



TEAGASC

# Research

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## International Year of Family Farming

Sediment fingerprinting  
Sensory food network  
Energy from pig manure

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## International Year of Family Farming 2014

The UN has designated 2014 as the International Year of Family Farming (IYFF 2014) 'to raise the profile of family and smallholder farming by focusing world attention on its significant role in alleviating hunger and poverty, providing food security and nutrition, improving livelihoods, managing natural resources, protecting the environment, and achieving sustainable development, in particular in rural areas'.

Around the world family farming is extremely diverse, ranging from basic food provision and subsistence production to market-oriented, often intensive farms based on modern technologies. For the IYFF 2014, the Food and Agriculture Organization of the United Nations (FAO) has defined family farming as follows:

*Family farming (which includes all family-based agricultural activities) is a means of organising agricultural, forestry, fisheries, pastoral and aquaculture production, which is managed and operated by a family and predominantly reliant on family labour, including both women's and men's. The family and the farm are linked, co-evolve and combine economic, environmental, social and cultural functions.*

Family farming is the dominant form of agriculture globally, accounting for more than 80% of all farms and 70% of the world's food. There is a growing realisation that this form of production is essential in meeting future food security challenges. This means that family farms will have to be at the heart of agricultural innovation if production is to keep pace with global food demands, which the FAO projects will require an estimated 60% increase in production by 2050.

Family farming is not unique to smallholders in less-developed countries, nor is it a technologically backward sector. Most large commercial farms are organised as family farms because the flexibility to adapt to changed circumstances that is the hallmark of family organisations enables them to become low-cost and efficient producers.

In this issue of *TResearch*, we mark IYFF 2014 in Ireland by publishing a series of articles that demonstrate the resilience and significance of Irish family farming as it continues to be at the heart of rural employment, sustaining the fabric of rural areas and contributing to balanced territorial development and sustainable economic growth.



**Dr Lance O'Brien**

Foresight and Strategy Manager, Teagasc

## Bliain Idirnáisiúnta na Feirmeoireachta Teaghlaigh 2014

D'ainmnigh na Náisiúin Aontaithe an bhliain 2014 mar Bhliain Idirnáisiúnta na Feirmeoireachta Teaghlaigh (BIFT 2014) "chun próifil na feirmeoireachta teaghlaigh agus feirmeoireacht mionsealbhóirí a spreagadh trí aird dhomhanda a dhíriú ar a ról suntasach maidir leis an ocras agus an mbochtaineacht a mhaolú, slándáil agus cothú bia a chur ar fáil, feabhas a chur ar bheathaí, acmhainní nádúrtha a bhainistiú, an comhshaol a chosaint, agus forbairt inbhuanaithe a bhaint amach, go háirithe i gceantair thuaithe."

Tá an fheirmeoireacht teaghlaigh an-éagsúil ar fad ar fud an domhain, ó fheirmeacha bunsoláthair bia agus táirgthe cothaithe go feirmeacha a dhíríonn ar mhargaí, ar dianfheirmeacha iad go minic atá bunaithe ar theicneolaíochtaí comhaimseartha. Le haghaidh BIFT 2014, shainiaithint an EBT an fheirmeoireacht teaghlaigh mar a leanas:

Modh is ea an Fheirmeoireacht Teaghlaigh (lena n-áirítear gníomhaíochtaí talmhaíochta bunaithe ar theaghlaigh) chun táirgeadh talmhaíochta, foraoiseachta, iascaigh, tréadach agus dobharshaothraithe a eagrú, arna bhainistiú agus arna oibriú ag teaghlach agus a bhraitheann den chuid is mó ar shaothar an teaghlaigh, lena n-áirítear saothar na mban agus na bhfear araon. Tá an teaghlach agus an fheirm nasctha, agus déanann siad na feidhmeanna eacnamaíocha, comhshaoil, sóisialta agus cultúrtha a chomhfhorbairt agus a chomhcheangal.

Is í an fheirmeoireacht teaghlaigh an cineál talmhaíochta is mó atá i réim ar fud an domhain, agus is feirmeacha teaghlaigh iad 80% de na feirmeacha ar fad agus is astu a thagann 70% de bhia an domhain. Tá sé á aithint níos mó agus níos mó go bhfuil an cineál seo táirgthe riachtanach chun dul i ngleic le dúshlán slándála bia amach anseo. Ciallaíonn sé sin go gcaithfidh feirmeacha teaghlaigh a bheith i gcroílár nuálaíocht na talmhaíochta má tá táirgeadh le coinneáil suas le héilimh dhomhanda bia, agus réamh-mheasann an EBT go mbeidh gá le méadú thart ar 60% ar tháirgeadh faoi 2050.

Níl an Fheirmeoireacht Teaghlaigh uathúil i measc mionsealbhóirí i dtíortha beagfhorbartha, ná níl earnáil na feirmeoireachta teaghlaigh chun cúl i dtaobh na teicneolaíochta ach oiread. Tá formhór na bhfeirmeacha tráchtála móra eagraithe mar fheirmeacha teaghlaigh toisc, leis an tsolúbacht chun oiriúnú do chúinsí athraithe, ar sainmharc é sin de chuid eagraíochtaí teaghlaigh, is féidir leo a bheith ina dtáirgeoirí ísealchostais agus éifeachtacha.

San eisiúint seo de *TResearch*, sonraímid BIFT 2014 in Éirinn trí shraith airteagal a fhoilsiú ina léirítear athléimneacht agus suntasacht fheirmeoireacht teaghlaigh na hÉireann agus í fós i gcroílár na fostaíochta tuaithe, ag cothú chreatlach na gceantar tuaithe agus ag cur le forbairt chríche chomhromaithe agus le fás geilleagrach inbhuanaithe.

**An Dr Lance O'Brien**

An Bainisteoir Réamhfhéachana agus Straitéise, Teagasc

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## Dr Rachel Creamer

Dr Rachel Creamer is a Soil Quality and Classification Research Officer at Teagasc, Johnstown Castle. She completed her PhD at Newcastle University in the UK in 2005. Her PhD thesis explored the effect of increasing metals concentrations on soil biodiversity.

Dr Creamer joined Teagasc in 2008 and is currently heading up a number of projects. She is the principal investigator of the Research Stimulus Fund (Department of Agriculture, Food and the Marine) project 'Soil Quality and Research Assessment (SQUARE)' that looks at soil structural quality and soil functioning at 160 sites across Ireland. Dr Creamer is also the principal investigator of a desk study project looking at research to date on soil quality in Ireland, which is funded by STRIVE (Environmental Protection Agency). The project reviews legislative demands, both nationally and from a European perspective and will develop schema for monitoring of soil functions in the future.

Other research projects include a five-year project – The Irish Soil Information System – updating the soils information and maps available in Ireland. Using a combination of predictive mapping techniques and traditional soil survey, this project will develop a new soil map for Ireland. Dr Creamer says the outcome of this project will be immense as many universities, Government agencies and the general public will have use of the final product – a 1:250,000 scale soil map of Ireland – through a new website, map viewer and associated databases. Furthermore, Dr Creamer is the lead Irish project partner on the GS-Soil project looking at the implementation of the EU INSPIRE Directive guidelines on the Harmonisation and Semantic Interoperability of soils data within Europe. She is also the lead Teagasc partner on the Ecofinders project. This collaborative FP7-funded project includes researchers from 23 institutes across 10 countries working to increase our knowledge of soil biodiversity and its role in ecosystem services across different soils, climate types and land uses. Dr Creamer also acts as a primary and co-supervision of nine students in collaboration with a range of universities: Cranfield University, UK; University College Dublin; University of Limerick; and NUI Galway. In 2008, Dr Creamer became the Irish representative on the European Soil Bureau Network, which consists of soil science representatives from every country in Europe. The purpose of the network is to provide support and advice to the European Commission on soils through the Joint Research Council. In 2009, she was elected the Chair of the Network for a period of two years.

Dr Creamer is a member of the council at the Soil Science Society of Ireland. She was previously a council member of the British Society of Soil Sciences and a member of the Institute of Professional Soil Scientists.

## Walsh Fellows overseas training awards

Grace Kelly; Michael Egan; Tara Carthy; Dheeraj Rathore; Christine Cummins; Ian Thomas; and, Lisa Zychowski, some of the awardees of the 2014 Walsh Fellowship Short-Term Overseas Training Programme, with Professor Gerry Boyle, Director of Teagasc and Dr Lance O'Brien, Teagasc Walsh Fellowship Scheme Manager. Nine fellows were successful in their application to spend part of their PhD at overseas institutes in Australia, Canada, New Zealand, Sweden, the UK and the US.



## Wild flowers for bees

Biodiversity and the health of bees was addressed at the recent Teagasc Crops and Spraying 2014 Open Day with Catherine Keena, Teagasc Environmental Specialist. It was highlighted that there are many different species of bees and that growing wild flower mixes on tillage farms can help the survival of these species and other biodiversity.





## SFI funding awards

Two Teagasc projects have received funding under the recent competitive funding call from Science Foundation Ireland. Dr Avelino Alvarez Ordóñez received funding for 'New weapons to fight old enemies – biocontrol of spoilage and pathogenic bacteria in the dairy industry with novel inhibitors of quorum sensing and biofilm formation'. Dr Orla O'Sullivan received funding for 'Investigating the impact of high intensity exercise and/or protein intake levels on gut microbial diversity'.



Pictured at the funding awards announcement are: Dr Avelino Alvarez, Teagasc; Professor Mark Ferguson, Director General Science Foundation Ireland and Chief Scientific Advisor to the government; Dr Orla O'Sullivan, Teagasc and Dr Raymond Kelly Head of Research Support, Teagasc.

## Lecture series



Simon Coveney, the Minister for Agriculture Food and the Marine, gave the last in the Teagasc/RDS lecture series, entitled 'Ireland's Response to Global Grand Challenges in Agriculture and Food'. A full report will appear in the autumn issue of *TResearch*. The lecture is available on the TeagascMedia YouTube channel.

## Commercialisation case manager



Dr Sharon Sheahan recently commenced her role at Teagasc as commercialisation case manager, Technology Transfer Office (TTO). This post is supported by Enterprise Ireland, through the Technology Transfer Strengthening Initiative, through a consortium, which comprises the TTOs of UCC, Teagasc and Cork IT. Sharon's role is to facilitate the commercialisation of intellectual property, by working closely with researchers, industry partners and consortium TTO staff to maximise exploitation of such research outputs.

## Teagasc national berry seminar



**Gary Mc Carthy, Vice Chairman, ISFGA; with Paddy Browne, Head of Crops, Environment and Land-Use Research Programme, Teagasc; Dr Eamonn Kehoe, Teagasc, Wexford; and Dr Jim O'Mahony, Head of Tillage Crops KT and Horticulture, Teagasc at the Teagasc National Berry Seminar in May.**

The Teagasc National Berry Seminar and Trade show, which took place in Carlow in May, heard how further growth in the Irish berry sector is expected. Dr Eamonn Kehoe of Teagasc said that the Irish berry sector continues to be one of the most challenging, rewarding and profitable sectors of Irish horticulture. He said that protected strawberry production continues to be the mainstay of the berry industry in Ireland. The fresh strawberry industry, in particular, continues to grow each year and consumers are now eating €37 million worth of these berries every year. The seminar was organised by Teagasc in association with the Irish Soft Fruit Growers Association and Bord Bia. The latest research and development taking place in Teagasc for the soft fruit sector was outlined, as well as an update on the integrated pest management of crops. The proceedings from the event are available on <http://www.teagasc.ie/publications/>

## Agricultural Research Forum

Over 200 delegates attended the Annual Meeting of the Agricultural Research Forum in Tullamore in March. This meeting provides an opportunity for the presentation and publication of new scientific information relating to the sciences of agriculture (including animal and crop science, molecular biology and biotechnology), environment, soil, food, agri-

economics and forestry, as well as an opportunity for scientists, specialists, advisors and others working in the above areas to interact and exchange views. There were 151 papers presented at the two-day event. The full proceedings of the conference are available from: <http://www.agresearchforum.com/publicationsarf/2014/arfproceedings2014.pdf>

## Declining bird numbers

The recent Bird Atlas, produced by Teagasc, has confirmed the startling decline in the breeding range of a number of the more popular farmland bird species in Ireland. Farmland bird species now constitute the majority of the 26 breeding birds of highest conservation concern with, for example, the range of Lapwing, Curlew and Dunlin declining by 45%, 73% and 81% respectively, over the last 20 years. Current revisions within the Common Agricultural Policy, incorporating dedicated agri-environment measures and schemes under the Rural Development Programme, are an excellent opportunity for Ireland to address declining farmland bird numbers and achieve sustainable objectives under the EU Birds Directive. The atlas is available from the Birdwatch Ireland website.



## Irish rugby team has exceptional guts

Scientists at the Science Foundation Ireland-funded Alimentary Pharmabiotic Centre (APC) at UCC and Teagasc Food Research Centre, Moorepark, have carried out a study in conjunction with the Irish Rugby Football Union that has revealed that exercise and associated dietary changes influence gut microbial diversity. The research is published in the leading international journal *Gut*. The importance of our gut microbes in health and defence against disease is becoming more apparent. In particular, high microbial diversity has been associated with increased health whereas a low diversity of gut microbes has been associated with several diseases and syndromes, including obesity.

To investigate the impact of exercise and diet, scientists at the Alimentary Pharmabiotic Centre studied a group of 'elite' athletes – the Irish rugby team. The study was carried out with 40 male elite professional rugby players (mean age 29; mean BMI = 29.1) immediately prior to the last Rugby World Cup. Because of the physical size of modern rugby players, two groups of healthy male controls of similar age but with BMIs of >28 and <25 were used.

This study highlighted that the gut microbiota of the Irish rugby team had a very high diversity relative to the general public (as revealed by High Throughput Sequencing). The athletes are an exceptional group in terms of their dietary intake, fitness/endurance and, now we know, in relation to their gut microbiota. This high diversity is particularly linked with exercise and protein consumption and suggests that eating specific proteins and/or exercise can provide a means of increasing gut microbial diversity. This is the first report that exercise increases microbial diversity in humans. While it has previously been shown that diet influences microbial diversity, we can now report that protein consumption, in particular, positively correlates with microbial diversity.

The study poses new questions and the Cork team is now prospectively testing the impact of exercise on the microbiota in amateurs of various degrees of fitness and will distinguish the effects of exercise from associated dietary changes.



Tim Guinee, Principal Research Officer in the Department of Food Chemistry and Technology at the Teagasc Food Research Centre, Moorepark, receiving the 2013 Gold Medal Award from Teagasc chairman Dr Noel Cawley.

## Professor Tim Guinee Wins Teagasc Gold Medal

The 2013 winner of the Teagasc Gold Medal is Professor Tim Guinee, Principal Research Officer in the Department of Food Chemistry and Technology at the Teagasc Food Research Centre, Moorepark. The Teagasc Gold Medal is awarded on an annual basis to a serving staff member who has made an outstanding contribution to the organisation and to the agri-food sector.

## Innovative all-Ireland artisan producer network

Teagasc, together with the Causeway Coast and Glens Heritage Trust from Northern Ireland, recently hosted the Économusée All Ireland Business and Networking Forum in the Ballinahown Craft Village, Co Westmeath, at which the All Ireland Économusée Network was established.

An Économusée is an artisan business that opens its doors to the public to provide a learning and interpretive experience for visitors.

At the forum, a brochure and a specially designed web-based sales platform for the newly established network were launched by Carl-Éric Guertin, CEO of the International Économusée Network Society, which is based in Québec, Canada.

The forum was the culmination of a two-and-a-half-year

innovative rural enterprise support project called Craft International, which was funded by the EU Northern Periphery Programme. Together with seven partners from around Europe and Canada, Teagasc and the Causeway Coast and Glens Heritage Trust supported the development of rural artisan producers on the island of Ireland.

Speaking at the Forum, Dr Kevin Heanue who led the project for Teagasc said: "The Économusée concept and project is an innovative model of rural enterprise support, which helps artisan producers diversify their businesses into the cultural tourism market by providing them with a six-step template to help them structure the visitor experience. There is potential for the model and network to be expanded further in Ireland."

## Teagasc supporting Smart Futures & SciFest

Teagasc is partnering with Smart Futures and SciFest to promote careers in science, technology, engineering and maths (STEM).

Smart Futures ([www.SmartFutures.ie](http://www.SmartFutures.ie)) is a collaborative programme between Government and industry that promotes careers in STEM to post-primary students, parents and guidance counsellors. This year, Smart Futures is partnering with SciFest ([www.SciFest.ie](http://www.SciFest.ie)), a national science competition that sees schools across Ireland take part in science fairs. Students with winning projects go to compete in regional heats in the Institutes of Technology in a bid to make it to the national final.

Dr Rita Hickey, Teagasc Food Research Centre, Moorepark, who spoke this year at Limerick IT, says: "Smart Futures is an excellent way of introducing secondary school students to careers in science that they may not have been aware of previously. Students will automatically think of the more traditional roles in science and not realise that alternative options exist." Teagasc researchers who gave presentations at Institutes of Technology around the country included: Dr Dilip Rai, Dr Sinead McCarthy, Dr Maria Hayes, and Dr Anne Mullen, Ashtown; Dr Rita Hickey, Moorepark; and Dr Daire Ó hUallacháin, Johnstown Castle.



## 2014 Teagasc Fulbright Award

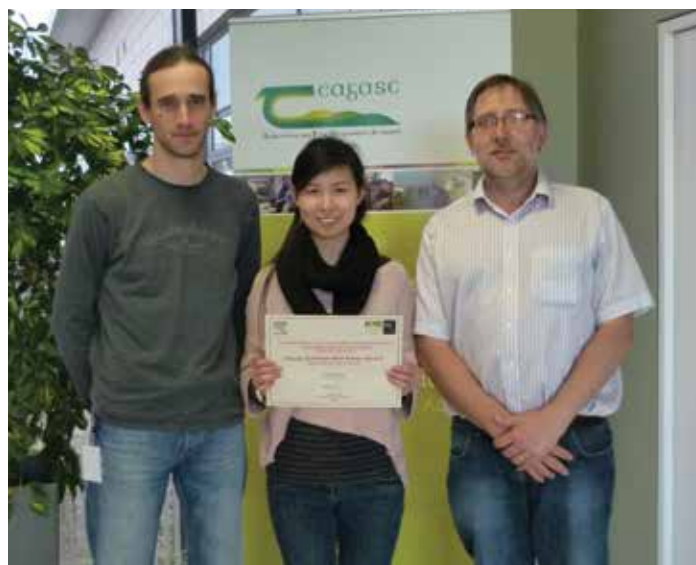
Niamh Murray was recently awarded the 2014 Teagasc Fulbright Award. Niamh is currently enrolled in a Research Masters with Food for Health Ireland (FHI), based in UCD on a scholarship funded by Enterprise Ireland. Niamh plans to transfer to a PhD programme this year. She will use her Fulbright award to spend 12 months in the University of California, Davis, investigating the 'Flavour and Sensory Attributes of Bioactive Milk Peptides'. Milk peptides have been shown to have a number of health benefits including anti-inflammatory and anti-hypertensive effects. In addition, they have the ability to control glycaemic response, protect against infection and enhance immune responses. Therefore, they have excellent potential for the development of innovative foods with health benefits.



Dr Frank O'Mara with Teagasc Fulbright Award recipient Niamh Murray and Dr Lance O'Brien, Teagasc Fulbright Scheme.

## Food Structure and Functionality Forum

Congratulations to Meng Li who received the Young Scientist Best Poster 2nd prize at the Food Structure and Functionality Forum Symposium for her poster entitled: The effect of covalent labelling techniques on dairy protein stabilised emulsions. Meng is a Teagasc Walsh Fellow working in the Department of Food Chemistry and Technology. Her research involves developing new confocal microscopy techniques for characterising dairy-based emulsions. She works under the supervision of Dr Mark Auty and co-supervisors Dr Andre Brodtkorb and Dr Seamus O'Mahony (UCC). Her work forms part of a larger dairy levy-funded project developing SMART ingredients for the dairy industry.



## Index of the economic strength of rural towns

Teagasc Head of Rural Economy and Development, Professor Cathal O'Donoghue recently presented the Teagasc Index of Rural Towns in Dublin. Speaking at the launch, he said: "Rural towns and their immediate hinterlands account for about a third of the population and have been affected to a greater extent by the economic crisis in terms of unemployment."

He added: "These rural towns have had a lower focus in national development strategies over the past decade and a half. However, the launch of the CEDRA report next week will help to fill this policy vacuum."

Analysing the index, he noted that there is huge variation between the strongest and weakest towns:

- There is a 50% point difference between the unemployment rate in the strongest 20 per cent and the weakest 10%.
- There is a large 40% point difference in the levels of tertiary education in the strongest and weakest towns.
- The weakest towns also have a larger proportion of unoccupied housing than average.
- Additionally, stronger towns have positive net migration rates while weaker towns suffer negative ones.
- Weaker towns are more likely to be towns within net-inward commuting than outgoing commuting, reflecting their economic importance in more peripheral areas.

A full report will appear in the autumn issue of *TResearch*

### FameLab

Well done to Ruairi Robertson, Teagasc Food Research Centre, Moorepark, who came second in the FameLab Ireland finals last night. Ruairi spoke about how the bacteria in our gut can affect mood and about probiotics that are being developed in this area. Sara Vero from Teagasc, Johnstown Castle, also competed. Sara talked about the cleansing and antibacterial properties of soil.

FameLab is a global science communication project. The FameLab Ireland 2014 finals can be viewed on <https://dublin.sciencegallery.com/events/2014/01/famelabirelandnationalfinals2014> (Ruairi's talk starts at 37:18 and Sara's at 1:06.45).

Ruairi and Sara have participated in a number of Science Communication initiatives this year. Ruairi also competed in UCC's 'Science for All' final. Ruairi, Sara and Dr Ewen Mullins, Teagasc, Oak Park, participated in 'A Pint of Science' festival, which took place in Dublin in May. The festival that aims to make science accessible and fun by bringing current scientific research to the welcoming atmosphere of the pub. Sara also won the AECOM Student Environmental Award competition 2014.

### World-first Pasture Profit Index

The Pasture Profit Index for perennial ryegrass cultivars in Ireland has been developed by Teagasc in conjunction with the Department of Agriculture, Food and the Marine and a prototype of the index was launched in May. The purpose of the index is to assist grassland farmers to identify the best perennial ryegrass cultivar(s) for their farm. The index comprises of six sub-indices: spring, mid-season, and autumn grass dry matter (DM) production, grass quality (April to July, inclusive); and 1st and 2nd cut silage DM production and persistency. The economic merit of a cultivar for each trait was calculated by determining the difference between its performance and the base value for that trait, and this was then multiplied by the economic value for that trait using the Teagasc Moorepark Dairy Systems Model.

## Prestigious honour for Teagasc researcher



Dr Paul Ross PhD, DSc, Teagasc Food Research Programme, Moorpark, Fermoy, is one of 88 microbiologists have been elected Fellows of the American Academy of Microbiology. This prestigious honor recognises those who have made significant contributions to the field of microbiology. Fellows of the Academy are elected annually through a highly selective, peer-review process, based on their records of scientific achievement and original contributions that have advanced microbiology. There are over 2,400 Fellows representing all subspecialties of microbiology, including basic and applied research, teaching, public health, industry, and government service. Dr Ross is the only Irish representative among the 88 Fellows elected.

## Predicting nitrogen mineralisation

Noeleen McDonald, Teagasc Johnstown Castle, recently published a paper from her PhD work in SSSAJ entitled: 'Evaluation of soil tests for predicting N mineralisation in temperate grassland soils. This paper has been selected as the highlight paper from SSSAJ in their most recent issue. CSA-News (Crop Soil Agronomy) is the monthly magazine of the three American agricultural societies. Each month they have a cover article plus one highlighted paper from each of the five journals published by the societies. See: <http://t.co/8XEm05gObe>

## Pioneering agri-food research

The first joint Science Foundation Ireland/Teagasc themed research funding call, 'Future Agri-Food' awarded €2.5 million to two research projects. 'Using precision technologies, technology platforms and computational biology to increase the economic and environmental sustainability of pasture based production systems' is led by Dr Laurence Shalloo, Teagasc, in collaboration with Dr William Donnelly of Waterford Institute of Technology (WIT). The research focuses on the use of information and communication technologies for agriculture, often referred to as smart agriculture or e-agriculture. 'The development of early non-invasive and reliable

molecular biomarkers of pregnancy in dairy cattle' is led by Professor Michael Diskin of Teagasc in collaboration with Professor Mark Crowe of University College Dublin. The aims of this project are to use the latest targeted molecular approaches to validate and commercialise recent findings of putative novel molecular biomarkers of early pregnancy in dairy cows, and progress them to application and licensing as inline automated systems for pregnancy diagnosis in cattle. This proposal will involve collaboration with Dr Eithne Dempsey, Institute of Technology, Tallaght and Professor Pauline Rudd of the National Institute for Bioprocessing Research and Training.

## AranLIFE

The Minister of State in the Department of Arts, Heritage and the Gaeltacht, Dinny McGinley, TD, officially launched the AranLIFE project on Inis Oírr in June 2014. The key objective of the project is the further development and demonstration of best-practice management as it relates to conservation among the farmers of the Aran Islands. Local farming knowledge and experience will be harnessed, as well as scientific expertise to overcome some of the challenges associated with island-farming.

The AranLIFE project, which is worth €2.6 million is an integrated project between the Department of Arts, Heritage and the Gaeltacht, Teagasc, the Institute of Technology Sligo and the farming communities of the Aran Islands. Additional funding is provided by the Department of Agriculture, Food and the Marine, the Heritage Council, Galway County Council and Fáilte Ireland.



**The AranLIFE project team Amanda Browne, Patrick McGurn and Gráinne Ní Chonghaile with Minister of State Dinny McGinley.**

It is estimated that approximately 70 farms across the three islands will participate in the project, which will last four years.

## Alltech Young Scientist



**Dr Inge Russell, director of the Alltech Young Scientist Competition; Gillian Johnson, undergraduate winner of the Alltech Young Scientist Competition; and Dr Mark Lyons, Alltech vice president, at the 30th Alltech Annual International Symposium in the USA in May. Credit: ZimmComm.**

Gillian Johnson, a final year Equine Science student at the University of Limerick, has won first place in the Alltech Young Scientist Competition. Gillian won the regional phase (Europe, Africa and Middle East) of the competition in April and went on to the global phase in the final, which was held in Lexington City, Kentucky. Supervised by Dr Sean Fair in the University of Limerick and Dr Kieran Meade in Teagasc, Grange, Gillian performed a research project in Teagasc entitled 'Comparative Genomic Identification and Characterisation of a Novel  $\beta$ -Defensin Gene Cluster in the Equine Genome'. Briefly, Gillian identified a cluster of 13 novel  $\beta$ -Defensin genes which she found to be expressed along the reproductive tract of the mare and stallion.



# Beetle threat to horticultural Eucalyptus crops in Ireland

The parasitoid wasp *Enoggera nassau* in the act of parasitising a beetle egg.



Researchers at Teagasc and University College Dublin are investigating the biological control of a new insect pest of Irish forestry and horticulture.



The accidental introduction of the Eucalyptus leaf beetle pest, *Paropsisterna selmani* into Ireland, poses a significant threat to our commercial foliage, biomass and forestry industries. This is the first paropsine leaf beetle to become established in Europe and it was initially discovered damaging foliage crops in Kerry in 2007. It is now commonly found in many areas of Cork. Predictions of the patterns of spread, suggest that it is only a matter of time before it is established throughout the island and this poses a bio-security risk to the UK and mainland Europe. The colourful beetle defoliates Eucalyptus trees and even small amounts of damage renders Eucalyptus foliage crops unmarketable. In the absence of natural control, insecticide applications have been used by foliage growers, but the unfortunate side-effect of this is the disruption of the successful biological control of another invertebrate pest, a sap-sucking psyllid. Access difficulties deem that insecticides are not a viable option for the forestry or biomass sector.



## Dorothy Hayden,

Teagasc Walsh Fellow  
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## Bicontrol agents

A parasitic wasp, *Enoggera nassau* has been used as a bio-control agent of similar leaf beetles in New Zealand and was imported into a quarantine insectary in University College Dublin (sponsored by Coillte) for further study. Dorothy Hayden, a Teagasc Walsh Fellow PhD student, is currently investigating the suitability of this egg parasitoid as a biocontrol agent for the leaf beetle in Ireland. The research will provide the necessary information to fulfil the requirements of a risk assessment required, if a field-release application is considered safe. The benefits of establishing a natural control agent for the beetle under field conditions include:

- retention of valuable market share and profitability for foliage growers
- growth of biomass and short rotation forestry
- resumption of biological control of the psyllid pest where insecticides had been used
- positive environmental benefits, and
- reduced likelihood of the beetle spreading to neighbouring countries.

“Our research is investigating whether it is safe to release the biological control agent into Ireland. We are investigating its response to Irish weather conditions, its success in attacking the pest species and the extent to which it will only attack the pest species. This work will also inform future control strategies if similar leaf beetles are accidentally introduced into Europe,” says Dorothy.

The eucalyptus leaf beetle pest  
*Paropsisterna selmani*.





# NetGrow Toolbox for Innovation Networks



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The EU NetGrow project to support 'smart' networking by food SMEs culminated in an event in Brussels recently, at which the NetGrow Toolbox was launched.

A toolbox to support the strategic management of innovation networks in the context of open innovation was launched at a unique networking event in Brussels on April 10. The occasion, which brought policy makers, food companies and researchers together, marked the final event held by the NetGrow consortium. The consortium, funded by the European Commission, undertook research with the ultimate aim of enhancing the innovativeness of food SMEs through the management of strategic network behaviour and network learning. By examining the network preferences of food SMEs and the performance of networks, the consortium produced a research-based toolbox in support of this aim. Teagasc, with a research team comprising Drs Maeve Henchion and Douglas Sorenson, were one of nine partners in the consortium, and were lead partners for one work package.

## Networking for development of SMEs

Professor Xavier Gellynck, project coordinator from

the University of Ghent, outlined the rationale for the project, i.e., that networking with other businesses and organisations can help SMEs develop their operations and adopt innovative practices, thereby contributing to their competitive position and growth. Dieter Brigitta, Research Programme Officer at the European Commission welcomed the development of the NetGrow Toolbox and outlined some relevant issues in the EU's new Research and Innovation programme Horizon 2020. Dr Frances Fortuin and Roland Klefoth from Food Valley NL introduced the NetGrow Toolbox. They showed that the toolbox is like a recipe book whereby each tool is ordered in a logically sequential way, but each tool can also be used independently of the other tools.

## NetGrow toolbox

The NetGrow toolbox has nine hands-on tools that can be used by different target groups as follows:

- 'Why Networks Work' is meant as an appetiser to show how putting some extra effort into finding the right network can really pay off for food SMEs;
- 'Find your Network' is a tool intended to help food SMEs make a first selection from the wide variety of networks available in Europe. It provides an overview of the different types of food networks and the kind of services offered by each one;
- 'Identify your Needs' is designed to help food SMEs translate their company's ambitions, challenges



or problems into expressed needs to be addressed by their network(s);

- 'Define Innovation Process Steps' can be used by food SMEs to take a critical look at their own innovation process and to determine which steps in the process require support from their network(s);
- 'Evaluate your Network' and 'Match your Needs' provide a set of questions and schemes that can be helpful in the process of network selection;
- 'Creating Excellent Networks' and 'Customer Satisfaction' are tools specifically developed for network managers to align their network offerings to the needs of food SMEs. 'Creating Excellent Networks' provides suggestions and recommendations, whereas 'Customer Satisfaction' provides hands-on guidance for managers of food networks to set up and analyse their own customer satisfaction survey; and,
- Finally, the toolbox provides recommendations for policy makers on how to create optimal conditions for food networks as a way to increase innovation, economic growth and sustainable competitive advantage in the food sector in Europe.

### Barriers to innovation and networking

The strength of the toolbox lies in its confrontation with the business perspective throughout its development, i.e., it is tailor-made for food SMEs, based on their inputs during the research phase of the project and, also, their valuable feedback provided during the two-stage testing of the toolbox with food SMEs and network organisations.

Following the presentation of the toolbox, a keynote speech from Dr András Sebök, General Manager from Campden BRI (Hungary) and member of the research expert group of FoodDrinkEurope, reported that SMEs are not homogeneous in their innovation behaviour. It also highlighted that companies like to learn from each other but emphasised that they needed successful examples to do so. Lack of trust and lack of knowledge and skills are barriers to innovation and networking according to Dr Sebök.

### Practical experiences of networking

This was followed by three key-note speeches from Dutch, Irish and Italian businesses that have practical experience of being involved in various networks. Rob Bendsdorp, Operational Director, DOC Kaas (the Netherlands), a company that processes in excess of 1 billion litres of milk per annum said that companies need to share the knowledge they have in order to obtain the knowledge they don't have. He said that networking is not about "free drinks and a nice day off", but that it is important to legitimise the time spent networking by ensuring that all successes that arise from networking are celebrated and that benefits that arise from networking are clearly acknowledged. He gave practical examples of information shared and gained in his company to illustrate this.

Ross Campbell, Business Director, Cybercolloids Ltd (Ireland) gave practical tips for companies getting involved in networking, including being "vulnerably honest". He also said that "intelligent receivers" are needed within companies for networks to work well. He gave an example of a role policy makers could undertake in relation to supporting SMEs to protect and commercialise intellectual property.

Giampiero Reggidori, Apoconerpo (Italy) outlined the structure of his successful organisation. With a turnover of €705 million, the group comprising 7,100 farmers, 56 packhouses and a sales



Pictured at the NetGrow event in Brussels are (from left): Professor Xavier Gellynck, University of Ghent, Project Coordinator; Dr Maeve Henchion, Head of Department, Agrifood Business and Spatial Analysis, Rural Economy and Development Programme, Teagasc; and Ross Campbell, Business Director, Cybercolloids Ltd.

operation, sells fruit and vegetables to the retail and processing trade in Italy and to the export market. One of its key strengths is the technical advice and information it gives to farmers through farm visits and through the use of the internet and SMS supports. The organisation also undertakes research, the nature of which is influenced by a range of stakeholders.

Karen Thorsted Hamann, Director, Institutet for Fødevarestudier & Agroindustriel Udvikling (Denmark) outlined the challenges of developing a new network, based on hands-on experience from a new cluster in Denmark.

Although the NetGrow project ended on April 30, its insights and impact will continue with the establishment of an international forum to support SMEs and network organisations to adopt the NetGrow Tools. Karen Thorsted Hamann, member of the NetGrow consortium and manager of an SME herself, has agreed to lead the creation of this international forum.

Dr Henchion, Teagasc, said that the more companies become involved in the activities of networks, and the more they interact with others, the better their performance will be: "However, these activities cannot be ad hoc because time and money are scarce in all organisations, regardless of size. The NetGrow Toolbox can help companies and network managers to ensure that scarce resources are used well." For example, she said, it can help companies to decide which network they should become involved with and it can help network managers to review their network and ensure they are meeting their members' needs.

The NetGrow toolbox, which contains guidelines, questionnaires, recommendations and other tools that can help companies network more strategically and learn within networks, is available at [www.netgrow.eu](http://www.netgrow.eu)

Alternatively, hard copies may be requested by emailing [maeve.henchion@teagasc.ie](mailto:maeve.henchion@teagasc.ie)

The NetGrow consortium comprised Ghent University (Coordinator, Belgium); Institutet for Fødevarestudier & Agroindustriel Udvikling (Denmark); Institut Polytechnique LaSalle Beauvais (France); University of Bonn (Germany); University of Debrecen (Hungary); Teagasc (Ireland); University of Bologna (Italy); Food Valley NL (Netherlands); Skane Food Innovation Network (Sweden) and was funded by the EU Framework Programme 7.



# Sensory Food Network Ireland

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Funding has recently been awarded to establish a national network of excellence in sensory science on the island of Ireland.

Sensory Food Network Ireland is a new national network of excellence, funded by the Department of Agriculture, Food and the Marine, under the FIRM programme. The network is coordinated by Drs Eimear Gallagher and Sinéad McCarthy from Teagasc, Ashtown and also includes all leading institutions with expertise in sensory science from the island of Ireland. These partners include Agri-Food and Biosciences Institute; University College Cork; University College Dublin; Dublin Institute of Technology; College of Agriculture, Food and Rural Enterprise; St Angela's College, Sligo; Galway-Mayo Institute of Technology; University of Ulster; Northern Ireland Centre for Food and Health; and Limerick Institute of Technology. The network will work as

a sustainable unit to address documented needs and gaps by the food industry in relation to sensory science. It will also ensure that good practice and the highest level of service will be assured to industry.

## Scientific excellence in sensory food science

As well as a first-class service to industry, the network aspires to the highest level of scientific excellence in research in sensory food science. All members of the network are dedicated to developing and improving research into sensory and consumer testing methodologies, with the aim of launching Ireland on the international map in this field. The over-arching objective of the network is to promote integration, ensure sustainability and build a robust model for all sensory science activities on the island of Ireland. One aspect of this will be to accomplish excellence and international recognition in the discipline of sensory science service and research. Mr Declan Troy, Assistant Director of Research at Teagasc



## Growing importance in the food industry

The importance of this network has been endorsed by Mr. Richard Howell, Head of Research & Codex Division, Department of Agriculture, Food and the Marine: "This investment by DAFM will strengthen and integrate the current expertise in sensory food science in Ireland and provide a platform that will better address the commercial needs of the food industry in terms of new product development and the opening of new markets thereby assisting in reaching our Food Harvest 2020 targets. It will also help promote good nutrition and healthy eating."

Worldwide demand for food, decreasing trade barriers, changing lifestyles, expanding world markets and removal of EU quotas continue to accelerate the Irish food industry's need for new products, quality improvements, extended shelf-life and more efficient ways of producing products. Success in this regard depends on the industry's ability to satisfy consumer demand and expectations. In particular, it needs to develop precise knowledge about how these sensory expectations are implemented and measured.

Sensory Food Network Ireland will have a dual role to play in serving the Irish food industry: Firstly, as a specialist service to the marketing, development and manufacture of new and modified food products. Monitoring competition by evaluating new and current competitive products, measuring new product differences as a function of scale-up, measuring sensory differences as a consequence of lowering production costs or ingredient/package variables. Secondly, it has a research role in improving the methodology of testing, devising the most appropriate tests for real-time problems and improving the expertise in flavour chemistry and sensorimetric methodologies.

The network of excellence will strengthen existing scientific and technological excellence in sensory science by integrating at national level the critical mass of resources and expertise needed to provide leadership and to be a future international force in this area. This expertise will be networked around a joint programme of activities (both research and service provision) aimed principally at creating a progressive and durable integration of the research capacities of the network partners, while, at the same time, advancing knowledge on the topic.

A dedicated website will provide updated information on training events, research highlights and upcoming seminars and conferences [www.SensoryFoodNetworkIreland.ie](http://www.SensoryFoodNetworkIreland.ie)

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A stylized map of the United Kingdom and Ireland is shown in a light green color. Overlaid on the map are several interlocking gears in a darker green color. The title 'UK-Ireland business summit' is written in a large, blue, sans-serif font across the middle of the map.

# UK-Ireland business summit

An action report was recently published following the first UK-Ireland food business innovation summit. It outlines three priority actions that will help build success for the future.

Against a backdrop of increasing interdependence between Ireland and the UK, Taoiseach Enda Kenny and Prime Minister David Cameron agreed that a Joint Statement, issued in March 2012, would be the foundation for building even stronger relations between the two nations.

The agri-food sector was specifically identified as an area that holds considerable potential for closer cooperation. Declan Troy, Assistant Director of Research and Director of Technology Transfer Office, Teagasc, says this makes perfect sense since the UK is the biggest customer of Irish food and drink exports; while, similarly, Ireland is a key customer for UK food and drink products.

#### **An action plan**

As a direct consequence of the call to support the needs of the food and drinks sector, Teagasc and the Institute of Food Research (IFR) in the UK, supported

by a number of other UK and Irish partners, organised the first UK-Ireland Food Business Innovation Summit, which was held in Dublin in May 2013.

The recently-published report, *Innovation in the Ireland and UK Food Sector: Ambitions for Action*, is a dissemination of the outcomes from that event and outlines three areas for greater collaboration between the islands: innovation, skills and research.

"The aim of the event was to have a discussion on how the two regions can join in non-competitive food areas and use best practice from the two regions," explains Declan. The UK-Ireland Food Business Innovation Summit brought together leading UK and Irish food company executives and retailers, along with policy makers, research managers and educationalists to debate key challenges and opportunities for innovation in the agri-food sector on both islands.

Five keynote speakers, who Declan describes as thought-leaders in the industry, addressed attendees at the event. Subsequently, delegates divided into several focus groups to discuss potential areas for cooperation between the two nations. The resulting report, *Innovation in the Ireland and UK Food Sector: Ambitions for Action* summarises these discussions and outlines three targeted actions for collaboration that will support food innovation in the two islands.



### Ireland-UK food hub

The first of these proposed initiatives is the creation of an Ireland-UK food hub, which is at the initial stage of development. The hub will consist of the main agencies in the agri-food business, government departments and stakeholders from both regions. The remit of the hub is to identify joint, key-growth areas for collaborative action. The hub will also act as a focal point for innovation cooperation in the food supply chain, encouraging and supporting collaboration between SMEs, retailers, large producers and manufacturers, universities, technology centres and research providers, consumer organisations and government agencies.

The hub will support the Summit's other recommendations including: improved competitiveness and developing an 'ecosystem for entrepreneurship'.

Taking cognisance of the competitive nature of the food industry, Declan concedes that there is a point in which collaborators will have to go their separate ways. "We are not focusing at market-level cooperation. This would be more 'downstream' in the food chain, such as the creation of business research programmes, or the initiation of education programmes."

### Improving competitiveness

The UK and Irish hub partners will collaborate to improve the competitiveness of the food industry by working with the UK Technology Strategy Board (TSB), Enterprise Ireland and other agencies to address common challenges affecting the UK-Ireland food value chain. Declan refers to the growing consumer trend for reduced salt and sugar levels in food, as well as generating value from current food waste streams, as examples for areas for combined research.

Furthermore, it recommends that funding agencies covering the agri-food sector in both regions should explore the creation of bilateral funding programmes to underpin the key growth collaboration areas. These programmes, it adds, should take the form of public/private partnerships to integrate industry, education and research activities across both regions in the areas.

Additionally, the report encourages the stimulation of inter-company collaboration and learning. In practical terms, Declan explains, this could be an opportunity for companies who avail of Innovation Vouchers in Ireland and the equivalent funding in the UK to combine their funding to research a common cause. "In other words, can the Irish companies avail of expertise in the UK and vice versa? We would be very strong on meat and dairy and they would be strong on process engineering and manufacturing and alcoholic beverages and brewing."

Declan says the exchange of knowledge is already taking place in an informal way. "We are already building specialised food research

infrastructure here, and there are UK food companies visiting these facilities with a potential for open-innovation collaborations. But, the question is, do all the companies in the UK know what we have and do all the Irish companies know what is in the UK? So, that will be another action between the two."

### Pioneering an 'ecosystem for entrepreneurship'

The dominant thread, throughout all discussions on education, innovation and entrepreneurship, was the importance of skills. Through the hub, it is intended to create, what the report calls, a UK-Ireland 'ecosystem for entrepreneurship'. It will achieve this through improved access to finance and the innovation skills base.

Declan says the hub will also develop active interfaces between academia and industry to create industry-relevant education, including innovation and entrepreneurship-focused courses.

Declan says there is an opportunity for joint, educational programmes and modules between the universities. This he said could include joint-funding PhD students to partake in studies in both the UK and Ireland.

Marketing of the sector to attract talented individuals was also highlighted as an area for improvement. It is hoped this will encourage younger people in the UK and Ireland to engage with the sector, as well as identifying areas for innovation in the skills chain in both regions.

### A common agenda

Declan says both markets experience similar challenges and opportunities. He adds that examples of collaborations, such as those outlined in the Summit report, are already taking place in a fragmented manner. The Ireland-UK food sector hub, he suggests, would provide a cohesive structure for such collaborations.

In the EU, a similar initiative, Horizon 2020, has funded Knowledge Innovation Communities (KIC) that carry out research in areas such as information and communications technology, climate change, and energy. Declan says there will be similar funding for a food KIC down the line and he believes the Ireland-UK food hub will be aligned with the ambitions of that initiative.

The first meeting of representatives of the Ireland-UK food sector hub will take place in March and it is proposed that a second, follow-on UK-Ireland Food Business Innovation Summit will take place in the UK in 2014 or early 2015.

Based on an article first published in *Irish Food* Issue 2, 2014.

# Storage conditions and potato glycoalkaloids

At a recent ‘waste not, want not’ event for the food industry, Teagasc researchers presented on the effect of storage conditions on the levels of toxic glycoalkaloids in potatoes. These must be monitored, on the one hand, for potato producers and associated manufacturers but, on the other hand, offer potential for use in the drug manufacturing industry.



Ireland produces a significant amount (232,000MT) of potatoes. Irish consumers' spending on potatoes stands at approximately €162 million each year; with 95% penetration to Irish households. Potatoes, being a good source of protein, vitamins and minerals with low fat content, are attracting more and more consumers worldwide every year, which is reflected in the growth of annual production by 15.2% in the period 2002 to 2012 (FAO, 2012). However, the potato is also known to contain a potential toxic group of compounds called glycoalkaloids, which are sugar-bound alkaloids. Potato glycoalkaloids are currently being monitored in marketed potato and potato products by the regulatory bodies across the globe. According to the United States Department of Agriculture (USDA), a maximum recommended level of glycoalkaloid in potato is 1mg/g dry weight (DW). Previous research studies have shown exposure to light and elevated temperature significantly enhanced the glycoalkaloid levels in potato tubers (Petersson *et al.*, 2013; Sengül *et al.*, 2004). However, the extent of the effect largely varies with the potato cultivars. Since Irish potato processing industries utilise mainly the local produce, a study of the effect of storage conditions on the major Irish cultivars was warranted.



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## Storage test conditions

Five potato varieties, namely: Cultra, Lady Rosetta, Maris Piper, Rooster and Premier (commonly processed and consumed in the island of Ireland), were subjected to the following storage conditions: 4°C in dark (4°C, dark); room temperature (RT), approximately 23°C in dark (RT-dark); and light (RT-

light) for a period of 90 days. These storage parameters were chosen considering the normal practice by the growers and processing industries. Levels of glycoalkaloids in whole potato, peel and pulp were monitored at an interval of 30 days, i.e., at day 0, 30, 60 and 90 of storage. In all the varieties, glycoalkaloids ( $\alpha$ -solanine and  $\alpha$ -chaconine), showed a significant difference among the samples of different storage conditions. All the samples from room temperature, irrespective of light or dark (except Premier), showed the highest level of total glycoalkaloids at 30 days storage followed by a gradual decrease at days 60 and 90 (Figure 1). This indicated that biosynthesis of glycoalkaloids was triggered as a stress response from storage at room temperature in the month-long period. Following 30 days of storage, the potato tuber cells might have undergone a detoxification approach as an excessive amount of glycoalkaloids in the cells would be damaging to cell membrane and membranes of organelles. Among the potato varieties chosen, Lady Rosetta had the highest while Premier had the lowest glycoalkaloid content regardless of storage condition (Figure 1a, d). The Premier potatoes did not reach the maximum level required for cytotoxic effects in any of the storage conditions, and hence accumulation of glycoalkaloids continued until 90 days. In general, room temperature samples (RT-dark and RT-light) had higher glycoalkaloid content than the samples stored at 4°C, which indicated that the accumulation of glycoalkaloids occurred faster at elevated temperature. As expected, samples of RT-light showed higher levels of glycoalkaloids compared to the RT-dark samples, since light is one of the stress factors for plants.



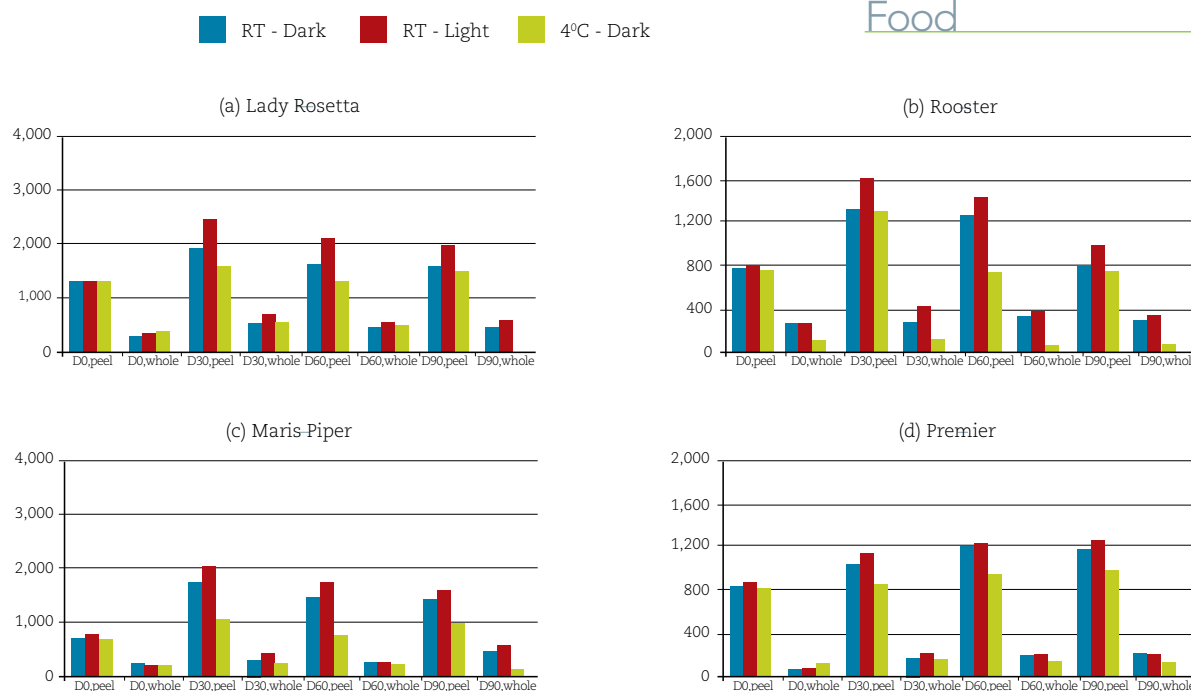


Figure 1. Changes of total glycoalkaloid content as a response to temperature and light in different potato cultivars, (a) Lady Rosetta, (b) Rooster, (c) Maris Piper, and (d) Premier.

### Chilled storage

Contrary to room temperature, total glycoalkaloid content of the chilled storage (4°C) had a significant increase at day 90 (Figure 1). As the samples of 4°C after 60 days maintained good quality by retaining moisture and preventing sprout growth, these samples were equally physiologically more active than their counterparts in RT-storage. Therefore, these samples could initiate biosynthesis of glycoalkaloids again after 60 days, whereas the samples at RT after 60 days became soft, dehydrated and sprouted leading to continuous decline in glycoalkaloid in tubers. Other quality parameters such as browning and greening were minimal in chilled storage. While potatoes stored at RT-dark were prone to quick and robust sprouting and moderate wilting. Storage of tuber in light at RT showed moderate to robust greening, wilting and sprouting at the end of the storage trial experiments. Therefore, a chilled storage of potato tubers is highly recommended.

### Acceptable levels

This storage study also showed the glycoalkaloids of potato pulp and whole potato were below the threshold level set by USDA even at or after 30 days of storage, where the glycoalkaloid accumulation in peels peaked in the room temperature. Therefore, consumption of potato pulp and whole potato can be considered safe even if the tuber surface, i.e. peel is green. However, one must be cautious with variety Lady Rosetta, the pulp of which is primarily used for crisp manufacturing. According to Friedman and McDonald (1997), toxic effect might commence if an individual consumes more than 1mg/kg body weight of glycoalkaloid. This means that an individual of 70kg will require 70mg glycoalkaloid to have onset of toxic symptoms. For consumption of 70mg glycoalkaloid, the individual will need to consume 500g of fresh weight whole potatoes of Lady Rosetta stored at RT-light for 30 days. Nonetheless, all the varieties including Lady Rosetta contained glycoalkaloid in the range of 0.05 to 0.31mg/g DW before the storage. In this case, it will require consumption of more than 1kg of fresh whole Lady Rosetta, which is unlikely portion to be consumed, to have toxic effect. Hence, consumption of only peel, which is very unlikely, should be avoided regardless of storage conditions.

### Relevance to industry

Potato processing industries have to procure potato tubers well before they process them. So they store them for using at a time when potatoes are not available from the growers. However, storage condition might enhance the tuber's level of glycoalkaloid which is a potentially toxic compound. Industries also use different cultivars to make their products due to fluctuations in availability. Therefore, information on these topics is important for the industry to assure a safe product for the consumers. For the phytopharmaceutical industry, where alkaloids are much sought after for potential anticancer drug development, potato peels after 30 days of storage at room temperature in light will be an excellent source. Our own studies in this project have shown that the sprouts and berries might be a suitable alternative to peels as they contain very high levels of glycoalkaloids. Nevertheless, the biggest advantage of potato peels is their abundance in Irish agri-food processing industries.

### References

- Friedman, M., McDonald, G.M., and Filadelfi-Keszi, M. (1997) 'Potato glycoalkaloids: chemistry, analysis, safety, and plant physiology'. *Critical Reviews in Plant Sciences*, 16(1): 55-132.
- FAO. (2012) 'FAOSTAT'. Accessed at <http://faostat.fao.org/site/339/default.aspx>
- Petersson, E.V. et al. (2013). 'Glycoalkaloid and Calystegine levels in table potato cultivars subjected to wounding, light, and heat treatments. *Journal of Agricultural and Food Chemistry*, 61:5893-5902.
- Sengül, M., Keles, F. and Keles, M.S. (2004) 'The effect of storage conditions (temperature, light, time) and variety on the glycoalkaloid content of potato tubers and sprouts. *Food Control*, 15(4): 281-286.

### Acknowledgments

This study has been carried out with the financial support from the Potato Peel project funded under the Food Institutional Research Measure (FIRM, 08/RD/AFRC/673) by the Irish Department of Agriculture, Food and Marine.

# Controlling textural deterioration in high-protein bars

The use of milk-derived protein powders as ingredients in high-protein, energy and nutrition bars has grown significantly in recent years.

High-protein bars are popular as meal replacers and with consumers engaged in exercise and weight loss. They provide healthy alternatives to conventional snacks due to high levels of protein (15-35% w/w) and other nutritionally beneficial ingredients. Inclusion of protein at such high levels, however, can result in adverse quality effects, specifically hardening reactions, which can make products unacceptable after four to six months. Such storage stability issues present a challenge to protein bar manufacturers.



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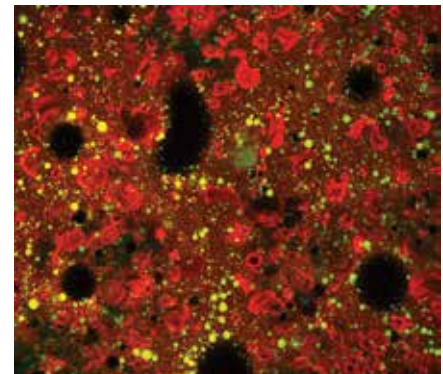


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## Components of protein bars

The most commonly used proteins in high-protein bars are derived from milk and soya. Commercial bars may contain as many as six or more types of protein, which makes their individual contributions to hardening almost impossible to determine. Anecdotal evidence, however, suggests that mixtures of proteins are beneficial with respect to hardness, compared to single protein systems.

Typical bar systems contain protein (in powder form), carbohydrate (various fructose and glucose syrups) and oils (usually vegetable), in an approximate calorific ratio of 30:40:30, respectively. Plasticising agents, such as glycerol and other sugar alcohols, are also included to control moisture levels and provide structural flexibility. High-protein bars contain low levels of moisture (approximately 15% w/w) and have water activities (chemically available moisture) in the region of 0.6, which is below that at which microbial



Representative CSLM image of high-protein snack bar. Red: Protein/carbohydrate; Green: Fat; Black: Air voids)

spoilage occurs and precludes the requirement for refrigeration – a considerable advantage in terms of transport and storage costs.

## Manufacturing process

Manufacture of protein bars is a relatively simple process that involves mixing of ingredients with the carbohydrate phase acting as a binding agent for the other components. Subsequent physicochemical changes, however, are less well-understood and a complex array of factors determines stability over time. A number of mechanisms for the development of hardness have been proposed to date. These include aggregation of proteins, following formation of both intermolecular, disulphide bonds and non-covalent interactions; Maillard reactions (protein-sugar interaction); moisture migration and phase separation phenomena. Moisture loss is not a contributing factor as products are sealed to prevent drying.



### Hardening in protein bars

In effect, no single causative mechanism is responsible for hardening in protein bars. Rather, it appears to be due to a number of, sometimes confounding, chemical, physical, thermodynamic and process-related factors. It is generally accepted, however, that discontinuities in the osmotic potential between different components or micro-regions, within the bar matrix, are the driving force for hardening. Mixing of protein powders with liquid carbohydrates (the main source of water) results in a non-equilibrium state in which differences in the chemical potential of water cause diffusion of moisture into powder particles, i.e., from regions of high to low water activity. Partial hydration of proteins (moisture levels are insufficient for complete hydration) results in molecular re-arrangement, protein aggregation and structural change. Over time, the system undergoes an increase in entropy (decrease in free-energy) as equilibrium is approached.

### Understanding physical and chemical factors

The objectives of this project were to explore the effects of a variety of milk protein powders on textural change in high-protein bar



systems and to improve fundamental understanding of the physical and chemical factors that govern structure formation and stability in concentrated, food matrices.

The research, carried out in collaboration with Professor Yrjö Roos (Department of Food and Nutritional Sciences, UCC) examined a wide range of factors thought to affect textural deterioration over time. These included comparison of the roles of individual milk protein powders, control of bar macro-structure through the use of co-dried powders (mixed protein and protein/carbohydrate powders produced by spray drying) and detailed analytical examination of ingredient interactions and mechanisms in model bar systems. Subsequent research explored 'jamming' phenomena of powder particles in high-solids systems, the nature of the 'liquid-solid transition' during the viscoelastic development of solidity and the effects of concentration on particle organisation and change during storage.

The work employed a wide range of analytical techniques to characterise the physicochemical properties of powders and protein bar systems. These included particle size analysis, density measurements, moisture sorption behaviour, texture analysis and rheology, confocal scanning laser microscopy (CSLM), X-ray diffraction and infra-red spectroscopy, thermal analyses and others.

### Overall findings

Overall findings of the project demonstrated that milk protein powders have different concentration windows or critical volume fractions at which hardening becomes unacceptably high and that such differences are dependent on the solvent environment and on the physical properties of powder particles, specifically the effects of limited-hydration on macro-structural stability (Hogan *et al.* 2012). The use of whey-based proteins, including hydrolysed derivatives, proved more effective than casein proteins in minimising textural deterioration. The extent of hardening can be improved by minimising the osmotic differential between components and by control of protein and lipid oxidation reactions (Potes *et al.*, 2013). Co-drying of proteins altered the hydration characteristics of protein powders and provided alternative functionalities to protein bar systems. The development of solidity at lower volume fractions (due to greater attraction between particles and lower interaction energies) also resulted in less extensive hardening. Understanding particle associations under confined (high-solids) conditions can provide insight into the thermodynamic stability of powder particles in such non-equilibrium systems.

### Potential as probiotics, functional foods and micronutrients

High-protein bar products offer considerable potential as vehicles for transport and delivery of high-value components such as probiotics, functional foods and micro-nutrients. Solid (protein powder) and liquid (oil and aqueous carbohydrate) phases, allow ingredient partitioning. Low chemical reactivity (due to low water activities) also allows sensitive ingredients to be segregated and stabilised, over extended periods, without loss of functionality. On the basis of results generated during this project, further funding was granted, by the FIRM Programme, to develop pro- and pre-biotic laden, high-protein bar products (FIRMPlus: Development of high-protein bars as vehicles for functional ingredient delivery).

Research into ingredient interactions in model, high-protein bars has led to an improved appreciation of the relationships between molecular and macroscopic change in concentrated food systems. Such information can help extend the application range of milk protein powders and contribute to their use as high-quality, functional milk ingredients. With the ending of milk quota restrictions in 2015, and in anticipation of significant increases in milk volumes for the coming years, the ability to create and control texture in dairy products should contribute towards full exploitation of national milk output.

### Acknowledgements

'Water activity control and texture stabilisation of high-protein snack bars' and 'Development of high-protein bars as vehicles for functional ingredient delivery' were funded under the National Development Plan, through the Food Institutional Research Measures (FIRM), administered by the Irish Department of Agriculture, Food and the Marine.

### References

- Hogan, S.A., Chaurin, V., O'Kennedy, B.T. and Kelly, P.M. (2012) 'Influence of dairy proteins on textural changes in high-protein bars'. *International Dairy Journal*, 26: 58-65.
- Potes, N., Kerry, J.P. and Roos, Y.R. (2014). 'Protein modifications in high protein-oil and protein-oil-sugar systems at low water activity'. *Food Biophysics*, 9: 49-60.

# 2014 International Year of Family Farming (IYFF)

The UN Food and Agricultural Organisation (FAO) has designated 2014 as the International Year of Family Farming (IYFF). During the year, it is the aim of the FAO to raise the profile of family farming and smallholder farming by focusing world attention on its significant role in eradicating hunger and poverty, providing food security and nutrition, improving livelihoods, protecting the environment, and achieving sustainable development. The 2014 IYFF will promote broad discussion and cooperation at the national, regional and global levels to increase awareness and understanding of the challenges faced by smallholders and help identify efficient ways to support family farmers.

Given the critical role of the family farm in Ireland, Teagasc has marked the year by organising a series of activities:

## Irish Family Farm Stories: Online Video Project

Teagasc commissioned a series of online videos that highlight the importance of the family farm in Ireland and demonstrate the contribution of family members to farming tasks over the course of the year. Videos can be viewed at: [www.teagasc.ie/publications/year-of-family-farming/](http://www.teagasc.ie/publications/year-of-family-farming/)

## National Conference on Family Farming

On November 4, 2014, Teagasc, in association with the IFA, will hold a major international conference in Dublin on family farming, with President Michael D. Higgins as keynote speaker.

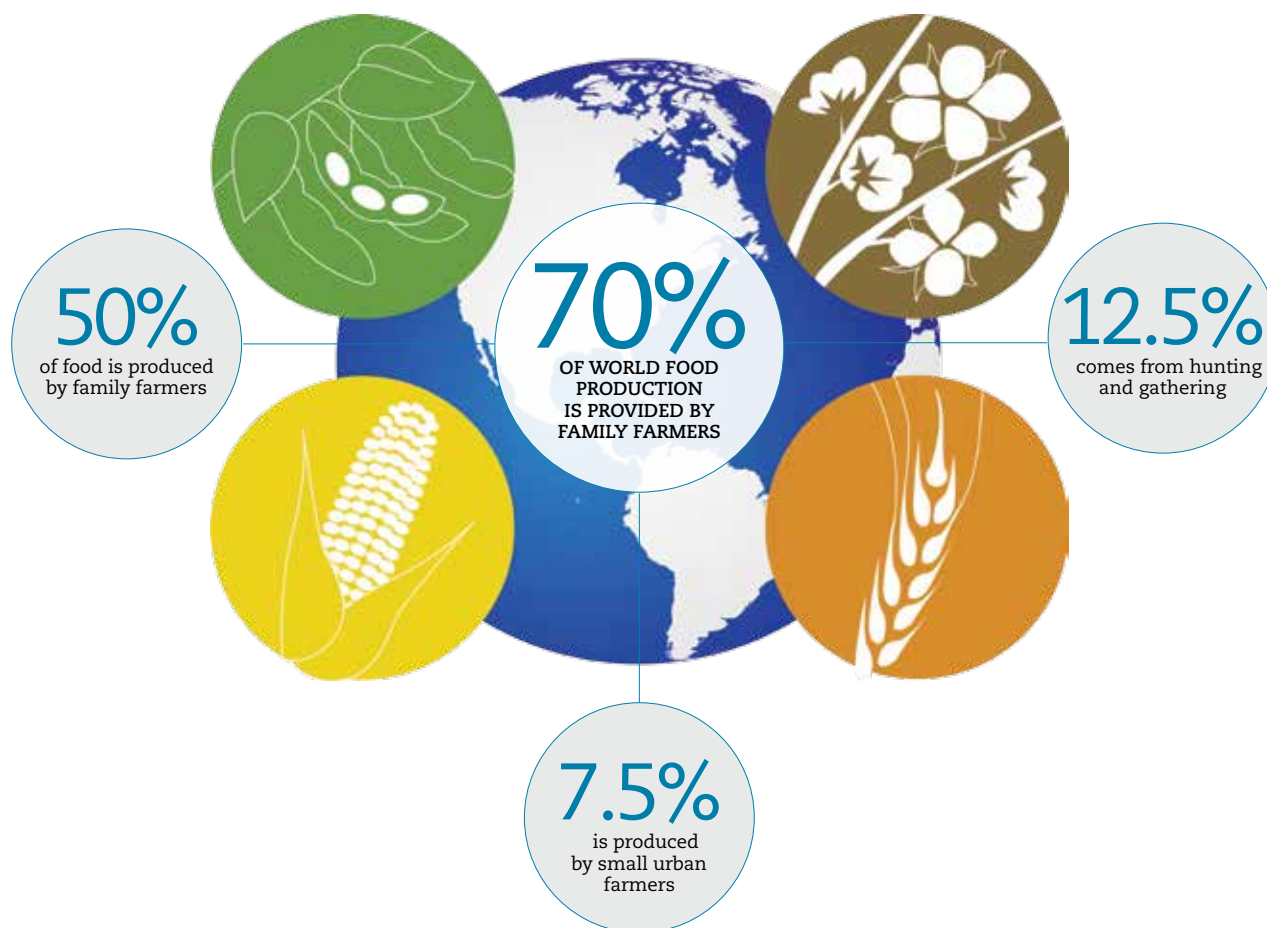
## Family Farm Competition

Teagasc also co-sponsored a Family Farm competition in the *Irish Farmers' Journal*, which runs over the summer months. The winners will be announced at the International Conference on Family Farming on November 4. The competition will focus on the following aspects of family farming: pride in family, product and place; coping with challenge; and, contribution to local community/voluntary groups.

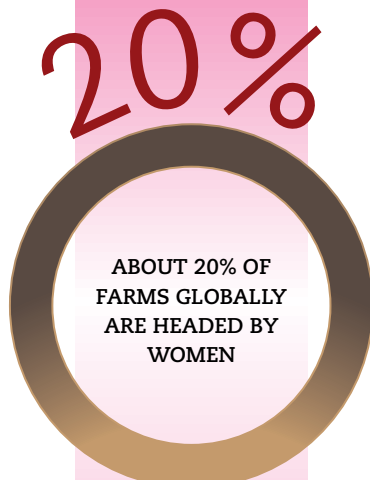
## Academic Conference

In June, Teagasc, in association with the Royal Irish Academy, held a conference, entitled: Family Farming in Ireland – Continuity and Change in Airfield House, Dundrum, Dublin.

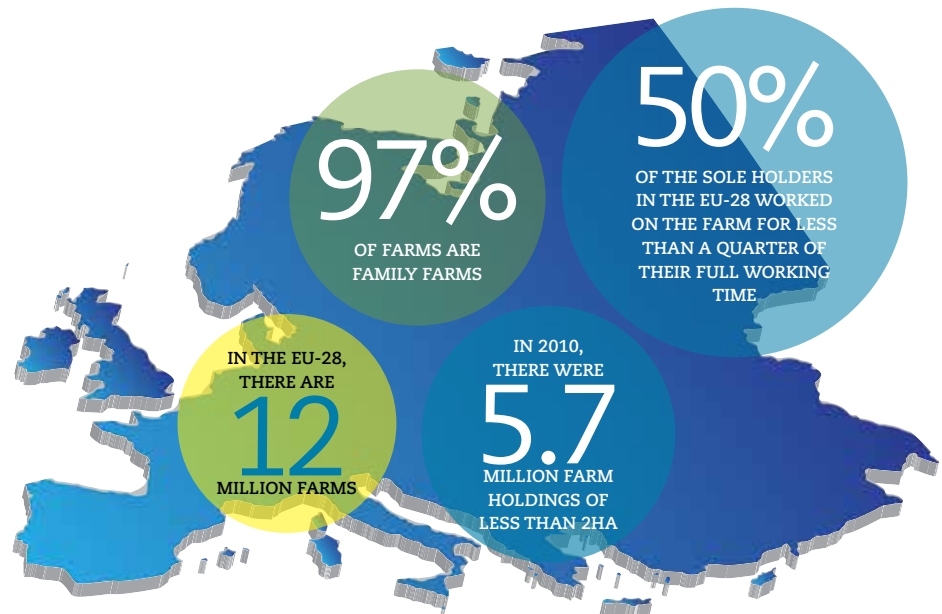
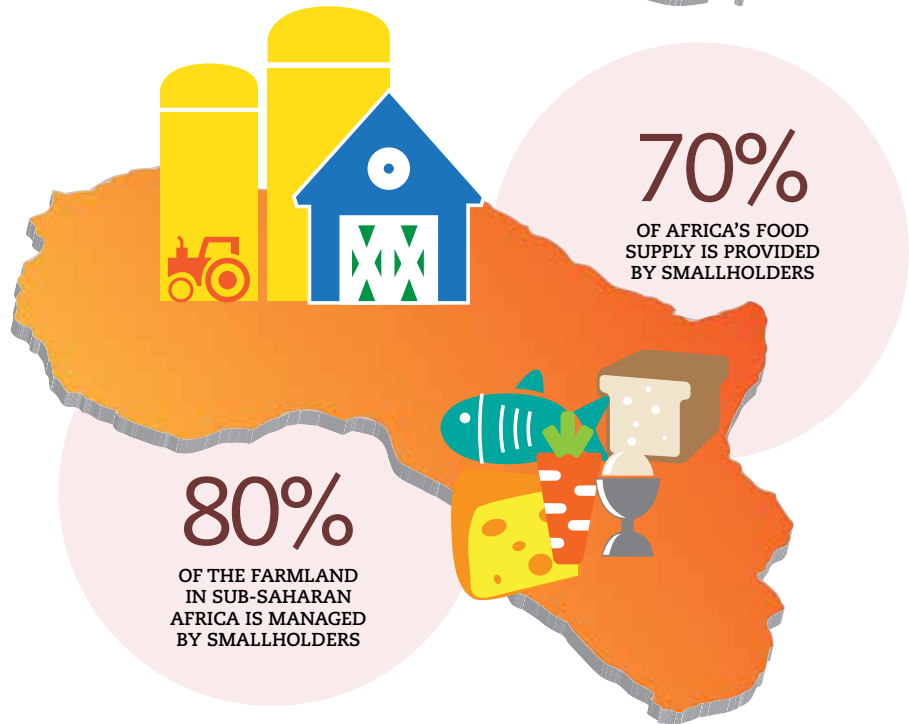
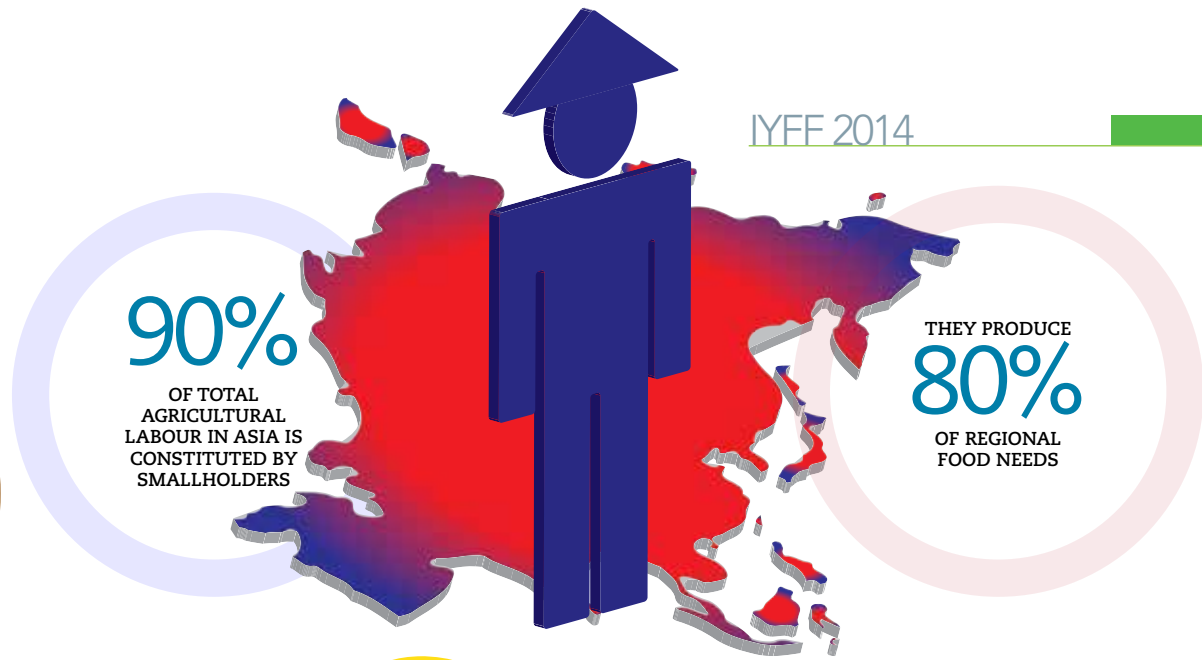
## Family farming in figures







About 70% of women work in agriculture in poorer countries





# Policy tools to support family farming in Europe



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To mark the International Year of the Family Farm, the European Parliament recently held a conference to examine the challenges facing family farming in Europe and to explore the policies available to support farm families. Teagasc economist Dr Thia Hennessy, who was invited to address the conference, explores the effectiveness of the Common Agricultural Policy (CAP) in enhancing family farming in Europe.

## What is a family farm?

Reaching a common understanding of what constitutes a family farm is challenging. For many, family farming is synonymous with small farms and a discussion of family farming leads to a small farm versus large farm debate. However, within Europe there are many large, commercially viable farms that are also family-owned and operated. The Food and Agriculture Organization of the United Nations (FAO) defines a family farm as “an agricultural holding, which is managed and operated by a household and where farm labour is largely supplied by that household”. Using this definition, over 97% of the 12 million farms in Europe can be considered family farms. However, the prevalence of family farming varies by member state (MS); for example, less than half of the agricultural land in Slovakia, the Czech Republic, Bulgaria, France and Estonia, is family-operated.

Family farming in Europe is very diverse. The average family farm in the Netherlands is 32ha and generated an annual income of over €90,000 in 2010, compared to the average farm in Romania which produced an income of just €5,000 on 12ha.

## Designing policy to support family farming

While family farming is at the heart of the European Model of Agriculture and has been supported by the Common Agricultural Policy (CAP) for many years, a number of factors – both internal and external to the family – continue to threaten the efficacy of the family farming business model. These challenges are numerous and diverse: external forces, such as low and volatile output prices or high input prices, lack of access to credit, poor bargaining power in supply chains or with land owners, and a lack of off-farm employment opportunities. Other challenges are internal to the farm family, such as aging households, low education levels, a lack of successors and low rates of female participation.

The sheer diversity of farming in Europe means that the challenges facing families differ across MS and by farm size and structure. As such, designing an agricultural policy that can support family farming in all its shapes and sizes across the EU is extremely difficult and especially if that policy is a common one such as the CAP.

## CAP impact on family farming

Supporting the family farm has been at the centre of the CAP since its foundation and CAP Pillar I schemes – first in the form of price support and latterly as decoupled direct payments – have transferred considerable funds to family farms over the decades. These subsidies have significantly boosted farm incomes and have facilitated the survival of a large number of family farms that otherwise would have been economically non-viable. Pillar I schemes are the subject of frequent criticism for favouring larger, more productive farms but it should be noted that in the majority of cases these larger farms are also family-owned and operated.

The overall impact of CAP Pillar I policies on the sustainability of the family farming model is complex.



Pictured at the recent European Parliament Conference on Family Farming in Brussels are Dr Marcela Villareal, FAO Director of the International Year of the Family Farm; Mairead McGuinness, Irish MEP; and Dr Thia Hennessy, Teagasc.

On the one hand, the policies have been successful in maintaining a large number of family farms in business. However, on the other hand, this has slowed the pace of structural change in the sector, a process that is desirable from an economic perspective as it facilitates the transfer of resources to the most efficient farms and allows for new entrants, thus making the overall farm sector more competitive. The Pillar I subsidies, which are land-based, have also inflated agricultural land prices and rents thus making access to farmland - both for families wishing to expand, and for new entrants - limited and expensive and supporting land owners rather than active farmers.

In general, CAP Pillar II policies are more targeted than Pillar I. Pillar II is more flexible and programmes can be tailored to the individual situations and needs in the various MS and as such there is more scope to address the specific challenges facing family farms. Pillar II policies have successfully supported intergenerational transfer through retirement and succession schemes and promoted farm modernisation through investment programmes. While these schemes have enhanced the opportunities for family farms, evaluations have shown that they do not always represent “good value for money” and they suffer from participation bias with larger and more educated farmers being more likely to participate. Such schemes have also been criticised for having a considerable deadweight effect, funding retirements, new entrants and investments that would have occurred anyway, without the financial assistance.

### Will CAP support family farming?

The most recent reform of the CAP, finalised in 2013, aims to tackle the unequal distribution of direct payments both within and between MS. Through a process known as ‘external convergence’, funds will shift from MS with the highest direct payments to those with the lowest. While ‘internal convergence’, a process, which stimulated considerable debate in Ireland, is aimed at addressing the unequal distribution of payments within MS, by redistributing funding from those with the highest per hectare payments to those with the lowest. MS can also opt for more accelerated redistribution by offering higher payments on a farmer’s initial hectares up to the average farm size using the Redistributive Payment Scheme.

In theory, internal and external convergence can be used to further support the financial situation of family farms, but convergence is a zero-sum game – many of those farmers losing under convergence are also family farms. This point highlights the complexity of designing policies that support all types and sizes of family farms.

The new Pillar II places considerable emphasis on knowledge transfer and innovation. Clearly family farms can benefit from more effective transfer of knowledge allowing them to adopt new technology and improve productivity. While the funding available for the innovation and farm advisory schemes is significant, their success will be highly dependent on the level of farmer participation, and so significant efforts will be required to encourage participation; especially from previously under-represented cohorts such as small and less educated farmers.

With a view to tackling the generational renewal problems in agriculture, the new CAP offers considerable start-up aid for young farmers. The potential total value of the aid is substantial and is likely to be sufficient to stimulate genuine new entrants, thus overcoming a major criticism of previous programmes. However, the new CAP does not make provisions for an early retirement scheme and, as such, only one half of the intergenerational challenge is addressed by this CAP reform.

### Future EU prospects for family farming

The resilience of the family farm model in European agriculture is evident – having survived wars, economic crises and major policy reforms. It is the predominant business model in European farming and this is a situation likely to continue in the future.

The CAP has provided significant financial support to family farms across the EU. Irish family farms have received over €50 billion in CAP subsidies in the 40 years since joining the Union. While such financial support for farming is of course welcome, it is crucial that a culture of subsidy dependence is avoided and that the CAP policies of the future should be more targeted at improving the productivity, efficiency and market-orientation of family farms.

This article is based on the briefing note “CAP Tools to Support Family Farming in the EU” prepared by Thia Hennessy for the European Parliament. <http://bit.ly/familyfarmpolicy>





The world's average farmer keeps just three milk animals with an average annual milk yield of approximately 2,100kg/animal/year. Photo: ©FAO/Sergey Kozmin.



# Economic competitiveness of the Irish family farm

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The International Year of Family Farming (IYFF) in 2014 has raised a number of issues related to the economic and policy context of family farming (FF), which covers a wide variety of organisations, economics and scales of farm production internationally. Evidence of how the Irish family farm unit relates to the size and economics of farming worldwide is presented here.

From the outset, it is important to note that while this paper focusses on economic aspects of FF, agriculture involves a number of important interactions with policy for other areas such as political, social and environmental. However, given the high levels of public expenditure on agriculture through mechanisms, such as the CAP, the purely economic view taken in this paper is considered justified.

Using dairy farming in Ireland as a case study, we look at the relative size and profitability of the average

size dairy farm in Ireland with other dairy farms internationally. The data is based on the findings of the International Farm Comparisons Network (IFCN) for dairy in 2013.

## IFCN dairy results on size and profitability

Milk production worldwide is carried out on around 122 million dairy farms (IFCN estimate), which stock 363 million milking cows and buffaloes. This means that the world's average farmer keeps just three milk animals with an average annual milk yield of approximately 2,100kg/animal/year. Of course, building averages is an oversimplification. There is a wide range of dairy farms in the world keeping less than three cows per farm on the one hand; and, on the other hand, in some countries dairy farms are much bigger and keep over 1,000 cows per farm. This simple example shows the very different structure of dairy farming across the world. Furthermore, production systems also differ significantly in terms of farm size, housing, milking and feeding systems; the remainder of this article puts the Irish dairy farming system into context by focusing on how typical Irish dairy farms compare internationally in terms of costs of production and returns.

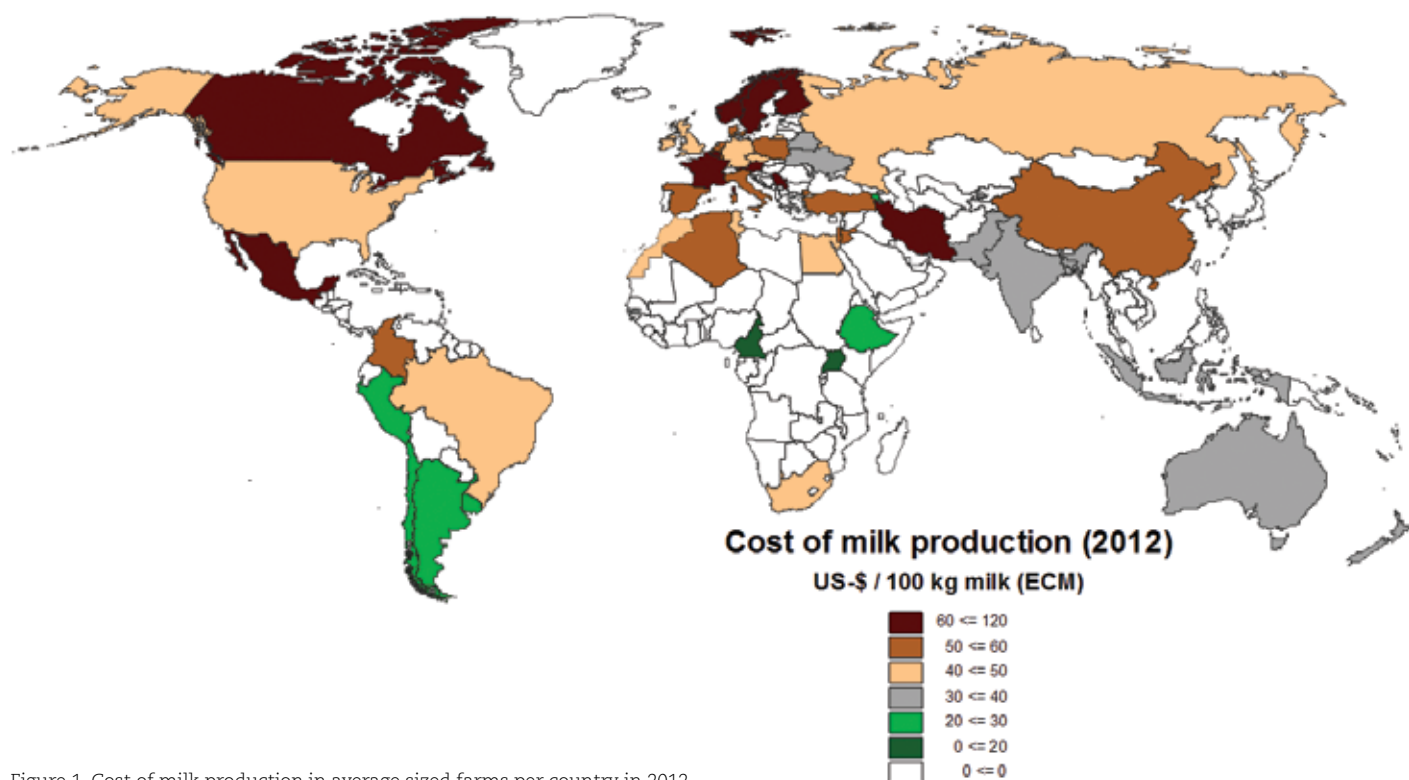


Figure 1. Cost of milk production in average sized farms per country in 2012.  
Source: © IFCN Dairy Research Center 2013.

### Cost of milk production 2012 by world region

The annual IFCN work of comparing typical farms around the world has been an on-going process since the year 2000. The costs and returns outlined in this article relate to what is called 'typical farms' in each region of the world.

A simplified global overview on costs of milk production is shown. The illustration is based on the results of the typical average sized farm analysed per country in 2012. The average cost of milk production in 2012 over all countries analysed was USD\$46/100kg milk. Cost of milk production ranges from USD\$4 per 100kg milk in extensive farming systems in Cameroon (where beef is the major output and milk is a side product) to USD\$128 for an average sized farm in Japan. The results can be summarised as follows:

- **Low cost regions:** Based on the average-sized farms, three low cost regions have been identified: a) Argentina, Peru and Uruguay; b) Central and Eastern Africa; and c) Central and Eastern Europe. Some selected countries in Asia (except Japan and large farms from China) also have low costs.
- **Western Europe:** The leading farms in Western Europe had costs ranging from USD\$40 – 55. The cost of milk production for the average size farm in Ireland in 2012 was around USD\$47 per 100kg of milk.
- **The US:** The small farms in Wisconsin and New York had a cost of USD\$50. While, the large farm in California had the lowest cost of about USD\$33. In general, the average costs of all typical farms analysed in the US did not change and stayed at a level of USD

\$41.4 in 2012 compared to 2011 (USD\$41.02).

- **Oceania:** The cost level in Oceania was about USD\$35.

Based on the results above, the average-sized, typical Irish dairy family farm had costs that were less than mid-way in the range of all countries examined. When this global map is represented for the larger size Irish dairy farm, we see that the larger size Irish dairy farm manages to receive a margin over total economic costs (including the cost of owned resources), which is noteworthy given that a large proportion of typical farms in the countries examined did not derive a positive margin over total economic costs.

Hence, we can conclude, based on this data of the distribution of costs and returns worldwide, the ability of the larger Irish dairy family farm to compete in the longer term, in a global context, is affirmed.

While the larger-sized Irish dairy family farm may not have the lowest economic costs in the world, it must be remembered that competitiveness is about survival and not always about being the best in the world and (on larger farms) a considerable number of the typical farms examined internationally had economic costs well in excess of the Irish situation. Furthermore, as the Irish family dairy farm transforms to larger scale production in a no quota situation, the Irish family dairy farms' competitive position will be strengthened.

### Cost indicator:

Costs of milk production include all costs from the profit and loss account of the farm. From this cost level, the non-milk returns from sales of cull cows, heifers, calves, manure, etc., and also returns from coupled direct payments, have been deducted. Furthermore, the opportunity costs for own labour, land and capital are included. For creation of the world map, the average size farm from each country was used.

### The IFCN - International Farm Comparison Network

- is a global network of dairy researchers from 95 countries cooperating with over 100 companies representing the dairy chain. The IFCN is independent from third parties and committed to truth, science and reliability of results. The main research focus of the IFCN and its core competence is in the field of milk production, milk prices and especially dairy farm economics. Further details: [www.ifcndairy.org](http://www.ifcndairy.org)





# Farming in Ireland 1971-2011: Continuity and change

As the agri-food industry evolves it is having a marked effect on the make-up of farm households in Ireland.

Farming in Ireland has been shaped by a number of high-level processes that are evident across much of Europe and other industrialised countries. These include consolidation (fewer, larger farms), intensification (enhancing productivity - per Ha, per animal or both) and specialisation (concentrating on a particular enterprise). At the farm level, a number of other, interrelated, developments have affected these processes, most notably the long-term decline in the real price of food, increasing off-farm employment (income) and farm succession (or lack thereof). These changes are the visible manifestation of economic and technological forces driving the evolution of Irish farming. Taken together, these processes have shaped the restructuring of farm enterprises throughout Ireland. Related to these developments are a range of social and demographic changes affecting the composition of farm households, i.e. changes in the number of single person households, households with children over 19 and those without. This article

briefly considers the changing composition of farm households in Ireland between 1971 and 2011 within the context of substantial changes to the number, structure and types of farm enterprises.

## Farm households

According to the Census of Population (2011), there are 85,700 farm households in Ireland, i.e., where the household reference person classifies themselves as a farmer. There are a further 10,000 households headed up by a farm worker. Taken together, these households account for slightly less than 6% of the total number of households in the state. This represents a substantial reduction on 1971, for example, when 179,000 households were headed by farmers, or 25% of all households. Part of the reduction was driven by a fall in the number of farm households (-46%) and part by the increase (+44%) in the total number of households. Though it is difficult to directly compare between 1971 and 2011 because of changes in the classification of farm households, it is possible to compare broad categories of household. The proportion of single person households increased (1%); the proportion without children of any age declined; and the proportion with children increased.



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The Austin family from Louisburg, Co. Mayo. Richard and Lorena Austin and their two children, Dara, and Liliana.

land and the climate, with tillage and dairy concentrated in what is generally referred to as the better, dryer areas of the south and east, sheep are increasingly concentrated in upland areas; and beef producers are concentrated in the more marginal and wetter areas of the west and northwest. These changes reflect, in large part, the evolving challenges of farming in Ireland. Farm enterprises have to continually navigate changes in the technology of farming, the policy environment that governs how food is produced and the increasing role of the global market in determining prices for their output. These drivers of change operate within the context of structural, environmental, human and capital constraints that, in turn, are filtered through and conditioned by social and cultural institutional structures, e.g., the family, community and the wider industry.

### Continuity and change

Farm households have proven resilient, but not immune to change. The overview provided above highlights the substantial change in the number of farmers and the size of farms. What we see, therefore, is a community that is characterised by continuity and change. Continuity is ensured through social and behavioural norms that facilitate certain types of change, e.g., renting out land or changing from dairy to beef production; but are resistant to others, e.g., selling farmland or planting forestry. There is a question as to whether these norms are location or place based, i.e., do they vary between localities or biophysical regions. Research in other jurisdictions has established that this is the case but, as yet, research in Ireland has yet to sufficiently engage with this particular issue.

Though farming in Ireland has transformed over the past three decades through consolidation of ownership or management of the land and substantial specialisation, in other respects it remains largely unchanged. Family ownership, management and operation of the land/farm remain at the heart of farming in Ireland. The continuity of ownership and, particularly, operation of land remains largely unchanged – it was and remains the preserve of family farms. The practice of farming the land through the exploitation of the strengths of family ties ensures the continuity of behaviours, norms and practices that produce the landscape that frames our sense of place and community identity. These practices are not impervious to change. The relatively slow pace of change in land ownership is set against a fast-changing economic and climatic environment. The coming years will see farm businesses and, by extension, farm households more exposed than ever to the vagaries of the market place. This will most likely drive further farm consolidation and specialisation. The abolition of the milk quota next year will, more than likely, accelerate the pace of change. Much of this consolidation is likely, certainly in the short term, to occur through the rental market. Social change resulting from farm succession and land ownership will also prompt different or new approaches to farming, for example, collaborative farming. While these developments might be characterised as departures from the past they will continue to be based on family ownership and management of land and farms. In this one respect, at least, farming will be unchanged for the foreseeable future.

### References

- Central Statistics Office (1975) Census of population 1971 – Occupations. Stationery Office, Dublin
- Central Statistics Office (2012) Census of population 2011 – At Work - Employment, Occupations & Industry in Ireland. Stationery Office, Dublin
- Central Statistics Office (2013) Census of population 2011 – Place of Work, School or College - Census of Anonymised Records (POWSCAR)

### Changing landscape of Irish farming

These data mirror the wider changes that have affected farming in terms of consolidation, intensification and specialisation among farm enterprises. For example, the number of farms in Ireland declined from roughly 280,000 to 140,000 (-50%) between 1970 and 2010. The difference between the number of farm household and the number of farms is accounted for by the practice of some households farming more than one farm and some households renting out all or most of their farm and, hence, are not necessarily classifying themselves as 'farm households'. Interestingly, the ratio of farms to farm households, 1.6:1, is the same in 2010 as it was in 1970. The change in the number of farms has resulted in changes in the size structure of farms in Ireland. While the number of farmers in each size category of farm has declined, the declines are proportionally greater among farmers farming smaller areas compared to larger farms. There was a, roughly, 80% fall in the number of farms under 50 acres between 1971 and 2002 compared to a 25% decline in the number of farmers with farms greater than 50 acres. Proportionally, farmers farming areas over 50 acres grew from 38% of the total number of all farmers to 71% during this period. These developments have been accompanied by increasing specialisation as farm enterprises increasingly focus on the production of a limited number of products, e.g. milk, sheep or beef. This process has also resulted in geographic specialisation where, increasingly, particular types of farm enterprise are clustered in specific parts of the country. This reflects the relative quality of

**Ireland:**

To provide a solution to scale, resource and social support deficits on farms, and through detailed planning and periodic revision, offer customised arrangements that lead to enhanced power-sharing, quality of life and farm efficiency (Macken-Walsh and Roche, 2011).

**UK:**

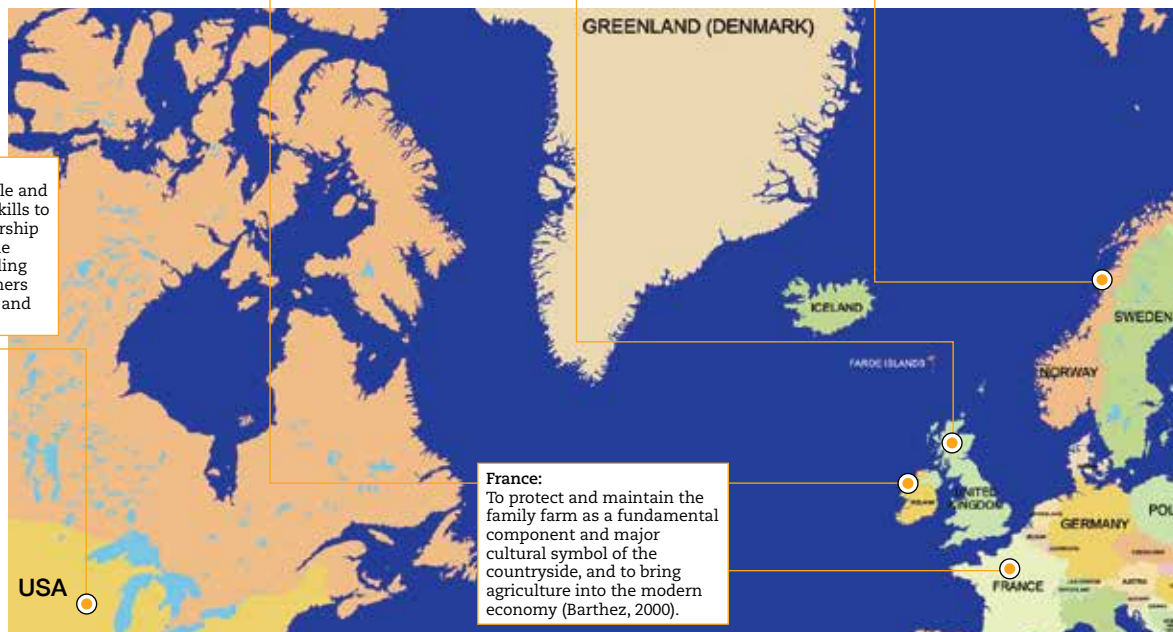
To increase the scale and efficiency of farms in order to respond to the 'cost-price squeeze' in producing agricultural commodities (Turner & Hambly, 2005).

**Norway:**

To address the problem of the 'one-man-farm' and, in families where the spouse is working full-time off-farm, to reduce farming work-loads to free up time for more domestic work (Kirbak and Egil-Flø, 2005).

**US:**

To provide the scale and diverse industry skills to take greater ownership of and move up the value chain by selling directly to consumers (Lyson, Stevenson and Welsh, 2008).



# Strategies of resilience: Cooperation in Irish family farming

## Family farming: strategies of resilience

Ireland's family farming heritage holds crucial elements of rural sustainability – established networks of social support; cultural traditions resourcing ethno-industries such as tourism and craft; and localised human-ecological knowledge important for environmental custodianship. The 'small, not multinational' symbolic value of family farming is strategically used to authenticate the 'brand-centred, consumer focused' marketing 'story' of Irish food and drink internationally (*Food Harvest 2020*), as well as other rural products and services. Family farming is an institution that is particularly enduring in the Irish countryside and this article presents insights from recent Teagasc sociology research on the resilience strategies of family farms. What are the characteristics of these strategies, which have achieved extraordinary resilience throughout periods of intense change and challenge? A fundamental component of Ireland's agri-food industry, there is a clear argument for paying closer attention to the adaptive strategies of family farmers, and for policy and extension to engage with and develop these strategies in furthering the sustainability of Irish agriculture. A range of sociology projects led by Teagasc, including projects on collaborative ventures, gender specific issues in agriculture, and farmers' technology and business

decision-making, all shed light on the make-up of family farm resilience strategies.

## Social, cultural and economic factors

A defining characteristic of family farm decision-making is that it is informed by social, cultural and economic factors interdependently. The value placed by family farmers on social relationships (between family members and farmer peers); cultural forms of prestige (styles of behaviour and possessions that are esteemed by farmers); and economic (material) wealth, all influence family farms' resilience strategies. Rather than factors such as profit maximisation or 'objective' scientific information influencing family farm decision-making, subjective and culturally shared wisdom and a wide range of relationship, esteem and material wealth considerations determine how farmers use information available to them in furthering their resilience strategies. Research that focuses on farmers' subjectivities and the intricate interdependencies between economic, social and cultural concerns demonstrates that the family farm is not only an economic business, but a site of shared social relationships and practices and a culturally-esteemed knowledge source.

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Common resilience strategies – identified in the literature spanning over a century – illustrate interdependencies of social, cultural and economic concerns: conventions of inheritance that favour a single male heir so as to maintain farmland intact in the family name; the fostering of 'stem family marriage', i.e. strong social contracts of responsibility between older and younger generations; traditions of 'inter-farm cooperation' within communities of family farms to ease workloads; and, more laterally, specialisation, part-time farming and off-farm work undertaken by primary operators and spouses (Byrne *et al.*, 2001). While resilience strategies have changed, the social framework of the family farm has remained intact. Teagasc Sociology research has recently highlighted how farm level strategies to respond to impending dairy quota deregulation rely heavily on the knowledge and labour of the extended family farm (McDonald *et al.*, 2014). Relationships within farm families have changed, however. The cultural effects of off-farm work, greater gender equality, and increased access to leisure and educational pursuits drive different motivations and relationships within the farm household.

### Cooperation for the 21st century: collaborative farming

Research on formalised joint farming ventures – organisational innovations that formalise farmers' collaborative work – suggests that they are popular because they represent a credible resilience strategy in contemporary agriculture. Joint farming ventures – including partnerships, contract rearing, share farming and producer groups – are potentially responsive to not only the economic needs of farmers and the pragmatic needs of operating farms, but work within established, but transforming, socio-cultural pathways within farm families and communities.

Farm partnerships, for example, an established type of joint farming venture in Ireland, have involved diverse members of farm families and communities – fathers and sons; uncles and nephews; farmers with no heirs and neighbouring younger farmers; neighbouring farmers of similar ages; sisters and brothers; mothers and sons; and, mothers and daughters. Research has found that partnerships represent the diversity of social relationships within communities of family farms and offer opportunities to develop farming to respond to contemporary social arrangements and economic challenges (Macken-Walsh and Roche, 2011). A range of joint farming ventures has been found to respond to contemporary challenges experienced by family farms, such as social isolation, low farm economic viability, diminished cultural enjoyment and a desire to improve quality of life.

It is the peculiar social and cultural dynamic of family farming that supports the motivation for and operational success of joint ventures. While joint ventures typically result in enhanced farm business planning as a result of formalised work sharing agreements, they do not give rise to solely corporate dynamics. It is in this context that Norwegian sociologist Almas (2010) raises the question of whether the consolidation of individual family farms as a survival strategy means an end to the family farm? He concludes that joint farming ventures represent a highly adaptive strategy for family farms, in strengthening their resilience. While increased efficiency and productivity is associated with joint farming ventures, research shows that farmers working together, to achieve mutually understood social, cultural and economic priorities, continues to be important to family farms.

### Collaboration & innovation

Existing social relationships, expediting formalised collaborative efforts between farm families, are conduits through which the

pooling of diverse physical and human resources can be realised. Without these established social relationships, fostering the 'clever alliances' that are crucial for innovation in agriculture at farm level, and also in farm-resourced SMEs and agricultural cooperatives, would be a different and more complex task for both extension and policy. Contemporary family farming in Ireland reflects changing gender roles and the pursuit of new organisational as well as technological innovations, illustrating the 'room to manoeuvre' (O'Hara, 1998) that has long been associated with family farms. From a sociological perspective, successful policy and extension initiatives promoting diverse joint farming ventures entail exploiting and further developing family farm resilience strategies that are part of cultural knowledge. Participatory extension models, of which social relationships are a crucial part, can support clients to chart their collaboration to exploit future strategies of sustainability.

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### References

- Almas, A. (2010) 'I have seen the future and it works! How Joint Farming may solve contradictions between technological level and farm structure in Norwegian dairy production', In (eds.) Bonanno, A., Bakker, H., Jussaume, R., Kawamura, Y., and Shucksmith, M. From Community to Consumption. New and Classical themes in Rural Sociological Research, pp3-16 Emerald,
- Barthez A. (2000) 'Le droit comme expression culturelle'. Processus de légalisation du travail familial en agriculture: le cas du GAEC. *Revue de Droit Rural* n 288 621-632
- Byrne, A., Edmondson, R. and Varley, T. (2001), Arensberg and Kimball and Anthropological Research in Ireland: Introduction to Conrad Arensberg and Solon Kimball, Family and Community in Ireland (Third Edition), CLASP: Ireland, pp1-101.
- Department of Agriculture, Marine and Food (2011). Food Harvest 2020: Milestones for Success Available online: [www.agriculture.gov.ie/media/migration/publications/2011/FoodHarvestProgressReport260711.pdf](http://www.agriculture.gov.ie/media/migration/publications/2011/FoodHarvestProgressReport260711.pdf)
- Kirbak, L and Egil-Flø, B. (2005) 'Joint farming – between Good Agronomy and Modern Masculinity' Conference paper to the XXI Congress of the European Society for Rural Sociology, Keszthely, July 2005, pp. 1-17
- Lyson, T.A, Stevenson, G.W. and Welsh, R. (2008) Food and the Mid-Level Farm: Renewing an Agriculture of the Middle, Massachusetts Institute of Technology
- Turner, M and Hambly, J. (2005) 'Agricultural restructuring: The potential role of joint venture arrangements', University of Exeter, Centre for Rural Research, Annual Review 2004: Available online <http://centres.exeter.ac.uk/crpr/publications/pdfs/annualreview/AnnualReview04.pdf>
- Macken-Walsh, A. and Roche, B. (2012) Facilitating the Establishment of Farm Partnerships a Participatory Template, Teagasc, Carlow ISBN: 10 -1-84170-585-3 pp.1-22
- Macken-Walsh, A., Crosson, P., Murray, A. (2012) 'A qualitative study of Irish beef farmers' production decisions: summary and implications for extension, Teagasc, Oak Park, Carlow, November 2012 pp. 1-17
- McDonald, R., Macken-Walsh, A., Pierce, K., Horan, B. (2014) 'Farmers' responses to a deregulated dairy regime: insights from Ireland's new entrants scheme, *Land Use Policy*, 41, pp. 21-30
- O'Hara, Patricia. 1998. Partners in Production? Women, Farm, and Family in Ireland. Oxford: Berghahn Books



# Farm households in Ireland



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Pictured with An Taoiseach, Enda Kenny (front left) at the launch of the recent CEDRA report entitled 'Energising Ireland's Rural Economy' in Castlebar, Co Mayo were (back row, from left) Dr David Meredith and Dr Kevin Heanue, Senior Research Officers, Teagasc; Professor Cathal O'Donoghue, Teagasc Head of Rural Economy and Development Programme and CEO of CEDRA, Professor Gerry Boyle, Teagasc Director and Pat Spillane, Chairperson of CEDRA (front right).

The family farm is at the heart of the Irish agricultural industry. In the 2010 Census of Agriculture there were about 140,000 farms. This article discusses trends associated with the viability of family farms, the importance of off-farm income, the impact of the economic downturn and plans contained within the recent report of the Commission for the Economic Development of Rural Areas.

## Farm and farm numbers

In Teagasc, we have developed a measure known as farm viability to assess the financial strength of a farm. Using this measure, a farm is viable if its income

from agriculture is greater than the agricultural minimum wage (agricultural workers have been covered by different rates from the national minimum wage since it was introduced in 2000) and where there is a return of 5% on non-land assets. Essentially, this is a measure of the opportunity cost of the assets and labour of a farm, the return it could receive from utilising its labour or capital elsewhere.

In the most recent Teagasc National Farm Survey, 38% of farms were viable. Breaking down by sector 71% of tillage farms, 68% of dairy farms and 58% of mixed farms were viable under this measure; while less than 30% of cattle and sheep farms were viable, with cattle-rearing farms having the lowest share with 18%.

Historically, farm input prices have tended to grow at a faster rate than output prices, a process known as a 'cost price squeeze'; a process common in mature commodity sectors like agriculture. Between 1995 and

2005, input prices rose faster than output prices in eight of the 11 years. Therefore, by 2005 output prices were 93% of the 1995 levels, but input prices were 126% of these levels. This process has the impact that, if there is no innovation and no improvement of yield, scale or efficiency, farm incomes from the market will decline.

The impact of this trend was evident in the decline in the number of family farms over the 1990s. In 1991 there were 171,000 farms, declining to 141,500 in 2001. This was part of a longer term trend that saw decline from 280,000 farms in 1970 and 318,000 farms in 1949. This decline has been particularly evident among smaller farms with a size of less than 20 hectares, which declined in number by a third during 1991 to 2001. Conversely, the average size of a family farm rose over this period by 23% to 32 hectares.

However, with growing food demand globally, the situation has changed over the past decade. Since 2005, only three of the nine years have seen input prices grow at a faster rate than output prices. This is particularly visible in the period since the crash in 2009, where output prices fell by, on average, 17% and input prices fell by 8%. Since then, output prices have jumped back by 45%, while input prices have grown by 19%, with a consequent increase in farm incomes. To some extent, as a consequence, the decline in the numbers of family farms has slowed down, with a decline of only about 1,500 farms in the decade 2000-2010.

### Off-farm income

From a household perspective, income from farming tells only part of the story. Like other small business households, farm households depend not only upon incomes from their enterprise but also rely on incomes from other sources.

To account for this, Teagasc has an indicator known as 'Farm Sustainability' for farms that have incomes below a viable threshold, but where the farmer or their spouse has off-farm employment. In 2012, according to the Teagasc National Farm Survey, 29% of farms were categorised as sustainable. Breaking down by sector, cattle rearing, cattle other and sheep farms had sustainability rates of 43%, 30% and 35%, respectively; while dairy, mixed and tillage were 17%, 23% and 12% respectively.

The 'residual' category of those whose farm income is below the viability threshold, and who do not have off-farm employment, are vulnerable. In 2012, 33% of farms were categorised as vulnerable in the National Farm Survey. Given their low viability, cattle and sheep farms had the highest share at about 40%, compared with about 15% for other farms. This high vulnerability rate has resulted in a higher relative poverty rate for farm households at 20% as compared to 18% for other rural households and 11.9% according to an analysis done in 2011 by the Department of Agriculture, Food and the Marine.

Improvements in farm incomes, as a result of the faster growth rate of output prices since the crash, has seen an improvement

in the viability rate. However, there has been relatively little impact on vulnerability. This is because of the collapse in off-farm employment. In Figure 1, we report the off-farm employment rate of working age farm households, which rose for the farmer from about 35% in the mid-1990s to over 50% in 2008. However, this gain was wiped out in the two years post-crash. The employment rate of their spouses increased at a faster rate from a lower base to a higher peak. However, the decline has been much smaller since the crash due to the greater reliance of farm holders on construction employment, while their spouses were more reliant on sectors that were less severely impacted by the decline.

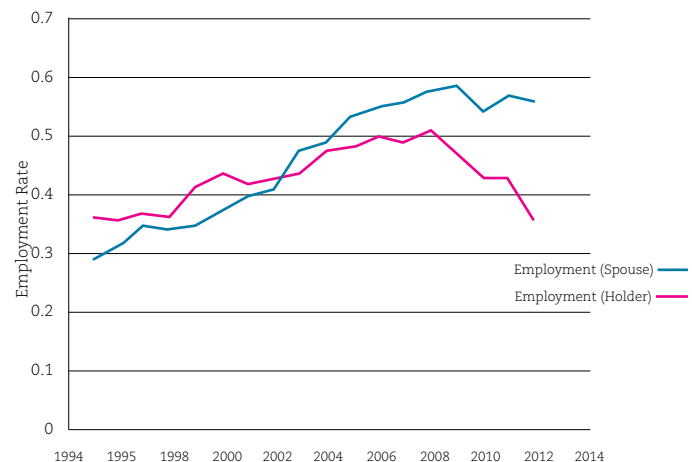


Figure 1. Off-farm employment rate of holder and spouse  
Note: These statistics relate to farms with a holder and spouse of working age only

### CEDRA report

The big reduction in off-farm employment was mirrored by declines in employment in rural areas more generally, where unemployment rose by 192% between 2006 and 2011, compared with 114% in urban areas. As a consequence, the Government established, under the Chairmanship of Pat Spillane in November 2012, the Commission for the Economic Development of Rural Areas (CEDRA) to develop a strategy to improve the economic situation in rural areas. Teagasc was central to the organisation of CEDRA, leading the Secretariat, facilitating over 100 consultative meetings and extensive research programme resulting in 23 research papers. The report was launched in April 2014, containing 38 recommendations; comprising both structural and sectoral recommendations. The report and supplementary research material can be accessed at [www.ruralireland.ie](http://www.ruralireland.ie) and will be summarised in a future *TR*Research article.

# Succession and inheritance of family farms in Ireland

Teagasc Knowledge Transfer specialists tackle the complex topic of succession and inheritance in the current economic climate



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The increased life span in Ireland, coupled with a demand for higher living standards, has put pressure on the structured handover of family farms. With some families, the generation gap can be quite short so there is a requirement for one or other of the older or younger farmers to seek an alternative income away from the farm for a number of years. Traditionally, many farms are passed from one generation to the next on the death of the farmer. The policy of the Government is to provide incentives to encourage early transfer, but there has been limited success. Farmers would say that the uncertainty surrounding Common Agricultural Policy (CAP) reform does impact on their transfer decisions, with many being afraid to transfer in case they lose potential additional payments for retirement/installation. The age profile of Irish farmers is high with only 6.9% of the farm holders under the age of 35 while 24.9% are above the age of 65 according to a CEJA (Conseil Européen des Jeunes Agriculteurs, 2010) report.

The concept of family 'Milk Production Partnerships' was introduced in 2002; and there are currently 702 milk production partnerships in existence. These enable the older and younger generation to enter into a business arrangement aside from the ownership of the land. The ideal model is one where the older farmer has a higher percentage of the farm profits at the start of the agreement but this profit share changes over time so that the younger partner gains the higher percentage. This may occur as the older farmer starts receiving the old age pension. The benefit of these partnership arrangements is that they combine the enthusiasm and education of youth with the experience of age.

## Some of the challenges

The challenges that are facing the family farm are similar to what they have always been: income pressure that is being driven by the constant cost-price squeeze on farms and the requirement for increased scale. During the Celtic Tiger, the potential for younger people to earn more money off-farm

than from farming put a lot of pressure on the long-term survival of the family farm structure. In addition, within families an expectation developed that the person taking over the farm would contribute financially to the other non-farming members as they were receiving such a large capital asset. This, in turn, put pressure on the new business and restricted the potential to develop. While this situation is occurring less, there is the overhang of this debt on some farms and there are cases currently where young farmers are being asked to assist their siblings who are in negative equity on their houses as part of a farm transfer deal.

## Transferring the family farm

In early February 2014, Teagasc held a 'Transferring the Family Farm' clinic in Enniscorthy to assess the demand for this type of engagement. This was run in partnership between the Teagasc Farm Management Specialists and the local Teagasc Regional management unit. Along with a presentation from James McDonnell, Financial Specialist, Teagasc, farmers were given the opportunity to engage one-to-one with industry specialists in the areas of law/transfer of land, accountants, financial specialists, social welfare specialists, mediation specialists, education, collaborative farming, etc. This was run over two sessions and over 350 farmers attended. Given the demand on the day, and the level of detailed questions that were asked, Teagasc decided to roll this out to all other regional management areas over the course of the autumn, running 11 more of these events. The professionals involved gave their time free of charge and were very impressed by the level of engagement.

## Succession planning

From our experience, it is essential for every farmer to have a farm succession plan in place. There are complex legal and taxation rules that, if planned for, can be managed easily. If not planned for, however, there could be a major impact on the viability of the farm business. Some of the issues relate directly to the absence of wills or the failure to keep these up to date. If a farmer dies intestate, the assets are divided by the rules on succession law – the spouse receives two thirds of the estate and children get one third split between them. There are cases where – though





IYFF 2014

# Family Estate Planning

the family agree that one sibling should receive the entire farm due to the fact that the land is transferring from sibling to sibling and the capital taxation rules are less advantageous on such transfers – some of the farm may need to be sold to meet the tax bill.

As part of the completion of a succession plan, all of the family need to be consulted. Too often parents assume that their children want to farm or do not want to farm. With the benefit of an open and frank discussion, all of the people involved know where they stand and can plan accordingly. It is really the parents who must take the initiative as they are the ones on whom the decision rests. If we want to increase the level of farm transfer nationally, we must come to terms with the concerns of the older farmers who own the land. A key concern is around income security.

## Government and EU policy

Food Harvest 2020 is the industry-led, Government-supported strategy prepared as a road map for the agri-food industry. This document recognises the importance of farm structure and the need for restructuring the industry. Some of the issues that are outlined that need to be addressed include:

- reducing farm fragmentation with the use of targeted supports;
- increasing farm efficiency levels;
- removing any impediments to land mobility; and,
- Government policy should have an integrated cross-departmental support for any taxation/policy incentives to encourage a more efficient Irish farming sector.

## Taxation review

In the 2014 budget, the Minister for Finance announced a taxation review of the agricultural sector. The Minister for Agriculture, Food and the Marine, Simon Coveney, TD, with his colleague the Minister for Finance, Michael Noonan TD, included a public consultation process for the 'agri-taxation review'. This has now been completed; all interested parties were encouraged to make a submission. Many of these submissions have been published by those parties that made them. There were four main categories that were sought to be addressed under this review: Income Tax, Capital Gains Tax, Stamp Duty and Capital Acquisitions Tax.

## Common Agricultural Policy

As part of the ongoing process of CAP reform, the Department of Agriculture, Food and the Marine have also held a public consultation on the Rural Development Programme, which all the key stakeholders have made submissions on. Succession and inheritance and the policies that the CAP supports will have an effect on the future trends in relation to this topic.

Succession and inheritance is a very complex subject. There is no 'one-size-fits-all' answer for any farm family. The Irish Government and the European Union have policies and targets that they would like to achieve. However, achieving these is complicated by the many different farming family situations on the ground.

Pilot-scale woodchip biofilters at Moorepark.

# Alternative uses for pig manure



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The Nitrates Action Plan introduced by S.I. No. 378 (2006) and the spiralling cost of fossil fuel prompted research into non land-spread options for pig manure. Despite restrictions and difficulties relating to the land spreading of pig manure, it is likely to be the most cost-effective use of pig manure in Ireland for the foreseeable future. Teagasc led a three-and-a-half year project to investigate alternative non-land-spread uses for pig manure. The economic feasibility of the alternatives investigated was also assessed.

## Anaerobic digestion

Anaerobic digestion was investigated in laboratory-scale digesters at National University of Ireland Galway (NUIG) and in a pilot-scale digester at Teagasc Moorepark. The laboratory work found that grass silage could be co-digested with pig manure at a volatile solids ratio of 1:1 (manure/silage) in the feedstock, and this was found to improve the specific methane yield. When the reactors were operated under an organic loading rate of up to 3kg volatile solids/m<sup>3</sup>/day and a grass silage volatile solids ratio of up to 40%, the system was found to be stable. The volumetric methane production was up to 501L/m<sup>3</sup> reactor/day. In subsequent pilot-scale experiments, the specific methane yield increased from 154mL CH<sub>4</sub>/g volatile solids added with mono-digestion of manure to 251mL CH<sub>4</sub>/g volatile solids added with anaerobic co-digestion of manure and grass silage (volatile solids ratio of 1:1). Volatile solids removal rates increased from 41.4% (manure alone) to 53.9% (manure + silage). The results show that co-digestion of pig manure and grass silage is preferable to mono-digestion of manure alone.

## Composting of manure solids

The separated solid fraction of pig manure was composted using different bulking agents (straw,

sawdust, shredded green waste and woodchips) at different ratios. Results demonstrated that addition of a carbon-rich bulking agent is required when composting the separated solids of pig manure. Of the bulking agents investigated, sawdust produced the best quality compost. Stable compost was produced using a carbon to nitrogen ratio as low as 16. This corresponds to a separated manure solids to sawdust ratio of 4:1 (fresh weight). In addition, microbiological analyses showed that pig manure-derived compost meets microbiological criteria for marketable processed manure products, as set out in EU regulations, as *E. coli* and *Enterococcus* were below limits and it was *Salmonella*-free.

## Use of solid manure as a fuel

A small-scale pyrolysis reactor in the University of Limerick (UL) was used to study the suitability of producing energy from the separated solid fraction of pig manure before and after composting. The use of all three end products of pyrolysis (biochar, bio-oil and gas) to generate energy was evaluated. The pyrolysis studies showed that the proportion of biochar, bio-oil and gas produced, and the physical and chemical characteristics of these products were influenced by both sawdust addition and feedstock composting. Increasing the sawdust content in the wood/manure mixture reduced the biochar yield and increased the bio-liquid yield. The biochar showed increased heating values, but reduced nutrient concentrations with increasing sawdust addition. The heating value of the gases produced also increased, while that of the bio-liquid was decreased with sawdust addition. Composting of the feedstock before pyrolysis increased the biochar and bio-liquid yield, but decreased the gas yield. The biochar showed reduced heating values, while the bio-liquid heating values increased with composting.



### Integrated Constructed Wetlands

Sixteen meso-scaled Integrated Constructed Wetlands (ICW) systems, each comprised of four cells, were constructed at Teagasc Moorepark to assess the treatment of the separated diluted liquid fraction of pig manure. Different application rates and flow rates were investigated and microbiological analyses were conducted to investigate the removal of pathogenic micro-organisms. The study demonstrated the potential of this technology to treat the separated liquid fraction of pig manure. However, due to the system's high sensitivity to ammonium, the separated liquid fraction of pig manure had to be greatly diluted before entering the ICW. This may limit the use of ICWs on pig farms due to the high land area required to construct such systems. Flow through the cells reduced mean counts of coliform, yeasts and moulds and spore-forming bacteria across all treatments, but there were no effects on *Enterococcus* or *E. coli* counts. Microbial removal was also investigated in large-scale on-farm ICW systems. Overall, reductions in enteric indicator bacteria counts were found across nine ICW systems treating dairy and piggery wastewater, with *E. coli* and *Enterococcus* non-detectable in the final effluent. Furthermore, *Salmonella*, when present in the influent material, was absent in the ICW effluent.

### Woodchip biofilters

Laboratory-scale woodchip biofilters at NUI Galway were successful in removing nutrients from the separated liquid fraction of pig manure. Therefore, six pilot-scale biofilters each comprised of a 1m aerobic woodchip layer and a 0.5m saturated woodchip layer, were constructed at Teagasc Moorepark to verify results and to demonstrate effects of scale, variations in temperature and rainfall. Reductions of up to 54% solids, 80% total chemical oxygen demand (COD<sub>t</sub>), 93% 5-day biological oxygen demand (BOD<sub>5</sub>), 86% total nitrogen (TN) and 79% total phosphorus (TP) were achieved in the pilot-scale woodchip biofilters. When different chemical treatments were investigated for polishing of the pilot-scale biofilter effluent, aluminium sulphate was found to be better than lime. It removed up to 84% turbidity, 76% COD<sub>t</sub> and 99.6% TP from the effluent. Microbiological analyses showed that *E. coli* and *Enterococcus*, although detectable in the biofilter influent, were almost always below the limit of detection in the effluent and *E. coli* counts were also reduced. Furthermore, *Salmonella*, although detected in the influent on some occasions, was never found in the biofilter effluent.

### Economics

A cost-benefit analysis of the technologies investigated was also performed. Anaerobic digestion of pig manure and grass silage (1:1; volatile solids basis) was unviable under the current tariffs, with costs at €4.80/m<sup>3</sup> manure. The solid-liquid separation of the digestate would cost an additional €12.40/m<sup>3</sup> manure. Subsequent treatment of the separated solid fraction by composting would add €2.10/m<sup>3</sup> manure. The use of ICWs to treat the separated liquid fraction would add €4.50/m<sup>3</sup> manure to the treatment costs, while the use of woodchip filters would add €2.80/m<sup>3</sup> manure. Therefore, these technologies are currently not cost-effective. Transport and spreading of raw manure for its fertilizer value is the most cost-effective option. For distances of up to 14km from the customer's farm, the tractor and vacuum tanker scenario is the most cost-effective option (€4.7/m<sup>3</sup>). For longer distances, it becomes more cost-effective to use a truck, with the cost of transporting and spreading manure within a distance of 50km to the customer's farm calculated at €7.7/m<sup>3</sup> manure.

### Conclusion

This project demonstrated the technological feasibility and effectiveness of several alternative uses/treatments for pig manure in Ireland. Economic analysis showed that land-spreading of pig manure for its fertilizer value is the most economic use for pig manure currently. Nonetheless, information on the effectiveness of and design guidelines for each technology examined are now available for adoption by stakeholders should economic conditions/supports change in the future.

### Acknowledgements

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For further details see: [http://www.teagasc.ie/publications/2011/1021/Moorepark\\_AlternativeUsesForPigManure.pdf](http://www.teagasc.ie/publications/2011/1021/Moorepark_AlternativeUsesForPigManure.pdf)

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Meso-scale Integrated Constructed Wetlands at Moorepark.



Pilot-scale anaerobic digester at Moorepark.



# Immune genes and bull fertility

A multi-disciplinary partnership between Teagasc, universities and industry stakeholders is investigating key genes involved in protection of the reproductive tract from infection but which may also regulate fertility.

This collaborative research builds on the discovery of a panel of novel genes in cattle, which have been shown to regulate fertility in other species, including in humans. Defensins are a class of host defence genes originally thought to be involved in protection from infection and which recent work has also shown to affect sperm function and fertility. Identification of key variants within these genes in cattle may allow the development of a test for poor fertility and ultimately the selection of bulls with improved fertility.

## Fertility in cattle

The Irish Cattle Breeding Federation (ICBF) and Animal Health Ireland have identified infertility as the single biggest threat to agricultural profitability. Pregnancy rates are approximately 45-50% in dairy cows but can fall as low as 25% with low fertility bulls. This variation is a major impediment to the use of high genetic merit bulls and limits genetic gain. Identification of the precise genes that regulate fertility can enhance the accuracy of selection, especially for low heritability traits like fertility. Furthermore, understanding the mechanisms that regulate fertility in both the cow and bull may open up new opportunities to improve semen extension, storage and enhanced use of fresh semen during periods of peak demand.

With the advent of genomic selection, there has been a shift from phenotypic selection alone to include molecular evaluation of a bull's DNA in order to identify the desirable sires for breeding. Sire fertility in Ireland can be evaluated using the percentage of pregnancies resulting from mating or an animal model that incorporates factors that may influence fertilisation such as health, age, breed, herd and fertility history of the cow, technician used, and timing of artificial insemination. Following physical examination and testing of sperm for quality and motility, bulls with desirable genotypes are selected for use in mating. Among the bulls that pass all known reproductive quality tests, there are still large differences (up to 28%) in pregnancy rates, which cannot be explained by the known and tested morphological features of sperm, and can pose problems for the industry.



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Sperm are made in the testes but only develop motility and the ability to fertilise eggs after one to two weeks travel through the epididymis. As it moves through several meters of tubule, the sperm is bathed in different concentrations of hundreds of proteins. These proteins, found in seminal fluid, are essential for the sperm to interact with the female reproductive system and the egg. Seminal proteins from animals of high fertility have been shown to increase the pregnancy rates when added to sperm from animals of lower fertility and defensins may contribute to this effect.

## Defensins – an emerging role in fertility

The current project is focused on one class of proteins, defensins, which are small cationic peptides, referred to as host-defense peptides as they exhibit anti-microbial activity. They are an ancient defence mechanism, found across kingdoms, in plants, insects and animals, active against both gram-positive and gram-negative bacteria, fungi and enveloped viruses. Their multiple methods of killing are thought to be the reason they have retained their potency against pathogens over the course of evolution. Although their role in fertility has not been previously examined in cattle, research in other species is showing exciting potential in this regard.

In addition to their role in defence,  $\beta$ -defensins have been shown to be involved in the regulation of fertility in the male (sperm maturation, capacitation) and in the protection of sperm from the female immune response while travelling through the uterus. In humans,  $\beta$ -defensin126 is produced in the epididymis and incorporated into the sperm glycocalyx, the protein-sugar sperm surface. Approximately one in five men are homozygous for a deletion in this gene, which has been shown to cause subfertility as mutant sperm cannot migrate as well through cervical mucus. The odds of pregnancy in couples where the male carries the double deletion were 60% lower than normal.

In cattle, defensin genes are found in four clusters, including a previously unknown cluster of 19 genes, which are expressed in both the male and female reproductive tracts (Narciandi *et al.*, 2011). Variations in the genetic sequences of these genes could cause differences in fertility between animals and treatment with alternate forms of the proteins may increase pregnancy rates.

## Collaborations and new technologies

ICBF provided fertilisation records for 7,000 bulls used in artificial insemination in Ireland and these

were used to identify bulls of high and low fertility. By restricting analysis to sires with highest reliability phenotypes (>1,000 matings) and defining the extremes as  $\pm 1$  standard deviation from the mean; the pregnancy rate for low-fertility bulls varied between 20% and 42% against between 53% and 66% for high-fertility bulls.

The National Cattle Breeding Centre provided DNA from AI bulls. To efficiently capture the regions of DNA that encode the 57 known bovine  $\beta$ -defensin genes, new DNA capture technologies are being employed. DNA baits are designed to match only the sequence of the defensin genes and a high-throughput sequencer is used to sequence the individual bases of DNA from each bull. Mutations will then be identified and those that may be related to the difference between high and low fertility sires will be tested in a larger panel. Professors Cliona O'Farrelly of Trinity College Dublin, Pat Lonergan of University College Dublin and Sean Fair of University of Limerick are collaborating in the project, using immunological and reproductive assays to elucidate the relationships between defensin mutations and sperm function. Our group would also like to adapt this approach to include stock bulls from dairy and beef breeds on Irish farms. As stock bulls are from a less intensively selected pool of animals, genetic and phenotypic variation is likely to be larger, although phenotypes will be more limited. Therefore, we are developing partnerships with other groups to generate phenotypes on these animals.

### Future prospects for fertility analyses

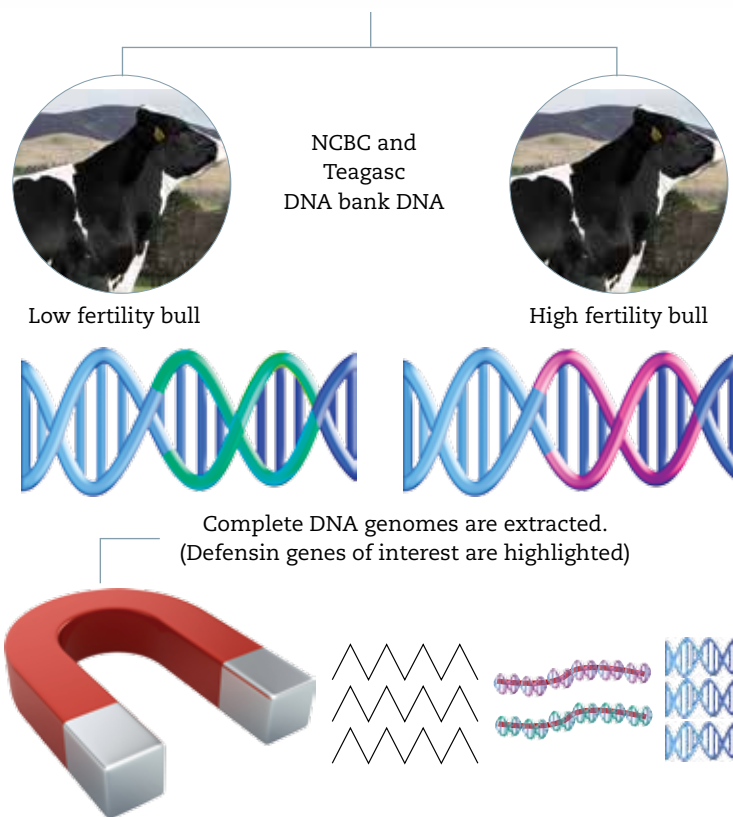
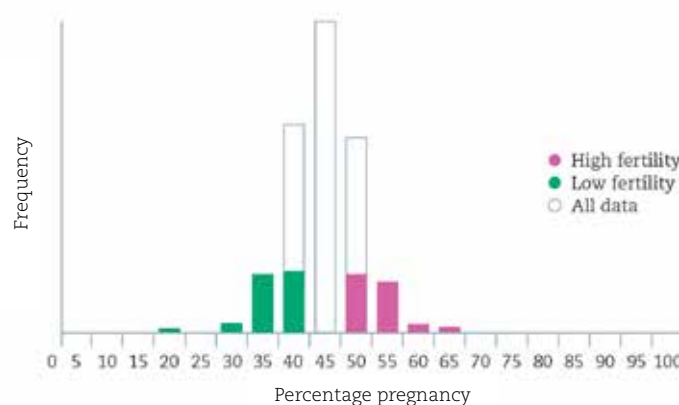
Based on the exciting findings in other species, we hope to explain at least some of the differences between bulls and their ability to produce a viable pregnancy from the first mating, to allow for the selection of bulls with higher fertility or the development of methods of increasing fertility for bulls of average or below-average fertility. It is hoped that this new knowledge will also enable the development of improved tools for the industry.

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### References

Narciandi, F., Lloyd, A.T., Chapwanya, A., O'Farrelly, C and Meade, K.G. (2011). 'Reproductive tissue-specific expression profiling and genetic variation across a 19 gene bovine beta-defensin cluster. *Immunogenetics*, 63(10): 641-651.

Bulls with extremely high and low fertility are identified. The immune genes of interest are targeted with specially designed baits and magnets are used to select only these regions, the rest are washed away before sequencing. The genes are compared between individuals and differences in the DNA sequence discovered.



Magnets are used to extract only the desired portions of the genome.

AGACTATTTAAC C TTAAGGGA ACCAATT

AGACTATTTAAC T TTAAGGGA GCCAATT

The sequences of genes in high and low fertility bulls are compared and differences identified.

# Groundwater vulnerability in agricultural karst landscape



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Figure 1. Right: ortho photo (geometrically corrected aerial photo). Left: LiDAR (light detection and ranging) image of a doline field in an agricultural karst spring zone of contribution. These images can be used to map surface karst features.

**New insights on phosphorus (P) retention along the transfer pathways within an agricultural karst landscape support revisions of previous groundwater vulnerability assessments for such environments. Farming in the studied karst area could pose less risk to groundwater than was anticipated.**

Karst landscapes are areas of limestone geology that have been eroded by dissolution, providing a rapid transit of groundwater that is an important supply of fresh, drinking water. Up to a quarter of the world's population relies on water from karst areas. More than a quarter of the land within the European Union and a fifth of Ireland is located on karstified limestone. Irish karst areas often have shallow glacial soils and have been considered to be at

high or even extreme risk of pollution owing to direct connections between land surfaces and groundwater. There is a particular concern that nutrients may move quickly and easily from the overlying agricultural land to the groundwater and below-ground network of channels. For example, this may happen via swallow holes (vertical shafts) and dolines (collapsed features creating a bowl-shaped depression – see Figure 1) due to low potential for soil buffering (retention and/or release of phosphorus (P) in a controlled manner). For this reason, specific groundwater vulnerability concepts have been developed in the European Union. In Ireland, groundwater is considered to be impaired and at 'poor status' when an Environmental Quality Standard of an annual mean concentration of 0.035mg/L of molybdate reactive P (the fraction of P that is available for algal growth) is exceeded and when the P delivered by that groundwater body is more than half of that received by a surface water body that is at less than 'good status'.



### Karst spring zone of contribution

The Agricultural Catchments Programme (ACP) was designed to provide a baseline of water quality response to agriculture in the years following the implementation of Ireland's Nitrates Action Programme (NAP) within five agricultural river catchments and one agricultural karst spring zone of contribution (ZoC). The karst spring ZoC is about 32km<sup>2</sup> and drains into the River Robe and Lough Mask in Co. Mayo. The river Robe interacts considerably with the regional groundwater body.

As part of baseline ACP assessments, all soils within the spring ZoC were surveyed for soil P status on a field-by-field basis. Soils were further classified and their potential to buffer P was assessed. Depth to bedrock was mapped and categorised into depth classes (from 0.5m depth and deeper) and surface karst features were characterised and mapped within a 46km<sup>2</sup> area covering the spring ZoC. Phosphorus concentrations and water discharge were monitored at a high temporal resolution (up to six times per hour) in the main spring draining the area. Local weather was monitored at two locations within the zone (rainfall on four locations).

### Contradicting risk of pollution

An 'intrinsic vulnerability' assessment, using existing criteria, suggested that 97% of the spring ZoC was at high to extreme risk of polluting groundwater with P. Despite this, and a relatively intensively farmed landscape (based on a coverage of high soil P index fields from a legacy of nutrient applications prior to the NAP), two and a half years of monitoring of P concentration in the main spring water showed no evidence of pollution. The P concentrations in spring water and loads leaving the ZoC were considerably lower than the other river catchments monitored within the ACP. To try to untangle the apparent contradiction of the extreme risk for pollution and good water quality, the potential for P retention along the nutrient transfer pathways was investigated based on soil P buffering, depth to bedrock and P retention within the aquifer.

### Phosphorus retention

Although the soils were relatively shallow in this area; this study showed that much of the P deposited is buffered by the soil due to a combination of clay-rich top soils and calcium rich sub-soils. Even in the dolines, bedrock fissures and larger conduits, P was, to some degree, likely to be buffered. The most common surface karst feature in the area are the dolines of which 1,327 were mapped and re-classified based on the potential to buffer P by the soil at the base. Only about 3% of the dolines in the area had no soil at their base and were re-classified to be of high risk for P loss to groundwater; 4–5% were mapped as moderately risky; and over 90% had enough soil at base to buffer against P leaching loss.

New analysis techniques using the high frequency monitoring of the water emerging from the spring made it possible to estimate the proportions of P being delivered via different pathways to the spring. This technique also gave an estimation of how much P may be retained within the aquifer. The analysis revealed that most P moves through small to medium sized fissures, which deliver 52-90% of P loads during storms. The loss of P via the spring was 93kg total P in the first monitored year and 138kg in the second (52 and 91kg of total reactive P). During one large winter flow event 18kg of total P and 12kg of total reactive P was estimated to be retained in the limestone aquifer, which was close to half of the event total.

### A new risk assessment

Based on these new conceptual models of nutrient loss and buffering processes, in this particular karst landscape, new categories of risk assessment were set. Those categories are used together with data on source pressures to develop the previous 'intrinsic vulnerability map' into a new 'specific vulnerability map'. This proposed vulnerability map classifies 14% of the site as highly vulnerable for P loss to groundwater with two thirds of low vulnerability and the remainder moderate. This is, therefore, a better comparison with the landscapes' P buffering and attenuation processes and observed water quality in the emerging spring. By overlaying areas of high source pressure (P index 4 soils) on high vulnerability areas, a 'Critical Source Area' map (Figure 2) identifies only 2% of the area as at high risk. Reducing legacies of high soil P to the optimum for grass and crop production and following existing regulations with regard to fertilizer and slurry applications offers a simple way to reduce that risk further. The assessment can be used to modify expectations of risk and focus management efforts in karst landscapes sensitive to nutrient loss and eutrophication. The work is ongoing and the 'Critical Source Area' map is being validated by comparing the response of P and spring water quality to the natural rain patterns over the area, as monitored by 10 rain gauges within the spring ZoC.

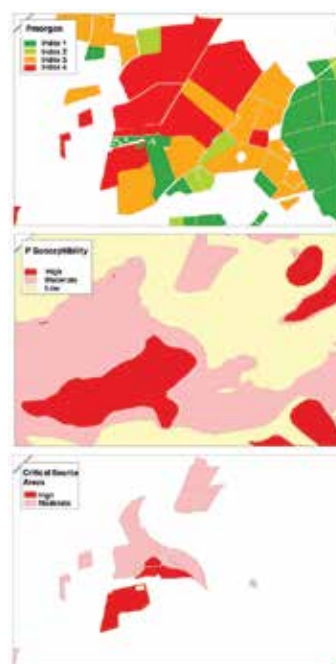


Figure 2. An example of how soil phosphorus status (top) and specific groundwater phosphorus vulnerability (middle) can be used to produce a critical source area map (bottom) for P transfer to groundwater over a section of the karst spring zone of contribution.

Top: dark green=index 1, light green= index 2, orange=index 3 and red=index 4.

Middle: red=high, pink=moderate, yellow=low.

Bottom: red=high, pink=moderate.

### Acknowledgements

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Detailed references for papers used in the preparation of this article can be found at [www.teagasc.ie/agcatchments/publications/](http://www.teagasc.ie/agcatchments/publications/)



# Sediment fingerprinting

In the Teagasc Agricultural Catchments Programme, Sophie Sherriff is using forensic geoscience to determine the source of sediment in our watercourses.

Soil erosion and the transport of sediment into streams and rivers are natural processes that shape the landscape around us. However, 'accelerated erosion' causes excessive soil loss and transfer of sediment into watercourses, especially fine-grained suspended sediment, and is a key catchment management concern throughout Europe.

Agricultural land and commercial forestry can produce elevated rates of soil loss. Greater livestock numbers, coupled with mechanised crop production and more powerful and heavier farm machinery, alter the physical properties of soils, increasing their susceptibility to erosion. Drainage operations, on-field trafficking, higher stocking densities and the loss of riparian corridors add to the problem by increasing the 'connectivity' between critical sources and receiving water bodies. Additional potential sources of sediment include farmyards, tracks and road verges, and channel banks.

Delivery of sediment to watercourses can result in degradation of freshwater habitats. Elevated suspended sediment concentrations in rivers can result in decreased light penetration in the water column – affecting primary productivity and compromising the navigation and functioning of aquatic species. Excessive sediment in a river bed can smother aquatic habitats for species such as the Freshwater Pearl Mussel and Atlantic Salmon, which are protected under the EU Water Framework and Habitats Directives.

Identification of sediment sources in order to target cost-effective catchment management is important to achieve at least "good" chemical and ecological water quality status requirements of the EU Water Framework Directive (2000/60/EC) by 2015.

## Source area identification

Sediment yield is the product of multiple erosion sources, pathways and storage relations in catchments. Assigning sediment to its upstream source (its provenance) is a complex, but potentially revealing task. Multiple factors (e.g., soil moisture, soil erodibility and slope) control the rates of soil loss. Additionally, the transportation of eroded material to watercourses is dependent on the presence, connectivity and efficiency of natural and artificial drainage systems. Consequently, only small areas within each source, known as "critical source areas", are responsible for the majority of soil loss and sediment-associated nutrients and contaminants. These critical source areas are priority areas for cost-effective sediment management.

Sediment fingerprinting is a novel technique for quantifying the relative contribution from different sediment sources at the catchment scale. The approach identifies candidate source areas (using desk-top and field-based geomorphological assessments). Soil samples are collected from the potential source areas (e.g., eroding fields or channel banks) and analysed for a variety of properties including geochemistry, radionuclide content, mineral magnetic properties and colour. These 'tracer' properties are analysed statistically and combined to generate a distinct composite signature for each source type. The sediment delivered to the catchment outlet is thus a mixture of eroded sediment from multiple source types. Fingerprinting involves the un-mixing of these different sources (using a numerical un-mixing model) such that the relative proportion of sediment from each source is quantified.

## Application of sediment fingerprinting

The sediment fingerprinting approach was applied to an Agricultural Catchment Programme (ACP) river catchment in Co Wexford. Land use within the catchment area is dominated by grassland, predominantly for beef and dairy, and soils are generally poorly drained.

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Figure 1. Time-integrated sediment sampler.

Seven potential sediment source types were sampled, i.e., topsoils, subsoils, channel banks, road verges, farm tracks, sub-surface drains and open drains. Sediments delivered into the channel network were sampled using in-stream time-integrated suspended sediment (TISS) samplers (Figure 1), mounted at different locations within the channel network and emptied every six to 12 weeks from May 2012 to June 2013.

All source and sediment samples were measured using mineral magnetic properties. Many sources had similar characteristics; meaning they were best integrated into three distinctive source types (field soils incorporating topsoil, subsoil and sub-surface drain samples; road sources incorporating road verges and track samples, and channel sources containing open ditches and channel banks). A statistical un-mixing model was used to quantify the relative contribution the different sources made to the in-stream TISS samples.

### Sediment sources

The un-mixing results show that the relative source contributions vary considerably throughout the monitoring period (Figure 2). Channel bank erosion is the key source of sediment, delivering on average 50% (range 17-71%). Field sources are next in importance with on average 33% (range 4-83%); whilst road sources make up the remainder at on average 17% (0-35%).

During the summer months the relative contribution from channel bank erosion is reduced, most likely as a result of increased strong vegetation growth protecting the channel banks. Additionally, the drier summer months mean river channels are shallower and the stream power is greatly reduced. Field contributions show a less seasonal pattern due to multiple mechanisms operating together, e.g., splash and surface runoff during intensive rainfall events, or flushing sediment through soil macro-pores and from sub-surface drainage features.

The fingerprinting technique offers valuable insight into the relative importance of different sediment sources within agricultural landscapes. Seasonal fluctuations are important,

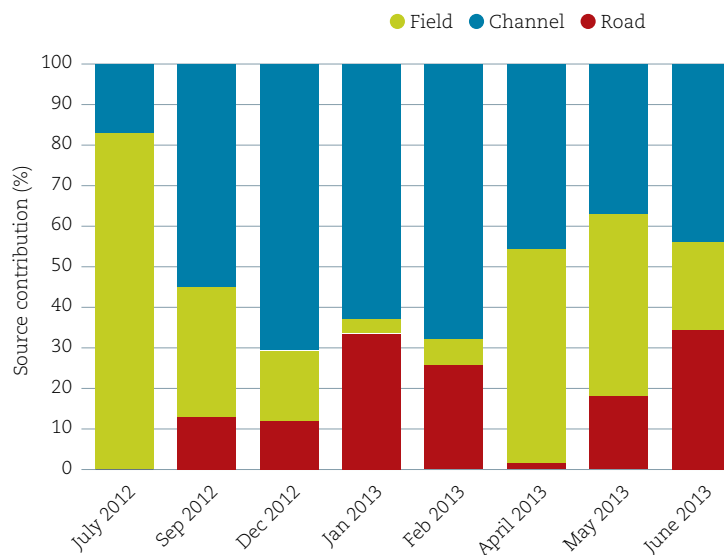


Figure 2. Statistical un-mixing of sink sediment samples.

suggesting that the environmental dynamics responsible for the initiation and transport for each source area are complex. On-going analysis of field samples – to increase the range of tracers used (including geochemical and radiometric properties) – will improve the ‘dimensionality’ of the analysis and increase the discriminating power of the model.

The preliminary results presented are being repeated and extended in two further catchments, featuring different soil, topography and land management practices. These studies will shed new insights into the sources and fate of fine-grained sediment within Irish agri-ecosystems. An additional objective of the study is to determine the rates of sediment loss in ACP catchments. Turbidity, used to infer the concentration of suspended sediment, is being monitored at high resolution in all study catchments. Accurate sediment yields are being calculated and benchmarked against similar erosion rates from around the world.

By determining the yield and primary sources of problematic sediment, cost-effective mitigation strategies can be designed and targeted – especially in relation to critical source areas yielding the highest nutrient or sediment into the channel network. Catchment management plans can thus address the specific nutrient, sediment and morphology pressures and help Ireland meet its regulatory obligations under the Water Framework Directive to protect and enhance the quality of freshwater environments.

### Acknowledgements

This project is funded by the Walsh Fellowship Programme. Overseas placement to the University of St Andrews was supported by the Walsh Fellowship Overseas Training Award. A placement to UTAS was supported by the Australian Bicentennial Scholarship Fund, UTAS and the University of Dundee. We would like to acknowledge research and technical support from the Teagasc Agricultural Catchment Programme team and from farmers and landowners within each of the catchments.





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# Water quality in tillage and grassland

Researchers at Teagasc Oak Park are developing a low-cost, easy-to-use water quality measurement system for use on tillage and grassland farms.

Much effort has been given to land management aimed at reducing the impact of excess water on land. Excess surface water can lead to overland flow, which can run from land through the drainage stream into rivers and streams carrying nutrients, pesticides and other chemicals. This phenomenon is selective and variable and does not happen on all land types or conditions; usually it can be found in areas where the soil is heavy or compacted by machinery or animals, or where the topography brings the water table to the surface. It is thought that between 30% and 40% of Irish tillage and grassland can be affected by overland flow in this way.

Teagasc has had a long-term research programme aimed at understanding and controlling overland flow issue since 1987. Early studies concentrated on individual sites with extensive site works and instrumentation designed to capture and record the phenomenon. These studies yielded high quality information regarding water flow and nutrient

content; however, due to the high variability of overland flow, attempts to model it were not successful.

A more recent trial at Oak Park, using expensive equipment and site works (Figure 1), recorded relatively small flows with corresponding low levels of phosphorous exported. Sediment loss was also low. The conclusion drawn was that this site was not a significant source of pollution. This was good news as the Oak Park site is comparable to other land that amounts to 16% of agricultural land in Ireland but bad news considering the set up cost of the sites. Subsequent efforts seek to reduce these costs.

## Improved equipment for measuring overland flow

Around the year 2000, interest developed in designing smaller, more mobile and less expensive equipment for measuring and sampling overland flow. Traditional equipment is very capable but has to be fixed in position and cannot be used to monitor many sites remotely from a research centre; also the cost involved was very large with a price as high as €100,000 for one site, based on the construction costs at the Big Bull Park, Oak Park. New equipment



has been developed over several studies at Teagasc, Oak Park, that is far simpler and less expensive and can be used anywhere. These devices are modular in design and can be set up to suit a given site – some units measure flows and some take a proportional sample and use this to indicate flow. The cost could be as low as €600 per site but some systems were substantially more expensive than this.

The first attempt by Teagasc to develop low-cost equipment saw the use of water table tubes and a spread-sheet model. Using this system, the water table was recorded three times per week and rainfall data was recorded daily. The model essentially matched rainfall data to obtain water table values and calculated overland flow with a precision comparable to traditional equipment. The method worked well on sites having a high water table, but not on fields affected by compaction or containing a shallow perched water table.

#### New methods for measurement of overland flow

New methods were needed to deal with such areas. About this time, several overland flow devices appeared in the literature. Teagasc built and worked with three of these. Two were found to be unsuitable, too complex or inaccurate for the requirements of a scientific study. A small 2m dam with logger (overland flow indicators, OFI) was the most practical. Including a weir and a simple open/close electrical sensor, it recorded the start and end times of overland flow (Figure 2). These data could then be compared to rainfall. These units were checked several times and scored very well against rainfall.

The issue of relating rainfall to OFI logger data remained an open problem to be dealt with for some time until a new model (OFI model) was devised. This was a simple statistical model which compared overland flow data and rainfall data. Initial predictions within existing overland flow sites were successful, but moving the model to new sites that did not have pre-existing overland flow data produced a high level of error. Additional data is therefore required to provide some improvement in the model's accuracy.

In a separate development, a new type of proportional sampler was developed at Teagasc. Similar to Figure 2, this sampler is mounted on a 2m wide dam with a small weir and an electronic logger to

record the start and stop times of overland flow. The sampler, which passes water through several small nozzles, takes a sample proportional to the main flow through the weir (Figure 2). As the overland flow sample is proportional to the main overland flow, the latter can be calculated from the volume of the sample and remain proportionality constant. This achieves the objective of the model, but the model output is still sought as a final check on the sampler data. This equipment, with sampler, logger, weir and dam is suitable for almost all situations and areas in which overland flow might arise. It is inexpensive at approximately €250 per unit and with three or four units required per site; the cost of testing a field is modest. It does, however, take at least three months to complete an investigation and this is a significant amount of time.

#### Natural indicators

The next phase of this modelling and overland flow work will look at natural indicators of soil wetness and overland flow. An indicator could be a plant, a microbial community in the soil, a feature on the soil surface, or general soil conditions. Potential plant indicators include the common rush, marsh thistle and some species of buttercups among others. Wheel ruts in the soil and flow marks will also indicate soil wetness. The lack of such qualitative evidence along with certain dry-land plants will usually indicate soil dryness. The result will indicate the potential risk of overland flow running as a series from 'high' through 'medium' to 'low' risk. The main advantage of this sort of qualitative approach is the speed with which it may deliver a reliable conclusion regarding the moisture status of a field. A trained individual should be able to examine – in an afternoon – plants and soil; if a microbial assessment is required it would take longer, perhaps two weeks. The former method could be used by anyone with a little training in identifying indicators and putting the data together to form a conclusion as to the risk of overland flow. It is likely that farmers themselves could do the assessment.

This research was funded by Teagasc core funding.

## Events

### SEPTEMBER

15 September

Teagasc, Johnstown Castle, Co. Wexford

#### Launch of the Irish Soil Information System (ISIS)

The overall objective of the ISIS project was to conduct a programme of structured research into the national distribution of soil types and construct a soil map, at 1:250,000 scale, which will identify and describe the soils according to a harmonised national legend. This event will be held in Johnstown Castle, the home of the national soil survey for many years. An international soil training course will be held to coincide with the launch.

Contact: [rachel.creamer@teagasc.ie](mailto:rachel.creamer@teagasc.ie)

17 September

Teagasc Conference Centre, Ashtown, Dublin

#### National Rural Development Conference, 'Finding off-farm employment'

The theme of this year's National Rural Development Conference, 'Finding off-farm employment' seeks to address the challenges facing many farm families dependent on off-farm income. The conference will hear from a range of speakers on the current significance of off-farm employment and how this has changed in light of the recession. The conference will also hear from Dr Matt Lobley, University of Exeter, on the issue of farm succession.

The conference is free to attend but as places are limited attendees must register: <https://www.eventbrite.ie/myevent?eid=11932324905>

Contact: [david.meredith@teagasc.ie](mailto:david.meredith@teagasc.ie)

### OCTOBER

14 October

Dublin (TBC)

#### Dairy expansion seminar series – benchmarking expansion on Irish dairy farms

Spring calving, pasture-based milk production can be the most labour-efficient system of milk production, however, there is a period of acute labour demand in early spring associated with compact calving and calf rearing. This acute labour demand will increase as herd sizes increase post quotas and will be exacerbated during the expansion process as farmers' project manage the expansion phase. The combined effects of expansion may lead to significant stress on the farm operator and, subsequently, impact negatively on both the farmer's health and viability of the business. This seminar will outline the key logistical challenges of managing expansion and larger dairy farm operations and identify the critical factors that minimise the stress on farmers and ensure a more sustainable expansion.

Contact: [roisin.condon@teagasc.ie](mailto:roisin.condon@teagasc.ie); Tel: 025 42330  
[http://www.teagasc.ie/events/2014/Dairy\\_Expansion\\_Seminar\\_Series.asp](http://www.teagasc.ie/events/2014/Dairy_Expansion_Seminar_Series.asp)

### NOVEMBER

4 November

Shelbourne Hotel, Dublin

#### Teagasc/IFA International Conference on Family Farming

The UN Food and Agricultural Organisation (FAO) has designated 2014 as the International Year of Family Farming (IYFF), which aims to raise the profile of family farming and smallholder farming by focusing world attention on its significant role in eradicating hunger and poverty, providing food security and nutrition, improving livelihoods, protecting the environment, and achieving sustainable development. Teagasc, in association with the IFA, will hold a major international conference with President Michael D. Higgins as keynote speaker. The 2014 IYFF will promote broad discussion and cooperation at the national, regional and global levels to increase awareness and understanding of the challenges faced by smallholders and help identify efficient ways to support family farmers.

12-13 November

Clarion Hotel, Cork City

#### Cheese Symposium 2014

This ninth Cheese Symposium continues a tradition to showcase recent developments in both fundamental and applied research. The symposium is again organised by Teagasc in collaboration with University College Cork and INRA (France) and aims to cover a broad range of themes associated with on-going cheese research and current market trends. The Symposium will provide a unique forum for academia and industry to share experiences on the latest developments and applications of cheese research. The programme will appeal to all involved in cheese research or production. The programme will feature key developments and updates from the all-Ireland cheese research project – 'CheeseBoard 2015' ([www.cheeseboard2015.com](http://www.cheeseboard2015.com)), along with highlights from the EU FP7 PLeASURE project 'Novel processing approaches for the development of food products low in fat, salt and sugar reduced', where Teagasc is contributing to the development of reduced fat, reduced salt (RFRS) mozzarella cheese for combination with other similarly 'reduced in' ingredients during pizza production. Contact: Niamh O'Brien; Tel: 025 42313; [cheesesymposium2014@teagasc.ie](mailto:cheesesymposium2014@teagasc.ie)  
[http://www.teagasc.ie/events/2014/cheese\\_symposium/](http://www.teagasc.ie/events/2014/cheese_symposium/)

### DECEMBER

5 December

Johnstown Castle, Wexford

#### Centenary Lecture to Mark Birth of Leading Irish Agricultural Scientist – Dr Tom Walsh

A special lecture will be held in Johnstown Castle, Wexford on 5 December (World Soils Day) to mark the centenary of the birth of the late Dr Tom Walsh. Dr Walsh was the first Director of An Foras Taluntais (AFT), and later of ACOT (AFT and ACOT merged to form Teagasc in 1988) and made fundamental contributions to the development of Irish agriculture, the economy and society. The lecture will be delivered by Professor John Ryan on the 'Evolution and Achievements of Irish Soil Science'. Professor Ryan is himself an internationally distinguished soil scientist and was the recipient of the prestigious International Service in Agronomy Award for 2004 from the American Society of Agronomy. <http://www.teagasc.ie/events/2014/20141205.asp>

For a list of Teagasc's food industry training schedule please see: <http://www.teagasc.ie/food/research/training/schedule.asp>  
For presentations from previous Teagasc events see: <http://www.teagasc.ie/publications/>