy, Germany, Denmark and Portugal. Crops such as field pea, fava bean, lentil, chickpea, lupin and peanut will be studied in terms of their suitability to specific regions, taking into account issues such as abiotic stress, yield variability and varietal selection.


Within Ireland, Teagasc researchers will focus on intercropping field peas with fava beans to mitigate against the risk of pre-harvest lodging, which is preventing the larger scale cultivation of an important protein crop. In the context of food processing, VALPRO Path will exploit beyond state-of-the-art innovations in the processing and manufacturing of plant proteins into food grade ingredients, such as protein flours and isolates.

Such ingredients will then be used to convey a function in multiple consumer products such as confectionery goods, pastas, nutritional drinks and many more.

Innovative production systems

With a focus on underpinning economic value for all actors in the supply chain, VALPRO Path will demonstrate and evaluate potential business models across five multi-stakeholder 'living lab' innovation production systems (IPSS).

Research Officer in Teagasc's Crop Science department Richard Lynch explains: "Each IPS will validate specific components of the supply chain from production to end-product formulation, addressing topics such as on-farm processing, nutrient tracking, life cycle assessment, logistics and packaging. Each IPS will also provide robust evidence of the social, economic, environmental and health benefits of plant protein production systems, thereby delivering a stronger ecosystem for plant protein production in Europe."

Based on the principles of co-creation, innovation and demonstration, VALPRO Path aims to design, validate and deliver sustainable and competitive plant protein cropping systems and value chains. The result will be more than 10 new, circular sustainable business models, showing how focussed research can come into practice. 

FUNDING

The VALPRO Path project received funding from the European Union's Horizon Europe research and innovation programme under grant agreement No 101059824. For regular project updates please visit the project website at: www.valpropath.eu

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Getting to know

Ciara Beausang



Research Officer **Ciara Beausang** tells us about the exciting work happening in her specialised field of anaerobic digestion, and the directions in which it's moving.

Hi Ciara! Could you tell us a bit about yourself?

I'm a Research Officer in anaerobic digestion based in Grange. Anaerobic digestion is a process whereby organic matter is broken down by microbes in the absence of oxygen. This results in the production of biogas, a source of renewable energy. Biogas can be purified to biomethane to substitute natural gas.

Where did your interest in scientific research stem from?

I've been fascinated by the natural world from a young age. I grew up close to nature in my native East Cork. In my early teens I watched the documentary *An Inconvenient Truth* and from there I was interested in future-proofing our planet.

What does your career path at Teagasc look like?

During my BSc I spent a summer on placement in Oak Park with the Crops Research Department. I undertook research on insect diversity in different potato varieties for my undergraduate dissertation. I enjoyed carrying out research and I decided to do a PhD at University College Dublin, where I looked at the environmental impacts of anaerobic digestion. I returned to Teagasc as a postdoctoral researcher, before taking up the position of Research Officer.

What are your current research interests?

Part of my role is to develop a research programme in the area of agricultural anaerobic digestion. The Government has an ambitious target of delivering up to 5.7 TWh of biomethane by 2030. This is the equivalent of approximately 10% of our current demand for natural gas.

What has been a particular highlight of your career at Teagasc so far?

It's an exciting time to work in the field of anaerobic digestion, which is an emerging technology in Ireland. I've been in my current role with Teagasc for just over four months and during that time I've had many opportunities to connect with people in industry, policy and civil society who are interested in learning about anaerobic digestion.

What are some of your interests/hobbies outside of work?

I'm passionate about food. Outside of work I enjoy cooking and sharing my food experiences on social media. I like trying new restaurants, experimenting with different ingredients and flavours, and learning about the history and traditions behind particular dishes.

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Sealant of approval?

Research at Teagasc is aiming to identify and provide recommendations to farmers on using teat sealant alone at dry-off in uninfected cows. This will help reduce antibiotic use in dairy farms without negative impact on udder health.

Infusing cows' teats with intramammary antibiotics at dry-off has been a common practice to cure existing infections and to prevent new infection over the dry period. The dry period and calving period are when cows are most at risk of new intramammary infections. However, regulation on veterinary medicinal products by the European Union states that antibiotics should not be used as a preventive measure. Therefore, it is no longer justifiable to treat cows with antibiotics at dry-off to prevent infections in the dry period.

An alternative is selective dry cow therapy. This involves treating uninfected cows at

dry-off with an internal teat sealant, an inorganic product that acts as a physical barrier preventing the entrance of bacteria to the gland.

Infections are indicated by a measure of somatic cell count (SCC), with the common cut-off point being <200,000 cells/mL for uninfected cows, explains Research Officer Pablo Silva Boloña.

"International research has shown no difference in the prevention of new dry period infections in uninfected, low SCC cows treated with an antibiotic plus internal teat sealant or with a sealant alone," he says. "However, Teagasc research found that cows with a SCC of <200,000 cells/mL treated with an internal teat sealant alone had higher SCC and infection levels in the following lactation compared to cows treated with antibiotic plus sealant."

Pablo further explains that most infections were caused by *Staphylococcus aureus*, which differs from international production systems. Therefore, treating



Treating uninfected cows with internal teat sealant may help reduce dependency on antibiotics but if not done properly it can have a negative impact on udder health

cows with an internal teat sealant alone is a challenge as some farmers might see this practice resulting in higher infection levels and SCC.

Factors linked with reduced SCC

To address this situation, Teagasc has conducted studies in 21 commercial herds, using dry cow treatment, milk recording and bacterial infection data from >2,000 cows to identify factors that can help implement selective dry cow therapy with reduced risk to udder health. The team found that the following factors at dry-off and the dry period were associated with reduced SCC in the following lactation:

- **Milk yield and dry cow treatment:**

There was no difference found in SCC at the beginning of the next lactation

ACKNOWLEDGEMENTS

The study team Clare Clabby, Pat Dillon and Ainhoa Valldecabres are gratefully acknowledged for their contribution to the research.

Recommendations

- Farmers should use their milk recording information to make dry cow therapy decisions.
- Internal teat sealant alone should be considered if SCC is $\leq 61,000$ cells/mL in first lactation cows and at least $\leq 100,000$ cells/mL in ≥ 2 lactation cows.
- If treating with teat sealant alone, implement measures to reduce milk yield to ≤ 15 kg/day near dry-off.
- Do not look at an increase in SCC in late lactation as normal. This is due to increased infections and will affect the cows' SCC in the following lactation.
- Clean cubicles twice per day during the dry period and early lactation.
- Use the CMT to detect high-SCC cows and quarters and take action when identified (treat, dry, cull).
- Infections with *Staphylococcus aureus* need to be reduced to improve the outcome of selective dry cow therapy.

between internal teat sealant alone or antibiotic plus internal teat sealant treated cows, when their milk yield at the last milk recording (30 days before dry-off) was ≤ 15 kg.

- **SCC at the last milk recording of the previous lactation:** Cows with lower SCC at the end of their lactation were also likely to have a low SCC at the beginning of the following lactation. Cows with an SCC of 50,000 cells/mL at the end of their lactation had an estimated 60,000 cells/mL ($\pm 30,000$) lower SCC in the following lactation compared to cows with an SCC of 150,000 cells/mL.
- **Cleaning cubicles:** Farmers that cleaned and disinfected cubicles twice per day had an estimated 40,000 cells/mL lower SCC cows compared to farmers doing it just once a day during the dry period and beginning of lactation.
- **California Mastitis Test (CMT):** This helps farmers identify subclinical infections (i.e. no visible signs) in cows. Farmers that regularly used the CMT to identify their high SCC cows had lower SCC cows (estimated 7,000 cells/mL lower) compared to farmers not using it.

The importance of recording

A previous study showed that the best information to predict infection in late lactation was the SCC at the last milk recording of the lactation. "If farmers are not milk recording, they should start by doing one in late lactation to guide dry cow therapy decisions," explains Pablo. "However, we encourage farmers to do multiple milk recordings throughout the year, as it is a helpful tool to manage mastitis."

The researchers also explored the SCC cut-off point that improved detection of infection in late lactation. The quarter-level SCC that maximised the correct classification of both infected and uninfected cows was 61,000 cells/mL for first lactation cows and 100,000 cells/mL for ≥ 2 lactation cows. However, the cut-off point for ≥ 2 lactation cows was less accurate in classifying both infected and uninfected cows, meaning that using any cut-off point will result in a higher error in correctly classifying ≥ 2 lactation cows as infected or uninfected compared to first lactation cows.

Pablo explains that there's no clear-cut solution to adjusting SCC cut-off: "By lowering the SCC cut-off point, farmers could detect and treat more of their truly infected cows; however, they will be unnecessarily using antibiotics on more uninfected cows," he says. "Conversely, by increasing the SCC cut-off, farmers could be missing the opportunity to treat more of their infected cows, but would reduce their antibiotic use." For now, the team has a set of concrete recommendations which can help farmers in their decision. **T**

> means greater than
 \geq means greater than or equal to
 < means less than
 \leq means less than or equal to
 \pm means plus-minus

FUNDING

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Digitally measuring meat

Researchers at Teagasc Food Research Centre, Ashtown, are investigating how effectively optical sensors and machine learning can be used to monitor the quality of processed meats and meat alternatives.

Processed meats represent a significant portion of the human diet. Numbers show that global meat consumption has risen steadily from 70.6 million tonnes in 1961 to 352.1 million tonnes in 2021.

Processed meats offer consumers a wide range of options, through a variety of processing and preparation methods, and even regional variances as seen with protected designation of origin (PDO) and protected geographical indication (PGI) varieties such as Spanish *jamón ibérico* and German *Ammerländer schinken*. All of these factors aim to offer a unique experience for consumers in terms of sensorial attributes like juiciness, texture and flavour.

Conversely, people are increasingly concerned with following healthy eating patterns. In this respect, consumers look for meat products with less fat, less salt, and fewer preservative chemicals such as sodium nitrite, without compromising on taste. Research Fellow Ahmed Rady explains: “In light of current enthusiasm to produce and eat more sustainable food, with a reduced carbon footprint associated with livestock and various stages in the meat processing chain, it is important to maintain the highest levels of quality assurance.”

These sustainability challenges have also led to huge investment, research and development efforts in the area of plant-based meat analogues (i.e. meat alternatives). In line with this, developing a deeper understanding of food quality properties will be important for future manufacturing.

Ahmed and the research team see digital tools as an effective way of measuring these properties.

“Digital tools nowadays are ubiquitous, relatively cheap, able to interactively connect with humans, and capable of generating enormous amounts of data that can be used to enhance the quality of products,” he explains.

“In the Digi-Meat project, we are investigating the feasibility of utilising different types of non-invasive sensors and machine learning algorithms to develop reproducible means for monitoring and predicting important quality aspects related to processed meats.”

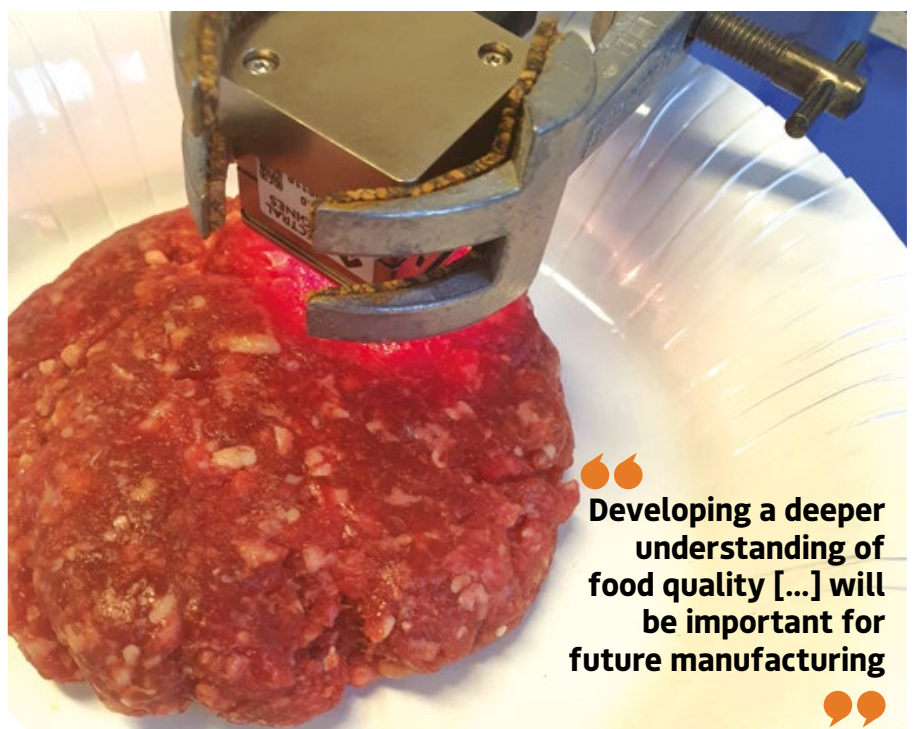
Beefing up the data

The team applied a range of sensors to

scan two major processed meat product typologies, beef burgers and cooked ham. These included optical sensors such as NIR range, RGB vision and hyperspectral imaging; ultrasonic 2D imaging; and dielectric microwave sensors.

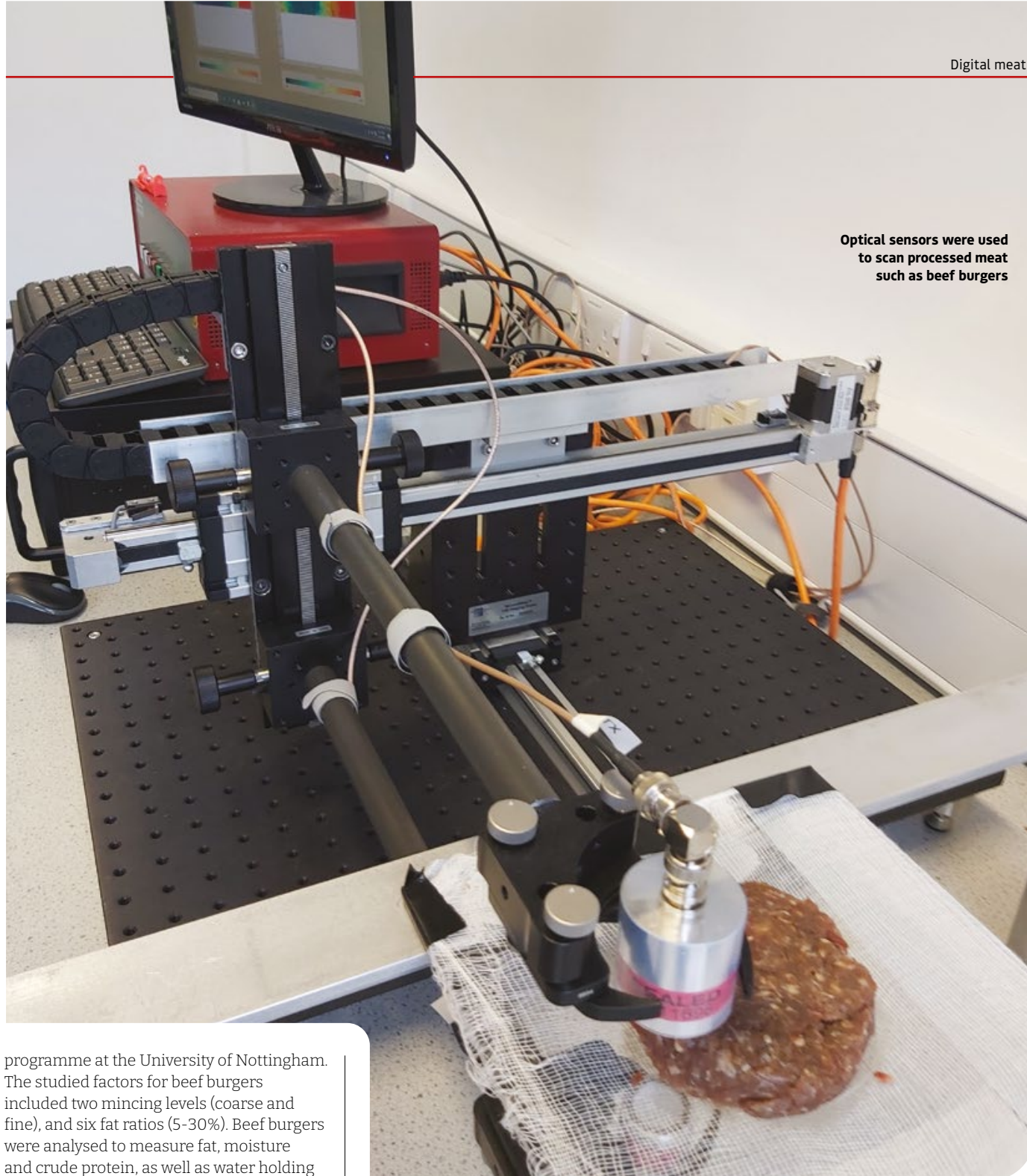
Ahmed explains that several factors were deliberately altered to generate the research targets, in order to obtain predictive models that are inclusive and cover a wide range of variability observed in meat processing chains.

To begin with, the researchers are focussing on the primary results of the beef burger modelling, which was conducted during the outgoing phase of the research



“Developing a deeper understanding of food quality [...] will be important for future manufacturing”

Optical sensors were used to scan processed meat such as beef burgers



programme at the University of Nottingham. The studied factors for beef burgers included two mincing levels (coarse and fine), and six fat ratios (5-30%). Beef burgers were analysed to measure fat, moisture and crude protein, as well as water holding capacity, pH and water activity.

"In addition, several machine learning algorithms were implemented, including one to create classification models for beef burgers based on fat levels," explains Ahmed. "Some of the algorithms used include Linear Discriminant Analysis (LDA), k-Nearest Neighbour (kNN), Decision Trees (DT), Artificial Neural Networks (ANN) and ensemble methods."

Initial results revealed that the hyperspectral imaging system tested was

effective in differentiating between minced burgers with different fat levels (5-30% in addition to back fat as a reference). "It was clear that both ranges were able to identify different components in the raw burgers with distinct absorption, which are likely to be moisture, lipids and pigments including oxymyoglobin, deoxymyoglobin and metmyoglobin," says Ahmed.

Coming off these initial positive findings, the team is excited to continue developing

their methods. The next step, explains Ahmed, is to develop validated predicted models for the studied attributes, using a wider range of machine learning algorithms. **T**

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The Agricultural Catchments Programme is in a unique position to assess and inform policy. Here, Research Officers Bridget Lynch, Michele McCormack and Ognjen Zurovec and Programme Advisor Mark Boland tell us about the programme’s vital, multidisciplinary work.

Catch-all solution

Photography: Mary Browne

Can you explain the history of the ACP team within Teagasc?

Bridget: The Agricultural Catchments Programme (ACP) was established in 2008 and has been fully funded by the Department of Agriculture, Food and the Marine since then. We are now approaching the end of the fourth four-year phase of the programme, and we have 23 staff located

across our six catchments. In the current phase, the programme has expanded to include gaseous emissions and carbon sequestration. In addition, the soil science research has expanded to include N and P soil solution monitoring, and the socio-economic research of the ACP farms using National Farm Survey (NFS) methodology.

What are your core priorities and objectives?

Bridget: The overarching objective of the ACP is to provide a scientific basis for policy review of the Nitrates Action Programme (NAP) and its derogation across different soil types and land-uses, as well as the influence of agriculture on the Water Framework Directive objectives. A team of technicians, technologists, researchers and advisors work with the over 300 catchment farmers to deliver this.

How does your research approach address these objectives, and how is it shared?

Michele: My research as a socio-economist is to bridge the gap between the biophysical sciences and farmer behaviour. This puts us in a unique position to build a holistic picture of the roles of soil, weather and farmer behaviour in understanding trends in water quality and gaseous emissions. ACP research findings are regularly presented at both national and international conferences.

Ognjen: The ACP has been surveying soil nutrient levels in catchments since



“
The ACP is building a comprehensive understanding of how agronomic and climate drivers influence nutrient loss and gaseous emissions.
 ”

Bridget Lynch, Ognjen Zurovec,
 Michele McCormack and Mark Boland
 standing outside the water-monitoring
 station at Ballycanew

its inception. This has yielded important scientific findings about how nutrients end up in surface and groundwater. We present our findings to many different audiences, such as scientists, policymakers, advisors, industry professionals, farmers and the general public.

Can you explain the importance of this work in the context of Irish farming and agriculture?

Bridget: Ireland has a goal of restoring all waters to 'good' status by 2027, and of reducing agricultural greenhouse gas emissions by 25% by 2030. The ACP is building a comprehensive understanding of how agronomic and climate drivers influence nutrient loss and gaseous emissions. In a nutshell, the ACP publishes and disseminates its findings, which assess the effectiveness of – and feed into – national policy.

Michele: To reach the environmental goals in both water quality and gaseous emissions, it is important to take a holistic approach. The ACP is in a unique position to gather data and apply robust scientific research to help answer questions pertaining to how Ireland

can achieve these goals and build a future for the next generation of Irish farmers.

Have there been any changes made in Irish farming as a result of your work?

Ognjen: Our recent findings reveal a 5% increase in the area with good overall soil fertility and a 20% increase in soils with optimal pH levels since the initial soil samples were taken in 2009. These results strongly support the dedicated efforts of Teagasc through its advisory service, including the ACP, in emphasising the importance of nutrient management planning on farms.

Michele: The most recent NFS data has allowed us to calculate a number of KPIs that span a wide range of environmental, economic and social metrics. This data allows us to place our ACP farmers within a wider dataset of farms where we can compare the results with similar farms across Ireland. One of the measures where the ACP farms are performing above average is in terms of Nutrient Use Efficiency. This good result indicates that the combined

efforts of research, knowledge transfer and farmers are working.

How important are farmers to the ACP?

Mark: From the beginning of the programme, farmers' understanding of the programme requirements, and their willingness to engage with advisors, researchers and technicians, has been exemplary. As an advisor I have been fortunate to form good relationships with the farmers I work with. We very much rely on the goodwill of the farmers to carry out our work, and, therefore, ensuring good lines of communication between ourselves and the farmers will allow the programme to continue to provide valuable research findings on key environmental issues.

Ognjen: All of our work is conducted on the land of farmers who generously support our research efforts. Their partnership and willingness enables us to gather essential data and measurements that form the foundation of our research. Furthermore, the participation of farmers is crucial in understanding the intricate ▶

interactions between agricultural practices and environmental sustainability. Without the invaluable cooperation of catchment farmers, none of our scientific investigations would be possible.

Michele: Understanding the role of farm management practices and farmer activities is crucial in building an overall picture of the drivers of water quality and gaseous emissions issues. We currently collect farm level data based on the Teagasc National Farm Survey (NFS). We also surveyed farmers in relation to Ireland's fifth NAP and in the past a number of surveys were carried out to investigate nutrient management practices on ACP farms. This data is crucial and, over the entire period, they have engaged positively in providing the ACP with this sensitive and personal data.

Have you noticed a difference in farmers' behaviour over the years? Has there been a change in their attitudes towards the environment?

Michele: The initial phase of the ACP was to evaluate the Nitrates Directive with a focus on protecting and improving water quality. Since then, environmental issues have become more important to society in general. Within the ACP we have observed a growing understanding and acceptance of the important role farmers have to play in the environmental debate.

Farmers have engaged with numerous technologies to assist them in bringing their farms in line with current environmental standards such as Nutrient Management Planning, soil testing, using ACP weather data to plan slurry applications and the use of Low Emission Slurry Spreading (LESS) equipment.

Mark: Farmers within the ACP have always been aware of the environmental concerns arising from agriculture, particularly around water quality. In the most recent phase of the programme, the addition of greenhouse gas monitoring has expanded the remit of the ACP. Farmers are becoming increasingly aware of the targets placed on agriculture to reduce emissions. While farming may be seen by many to be a business, most farmers have grown up surrounded by nature with an appreciation of the landscape they live in. They are prepared to make any necessary changes in their farming practices to enhance the environment they farm in.

Can you describe your team's broader contribution to Teagasc?

Bridget: The ACP epitomises 'Teagasc



Michele McCormack, Mark Boland, Bridget Lynch and Ognjen Zurovec standing at the stream side at the catchment outlet in Ballycanew

Together' with our multidisciplinary and diverse team. In addition, we directly address the organisation's mission to provide scientific leadership and support to Irish farmers in achieving a sustainable food system.

What are the team's values? What are the principles you work to that you think make your team successful?

Michele: The success of the ACP centres on several key principles: collaboration, trust, respect, accountability, excellence, adaptability, innovation and a desire for continuous improvement.

“ Within the ACP we have observed a growing understanding and acceptance of the important role farmers have to play in the environmental debate. ”

Are there any trends or changes to the field coming up that will affect your work?

Michele: In 2022 Ireland's NAP came into effect. This legislation introduced new measures to help Irish farmers achieve targets set out under the Nitrates Directive – for example, changes to closed periods, new livestock excretion rates and a reduction in chemical fertiliser.

ACP farmers were surveyed in relation to their opinions on the fifth NAP; farmers expressed concern in relation to the additional costs, both direct and indirect, associated with these changes. They also raised concerns in relation to a perceived lack of enforcement of regulations that

subsequently led to tighter regulations on all farmers.

Over the next period, we expect to see the results of these changes in the observed data. This will enable the ACP to evaluate changes in the NAP from a water quality perspective. **T**

What are you proudest of as a member of the team?

Bridget: In this phase, the gaseous emissions team set up five eddy covariance towers across the catchments, which took a lot of hard work from many colleagues. Currently all five are up and running.



Michele: Improvements in the farm data collection have allowed us to calculate a wide range of sustainability indicators for ACP farms. This will allow us to create a dataset unique to Ireland.

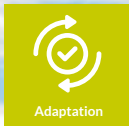


Ognjen: The recent addition of soil solution monitoring in the Timoleague catchment required significant effort from the soil research team. We anticipate valuable insights into nitrate leaching under various grassland systems and farming practices.



Mark: The level of engagement of the ACP farmers and my close working relationship with them. It makes my job easier knowing that farmers see myself as a trusted line of communication.





Grass measuring in a perennial ryegrass and chicory sward



Sharpening the sward

I

n recent years, there has been growing interest in the inclusion of clovers and herbs into grassland seed mixes to form more diverse sward mixtures.

These mixed swards have the potential to improve sward quality and increase animal intakes leading to significant improvements in animal performance.

Clovers are associated with increased crude protein content in the sward and a reduced requirement for artificial nitrogen application through biological nitrogen fixation. Deep rooting herbs such as plantain and chicory are drought-tolerant and can uptake minerals from deeper in the soil, giving a high mineral content in the sward.

An experiment was established in Teagasc Athenry in 2018 and ran for four production years (2018-2021) investigating a range of mixed swards and their impacts on both sward and animal performance under a

At Teagasc Athenry, researchers have been investigating the use of mixed swards in pasture-based sheep production systems. The results suggest increased diversity may be beneficial for animal performance.

pasture-based sheep production system.

The sward types included in the study were:

- perennial ryegrass (PRG)
- perennial ryegrass and white clover (PRG+WC)
- perennial ryegrass and red clover (PRG+RC)
- perennial ryegrass and plantain (PRG+Plan)
- perennial ryegrass and chicory (PRG+Chic)

The swards were stocked at 11.5 ewes/ha, managed in a rotational grazing system and received 130kg N/ha/yr.

"Results from this study found that all swards produced similar annual herbage yields of 10.5-11.5t DM/ha. However, lamb

performance was significantly affected by sward type," explains Research Officer Philip Creighton.

"Lifetime lamb performance was significantly improved when grazing any of the mixed sward types compared to the PRG sward type, resulting in lambs reaching the appropriate slaughter weight between 16 and 28 days earlier. Results show that most of this improvement in lamb performance was coming from the post-weaning period, during which lambs grazing the mixed sward types were gaining 22-43g/day more than the PRG lambs."

As a result of this improved performance there was also significantly less concentrate ►

Weighing red clover to determine clover content in the sward



Lisa McGrane uses a quadrat and shears to cut a pasture sample, which will be used to measure clover content in a perennial ryegrass and white clover sward

Andrew Downes

feeding required to finish lambs that were grazed on the mixed sward types. The highest performing lambs were those grazing PRG+RC and PRG+Chic, followed by those grazing PRG+WC and PRG+Plan, all of which were performing significantly better than those grazing PRG.

Philip adds that ewe performance was largely similar across sward types, with some improvements in ewe body weight and body condition score occurring from six weeks post-lambing until the following mating period.

Sow far, sow good

Achieving good establishment of a mixed sward is essential for its future productivity and persistence. Following the findings of the farmlet study, a series of detailed plot trials were established to investigate the effects of establishment method, seeding rate and perennial ryegrass ploidy, post-grazing sward height (PGSH) on the mixed sward types (PRG+WC, PRG+RC, PRG+Plan and PRG+Chic).

Preliminary results show that the establishment method had no effect on the establishment of white clover, red clover or chicory; however, the direct drill method aided the establishment of plantain in a PRG+Plan sward, relative to the conventional method (plough, till, sow).

Walsh Scholar Lisa McGrane explains: "Within a set total seeding rate of 25kg/ha clover and herbs were included at a low, medium or high level. Clover seed was

included at a rate of 2.5, 5.0 or 7.5 kg/ha and herb seed was included at a rate of 2.0, 3.5 or 5.0 kg/ha for the low, medium and high seeding rate treatments respectively."



Lambs grazing mixed swards reached slaughter weight 16-28 days earlier.



Results show that seeding rate had a significant effect on forage content in all of the mixed swards. "The low inclusion rate of 2.5kg clover/ha was sufficient to establish white clover, whilst the medium inclusion rate of 3.5kg herb/ha was sufficient to establish chicory. For the PRG+RC and PRG+Plan sward types high inclusion rates of 7.5kg clover/ha and 5kg herb/ha respectively were beneficial and led to higher red clover and plantain contents in the sward," says Lisa. "When the mixed sward types were sown using a diploid or a tetraploid perennial ryegrass, these were higher contents of white clover and plantain when sown with a tetraploid perennial ryegrass. However, there were similar levels of red clover and chicory when sown with a diploid or tetraploid perennial ryegrass."

Following the successful establishment of a diverse sward, grazing management can also have significant impacts, particularly on sward persistency, Lisa further explains. In a plot trial, three target PGSHs of 4.0, 4.75 and 5.5cm

were implemented over a three-year period.

"It was found that red clover persistence was particularly poor under severe grazing to 4.0cm PGSH, the lax grazing to 5.5cm PGSH had a negative impact on plantain and chicory persistence, whilst white clover persistence was similar under all three PGSHs applied. Across all sward types the intermediate 4.75cm PGSH was most suitable."

In conclusion, the mixed swards in this study provide significant improvement in animal performance whilst producing similar levels of herbage production relative to that of a perennial ryegrass monoculture, explains Philip. "Issues around forage persistency exist. However more detailed agronomy work will help to identify appropriate management advice for the use of mixed swards under sheep grazing."

The researchers are confident that implementing appropriate management advice can maximise sward persistence without negatively affecting animal performance and sward quality, thus supporting the successful incorporation of mixed swards on commercial sheep farms. **T**

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Lower Lake,
Johnstown Castle Estate

In with the new, out with the nutrients

A

hydrologist by training, Per-Erik Mellander is far from wet behind the ears. A longstanding interest in environmental systems, and of humans' place

within them, eventually led him to becoming one of the key drivers in Teagasc's Agricultural Catchments Programme (ACP). He spoke to *TRResearch* about the ongoing work of the ACP, and the importance of a cohesive view of land-use, hydrology and agricultural policy.

How did you get into this field?

I would say my way into this field was a long one, not a straight one. I did my undergrad

As head of water quality research for the ACP, Senior Research Officer Per-Erik Mellander is advancing vital knowledge in how water quality is impacted by agriculture and a changing climate.

Photography: Tom O'Connell

in Physical Geography at Uppsala University, Sweden, followed by a Masters in Soil Erosion in Lesotho. My interest was piqued by doing fieldwork, and by beginning to look at the bigger picture of physical geography. I undertook my PhD in Environmental Assessment at the Swedish University of

Agricultural Sciences. This was also very field-based, but in a cold climate – lots of snow hydrology. This then led to a greater interest in water quality and working with other forested catchments in northern Sweden. I would say I've always had an environmental interest – how we as humans fit into a ▶

larger environmental system, into the bigger picture.

What is catchment science?

So, a river catchment can be defined as the ‘endpoint’ for water of a given topographical area – it’s the area of land from which water flows into a river. Catchment science studies a combination of water quality and water quantity within a given catchment area, as well as related topics of soil types, geology, land-use and topography.

The ACP has selected six small catchments, roughly 10km² each, around Ireland. They were chosen based on them being representative of typical enterprises in

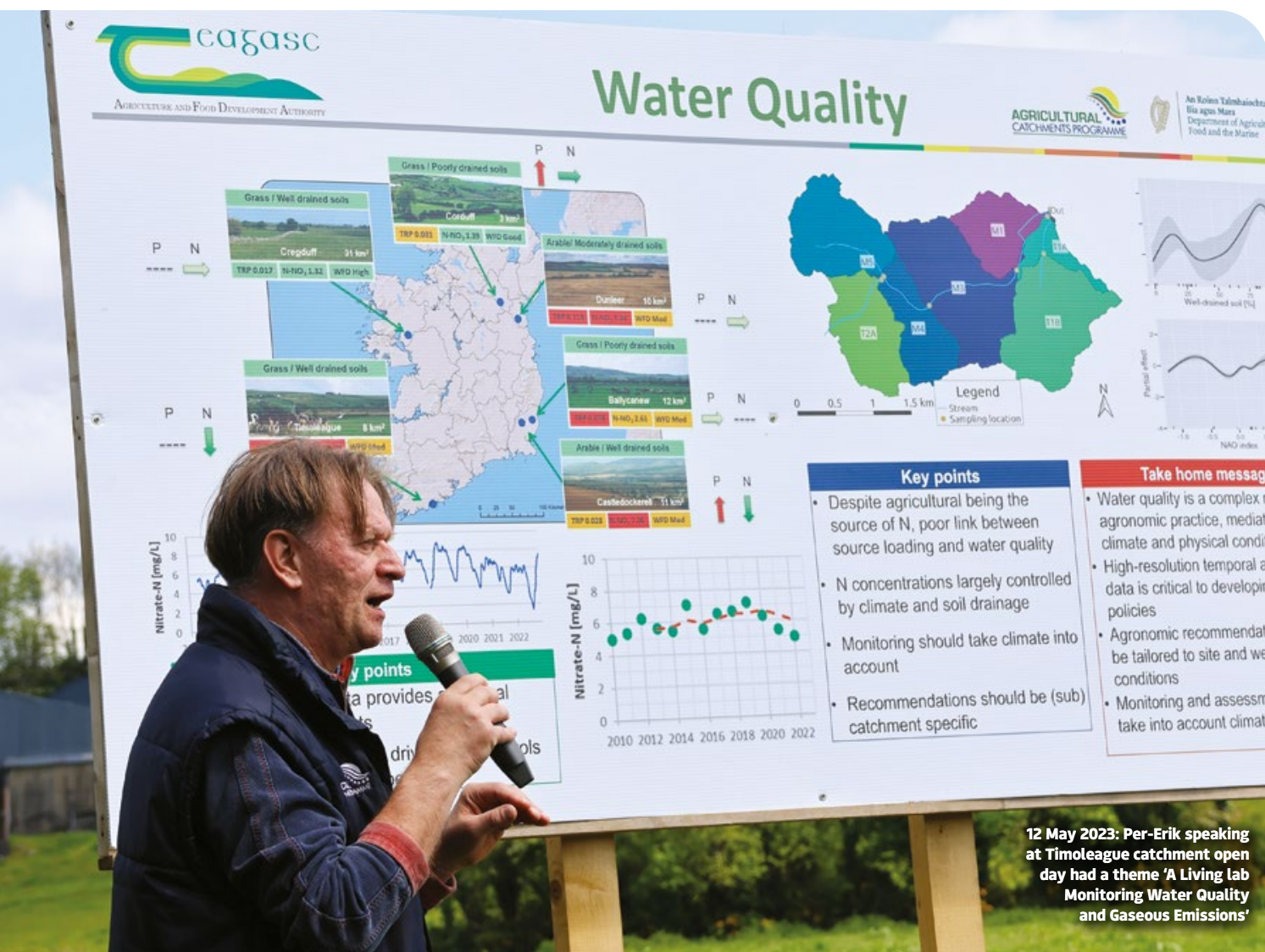
Ireland, and on different types of landscapes, in order to give us a representation of the typical enterprises found across Ireland. This allows us to develop a longer-term understanding of the effects of agricultural land-use on water quality.

What are some of the main issues and challenges regarding catchment science?

The main issue is that food production causes pressure on water quality. Producing food needs nitrogen and phosphorus, but if there is loss of these nutrients to water, this impairs water quality. Excess nitrogen and phosphorus in waterways leads to algal

growth, which in turn consumes all the oxygen in the water.

The overall challenge is one of how to continue producing food in the most sustainable ways possible. This requires us to understand as much as possible how, where and when nutrients get into water. If you can begin to map those pathways, then there’s further potential for mitigation. It has now become accepted that we need targeted measures to address the goals in improving water quality. Within that field there’s a lot of low-hanging fruit, but we will need much more science in order to understand the underlying processes and be able to reach higher-hanging fruit.



12 May 2023: Per-Erik speaking at Timoleague catchment open day had a theme ‘A Living lab Monitoring Water Quality and Gaseous Emissions’

How has this field developed over time?

In terms of techniques, there's been lots of development. The key one is near-continuous monitoring, where a sensor is deployed in land or water for automatic data gathering. We have been monitoring these rivers since 2009, and our current monitoring system gives us new information every ten minutes. This numeric data that comes in looks at things like concentration of some nutrients, such as nitrogen and phosphorus. Crucially, automated monitoring helps mitigate data being skewed by only a few sampled points.

Currently, however, there's no sensor for phosphorus, so this still requires wet chemistry, but we have an automated



The link between water quality and climate science may seem obvious, but the two have often been studied on a very different scale. Our data allows you to link the two more easily.



system for on-site analysis. Overall, though, continuous monitoring makes sure you don't miss out on any big events and it allows us to better understand how nutrients may be lost to water.

What are the impacts of this topic?

Part of what makes this monitoring so crucial is that it allows you to link water quality to climate issues. This may seem an obvious pairing, but the two topics are often studied at a very different scale – water quality being seen as local versus climate being seen as regional to global. Our monitoring allows a better understanding of both aspects over time, letting you map subtle changes and allowing you to build links more easily between these two issues.

Even though there's been a focus in this project on water quality, it's quite multidisciplinary. It touches on agronomic and socio-economic issues, and further physical issues like soil quality and gaseous emissions. So, again, it's about the bigger

picture: looking at the balance and gaining that holistic view of water quality as it pertains to land-use and climate change.

What research have you been doing?

My contribution falls within the remit of the ACP as we've discussed it. In particular, I've been working on finding a better understanding of nutrient mobilisation and delivery within given pathways to groundwater and rivers, which helps in understanding the effect of land-use on water. By using the high-resolution monitoring, I've developed a method for identifying and quantifying losses in different transfer pathways – how much is lost on the surface or below ground, for example. We've also developed a way to identify the type of risk of phosphorus pollution in catchments. Much of this work highlights the importance of data collection – these are all developments that have arisen from really exploring the wealth of data we have available.

Can you explain a bit about the ACP's relationship to policy measures?

Not only does our research try to understand what's going on within these catchments in order to plan for more efficient measures in future, but it's also evaluating current measures. Given the level of change we're dealing with, it's not always so easy. For example, time lags within a catchment need to be considered. So, what's monitored in a given catchment could be reflecting the results of a mixture of current measures and measures from several years ago. When trying to gauge the efficiency of policy measures, changes in policy can make it difficult.

It's a complex and constantly evolving system, but it shows the importance of our work. All of this research feeds directly into best management practice and helps to shape policy – within agronomics and agriculture, and climate policy.

Can you say a little about the immediate future of the ACP?

Validating current measures and being able to provide that kind of direct feedback – there's lots of interest in this type of work. It can shape measures to become increasingly efficient and more effective in delivering on policy objectives. The benefits aren't just at policy level either. There's interest in how this research can improve management practice.

Up close and personal

What's your favourite animal?

Being a Swede, I would have to say the moose. They're so gracious in the forest, yet so clumsy on hard surfaces. And they always look like they know something we don't!

If you hadn't ended up in research, what other job would you have wanted to give a go?

I would have wanted to be a musician. I play the clarinet, mandolin, guitar and flutes. I still make plenty of time to play music recreationally. I love playing it, composing it and listening to it.

What are you most proud of professionally?

In general, I'm proud to contribute to the kind of work that makes a positive difference in the world. More specifically, with the ACP project, I'm glad to assist in the important work of linking climate studies with water quality studies.

There's lots of collaboration within Ireland, for example, Teagasc and the EPA, which is exciting. Something we're looking to collaborate on further is this type of high-resolution data study of small catchments, allowing us to really understand those subtle shifts within a catchment.

The EPA has a large number of locations throughout the country. However, measurements are done less frequently than at ACP sites, whereas the ACP measurements are much more frequent at a smaller number of locations. Therefore, combining forces there would really provide a much fuller picture.

In general, we aim to understand more and more what role agriculture and future climate will play for water quality. We are starting to see monitoring equipment become more affordable, so hopefully it can become more widespread. We also want to continue and increase our collaborations with other researchers elsewhere and find better ways to improve water quality. **T**

Estimating farm accident levels in Ireland

Data collected by the Teagasc National Farm Survey examines the prevalence of farm accidents in Ireland. Consistent data collection helps provide realistic estimates, which further helps inform the most relevant safety practices.



The Teagasc National Farm Survey (NFS) has been conducting farm accident surveys in Ireland for 30 years. The data collected provides farmers, policy-makers and health and safety advisors with estimates of farm accident levels to assist with the design of farm safety initiatives.

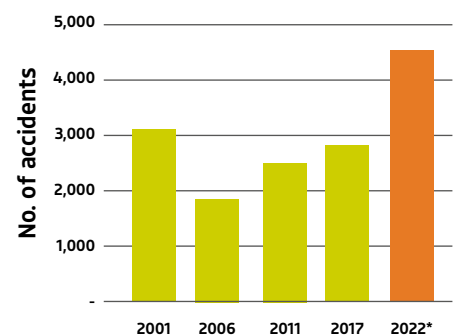
Earlier iterations of the surveys probed accident incidence using a five-year recall – i.e. farmers were asked whether there had been an accident on their farm in the previous five years. In the most recent survey, reported in 2022 for year 2020, this approach was modified whereby farmers were asked to recall if any accidents had occurred on their farm in the previous year.

A change in methodology

In 2020, 5% of respondents reported an

accident having caused injury to them or someone else on their farm. This is reflective of approximately 4,500 farm accidents

Figure 1: Farm Accidents 2001-2022* (year reported)



2001-2017: 5-year recall; 2022: 1-year recall. *Data reported in 2022 for 2020. Source: Teagasc National Farm Survey.

nationally (see Figure 1). Charted against previous years' surveys, the prevalence of farm accidents in 2020 may seem to have increased. However, the change in methodology regarding years of recall should be borne in mind, explains Senior Health and Safety Specialist Advisor John McNamara: "With longer recall periods – e.g. five years – people tend to recall only the more serious accidents. Conversely, with shorter recall periods people can remember a wider spread of both minor and major accidents."

Data collected through the NFS not only quantifies the prevalence of farm accidents, but also their types (as shown in Figure 2). Data from 2020 indicates that almost half of all farm accidents involved livestock (47%) with close to one-third (29%) as a consequence of trips, falls or blows. In a further 11% of cases the use of farm vehicles or machinery were contributory factors. A further 10% related to other causes, with 2% involving farm buildings.

"Compared to 2017, the data from 2020 indicates an increase in the proportion of accidents involving livestock, and trips, falls and blows, up 5% and 16% respectively," explains John. "On the other hand, we can see a reduction in the level of accidents involving machinery, down 14%, and buildings, down 4%."

Data from 2020 indicates that a majority of on-farm accidents (89%) involved family members. According to respondents, 80% of the accidents involved the farmer themselves, with 8% involving another family member and 1% the spouse. The remaining proportion of accidents involved farm workers (1%) and unspecified others (9%).

In addition to the type of accident recorded, information on the location of the accident is also collected. According to the 2020 survey, 52% of farm accidents occurred in the farmyard, with a further 26% taking place in farm buildings. One in ten accidents were in fields, with 1% on farm roadways or lanes.

Risk of labour loss

As noted, most accidents involve farmers themselves, mostly occurring in farmyards or farm buildings. Whilst it's reassuring to


see fewer accidents involving other persons and occurring further afield, the severity of reported accidents will require continued scrutiny.

As John explains: "Of accidents recalled from 2020, 80% required medical treatment according to the survey, with 46% of victims attending a hospital, a further 18% a doctor and 16% requiring first aid." Notably, he adds: "Additional data from the NFS collected in 2021 indicated that almost four in ten farmers do not have replacement labour in the event of them being unable to work due to illness."

In terms of those who indicated the time lost as a result of farm accidents in 2020, 22% indicated no work time lost. The highest proportion of respondents (32%) stated they were unable to work for between one and three days. Twenty one percent reported a work time loss period of between four and ten days. Two percent and four percent of accidents respectively resulted in a loss of time worked of between 11 and 30 days and 31-60 days, while 19% were unable to work for more than 61 days.

Although farm accident numbers for 2020 may appear to have increased, the adjusted methodology from five-year to single-year recall accounts for some of this shift. A change in proportions for accident type shows a positive trend in those involving machinery - decreased by 14% since the previous survey. However, trips and falls and accidents involving livestock

– did increase proportionately, possibly related to 'hurrying' and livestock number changes.

An area of concern relates to loss of work time, 32% of respondents lost between one and three days of work time, and almost 40% signalled that they had no replacement labour available. "Hopefully, continued surveys and data collection can inform policy and safety initiatives towards mitigating this risk," says John. "Shortening the recall period used for the Teagasc National Farm Survey may help prevent underreporting of accidents deemed as minor, and thus draw attention to a broader intersection of accident types." 

» Further information

Complete findings of the NFS farm accident survey 2021 can be found at: <https://www.teagasc.ie/rural-economy/farm-management/farm-health--safety/>

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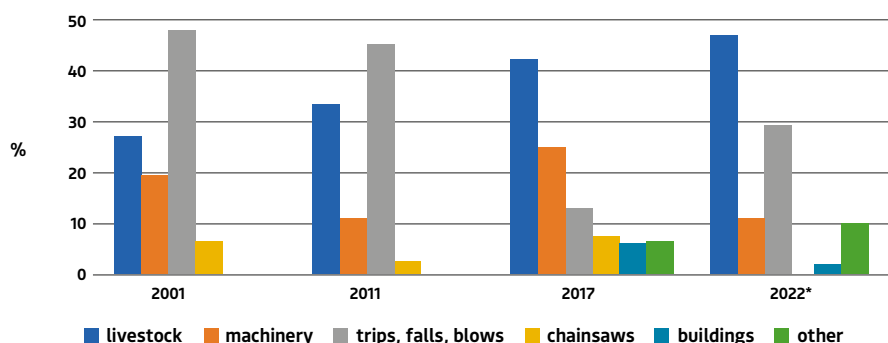
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Figure 2: Farm Accident types 2001-2022* (year reported)



*Data reported in 2022 for 2020. Source: Teagasc National Farm Survey

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Understanding labour time-use on dairy farms is key to identifying strategies to reduce labour demand and establishing sustainable workloads.

Achieving sustainable workloads on dairy farms

In recent years, Irish dairy farms have expanded to meet increased demand for dairy products, resulting in larger farms with greater requirements for labour input. Simultaneously, the number of people employed in agriculture has been in decline.

The issue of labour requirement and availability is exacerbated within pasture-based milk production systems; these systems are characterised by a compact calving pattern designed to maximise the utilisation of grazed grass. This creates an unbalanced workload over the seasons with 33% of total farm labour requirements occurring across three months in springtime.

The reduced availability of workers, combined with farmers placing increased emphasis on achieving a good work/life balance has led to work organisation and efficiency emerging as a priority research topic, particularly in pasture-based production systems.

“To achieve improved labour efficiency through better time-use and productivity, a greater understanding of the peak workload on farms is required,” says Research Officer Marion Beecher.

“While a number of studies have identified individual elements that could save time, the effect of these techniques, individually and in combination with labour demand, using real-time on-farm data, is unknown to-date.”

More in-depth examination could highlight the most effective strategies to reduce labour demand and guide farmers on decision-making.

In order to gather data, the research team recruited 76 farmers and their workers to record their labour time-use. This was done using a smartphone application on one alternating day each week from the 1st February to 30th June 2019. This ensured that tasks completed routinely on an individual day were recorded, while at the same time, the recording would not be considered too inconvenient for the farmers involved. Contractors and any workers not using a smartphone recorded their labour input through an online form.

“Following the study, a variety of labour-saving techniques were implemented and work practices modified on many of the farms, mainly as a consequence of the labour data generated,” says Marion. These changes were recorded through a survey with

the farmers involved. A subsequent recording of time-use was conducted in the springtime of 2021 on 57 of those farms that made technology and/or work practice changes.

Labour efficiency improved as herd size increased, though there were large variations observed across farms, highlighting both highly efficient farms and farms with scope for improvement. However, herd size did not impede farmers in being labour-efficient; highly labour-efficient farms were observed with small and large cow herds.

In the 2019 study, farmers worked on average 60 hours/week from February to June, while milking (31%) and calf care (14%) were the most time-consuming tasks.

Using the longitudinal data of 2019 to 2021, positive effects on labour efficiency were seen through the implementation of new facilities, technologies and work practices – such as milking parlours and automatic calf feeders. As a result, total labour efficiency improved by 7% – equivalent to 0.7 hours/cow over the five-month data recording period.

A holistic approach to efficiency
The research identified 59 work practices and technologies as being associated with labour efficiency. On average, farms

33%

Compact calving patterns associated with pasture-based systems mean that 33% of total labour requirements occur across three months.



Dairy production systems have an unbalanced workload due to calving patterns. Implementing labour efficiency practices may be key to combatting unsustainable workloads

Placing greater value on the sustainability of workload will be essential for future dairy farming systems.

implemented 31 of these labour-efficient work practices and technologies.

“Using an accumulation technique to identify and estimate the effects of labour-saving practices and technologies was a novel aspect of the study, allowing us a more holistic approach,” explains Marion.

“Previous studies hand-picked a selection of work practices or technologies implemented on the most labour-efficient farms, whereas this study incorporated all work practices and technologies before removing those not associated with labour efficiency. This removed any potential bias regarding the selection of labour-efficient work practices and technologies.”

A further novel aspect of this study was the development of a framework to measure farm work organisation effectiveness using the time-use data collected.

“Studying work organisation in other industries and within agriculture allowed us to identify three key characteristics or measures of work organisation: efficiency and productivity, flexibility and standardisation,” says Marion.

Work efficiency and productivity are key characteristics of any work system, focusing on maximising the output from inputted labour without negatively affecting work quality. Flexibility is important in terms of achieving a balance between work and personal life. This can be challenging on farms due to the repetitive nature of tasks such as milking and calf care; the consequent effects of which mean farmers often work seven days per week. Standardisation refers to the sequence and structure of tasks to ensure high standards of work quality. These three characteristics

were measured in terms of farm hours worked per cow and farmer hours worked per day; length of the farmers’ working day and the number of days off; number of different tasks completed by the farmer per day and the finish time of the farmer.

The top 25% of farms in terms of work organisation effectiveness had better labour efficiency, lower labour input, shorter work days and earlier finishing times than the bottom 25% of farms. Some of the savings in hours worked were likely due to those farms having labour-saving facilities, technologies and work practices as well as effective work organisation. Improvements in work organisation can have positive outcomes for job satisfaction and optimise business performance, particularly through improved labour productivity and efficiency.

“Our study has shown that dairy farming systems can be sustainable in terms of labour demand and input,” says Marion. “The adoption of different strategies with respect to farm facilities, work practices, technologies, work organisation or a combination can allow farmers to make logical decisions to address their given labour challenges.”

Placing greater value on the sustainability of workload will be essential for future dairy farming systems. The positive cases observed in terms of farmer working hours and the potential flexibility of the dairy farming workload should be highlighted; both to address the negative perceptions associated with careers in dairy farming and to show farmers what can be achieved on their own farms. **T**

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Where farming and biodiversity unite



amous for its exposed limestone landscape and rich biodiversity, the scenic Burren is located between north Clare and south Galway. The region contains a range of interesting geological features, some of the best limestone pavements anywhere in the world and species-rich grasslands. It is renowned for its monuments, ranging from stone forts to megalithic tombs, a remarkable legacy in stone, tracing the evolution of farming society on this rocky outpost. It is celebrated for its flora and fauna, with

Did you know?
The name Burren originates from the Gaelic word 'Boireann', which means 'place of stone'.

The BurrenLIFE project, which ran between 2005 and 2010, developed a new model for the sustainable agricultural management of the priority habitats of the Burren region. It is a project regarded by many as an emblematic 'LIFE' nature project.

three-quarters of all of Ireland's native flowers found here. Most of the region is protected as a Special Area of Conservation (SAC). It is no wonder then that the unique Burren region has become a shining example within Ireland and for the rest of the EU of how to protect high-nature-value areas –

and the special role of farmers. The BurrenLIFE project developed an evidence-based approach to managing species-rich grasslands, other limestone habitats and water quality as part of livestock systems in the Burren. It was selected in 2010 as one of the "Best of the Best" nature projects from the LIFE Programme, the EU's funding instrument for the environment and climate action.



Over 178km of stone walls have been repaired since the BurrenLIFE project began, enabling more targeted grazing and easier management

Farm demonstration events were a key peer-to-peer approach to sharing best practice



The project was used by DG Agri as an example to guide future European Innovation Partnerships (EIPs). It was instrumental in not only informing the development of existing and future agri-environmental policy and schemes, both in the Burren and elsewhere, but it also became a template for the advancement of future research.

Farming in the Burren

Farming plays a vital role in maintaining



The Burren IFA and the local farming community were true partners in the project and their leadership and championing of the project underpinned the transfer of the project's messages.

the Burren. Without the farmers, the Burren as we know it would cease to exist. For almost 6,000 years, the exploitation of the land by generations of farmers shaped the region, creating a dramatic landscape. However, reduced farming activity in recent decades led to the slow degradation of priority habitats through under-grazing, abandonment and the loss of land management traditions.

Brendan Dunford, BurrenLIFE Project Manager, reflects: "In essence, the BurrenLIFE project supported the farmers of the Burren to deliver defined environmental objectives: maintaining their traditional system of seasonal cattle grazing, while protecting the region's unique plant life."

The resultant landscape is the product of thousands of years of farming activity, but protecting the Burren hasn't proved easy.

"It's an evolving entity, continually influenced and subjected to a range of forces," continues Brendan. "Hence, the continuation of farming is the best way

Before BurrenLIFE

Brendan Dunford, BurrenLIFE Project Manager, took part in a four-year Teagasc-sponsored post-graduate research study, the precursor to BurrenLIFE, from 1998 to 2001. Teagasc published his PhD research project in book form as *Farming and the Burren*.

In securing funding through the EU LIFE fund, the project partners of National Parks and Wildlife Service (NPWS), Teagasc and Burren Irish Farmers' Association, sought to address some of the issues identified in the initial project and to develop a blueprint for the Burren's sustainable management. The BurrenLIFE project carried through from 2005 to 2010 and was acknowledged as the first major farming for conservation project in Ireland and one of few EU projects to place farmers at the helm of the conservation agenda.

Back in the early 2000s, Brendan noted: "Often when we think about biodiversity in farming, we think these two just don't get on very well. Farming is viewed as being very destructive towards our environment, biodiversity or water quality or habitats, but actually that's not always the case."

"And in most of our high-nature-value farmed landscapes in Europe, it's because of farming that we have those special values in the first place. So, what I'd say is the wrong type of farming is very destructive. But the right type of farming is critically important."

to protect this landscape. But we've seen a dwindling number of farmers and a decline in old traditions such as the grazing of the hills in winter in favour of more productive and convenient solutions."

Out-wintering and transhumance

For thousands of years, the tradition of out-wintering has been practised in the Burren. In contrast to other regions in Ireland, the practice of housing cattle was unfamiliar. The term 'transhumance' describes the seasonal movement of livestock between summer and winter pastures. In the Alps, it refers to the moving of livestock up to summer pastures, but in the Burren the reverse is the case.

James Moran, Conservation/Ecology Specialist on the project, explains: "Winterages are uphill areas of land where grass grows among the exposed limestone rocks and are ideal areas for out-wintering cattle."

From mid-October onwards, farmers herd their cattle up onto the rocky Burren winterages where the heat absorbed from the summer sun by the limestone is slowly

released in the winter, resulting in a dry warm place for livestock to lie.

"Winterages provide an abundance of forage," continues James, "as the high-nature-value lands provide the cattle with a wide range of species-rich grasses and herbs to graze on for the winter months."

Blueprint for new initiatives

The experience gained through research and on-the-ground work by the project partners acted as the blueprint for the development of new initiatives to support farmers in other parts of the country and the EU, where good farming practice is essential for the maintenance of high-nature-value areas shaped by thousands of years of farming.

One of the key success factors in the BurrenLIFE project was the support of the Burren Irish Farmers' Association and the local farming community.

"They were true partners in the project,"

says Brendan, "and their leadership and championing of the project underpinned the transfer of the project's messages.

"Building on these farmers' practical knowledge, experience and skills, Teagasc was instrumental in bringing their technical expertise to bear on the situation, to include investigating new systems of supplementary

feeding, targeted grazing and water provision – not just for their production value but also for their value in conserving the Burren's rich heritage."

This back to basics ground-up approach was implemented on a select number of BurrenLIFE monitor farms, with a LIFE plan compiled to cater for the unique situation existing on each and every farm.

The Burren's expansive and diverse landscape cannot be managed in isolation from the farmers.

"The positive role they have played through their bespoke traditions and ongoing hard work are critical for the

Did you know?

In 2019, the tradition of 'Winterage in the Burren' was added to a UNESCO inventory of Intangible Cultural Heritage celebrating living cultural heritage practices in Ireland.

The Burren is a biodiversity hotspot, hosting over 70% of our native flora and supporting a vast array of wildlife





During BurrenLIFE, a database of over 80 local 'conservation contractors' was assembled, mostly from local farm families

Burren's future" says Brendan. "It's important that we celebrate and support this."

Research (on this and related projects), training and targeted incentives will help ensure these farmers' critical role is upheld and strengthened into the future.

Project objectives

One of the objectives of the project was to develop a blueprint for sustainable farming in this unique landscape, and to meet the needs of the special environment and that of the farmers who manage it.

An ambitious work programme included:

- implementing best-known management practices, including new feeding systems, redeployment of existing livestock and targeted scrub removal
- developing new support mechanisms for the sustainable management of the Burren habitats through research and advisory services
- marketing initiatives
- co-operative structures
- the revision of existing agri-environmental schemes.

Through a range of practical initiatives, aimed at empowering local communities, the project also incorporated enhancing

awareness and skills relating to the heritage of the Burren and its management.

Project legacy

After the BurrenLIFE project, Brendan, along with a number of colleagues, set about pioneering a farmer-led scheme, which incorporated, for the first time in Ireland, a 'result-based' approach to payments. As a direct consequence, the Burren Farming for Conservation Programme (BFCP) was launched by the Department of Agriculture, Food and the Marine in 2010, providing payments to farmers of about €1 million per year.


BFCP was ahead of its time in using a bottom-up approach, which made the Burren farmers key in the decision-making process. The programme has acted as a blueprint for other locally led schemes across Ireland and across Europe.

By 2013, over 14,500 ha of SAC were covered by the BFCP, covering 46% of the Burren SAC area. By 2022 this had increased to 23,000ha, over 70% of the SAC area. This work directly informed the expansion of targeted output-based agri-environmental projects in the Irish Rural Development Plan 2014-2020.



Ireland has already played a key role in relation to the innovative design of agri-environment schemes like the Burren Programme and more recently through the innovative delivery model of European Innovation Partnerships (EIPs). Sustainable agriculture can continue to protect and improve our environment while facilitating the growth of Ireland's EIP programme, which is among the most ambitious of any member state.

The years ahead will continue to determine how successful the novel approaches implemented through this project prove to be with the future of some of Ireland's and the EU's most valuable landscapes dependent on project innovations and successes.

"The BurrenLIFE project was just the beginning," reflects Brendan. "It was the basis from which to move forward in a more informed, inclusive, and ultimately, effective and sustainable manner." 

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CSI *Listeria*: Investigating foodborne pathogens



Listeria monocytogenes is an organism found widely in the environment but it can cause food poisoning if it enters the food chain.

Although infection with *Listeria* from consuming contaminated foods is extremely rare, with typically fewer than 1,700 cases per year in the EU, it can be a serious disease for those with underdeveloped or suppressed immune systems – the young, the old and the immunocompromised – and for pregnant women.

While cooking will kill the organism, it can grow at refrigeration temperatures. At-risk products are generally ready-to-eat (RTE) foods, foods that are consumed directly from the fridge without cooking. Examples include deli meats, fresh cheeses, and prepared salads such as coleslaw and salad leaves.

The *Listeria* Challenge Studies project sought to investigate a large collection of isolates gathered from the processing environment of RTE food products – dairy, meat, seafood and vegetables – to understand:

- how their genetics are linked to the physical characteristics they display
- how they respond to the stresses encountered in the food processing environment

A multi-institute consortium, led by Teagasc, has sought to understand the behaviour of *Listeria monocytogenes* in foods by studying a collection of isolates from foods and food processing environments in Ireland. The research team found that not all isolates are created equal, raising the question: should they be treated differently in terms of food safety management?

- how their response to stress influences how they behave in a food product
- how they can be controlled by the food business operator.

Dealing with stress

“The ability of *Listeria monocytogenes* to endure external stresses determines its ability to grow in food products,” explains Principal Research Officer Olivia McAuliffe.

“Analysis of our *Listeria* collection revealed a significant level of heterogeneity amongst isolates in response to such stresses. Some isolates exhibited extensive tolerance to low

temperature and commonly used food preservatives, such as organic acids and salt, while others appeared to have developed resistance to sanitisers commonly used in food processing plants to prevent microbial growth. Indeed, some isolates displayed multiple resistances, making these particularly hard to control for food businesses.”

Examining the genome sequences of these

“Some isolates showed extensive tolerance to common food preservatives, while others have resistance sanitizers used in food processing plants.”

isolates revealed some interesting information. Although the isolates were collected from a diverse range of food products and food processing plants, several groups



Pictured at the 2023 Symposium on *Listeria monocytogenes* in Foods in Ashtown, Dublin are project partners and invited speakers (l-r): Fabian Commichau (University of Hohenheim), Kaye Burgess (Teagasc), Achim Schmalenberger (University of Limerick), Birgitte Kalpollitis (University of Southern Denmark), Olivia McAuliffe (Teagasc), Ana Allende (CEBAS-CSIC) and Conor O'Byrne (University of Galway)



of isolates with highly similar genome content could be traced to single or multiple food businesses, providing evidence that these strains can persist in food processing environments. Some were associated with only one particular processing environment, suggesting that these isolates had adapted to that particular niche, while others were found across different processing environments, suggesting a more generalised persistence ability. Interestingly, some of the isolates were related to human outbreak isolates, providing evidence for a potential link between *Listeria monocytogenes* that are prevalent in the food chain and cases of foodborne infection.

A side of *Listeria* with your spinach?

One of the main objectives of the project was to establish how these isolates behave in various RTE food products. Consumption of salad leaves has increased dramatically in recent years as consumers look to increase their intake of these healthy products. Pre-prepared salad leaves tend to be consumed raw in salads and smoothies, and there has

been an increasing number of product recalls and foodborne outbreaks associated with these types of products in recent times – a significant challenge for food producers.


Identifying particular isolates from the collection that were derived from vegetable products, the project team examined their growth on lettuce, spinach and rocket and confirmed that these products can support the growth of *Listeria*, reaching numbers that could cause infection over the nine-day testing period. What was especially concerning in these findings was that spinach leaves in particular showed very little visual deterioration over this time. The leaves still looked fit for consumption after nine days, despite the high numbers of *Listeria* present. Such contaminated spinach could pose a serious health risk to consumers. There were also many environmental factors influencing the growth of the organisms on these leaves, including the leaf variety, the season, and whether the leaves were cultivated in polytunnel or open fields.

More work to do

At present, European Union regulations treat all *Listeria* isolates as equal, in terms of their resistance behaviour and their virulence, or ability to cause infection. Differences in stress responses and growth behaviour have been

documented in the Teagasc collection, while research from the team is also demonstrating differences in the potential virulence of these isolates.

“However, there is more work to do to discriminate between truly virulent strains and non-virulent strains,” says Olivia. “In time, the work gathered here will contribute to the identification of the most resistant and virulent stains. This will allow control measures to be targeted directly towards the most problematic strains for the industry and for predictive models to be built to enable food producers to assess the risk that these strains present to their business.”

The project wrapped up with a gathering of the project partners together with national and international experts at the 2023 Symposium on *Listeria monocytogenes* in Foods, May 24-25, Ashtown, Dublin. 

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Healthy diet, healthy body, healthy planet

Research is ongoing to identify healthy eating guidelines for sustainable diets that are beneficial for both personal and planetary health.

Food-based dietary guidelines (FBDG) have been developed for more than 100 countries worldwide. FBDG identify the type and balance of foods to consume for a healthy diet with adequate nutrients and are communicated using visual graphics such as pots, plates and pyramids. While graphically different across countries, the basic message in all guidelines remains the same; higher consumption of fruit and vegetables and minimum consumption of calorie-dense and nutrient-poor foods.

The food pyramid was first launched in Ireland as a visual graphic for healthy eating in 1993. Then, acid rain and air

pollution were the environmental concerns of the day and the link between food consumption and its climatic impact had not yet become mainstream. Our climate and our food consumption are linked by the greenhouse gas emissions (or carbon footprint) associated with food production and consumption. Food production and consumption contributes towards approximately 30% of greenhouse gas (GHG) emissions in the EU. Hence, the dual challenge now exists to develop healthy eating recommendations, like the food pyramid, to ensure that both personal and planetary health can be achieved, which is also known as a sustainable diet.

Senior Research Officer Sinéad McCarthy says: “In order to address this challenge and to propose realistic and culturally appropriate solutions for a sustainable diet, we must examine our current dietary patterns from a health and an environmental perspective.” This can identify where changes can be made to achieve

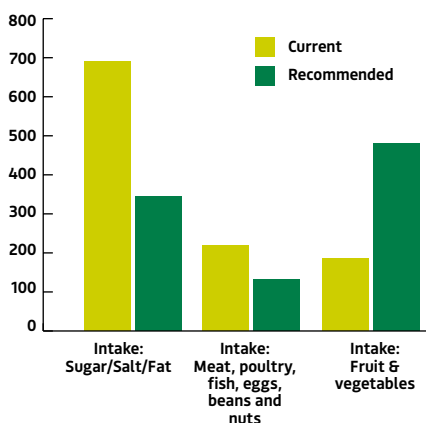
a sustainable diet that will benefit both personal and planetary health.

“As a part of an all-island research project ‘SuHe Guide’, and using data from the National Adult Nutrition Survey (NANS), our current food consumption

1.6kg CO₂/day

A saving of 1.6 kg CO₂/day could be achieved if we consume meat, reduce treats and replace them with fruit and veg.

Changes in food intake (g/day) required from current levels to achieve guidelines



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patterns were evaluated to identify the health (level of compliance with guidelines) and planetary impact (GHG emissions) of our current consumption," she says.

"The impact of improving compliance to guidelines that were not achieved was analysed to determine if achieving healthy eating guidelines (personal health) set out in the food pyramid would also be beneficial from a sustainability perspective (planetary health), thereby achieving the dual challenge."

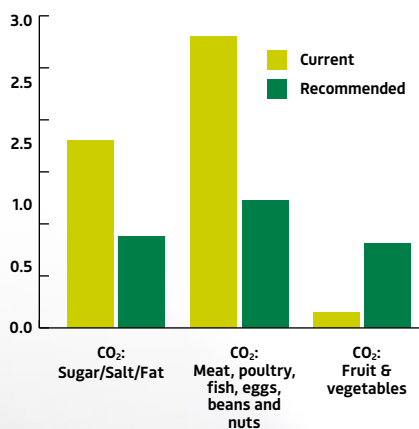
Change a little, change a lot

A comparison of the recommendations from the food pyramid with current eating patterns showed that consumption of both dairy and cereal/starchy foods aligns with the recommended intakes. However, the researchers noted that we far exceed the recommendation to consume sparingly

and no more than twice per week for foods high in sugar/salt/fat, with an average daily consumption of 690g from this shelf generating GHG emissions of 1.8kg CO₂/day.

We are consuming more than recommended from the protein shelf, with intake exceeding recommendations by approximately 90g. Consumption from

Changes in CO₂ (kg CO₂/day) if guidelines are achieved



this shelf generates 2.8kg CO₂/day GHG emissions per day. The most important shelf on the pyramid is the bottom shelf of fruit and vegetables; we should be eating more than five portions a day and ideally seven portions. However, compliance was low with most people consuming just over two portions per day with a very low GHG emissions value of 0.15kg CO₂/day.

"In order to achieve our healthy eating guidelines, our current treat consumption should be halved at least," says Sinéad. While this does not meet with guidelines, it is an achievable reduction that will bring about both health benefits and a reduction in GHG emissions.

If the treats are replaced with three portions of fruit and veg followed by a reduction in meat intake by one portion per day, the healthiness of our diets can be increased and concurrently bring about a significant daily reduction of 1.6kg CO₂/day in GHG emissions.

"This represents a 25% reduction in emissions with moderate and achievable changes to the familiar foods we currently consume," concludes Sinéad. "A simple rebalance of what we currently consume will meet the dual challenge of personal and planetary health." **T**

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Fundamentals of whiskey flavour

Ireland is the birthplace of whiskey. Records date back to 1405, although it is thought that Irish monks learned the art of distilling from the Moors of Spain as far back as the 11th century. Whiskey – or whisky – is mainly produced in Ireland, Scotland, USA and Japan, but, also in Canada, India and a host of European countries on a smaller scale.

Whiskey production peaked in Ireland in the 1800s with an estimated 88 distilleries in operation. However, only two distilleries were active on the Island of Ireland by 1975; Irish Distillers in Midleton, Co. Cork, and Bushmills Distillery in Bushmills, Co. Antrim. Apart from the establishment of the Cooley Distillery in Co. Louth in 1987, very little growth occurred in the sector until 2010. Today, however, there are over 40 distilleries in operation in Ireland. Most of these new operations are craft distilleries but some are relatively large-scale operations. The growth in Irish whiskey has been rapid as the value of exports increased from ~€200 million in 2010 to

whiskey flavour

Granted EU geographical indicator status in 2016, Irish Whiskey is an increasingly sought-after product globally. To help safeguard its status, researchers at Teagasc and Technological University Dublin are seeking to map its unique properties.

over €1 billion in 2022. A number of factors are responsible for this growth, such as better marketing, but also the ability to produce a more flexible or diverse range of products than some competitors.

€1 billion
The export value of Irish whiskey has grown from €200 million in 2010 to over €1 billion in 2022

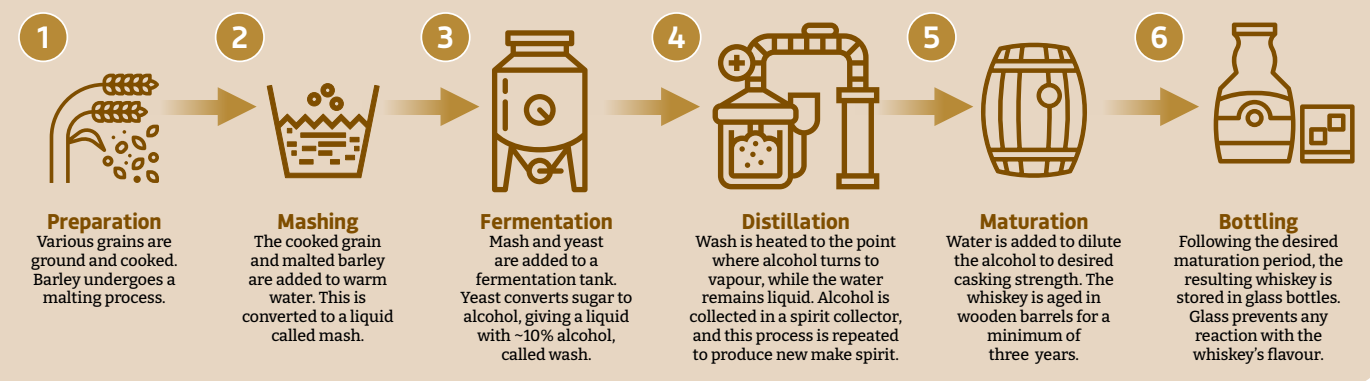
The main export markets for Irish whiskey are the USA (42%) and the EU (22%). Irish whiskey is subdivided into four main types; Irish Malt Whiskey, Irish Pot Still Whiskey, Irish Grain Whiskey and Irish Blended Whiskey, which is made by blending Grain whiskey with Malt whiskey and or Pot Still whiskey. Irish Blended Whiskey is by far the largest category making up over 90% of all sales.

A unique blend

“Irish whiskey received geographical indicator (GI) status within the EU in 2016, which not only provides assurance of quality and tradition, but also offers a level of protection against fraud,” explains Principal Research Officer for Teagasc Kieran Kilcawley. “For Irish whiskey to be recognised as both a spirit drink and of Irish origin, it must comply with certain legal definitions, under EU Regulations EU 2019/787 and 2021/1235 and the Irish Whiskey Technical File. In addition, Irish whiskey must be produced as well as matured on the island of Ireland.”

Whiskey production can appear as a relatively fundamental process; cereal

Schematic of the generic whiskey production process



(barley, wheat, rye, maize, etc), malting, kilning, mashing, fermentation, distillation, maturation and blending. However, as Kieran points out, minor alterations in the process can have a significant impact on the sensory characteristics of the final product.

"There are several unique aspects to Irish whiskey production," he explains. "These relate to the ability to utilise exogenous enzymes to enhance the conversion of starch into fermentable sugars, the use of wood other than just oak in the maturation process, and the relative uniqueness of Pot Still whiskey. In Pot Still whiskey the mash bill consists of a minimum of 30% malted barley, a minimum of 30% green (unmalted) barley and 5% other cereals. This is distilled in copper pot stills resulting in flavour profiles that differ from those achievable from a single cereal source."

The compounds responsible for the flavour of whiskey are known as congeners. These consist of a wide range of volatile, semi-volatile and non-volatile components, resulting from raw materials (cereals), or from one or more stages in the whiskey production process, with fermentation and maturation generally assumed to have the greatest impact.

On the nose

Teagasc, in partnership with the Technological University of Dublin, initiated in 2022 the project 'Identification of Biomarkers to Authenticate Irish Whiskey

and to Safeguard against Fraudulent Practices'.

The aim of this project is twofold, says Kieran: "We aim to create a database of key congeners in Irish whiskey that could be used to authenticate the different types of Irish whiskey, and also to enhance our understanding of the evolution and impact of these congeners in relation to sensory quality."

Flavour is predominately a combination of taste and aroma, with aroma having a significantly greater impact as it can be perceived both orthonasally (through the nose) and retronasally (from the mouth). In fact, more than 10,000 aroma compounds are known to exist as opposed to a minority of taste compounds.

Kieran explains that the first major step in the project was to develop a robust method to identify volatile aroma congeners in whiskey using gas

chromatography mass spectrometry expertise and capability within the Flavour Chemistry facility at the Teagasc Food Research Centre in Moorepark, Co. Cork.

"We utilised state of the art techniques, such as solid phase micro-extraction ARROW, and two-dimensional chromatography with time of flight mass spectrometry to achieve unsurpassed detection of volatile congeners in both new make spirit and mature whiskey," Kieran explains.

A novel method was developed that can

identify more than 200 individual volatile congeners. This was recently presented at the Worldwide Distilled Spirits Conference in Edinburgh, Scotland, organised by the Institute of Brewing and Distilling. This method is currently being used to generate a database of volatile congeners in new make and mature Irish Malt and Pot Still whiskey and subsequently in Grain and Blended Irish whiskey and in comparison to international products. **T**

'Sources of volatile aromatic congeners in whiskey', a review by Teagasc's Kieran Kilcawley and Thomas Kelly and Technical University of Dublin's Christine O'Connor, has been published online in the journal MDPI Beverages. You can read it at mdpi.com/2306-5710/9/3/64.

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Ahead of the packaging

Compostable packaging is a potential option to combat waste from single-use plastic. However, not all compostable packaging is suitable for home composting. Researchers at Teagasc Ashtown are examining further alternatives for a more circular economy.



lastic has been the primary packaging material in the food industry for decades. In 2021, global plastic production reached 390.7 million metric tonnes, with approximately 141 million metric tonnes (about 36%) used in packaging. The food industry alone accounted for about 60 million metric tonnes of plastic use.

It is important to note that the life of plastic is virtually never-ending. It can take hundreds of years to degrade and, while certain plastics can be recycled, they can only be recycled a few times before their usability declines. In some instances, thermoplastics can be melted and reformed almost indefinitely. Ultimately, most plastics end up as waste in landfill or water bodies.

Breaking it down

Shifting to compostable packaging material developed from biodegradable polymers appears to be an intuitive alternative to plastic application, as these can be returned to the earth after use when handled appropriately. These packaging materials have gained a lot of attention, particularly in the food industries.

“Biodegradable” refers to a substance that can be degraded by microorganisms in the environment. Mulch films, thermoplastic starch (TPS), polylactic acid (PLA), polyhydroxyalkanoates (PHAs) and polybutylene adipate terephthalate (PBAT) are some of the examples of biodegradable polymers. “Compostable” plastics are a

“Compostable plastics which are designed to break down under industrial composting conditions may not break down under home composting conditions”

subset of biodegradable plastics designed to break down under controlled environmental conditions into water, biomass and gases such as carbon dioxide and methane. Typical examples of compostable plastics are cellulose films, starch blends, PLA and PBAT.

Shivani Pathania, Research Officer at Teagasc’s Food Industry Development Department, explains: “Compostable plastics are designed to be either industrially- or home-compostable. Industrial composting

takes place in controlled facilities specifically designed to efficiently break down organic waste materials. These composting facilities operate at a temperature range of 50-70°C under controlled humidity and aeration. During this process, microbes such as bacteria or fungi, along with their enzymes, carry out biodegradation of the material, converting it into CO₂, water and biomass within 6 to 12 weeks.”

Home composting practices, however, vary widely, presenting more challenging conditions. It is carried out in a wide range of cooler temperatures, typically between 0-45°C, with variable humidity and oxygen levels.

“Therefore, compostable plastics which are designed to break down under industrial composting conditions may not break down under home composting conditions,” says Shivani.

Increasing awareness

Regarding the application of biodegradable packaging, Shivani cites a notion from the Ellen MacArthur Foundation:

“Compostable packaging is popularly seen as an answer to plastic pollution, but, while it has a role to play in a circular economy, it is not a silver bullet. Any time a piece of

Compostable plastics claims are subject to standards certified by accredited test institutes worldwide. The Seedling logo is a registered trademark owned by European Bioplastics confirming that the product is industrially compostable according to the European standard EN 13432.



European standard EN 13432



Home composting



Soil biodegradability



American standard ASTM 6400



European standard EN 13432 Australian standard AS 4736



Italian certification CIC



Japanese standard GreenPla



Canadian standard CAN/BNQ 00107-088



Monjurul Hoque displays his pectin-based packaging films at the lab in Teagasc Ashtown

packaging is used once – no matter how it is disposed of – it is single-use. Preventing waste in the first place should be the top priority.”

Shivani adds that the compostable packaging system can be effective when a company ensures both supply and collection of packaging material after use. “This kind of collection service lessens contamination and leakage and guarantees its circulation at the highest value. For example, the service provider company BioPak reported restricting 15,000 tonnes of compostable packaging going into landfills in Australia and New Zealand in the last five years.”

Compostable plastics have the potential to replace about 20% of flexible plastic

packaging. Also, the Bio-Based and Biodegradable Industries Association (BBIA) predicts that compostable packaging can take over almost 5-8% of total plastic packaging.

As Shivani points out, biodegradable packaging is starting to gain a foothold among some corporations in the sector:

“UK-based compostable packaging company Vegware reported an increase in sales of 53% in 2019 and a further 43% in 2020. In Canada, KFC has promised to replace all its consumer-facing packaging with home compostable packaging by 2025. Recently, Frito-Lay’s has taken the initiative to test and develop compostable packaging solutions for name-brand products such as Lay’s, Cheetos and Doritos.”

A clear solution?

Of course, this research isn’t just happening at corporate level. Within Teagasc’s Food Industry Development Department, Shivani is leading the Sustainable Food Processing and Packaging research group. She is also a project partner on the University College Cork (UCC)-led, Department of Agriculture, Food and the Marine (DAFM)-funded PECTIPACK project.

This project aims to utilise 100% bio-based resources, mainly apple pomace, to develop biodegradable or compostable packaging materials for bread packaging applications. Under the aegis of PECTIPACK, Teagasc Walsh Scholar Monjurul Hoque has extracted pectin from apple pomace and developed packaging films at lab-scale.

He has also studied pectin formulations with marine-derived ingredients such as sodium alginate and carrageenan to develop highly functional films for food packaging applications. As Shivani tells us: “Monjurul is currently developing a scalable pilot-scale process for compounding and film development.” Such research, she adds, is made possible by using the state-of-the-art equipment available in the DAFM-funded Advanced Packaging Suite at Teagasc Ashtown.

Packaging films developed by PECTIPACK, along with other packaging materials, were presented to approximately 100 visitors at Bord Bia’s Bloom Festival 2023 in Phoenix Park, Dublin.

“The response to the survey has been outstanding, with most respondents showing significant interest in potential alternatives to traditional plastic packaging,” says Shivani. “Specifically, many respondents expressed a preference for pectin-based packaging material, which is developed from food waste, and appreciated its clarity and physical properties.” **T**

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The ACP – a valuable team



For the past 12 years, final year Agricultural Science and Land Management students have been taken on an annual field

visit to the Agricultural Catchments Programme (ACP). This is done as part of the students' year 4 "Soil Nutrient Management" module. Students from South East Technological University go on to work in roles across the wider agri-sector, including farming, industry, research and policy. Understanding both the effects of land management and the scientific methodologies supporting our current knowledge is therefore crucial in equipping students for their future careers.

Enthusiasm and teamwork

While Teagasc personnel has changed a little over the years, team members like Edward Burgess and Per-Erik Mellander have been ever-present, helpful, informative and good humoured. The manner in which people like Edward and Per-Erik, along with many other researchers, advisors and technicians from the ACP, have engaged with our undergraduate students has been fantastic, and they have always been extremely generous with their time. It truly is a team effort from the ACP.

The ACP has a longstanding partnership with the Land Sciences department at South East Technological University, Waterford. Here, two SETU lecturers reflect on the ongoing value the ACP has for their students.

Words by: Tony Woodcock and Sara Vero, Agricultural Science lecturers, South East Technological University, Waterford.



The value of the ACP has always come across very strongly. This is clearly applied research that has tangible impacts on agricultural policy and which is clearly used to influence pieces of legislation that impact in a real way on farming practices on the ground. The focus on inputs, pathways and impacts of pollutants - be they nutrients or otherwise - on a catchment scale means the results gleaned from the research can be used to scientifically evaluate the effect of farm practices on water. These tangible outcomes are no doubt the reason why a great many of the staff working on the ACP are so energised, enthusiastic about their work, and always keen to share their results with the visiting students.

Constantly evolving

Recent expansion into the area of gaseous emissions has allowed the scientists to look more broadly at the eventual destination of

elements like nitrogen which of course, as well as being taken up by plants or lost to groundwater via leaching, can also be lost in the form of ammonia or nitrous oxide into the atmosphere.

The story being told by the catchment scientists is a complicated one and seems to constantly evolve. The variability of nutrient pathways depending on farm practices, soil type, weather conditions, etc, can be immense. With some processes taking a very long time and others happening relatively quickly, a full evaluation is always difficult to pin down. Nevertheless, the vast amount of data that continues to be collected as part of this research project allows scientists to speak more and more confidently about nutrient/pollutant impacts. Consequently, it emphasises the need for advice given to farmers, and government schemes and legislative tools, to be more targeted and ultimately more effective and impactful. **T**



Castledockrell catchment, Co Wexford

Events: my take-home message

Teagasc's researchers attend many events throughout the year, sharing the findings from their research with national and international audiences. Here, we capture the take-home messages – key pieces of information that our researchers want people to remember – from recent events.

Agritourism for sustainable agriculture

Event: Agritourism 2023 conference, Teagasc, Ashtown, Dublin
Date: 22 May 2023

Setting up on-farm holiday accommodation in the form of bed and breakfast or self-catering cottages is a popular diversification choice for farm businesses. There are now many other choices of accommodation such as glamping, pods, shepherds huts and yurts.

The National Agri Tourism Conference was co-hosted by the Irish Self Catering Federation (ISCF) and Teagasc. Barry Caslin, Energy and Rural Development Specialist at Teagasc, says: "Rural tourism is a perfect way to stimulate real impetus into encouraging footfall out of the towns and cities. There is such diversity in rural Ireland's visitor activities and attractions, as well as in our specialist farm food producers, all of which make a very compelling case

to venture out of the city boundaries."

The event, which was opened by Minister of State Pippa Hackett (Department of Agriculture, Food and the Marine), was well attended by farm families, agritourism providers and industry representatives; and showcased the many opportunities available to farm families in developing on-farm accommodation options to complement existing accommodation providers. It also covered developing complementary business activity, be that artisan food shops, fishing boats, cycling, heritage talks or walking tours. A range of topics discussed at the event included funding, planning permission and insurance for farm diversification.

"Over the past few years, fantastic diversified farm and rural businesses have opened up to visitors. There is a genuine



Presenters Anne Kinsella, Teagasc and Chair Galway Rural Development; John Finn, Chair Irish Local Development Network (ILDN); Barry Caslin, Energy and Rural Development Specialist, Teagasc; Tamara Fitzpatrick, Farming Independent; Jean Smyth, Fáilte Ireland; and Máire Ní Mhurchú, Chair of ISCF

focus on providing a great experience and developing unique local features and skills," Barry continues. "This conference provides important guidance that complements the resurgent interest in Irish food, heritage and holidays."

Sustainable sheep production

Event: Sheep 2023, Gurteen Agricultural College, Co Tipperary
Date: 17 June 2023

A focus on grassland and nutrition messages at this event highlighted the increase in performance and reduction in chemical nitrogen that can be achieved from using companion forages, such as red and white clover says Damian Costello, Teagasc Sheep Specialist.

Damian explains: "There needs to be a focus on correcting soil pH by liming and using protected urea in combination with grass budgeting and improving utilisation to improve soil fertility and maximise grass production."

Teagasc Sheep Specialist Ciaran Lynch focused on increasing the productivity, sustainability and competitiveness of Irish sheep production systems. In terms of breeding and genetics, Ciaran emphasised that high genetic



merit rams should be used. He says: "Recent enhancements to the sheep index system, including new health traits, the potential of genomics and ongoing work to identify sheep that have lower methane emissions are all showing progress for farmers and the industry alike."

The event attracted thousands of attendees and had everything from technical villages to cooking demonstrations with celebrity chef Neven Maguire.

Save the date

Catchment Science 2023

Date: 7-9 November 2023

Location: Clayton Whites Hotel, Wexford

The fourth international conference hosted by the Agricultural Catchments Programme, features a broad range of topics ranging from a session on 'Soil Fertility, Nutrient and Carbon Management' to a session on 'Knowledge Exchange and Stakeholder Engagement'.

The event brings together scientists, regulators and practitioners engaged with water quality and gaseous emissions in agricultural river catchments.

The conference is funded by the Department of Agriculture, Food and the Marine and includes field visits and a gala dinner.

Don't miss out on Teagasc's upcoming events! Visit our website to see what we have planned: www.teagasc.ie

Informing agricultural policy through data

Edward Burgess, Specialist in the Agricultural Catchments Programme, provides an overview of the ACP, and the continuing importance of its research.



is very important and will continue to grow as part of the ACP's remit in addition to its bio-physical analysis.

Developing new models

While water quality issues facing agriculture are imminent, climate change and gaseous emission targets are arguably the largest concern in the long term. Results from five eddy covariance towers measuring carbon balances on different farm practices across the catchment locations will soon become available. A lot more data is set to come on board such as soil carbon and nitrogen analysis and ammonia monitoring. The programme is devoting considerable efforts to develop models for this data in order to assign more accurate emission calculations, reflecting mainstream farm practices in Ireland and scale up the results for the entire country.

All of this work could not happen without the support from over 300 farmers and land owners across all six catchments. This support is much appreciated within the programme and cannot be taken for granted given the changes in regulations that have been and continue to be implemented for environmental reasons. **T**

The Department of Agriculture, Food and the Marine funds the ACP to evaluate measures implemented in Ireland under its Nitrates Action Programme (NAP). These measures are reviewed and amended every four years. The Nitrates Directive forms an integral part of the overarching Water Framework Directive (WFD), which requires groundwater and all surface waters – lakes, rivers, transitional and coastal – to reach “good status” by 2027. It naturally follows that the ACP also informs policy on agricultural actions necessary to go towards meeting this goal.

Understanding the implications

In Ireland there are currently approximately 7,000 farmers availing of a derogation to the Nitrates Directive's stocking rate limit of

170kg N/ha. A further 6,000 are exporting manures to bring their farms under this limit. These pasture-based farms include over two-thirds of the dairy herds in the country. A mid-term review of the Nitrates Derogation is currently taking place in Ireland, against a backdrop of other European countries not continuing to avail of the increased stocking rate allowance. Worryingly, recent national trends in water quality are not moving towards the WFD objectives. All of this has resulted in a greater focus on the ACP results than ever before.

Any possible future reductions to stocking rate limits will not only impact farms that exceed these limits, but also have consequences for other farms through the increased demand for land. A broad understanding of the socio-economic implications of any proposed regulatory changes across the whole agricultural sector

Novel fermented feed reducing methane



VALUE PROPOSITION

Our technology is a methane-reducing feed additive that can be used in a pasture-based system without negative effects on feed intake; the environment; productivity of animals; animals; or farmer and food safety; and with minimal effects on farm preparation.



OPPORTUNITY

Teagasc researchers have developed an enriched fermented seaweed additive that combines the known benefits of fermentation and enteric methane inhibition.

This novel approach increases palatability while effectively and safely reducing methane – by >10% – with potential to have a lasting impact on the rumen health.



DEVELOPMENT STAGE

Our enriched formulation has been extensively characterised and tested both *in-vitro*, using state-of-the-art RUSITEC systems, and also *in-vivo*, in beef and sheep, with further studies in dairy to follow.

Patent protection for this technology has also been sought.



ADVANTAGES

Our approach has multiple benefits over other technologies:

- >10% reduction in methane production
- increased palatability and digestibility
- ease of administration
- sustainably sourced from seaweed-ingredients
- safe for livestock and food.

Funding has been provided by the Department of Agriculture, Food and the Marine as part of the Seasolutions Project: seasolutions.ie



For further information contact Dr Karen Dawson,
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Lake-side view

Lakes and wetlands are incredibly diverse and host an amazing world of animals, plants and other organisms, making them a hot spot for biodiversity. These habitats also provide additional ecosystem services, including carbon sequestration and carbon storage; flood mitigation; pollination; and water quality benefits.

The FARM ECOS project has undertaken research to support the retention of farmland habitats (including lakes and wetlands), to enhance the quality of habitats and improve ecological connectivity from the farm to landscape scale.

This photo was taken on a sunny winter morning of the lake in Teagasc Oak Park.

Photo and description by:
Leona Murphy, Crop Science
Technician

Teagasc project:
FARM ECOS: Farming and Natural
Resources: Measures for Ecological
Sustainability