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# scrr

Scottish Consortium  
for Rural Research

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PORTPATRICK, WIGTOWNSHIRE BY GORDON MCKEE VIA WIKIMEDIA



## This issue in numbers

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**7%** woodland cover at JHI's experimental farm will more than double over three years – **page 3**

**500** individual salmon were studied to explore differences in the genes of farmed fish – **page 3**

**98%** of Brazilian beef production does not involve deforestation, studies show – **page 5**

**3** rivers in Scotland have been sampled for antimicrobial-resistant bacteria in invertebrates – **page 8**

## Building science for the future

Prof Sarah Skerratt, Scientific Director of SCRR, discusses resilience, mutual support and the crucial need for many different kinds of connectivity

THE THEME OF SCRR's 2020 mini-conference for early career researchers (ECRs) in November was 'Science for rural recovery and resilience'. Scientists from SCRR's member organisations reflected on how their work builds capacity for rural adaptation: across livestock sectors of poultry, sheep, beef and dairy; within environmental conditions for our essential bee pollinators; for health and wellbeing within community land ownership; and for science-based tourism.

While the ECRs' starting points may be different, their goals are the same: that is, to translate their findings so that they might be used by those living and working across Scotland's rural communities, and by those forming policies, practices and standards that will shape Scotland for decades to come.

The ECRs gave an exciting focus on the future. This focus connects to a

strong thread that runs through the resilience literature – that of the ability of individuals and communities to imagine, dream, plan and make deliberate choices for their individual or collective futures. Resilience research also recognises a context of constant change (either 'slow burn' or rapid), within which 'human agency' – the ability to imagine and act – is essential, but also unequally distributed.

Given that unequal distribution, resilience is underpinned by definitions relating to the centrality of links between people, in order that we can support, collaborate, mobilise; share resources and capital; make people-and-place connections; share values and beliefs, knowledge and skills. These functions of connectivity echo the very purpose of SCRR – reflected not only in the now-annual ECR mini-conference, but also in our newsletter and newly revamped website.

**Making connections: links of all kinds are key to the resilience of rural communities in Scotland (above)**

Particularly in these times of continuing challenge, there is the need for mutual support and kindness; SCRR reflects core resilience values of working together as a collective, making access to science more equitable, and creating further opportunities for science to contribute to Scotland's shared recovery.

## About SCRR

**THE SCOTTISH CONSORTIUM FOR RURAL RESEARCH** exists to promote sharing of ideas and techniques among a group of organisations active in research into land, freshwater, coastal and marine resources, and their uses.

Our member organisations have bases throughout Scotland and are at work all over the world: details are on the back page.

Members' reports

Royal Botanic Garden Edinburgh



# Rebuilding of Botanic Gardens glasshouses goes ahead after Scottish Government investment

Backing of £50m for 'Biomes' project at Royal Botanic Garden Edinburgh is part of Scotland's green recovery from the coronavirus pandemic

SCOTTISH GOVERNMENT FUNDING of £50m will sustain the place of the Royal Botanic Garden Edinburgh (RBGE) at the vanguard of global action to combat the climate emergency and address the biodiversity crisis.

The Low Carbon Fund backing covers five years' work on the visionary Edinburgh Biomes initiative, creating world-class facilities producing climate, economic, wellbeing and environmental benefits, as part of Scotland's green recovery from the coronavirus pandemic.

By supporting the project in the institute's 350th anniversary year, it will safeguard the Garden's heritage glasshouses while enhancing research facilities and addressing weaknesses in its ageing infrastructure. It also creates new green jobs, apprenticeships, training and investment in the construction sector post COVID-19. Redevelopment of the public and

research glasshouses, at the Garden's headquarters in Edinburgh, will also safeguard the globally important collection of plants housed in them. A state-of-the-art plant health suite will allow further advancement in this burgeoning area of research.

Simon Milne MBE, Regius Keeper, believes this is a landmark moment for the research organisation and visitor attraction: 'Edinburgh Biomes is the most significant project in the Garden's 350-year history to date. As one of the world's leading botanic gardens, it will enable us to forge ahead with pioneering work for Scotland and the world, working towards a green recovery and reinforcing the Scottish Government's reputation for strong leadership in tackling climate change and biodiversity loss.

'This will be a global resource within an international framework to address biodiversity loss and associated issues of climate change.

**Above: the Victorian palm house at the Royal Botanic Garden Edinburgh**

The work undertaken here reflects collaboration across international governments and organisations and can address the need for transformative change in how people co-exist with nature. With more than 20 per cent of the world's plant species at risk from extinction, our work is more important than ever. All known life depends on plants, and plants can provide the solutions to so many of the world's challenges.'

The most visible changes for the public will be the extensive restoration of the celebrated Grade A-listed public glasshouses, from the iconic Victorian palm houses to the modernist 1960s Front Range.

A striking new public glasshouse, initially built to decant specimens from houses under refurbishment, will eventually become the welcome area for the revamped and outstanding visitor experience.

The project will enhance tourism, recreation and the Scottish economy. Over its six years, 700 person years of employment will be directly supported.

After initial funding from the Scottish Government, the project gained planning permission in 2019. Since then, relocation of plants has been taking place with sensitivity to prepare for initial works, due to start in April 2021.

*For more information, contact Shauna Hay, [SHay@rbge.org.uk](mailto:SHay@rbge.org.uk)*

# Climate-positive farming arrives in Aberdeenshire

Scientists at the James Hutton Institute aim to achieve net zero or negative carbon emissions at Glensaugh

THE JAMES HUTTON INSTITUTE is developing climate-positive farming at its Glensaugh research farm in Aberdeenshire. The principal aim of climate-positive farming is to achieve net-zero or negative carbon emissions, while protecting and enhancing the natural assets of a farm and ensuring long-term financial sustainability.

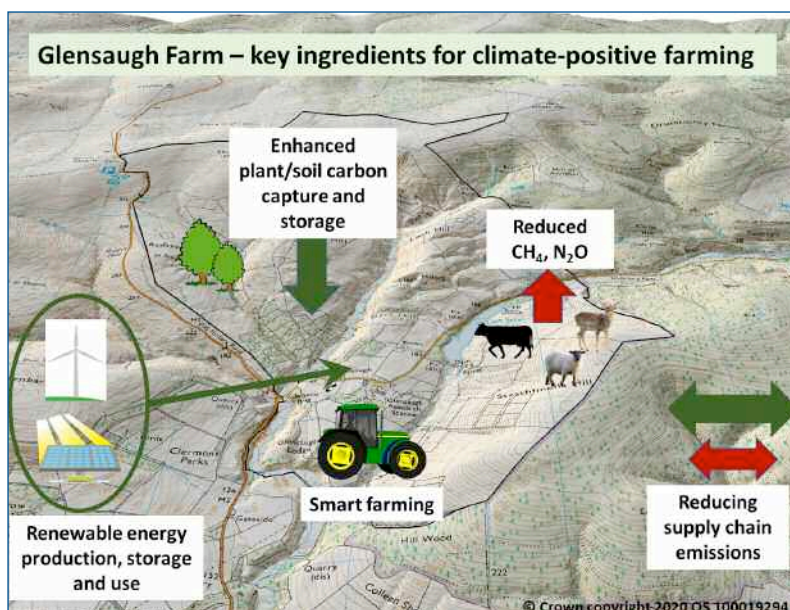
Moving towards net-zero carbon emissions will require innovations in technology and ways of working. The natural assets and infrastructure of the farm are being capitalised upon in a programme of research, testing and demonstration to plan for transformational land use options, and to understand on-farm and off-farm benefits or disbenefits.

Through this approach, it aims to demonstrate the scale and nature of transformation required in farming, and the significant contribution that the sector can make towards climate and biodiversity targets.

Glensaugh currently has roughly 7% woodland cover (70 ha), including a long-term agroforestry experiment. The woodland area will be expanded by 100 ha in the next three years, contributing to the ambitious goals of the UK and Scottish Governments to increase woodland cover to help progress towards targets of net-zero carbon emissions.

A wind turbine, solar PV panels and a biomass boiler provide a range of renewable energy sources. This mix

Right: how the elements of net-zero or negative carbon farming will combine at Glensaugh



helps smooth out some seasonal and weather-related variability associated with both wind and solar, but intermittency of energy supply is always an issue with renewable energy systems. Energy storage solutions are being explored to address this, with a primary focus of assessing the potential of hydrogen as a renewable energy storage medium for all electrical and heating requirements, including replacing some or all of the hydrocarbons currently used as farm-associated vehicle fuels.

Glensaugh has a range of outreach tools and information about the climate-positive farming initiatives at its own website (see below) where visitors can check out the research, data, webmapping tools and hyperlinked video tour of the farm from the air and on the ground.

For more information, contact [climate.glensaugh@hutton.ac.uk](mailto:climate.glensaugh@hutton.ac.uk), or Prof Alison Hester, [alison.hester@hutton.ac.uk](mailto:alison.hester@hutton.ac.uk). Glensaugh Farm is at [glensaugh.hutton.ac.uk/](http://glensaugh.hutton.ac.uk/)

# Genome explains differences in wild and farmed salmon

STRUCTURAL DIFFERENCES IN salmon genomes affecting brain genes may explain behavioural changes between wild and farmed populations.

A study of salmon has shed light on common variations in DNA that affect the function and expression of many genes. Researchers from the Roslin Institute and University of Aberdeen studied almost 500 salmon from around the world to identify and map variations in the genome – sections that are deleted, duplicated or inverted – to help explain behavioural traits seen in farmed fish. Insights into structural variation in salmon – which can affect commercially important

traits – could help inform selective breeding and support fish welfare.

The team's findings identify variations in genes linked to the brain and behaviour, and build on previous discoveries of behavioural differences between farmed and wild fish. For example, farmed fish tend to be less fearful of predators and more motivated to find food, which underpins their faster growth rate.

Structural variations also appear to have been influenced by a duplication of the genome, which occurred in an ancestral salmonid fish some 100 million years ago.



Professor Dan Macqueen and his collaborators have developed a novel method to reliably map structural variations across the salmon genome using sequencing datasets that are common in many species.

He anticipates that these findings will open the door to exploiting structural variation in salmon genetics, supporting research and applications in breeding and conservation, in addition to improving our understanding of genome biology and evolution.

The study is published in *Nature Communications*.

Members' reports

SAMS, Roslin Institute

# Impact of 'COVID-shock' on the UK's seafood sector

Research led by a team from Scottish Association for Marine Science (SAMS) aims to quantify the impact of the pandemic on the UK seafood industry and inform policy responses by government and business

A RESEARCH TEAM led by the Scottish Association for Marine Science (SAMS) has begun to investigate the impact of COVID-19 on the UK seafood industry.

The seafood sector incorporates significant processing and logistics operations within the supply chain, which begins with farming and fishing and ends with supermarkets, fishmongers and restaurants.

Analysis of the previous economic crash in 2008 showed huge implications for the seafood sector, which also needed a longer recovery time than other industries. There is also a great deal of uncertainty within the industry over a looming post-Brexit end to the transition period.

Now the RiseUp project, led by Dr Sofia Franco from SAMS, will seek to find out the extent of the so-called 'COVID-shock' in the industry and provide policy recommendations and advice to government and business, to help improve resilience in the sector.



The 18-month investigation, funded by the Economic and Social Research Council (ESRC) as part of UK Research and Innovation's rapid response to COVID-19, will also involve the University of Manchester and will conduct interviews and surveys during its initial data collection. The project also benefits from Seafish

**Seafood suppliers are recovering from the pandemic while also facing Brexit**

information and analytical input. Dr Franco said: 'The UK seafood industry is under unprecedented pressure to deliver on national food security during the COVID-19 / SARS-CoV-2 pandemic, while trying to adapt to remain viable.'

'Many livelihoods depend on the industry, whether that is people working within fishing and aquaculture sectors, supply chain companies and high street businesses. The location of many of these jobs – many in coastal and rural communities – is also significant in these local economies.'

'However, it is important to capture the systemic impacts to the UK seafood industry, how businesses are adapting and how the supply network has been affected.'

Dr Franco also said the project's recommendations must consider opportunities and concerns about the effect of an extended 'COVID-shock' on top of the uncertainty around the Brexit trade deal negotiations.

The project is keen to hear from companies across the seafood industry in gathering evidence on the effects of the COVID-19 disruption across the sector, the response from seafood businesses and the uptake of existing government support measures.

*Please contact the project lead at [sofia.franco@sams.ac.uk](mailto:sofia.franco@sams.ac.uk) if you would like to share your experience of how COVID-19 has affected your business.*

# Gene map to aid studies of key traits in sheep

GENETIC CODE INSIGHTS pave the way to more accurate research into traits of interest in sheep, such as health and resilience.

The study, led by Roslin scientists within the Centre for Tropical Livestock Genetics and Health, is a collaboration with an international team as part of the Ovine Functional Annotation of Animal Genomes (FAANG) project.

The scientists have identified points in the sheep genome where the process of switching on genes starts, known as transcription start sites. This enabled them to build a map of the location of all the genes in the genetic code of sheep, in a development that could help to understand the genetic basis of traits linked to health and food production.

Their discoveries will help improve the existing high-quality map of sheep DNA, with one of the highest resolutions in a livestock species to date, which can be freely used for



studies of sheep health, welfare, resilience, nutrition and productivity.

Outcomes from the research, which include analysis of multiple tissues from all organs, can be used to investigate how specific regions of the genetic makeup of sheep affect their physical and physiological characteristics.

The map was built from a single sheep from the Rambouillet breed, known for high-quality fleece and for being able to live in harsh conditions.

**Rambouillet sheep, the breed used for the genetic analysis**

The team used a technique called Cap Analysis Gene Expression (CAGE) sequencing to identify the start sites of the vast majority of genes in the Rambouillet reference genome, which was generated by scientists from Baylor College of Medicine in the US, and is a database that is representative of all the genes and genetic code for sheep.

Dr Emily Clark of Roslin Institute and CTLGH commented that sheep are hugely important farmed animals, providing a key global source of meat and fibre. The high-resolution annotation of transcription start sites in the genome generated for the Ovine FAANG project will give scientists a better map of the genome upon which to base their studies.

The study is published in *Frontiers in Genetics* and was funded by the US Department of Agriculture, National Institute of Food and Agriculture (USDA NIFA).



**Left: deforestation by fire is not linked in a simple way with beef production**

## Raising fires and cattle – why the story of deforestation is complicated

Dr Rafael De Oliveira Silva of the University of Edinburgh responds to the tendency to simplify the complexity of land use dynamics, demonising livestock producers and the role of market demand

RISING NUMBERS OF fires in the Amazon in recent times were widely interpreted as a consequence of deforestation to support agricultural grazing, but the reality is more complex, writes Dr Rafael De Oliveira Silva, Chancellor's Fellow, the Global Academy of Agriculture and Food Security, University of Edinburgh.

Burning fallow vegetation is an essential management tool for Amazon farmers. It is usually an efficient way to prepare land for planting crops and pastures. However, in 2019, there was a concerning and atypical increase in regular fires in Amazon. The Brazilian Spatial Research Institute (INPE) reported an 84% increase in fire warnings between January-August, compared with 2018.

This led to global outrage and a media narrative combining politics with an already emotive story linking deforestation to cattle ranching and ultimately, global meat consumption.

Linking ruminant production and consumption to land clearance, greenhouse gas emissions (GHGs) and biodiversity loss is a plausible sell for international campaigners and global

media eager for a simple narrative on culpability. Adding more fuel to the discussion, a recent paper, 'The rotten apples of Brazil's agribusiness', published in Science, claims that 20% of soybeans and 17% of beef exported from Brazil to Europe are 'contaminated with deforestation'.

**A recent paper, 'Fire, deforestation, and livestock: when the smoke clears', suggests that the link between deforestation and extensive land use for beef production is not as clear as commonly supposed**

But in an apparent contradiction, the same study also finds that most of Brazil's agricultural output is deforestation-free and that 2% of the farmers are responsible for 62% of all illegal deforestation.

This generated misinterpretation of the results in media outlets and among the public. This is because the Science paper is the first to apply the idea of 'contamination' for commodity-deforestation, a problematic methodological choice.

The misinterpretation occurs because 'contamination' is treated as a binary variable: the study does not differentiate between low or high contamination levels. So, for example, a 100 hectare farm in which 100% of the soybeans or beef were produced on recently deforested area is flagged as 100 'contaminated' hectares. In the same way, another 100 hectare farm that produced only 1% of its soybeans or beef on deforested land will also have its 100 hectares flagged as 'contaminated'. This numerical distortion is the main reason why such a large proportion of Brazilian export-oriented commodities are contaminated with deforestation.

In fact, around 98% of the production is deforestation free, as highlighted by the same study.

Reinforcing this narrative on the weakening link between deforestation and agriculture, another recent paper, 'Fire, deforestation, and livestock: when the smoke clears', which scrutinises the reasons for the fires and the subsequent increases in deforestation in the Amazon, suggests that the perceived link between deforestation and extensive land use for beef production is not as clear as commonly supposed.

The study suggest that, contrary to popular belief, the increased share of export-oriented beef might have contributed to weakening the link between beef cattle and deforestation in Brazil. In that sense, well-intentioned boycotts of Brazilian beef potentially weaken the importance of public and private policies incentivising sustainable farming.

For example, between 2015 and 2017 an average of 1.5 million tonnes of beef per year was exported to around 90 countries, while pasture area contracted by around 1 million hectares over the same period. In fact, data shows that gains in productivity via improvement of existing pastures, better animal performance measures, feed supplementation on-pasture and in feedlots, and improved animal genetics rather than pasture expansion explains recent production growth.

The recent increased deforestation in the Brazilian Amazon refocussed international attention on the fate of a global public good, but there is a tendency to simplify the complexity of land use dynamics, demonising livestock producers and the role of market demand.

Members' reports

University of the Highlands and Islands

# Research project puts science at the heart of rural tourism experiences

A new initiative involving Perth College UHI and West Highland College UHI aims to develop a new kind of tourism inspired by the scientific field trip

THE CENTRE FOR Mountain Studies at Perth College UHI and the Centre for Recreation and Tourism Research at West Highland College UHI are collaborating on an EU-funded project that aims to help tourism businesses in remote areas attract visitors by developing products based on scientific learning. The hope is that this will contribute to the recovery of the tourism sector post-Covid-19.

The SCITOUR project is multinational and involves partners from Finland, Iceland and Sweden. It has grown out of recent patterns whereby once remote destinations have become more accessible, and builds on trends that see people travel to visit museums, science centres, cultural and historic sites, or to witness specific natural phenomena or wildlife. It is also influenced by the idea of the academic field trip, where students are taken into the field for an extended period to learn in the environment.

SCITOUR tourism products will focus on communicating science in a fun, interactive way and will appeal to visitors who are curious about natural phenomena and in learning about the



regions they visit from local experts. The researchers have been engaging with rural businesses to ascertain the extent to which

**Above: 'field trip' tourism in Norway**

experience providers are currently engaged in scientific teaching and how the project can help them to further develop and market scientific tourism products.

The goal is to create an umbrella organisation that gives businesses a package of benefits including: access to an established scientific tourism identity using the brand name 'Wonder Seekers'; a website where they can market and sell their products; access to transnational promotional campaigns; a supportive network of businesses offering similar products; and access to guidelines reflecting all the expertise gained throughout the course of the project.

The research undertaken so far suggests that one likely market for these products are eco-tourists who are prepared to spend highly on quality experiences and to consider visiting in the shoulder or off-season.

Scientific tourism will involve small groups, outdoor and wilderness settings, and avoiding crowds by travelling out of season and to under-visited destinations. It will emphasise the importance of understanding the natural world and engender a respect for scientific learning. As such, it is hoped this will be a sustainable type of tourism trend suited to the post-pandemic travel sector.

For information contact Andy Ruck, [andy.ruck.perth@uhi.ac.uk](mailto:andy.ruck.perth@uhi.ac.uk) or visit [scitour.interreg-npa.eu/](http://scitour.interreg-npa.eu/)

# Phone app to help businesses navigate through crises

AS THE TOURISM industry in many countries is starting to move into what is hoped is a post-pandemic recovery phase, there will undoubtedly be structural and managerial readjustments for many businesses as they try to ensure that they are more resilient and able to adapt to future crises.

West Highland College UHI's Centre for Recreation and Tourism Research (CRTR) has recently been awarded funding aimed at addressing this issue.

The centre will work with both academic and business partners in Spain, Ireland, Germany, Denmark and Iceland in a three-year transnational collaboration. The project is funded by the EU ERASMUS+ programme.

The aim of the £445,000 initiative is to develop vocational education and training and curriculum resources that



**Left: the impact of Covid-19 on tourism has been visible throughout Scotland**

will help tourism businesses gain the skills needed to successfully navigate through crises by providing them with

the knowledge and actionable tools to analyse the specific extent of crisis impact and develop suitable countermeasures.

As the project's lead partner, CRTR will work in partnership with regional stakeholders to understand business needs and develop a valuable open-access training programme that will be accessible via a dedicated app.

Dr Steve Taylor, director of CRTR, said: 'Covid-19 is having a profound effect on the tourism sector across the globe. We look forward to leading this international collaboration that has the potential to provide meaningful, valuable resources for businesses and students alike to be better prepared for such destructive developments in the future.'

For details contact Dr Steve Taylor, [steve.taylor.whc@uhi.ac.uk](mailto:steve.taylor.whc@uhi.ac.uk)



## Support for the creative industries through traditional storytelling

A UHI collaboration, the Northword project will work through a website and phone apps to support the arts and creative practitioners in remote areas

THE PANDEMIC HAS highlighted the importance of digital platforms in supporting the arts, and the multinational Northword project will further harness this potential by creating a bespoke website and both Apple and Android apps aimed at promoting creative practitioners working in remote areas.

The project recognises that remote and rural creative businesses face unique challenges, such as difficulty accessing urban and international markets and a limited local customer base. The goal is to use the platform both to increase the visibility of these businesses and to host tools and training materials aimed at enhancing their digital marketing skills.

Part-funded by the EU Interreg program, Northword is led by Robert Gordon University Orkney but also draws on the experience and expertise



**Above and left: tourism in remote and rural Scotland could benefit from Northword input**

of the Centre for Recreation and Tourism Research (CRTR) at the University of the Highlands and Islands, together with partners in Northern Ireland, Russia, Sweden and Finland.

Each partner will collect stories from their region celebrating the history and heritage, language, archaeology, landscape and folklore that make northern communities unique. Creative practitioners in each country will then be invited to apply for a 2000 euro development grant, allowing them to create a new product or work inspired by one of these stories, ranging from crafts, jewellery, textiles and art to music, film, photography, dance and theatre.

Both the stories and the resulting products will subsequently be promoted through the Northword website and apps.

It is hoped that this will not only help support a creative industry currently suffering from the impact of Covid-19, but will also attract future visitors to discover these regions through the platform.

*For more information please contact Katie Murray at West Highland College, [katie.murray.whc@uhi.ac.uk](mailto:katie.murray.whc@uhi.ac.uk) or visit [storytagging.interreg-npa.eu/](http://storytagging.interreg-npa.eu/)*

Members' reports; news from SCRR

North Highland College UHI

SCRR Mini-Conference focusing on Early Career Researchers: November 11, 2020, held online

Science for Rural Recovery and Resilience

SCRR HELD ITS second mini-conference where Early Career Researchers shared new research, focusing on how they can guide us to move beyond these challenging times.

They told us what they'd been researching, looking to how rural Scotland moves into the 2030s and beyond, and they shared their own personal resilience, as their work has been interrupted this year. We had a shortcut to the latest thinking, interacted with some of Scotland's rural researchers and made new connections in an informal atmosphere.

More than 40 of us joined via Zoom and were enlightened by exciting new work in the areas of:

- bees adapting to land use policies as our essential pollinators;

- strengthening dairy cows' resilience through improving their traits;
- improving resilience of chickens in their local environments;
- health and wellbeing benefits of community land ownership;
- sheep methane emissions and mitigation strategies;
- helping to satisfy meat demand through microbiome-based breeding strategies in beef cattle;
- development of sustainable, science-based rural tourism.

We also voted in real time for the best poster and presentation. The winner was Bobby Macaulay (Glasgow Caledonian University; @bobmacaya)

**The winning posters, opposite: the overall winner was from Bobby Macauley of Glasgow Caledonian University, top, and the runner up was from Naomi Lean, SRUC and University of Edinburgh, below.**

for his work on health and wellbeing benefits of community land ownership, with the runner-up being Naomi Lean (Scotland's Rural College and University of Edinburgh) who presented on sheep methane emissions and mitigation strategies.

You can view their winning posters on the SCRR website.

Everyone who joined us thought it was a brilliant event and we're already planning the third one!

Thanks so much to all presenters and participants.

*For details of our events, please see the SCRR website at [scrr.ac.uk/events](http://scrr.ac.uk/events). The two winning posters are available to download from the event page, [scrr.ac.uk/past-events/science-for-rural-recovery-and-resilience/](http://scrr.ac.uk/past-events/science-for-rural-recovery-and-resilience/)*

Antimicrobial resistance in freshwater invertebrates

To what extent do resistant bacteria exist in the wider environment? New work at North Highland College UHI aims to find out

BACTERIA DEVELOPING RESISTANCE to the drugs that inhibit or kill them is perfectly natural. Alexander Fleming warned of this in 1945, regarding the potential misuse of penicillin.

With our extensive, and in many cases irresponsible use of antibiotics in the past century, such antimicrobial resistance (AMR) is now responsible for around 700,000 human deaths every year. According to some estimates, AMR is predicted to result in millions of annual deaths within the next few decades.

Fortunately, many areas have been identified where we can take action to prevent such a scenario coming to pass. Many bacterial pathogens (such as E. coli) become resistant through exposure to antimicrobials at their site of use, such as hospitals. However, we know that AMR bacteria exist beyond these sites.

What we are less aware of is how prevalent they are in the wider environment. Surveillance of AMR bacteria within wildlife populations has therefore been identified as a key



research area. Following on from work looking at resistant E. coli in Scottish wild deer, Environmental Research Institute (ERI) PhD research student Derek Elsby is also looking at AMR E. coli in freshwater invertebrates. Freshwater systems are particularly

**PhD researcher Derek Elsby sampling invertebrates from the Wick River while local cattle look on**

important in terms of AMR, because they are subject to an influx of antimicrobial residues from land run-off and sewage treatment effluents.

Over the 2019 summer, and with the help of ERI's Paula Fernandez, invertebrate samples were gathered from three different rivers in the Scottish Highlands, the Naver, Wick and Thurso rivers. E. coli present in the guts of these invertebrates was assessed for resistance to a suite of antimicrobials.

The results indicate that bacteria 'immune' to modern medicine do exist in the stomachs of these invertebrates. This is not entirely unexpected and is not currently a cause for concern, but provides a valuable baseline for future monitoring of AMR spread.

The next step is to investigate if local factors within a river catchment – including forestry, livestock grazing, wastewater treatment and urban settlements – have any association with the AMR within the bacteria found in our rivers' smallest inhabitants.

This work increases our understanding of antimicrobial resistance and, coupled with more responsible and informed use of our medicines, will contribute towards ensuring that our health care systems will continue to function effectively into the future.

*For further information contact: [derek.elsby@uhi.ac.uk](mailto:derek.elsby@uhi.ac.uk)*



# The role of community landownership in improving rural health

## Introduction

- Community landownership provides a means through which rural communities can be empowered to enact changes in their social and economic conditions, in ways accountable to the resident population.
- Positively affecting such conditions can improve health outcomes.

## Aim

- To empirically explore the theoretical potential for community landownership to improve health in rural Scotland. Specifically:
  - How and for whom community landownership can affect rural health;
  - The perceived extent of any such impact vis-à-vis other 'interventions'.

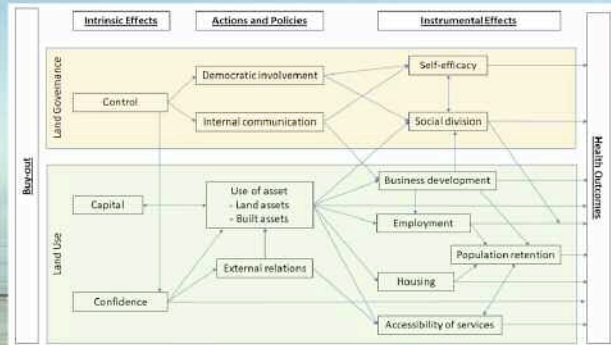


Figure 1- Empirically-informed conceptual model of the ways in which community landownership can affect rural health outcomes

## Methods

- 'Broad and deep' mixed-method, single case-study design.
  - Qualitative interviews:
    - 14 'external' stakeholders;
    - 16 'internal' residents.
  - Q Methodology (Fig. 2):
    - 40 statements
    - 62 residents.

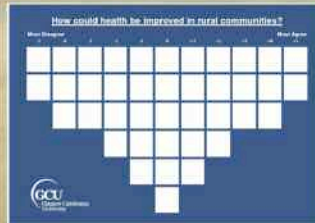


Figure 2- Q 'grid'

## Results

- Conceptual model outlining 'pathways' from land acquisition to health outcomes (Fig. 1).
- Community landownership provides the foundation upon which further health-improving initiatives can be developed.
- Health impacts are dependent on effective management and governance.
- Increased involvement in estate governance enhances potential for both positive and negative health effects.

## Conclusions

- Community landowners are not uniquely or inevitably capable of improving rural health.
- However, the locally-accountable democratic governance of an income-generating land asset combines the ability and compulsion to act in the interests of residents' health and wellbeing in ways which other actors or initiatives do not.

Dr Bobby Macaulay (bobby.macaulay@gcu.ac.uk)

Glasgow Caledonian University

Research funded by Wellcome Trust Doctoral Studentship

Supervisors: Prof Artur Steiner, Dr Neil McHugh, Prof Cam Donaldson

# How do parasite infections affect livestock greenhouse gas emissions?

N Lean<sup>1,3,4</sup>, N J Fox<sup>1</sup>, J Hillier<sup>2</sup>, M R Hutchings<sup>1</sup>, G Marion<sup>3</sup>

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- Global Academy of Agriculture and Food Sciences, University of Edinburgh, EH25 9RG, UK
- Biostatistics and Statistics Scotland, JOMB, King's Buildings, Edinburgh, EH9 3FD, UK
- University of Edinburgh, Old College, South Bridge, Edinburgh EH8 9YL, UK

## Background:

Methane from ruminant enteric fermentation represents both an environmental issue and a farm production loss.

- 12-17% of global methane emissions comes from ruminant's digesting their food [Denman *et al.* 2007]
- 2-15% of the total energy from livestock feed is lost to the atmosphere in the form of methane gas [van Nevel 1996].

Currently the impact of parasitism on ruminant methane emissions is estimated by multiplying standard emission by a factor representing the increased time parasitized animals take to reach slaughter weight.

However, a recent study [Fox *et al.* 2018] showed a 33% increase in methane emissions per kilogram of dry matter intake (CH<sub>4</sub>/KgDMI) near the peak of a *Teladorsagia circumcincta* parasite burden in lambs, compared to the uninfected control groups. This suggests a more accurate method to quantify the effects of parasitism on livestock methane emissions is required.

My PhD project will quantify the effects that the gutworm *T. circumcincta* has on sheep methane emissions throughout the duration of infection and explore potential methane mitigation strategies.

## Main questions:

- How does parasitism affect livestock GHG emissions over the course of infection?
- How does parasitism affect livestock methane emissions as a measurement of CO<sub>2</sub>-eq/ kg live weight gain?
- What is the potential for methane mitigation through parasite control?

## Measuring methane emissions from sheep:

Use respiration chambers to measure methane emissions over the course of a parasite infection  
Conduct experiment during Spring/ Summer 2021

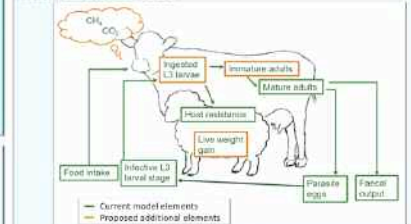
Take measurements of the lambs:

- Methane emissions throughout the parasite infection
- Food intake
- Live weight gain
- Blood TH2 to assess host immune response
- Blood pepsinogen to assess parasite larval damage
- Faecal egg counts to monitor parasite infection and confirm non-parasitized status of control groups.

Treat half of each group with anthelmintic drugs after peak parasite burden + peak methane yield to assess impact of parasite treatment.



## Mathematical model:



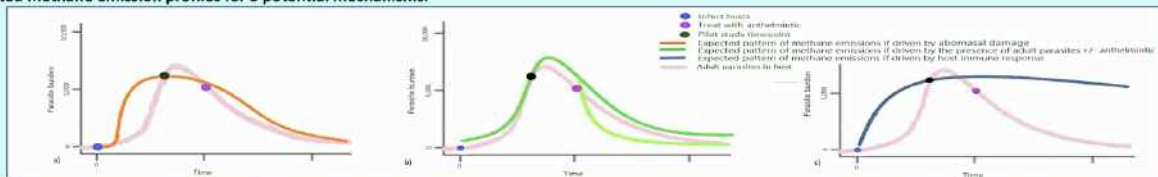
The mechanism behind the increased methane emissions seen in Fox *et al.*'s [2018] study is currently unknown. A mathematical model, using principles from the models of Roberts and Grenfell [1991] and Fox *et al.* [2015], will be developed to explore potential mechanisms.

## Potential mechanisms to be explored:

- Presence of different parasite life stages
- Host anorexia
- Damage to abomasal wall
- Host immune response

The model will influence the design and analysis of the experiment.

## Predicted methane emission profiles for 3 potential mechanisms:



Potential methane emissions from livestock during a parasite challenge if increased methane emissions are driven by a) abomasal damage, b) presence of adult parasites +/- if anthelmintic treatment is given, c) host immune response.

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### Challenging Upland Futures

Perth Theatre, October 5 & 6, 2021

A public forum with the aim to integrate knowledge and understanding on the uplands of Scotland, and to agree priority actions to help ensure that our uplands deliver the widest possible range of benefits. Participants: the wide diversity of stakeholders living in, and concerned with, the uplands of Scotland.

For more information contact Professor Martin Price, [Martin.Price.perth@uhi.ac.uk](mailto:Martin.Price.perth@uhi.ac.uk)

Please see our website for more events.

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