



Scottish Government
Riaghaltas na h-Alba
gov.scot

RESAS strategic research: 2015 highlights





contents

INTRODUCTION

From Chief Scientific Adviser Rural Affairs,
Food and the Environment **ii**

OVERVIEW OF RESAS STRATEGIC RESEARCH **A**

CONTEXT **B**

MAKING A DIFFERENCE **C**

Agriculture C01-07
 Climate Change and Air Quality C08-09
 Water and Renewable Energy C10-13
 Food and Drink C14-17
 Marine C18
 Rural Communities C19
 Land Use C20-21
 Ecosystems and Biodiversity C22-23

MEASURING THE DIFFERENCE **D**

Policy and Practice D01-03
 Trade and Industry D04
 Scientific Resilience D05-07





introduction



The Scottish Government supports land-based science in Scotland with a particular focus on innovation in agri-food systems balanced alongside the need to sustain Scotland's natural capital. This long-term investment, through the Rural and Environmental Science and Analytical Services (RESAS) Division, has built significant national capability in Scotland in land-based science and has supported the creation of valuable research platforms, a world class skills base and critical long-term data that informs policy decisions.

The research highlighted in this report showcases the excellent science funded by the Scottish Government. Particularly important is the interdisciplinary nature of the research across animal and crop sciences, environment, biodiversity, food and drink and rural communities. This science and investment underpins the development and delivery of key government priorities including: the four priorities of Scotland's Economic Strategy - investing, innovation, inclusive growth and internationalisation; a sustainable and thriving rural economy, particularly activity to enhance Scotland's food and drink; a cleaner, greener Scotland, especially our ambitious climate change targets; and a fairer and healthier Scotland that provides opportunities for a skilled workforce and tackles inequalities by addressing issues like food poverty.

Professor Louise Heathwaite

Chief Scientific Adviser Rural Affairs, Food and the Environment
December 2016





overview of RESAS strategic research

The Scottish Government is a significant funder of science in the area of rural affairs, food and the environment. This is achieved through an ongoing programme of strategic scientific research funded on a five-year basis through the Rural and Environment Science and Analytical Services (RESAS) division. The research highlighted in this Report was carried out during 2014-15, the fourth year of the 2011-16 Research Strategy. The research contributes to the development and delivery of rural affairs, food and environmental policy and the achievement of the Scottish Government's purpose and wider objectives, as set out in the National Performance Framework and Scotland's Economic Strategy.

Research so funded supports a Greener, Smarter and Wealthier Scotland, and contributes toward the achievement of a number of national outcomes, including:

- we value and enjoy our built and natural environment and protect it and enhance it for future generations;
- we reduce the local and global environmental impact of our consumption and production;
- we are better educated, more skilled and more successful, renowned for our research and innovation.

The Scottish Government's investment in rural affairs, food and environmental research provides a foundation for:

- the sustainable use of our natural resources;
- the productivity and profitability of our agricultural sector and rural businesses;
- the prevention and effective management and control of animal and plant diseases;
- our ability to respond effectively to global challenges such as food security and climate change.

The funding also helps maintain Scottish-based scientific capability of international standard and associated infrastructure at the Scottish Government's Main Research Providers (MRPs).





overview of RESAS strategic research

Strategic priorities

RESAS-funded research addresses current and emerging challenges to meet short- and medium-term policy needs. RESAS funding can also establish and support longer-term strategic research to understand change over time and enhance resilience to future threats. We also strive to enhance productivity and economic growth, maintaining critical infrastructure and research assets, while developing future research capacity and capability.

Scotland's Economic Strategy focuses on the two mutually supportive goals of increasing competitiveness and tackling inequality with four priorities in which the Scottish Government's actions can make a substantial difference:

Investing, Innovation, Inclusive Growth and Internationalisation.

Our strategic research investment contributes to Scotland's Economic Strategy in a number of ways:

Investing:

- Investing in research that provides Scotland with the skills and knowledge that it needs to grow in a global economy.
- Investing in and supporting a Scottish science base that is internationally competitive and improving its standing in the world.
- Developing tools and approaches which can assist community empowerment.

Innovation:

- Taking a leading role in developing a national strategy for rural and environmental research.
- Supporting the development of new products and processes which strengthen the performance of the agri-food chain or have environmental and health benefits.
- Mitigating the long-term impacts of climate change by supporting innovative research into natural flood management.
- Helping Scotland to meet its renewable energy targets through assessing future hydropower potential.

Inclusive Growth:

- Helping to create a more equal society by widening access to the knowledge created by our investment in research across Scotland.
- Promoting collaboration between research organisations to raise attainment and skills within our economy.
- Evidence on equalities in rural Scotland enables clearer assessment of Scottish Government policies.

Internationalisation:

- Further developing a research base that promotes Scotland's international reputation, attracts and supports talent from across the world in both fundamental and applied science.
- Supporting the development of international connections and collaborations that promote Scotland as a source of innovation and creativity.
- Successful leveraging of additional research funding to Scotland.

context

RESAS' investment in scientific research centres on applied science which provides a foundation for sustainable use of our natural resources and advancement over a wide range of rural and agricultural themes such as crop science, animal welfare, and global challenges like food security and climate change. Close working with industry maximises the impact our research funding is having in relevant sectors. Maintaining close relationships with other public funders (e.g. Scottish Natural Heritage (SNH), Scottish Environment Protection Agency (SEPA)), through for example the CAMERAS partnership (Co-ordinated Agenda for Marine, Environment and Rural Affairs Science) provides excellent opportunities for knowledge exchange, collaborations and joint outputs.

The research is funded through a variety of mechanisms, including a Strategic Research Programme which is primarily carried out by our Main Research Providers (MRPs). The MRPs are:

James Hutton Institute (Hutton): carries out research associated with crops, soils, land use, people and the environment. The research aims to make major contributions to the understanding of key global issues, such as food, energy and environmental security.

Scotland's Rural College (SRUC): supports land-based industries and communities with research focusing on sustainable agriculture, animal health and welfare, food chains, economics, and the environment.

Moredu Research Institute (MRI): carries out research into disease pathogenesis, the development of diagnostic tests and vaccines for livestock. Scientists work with farmers and vets to improve animal health and wellbeing and to support sustainable agriculture.

Rowett Institute of Nutrition and Health (RINH): carries out research into how nutrition can prevent disease, improve human and animal health, and enhance the quality of food production.

Biomathematics and Statistics Scotland (BioSS): undertakes the development and application of mathematical and statistical methods in agricultural, environmental, food and health research. BioSS is hosted by the James Hutton Institute for the benefit of all of RESAS's MRPs.

The Royal Botanic Garden Edinburgh (RBGE): carries out research in international, UK and Scottish plant systematics and conservation.

context

Centres of Expertise

RESAS funding has also established Centres of Expertise (CoEs) to encourage links between research carried out at MRPs, other UK research institutes and Higher Education Institutions (HEIs) with Scottish Government policy teams. The CoEs are:

Centre of Expertise for Waters (CREW):

delivers objective and robust research and expert opinion to support the development and implementation of water policy in Scotland.

ClimateXChange (CXC): provides research, advice and analysis to the Scottish Government as it develops and implements policies on adapting to the changing climate and the transition to a low carbon society.

Centre of Expertise on Animal Disease Outbreaks

(EPIC): brings together the best available scientific expertise under one umbrella to inform the Scottish Government and the livestock industry on reducing the impact of animal disease outbreaks.

Contract Research Fund

RESAS' Contract Research Fund provides flexibility to commission short-term policy led projects. The fund can also be used strategically to encourage partnerships with other research funders which can support capacity building in areas of common interest and foster connectivity across the research base in Scotland and beyond.





making a difference

RESAS funds applied science covering a wide range of areas and sectors. This includes natural science strengthening the understanding of environmental processes and impacts, from investigations into ecosystems and biodiversity and marine and coastal processes through to issues surrounding climate change and land use decisions. Our research also contains a significant portion of economic and social science that goes into supporting rural communities and agriculture. Some of our research is called down by industry or representatives of specific sectors, and as such we have dedicated teams researching renewable energy themes and supporting growing and resilient agri-food and drinks industries balancing public health, economic and environmental concerns. This means we can respond to requests as well as taking a proactive approach to new science and developments in these areas.

The following pages highlight the wide ranging nature of impacts across areas of work funded by RESAS in 2014-15.





agriculture - livestock

Building EPIC Influence

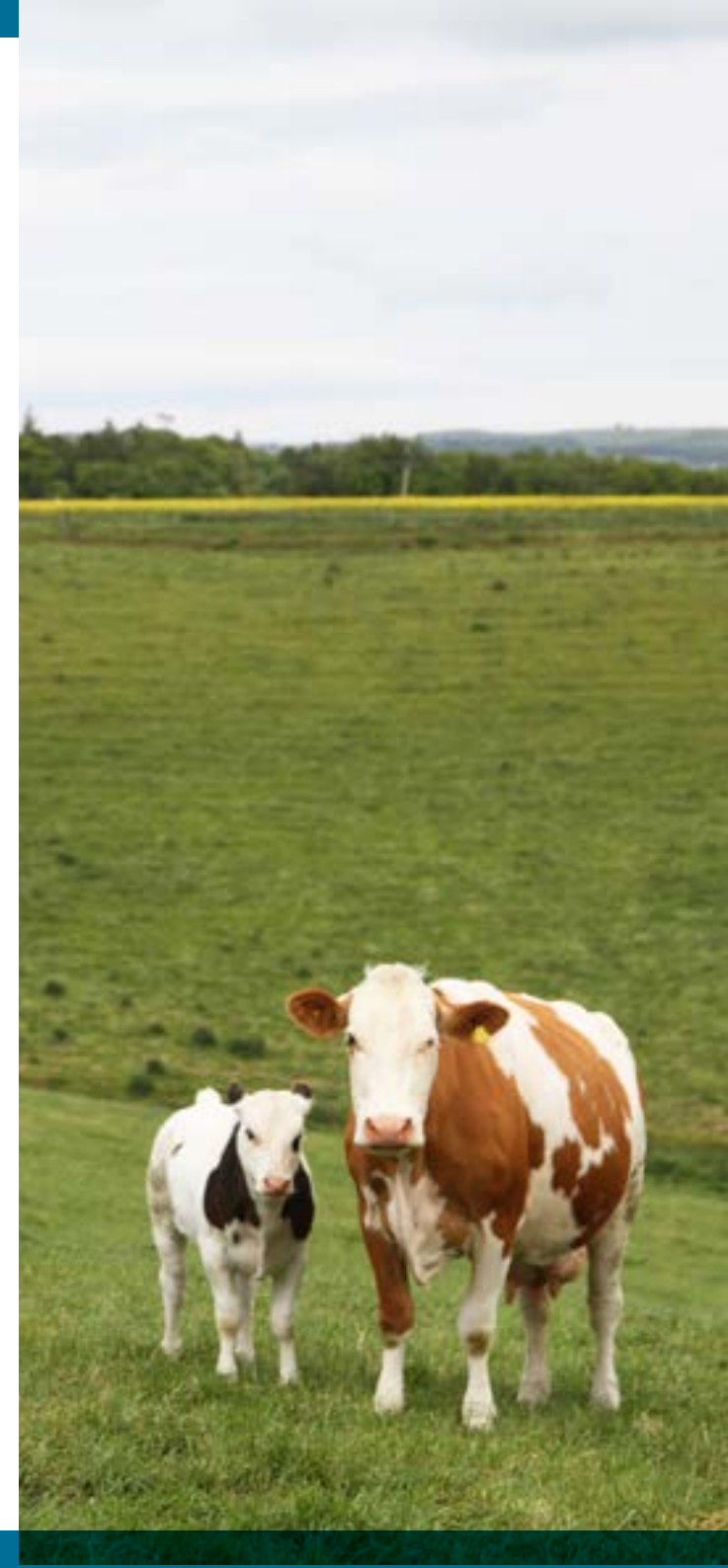
A 2014 report 'Animal and Plant Health in the UK: Building our science capability' co-authored by the UK Government Chief Scientific Advisor and the DEFRA (Department for Environment, Food & Rural Affairs) Chief Scientific Advisor is aimed at influencing policy makers at the highest level. The report used one of RESAS' Centres of Expertise, EPIC, as a case study to highlight a good model of how to secure the best available scientific advice to inform government policy.

Public Health and Cryptosporidiosis

Cryptosporidiosis is one of the leading infectious causes of gastrointestinal disease in humans. In the UK, around half of human infections are caused by *Cryptosporidium parvum*. *C. parvum* is highly prevalent in young livestock and can be transmitted to humans directly or via contaminated water. RESAS-funded researchers have developed a molecular typing scheme that can track the source of human outbreaks. Policymakers will be able to use this information to help reduce future risk to public health. In addition, funding has been awarded from the Biotechnology and Biological Sciences Research Council's Animal Health Club for a study on host factors determining resistance to cryptosporidiosis in cattle.

Healthier Cows, Healthier Milk

Milk can be an important source of micronutrients in the human diet. The levels of minerals, fats and proteins in milk can be measured by milk infra-red (MIR) spectral data. Selenium is a mineral present in milk and measurable by MIR, which is essential to human immune system function. RESAS-funded researchers have shown that lactating dairy cows often show a selenium deficiency, affecting the health of the cow and the nutritional quality of the milk. The use of MIR data will enable the selection of cows with optimal mineral status, resulting in healthier cows and healthier milk.





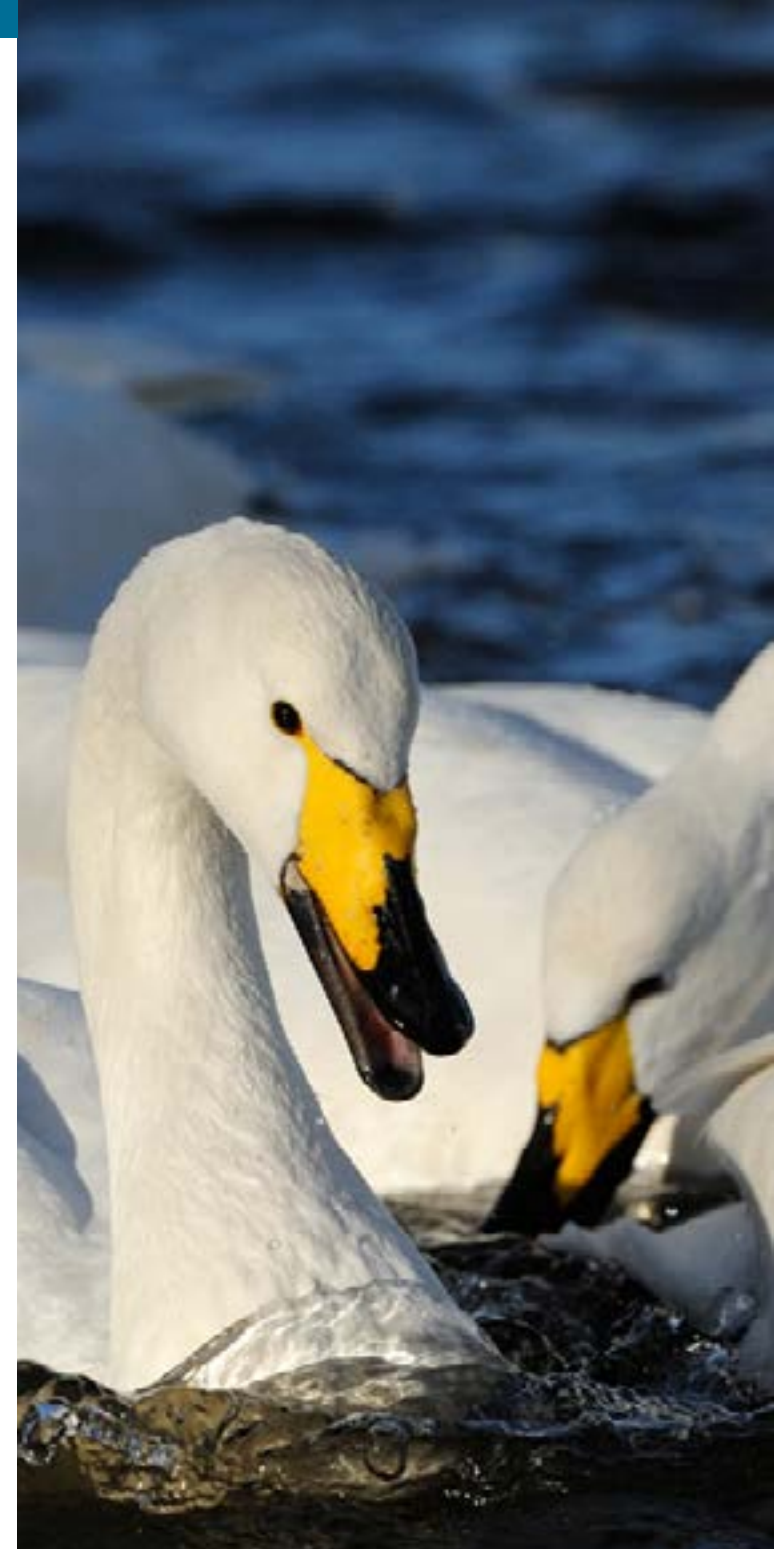
agriculture - livestock

Avian Influenza - Bird Migration and Genetics

Following an outbreak of avian influenza in England in November 2014, potential bird migration routes were evaluated by researchers to see how the disease could have been introduced. Routes and timings of migrations from a large number of species were identified. Several water bird species migrate from Siberia and mainland Europe, with their peak arrival time coinciding with the outbreak.

The genetic code of the UK virus was sequenced, and comparison with other sequences from European and worldwide collaborators enabled the source locations and bird species to be inferred. This indicated a single introduction from Asia into Europe had occurred in mid-2014, and that the disease was present in Europe for several months before first being detected with transmission between wild and domestic birds, but limited farm-farm spread. This can help to identify the most effective preventative measures, and highlights the importance of biosecurity.

The risk of avian influenza spreading to Scotland was also investigated, and a risk assessment and technical report was provided to the Scottish Government. This informed Scottish Government staff of the potential risks around any avian influenza outbreak, and helped be better prepared for the subsequent January 2016 case in Fife.





agriculture- livestock

Monitoring Pig Disease

Research funded by RESAS contributed methods and analyses used by industry funded surveillance schemes such as Wholesome Pigs Scotland and British Pig Executive Pig Health Scheme. These schemes ensure that the frequency of disease at pig farms is monitored, and can help identify changes where disease control measures may need to be implemented. Positive outcomes include a substantial reduction in the prevalence of mange in Scottish commercial pig herds.

Understanding Exotic Pig Diseases

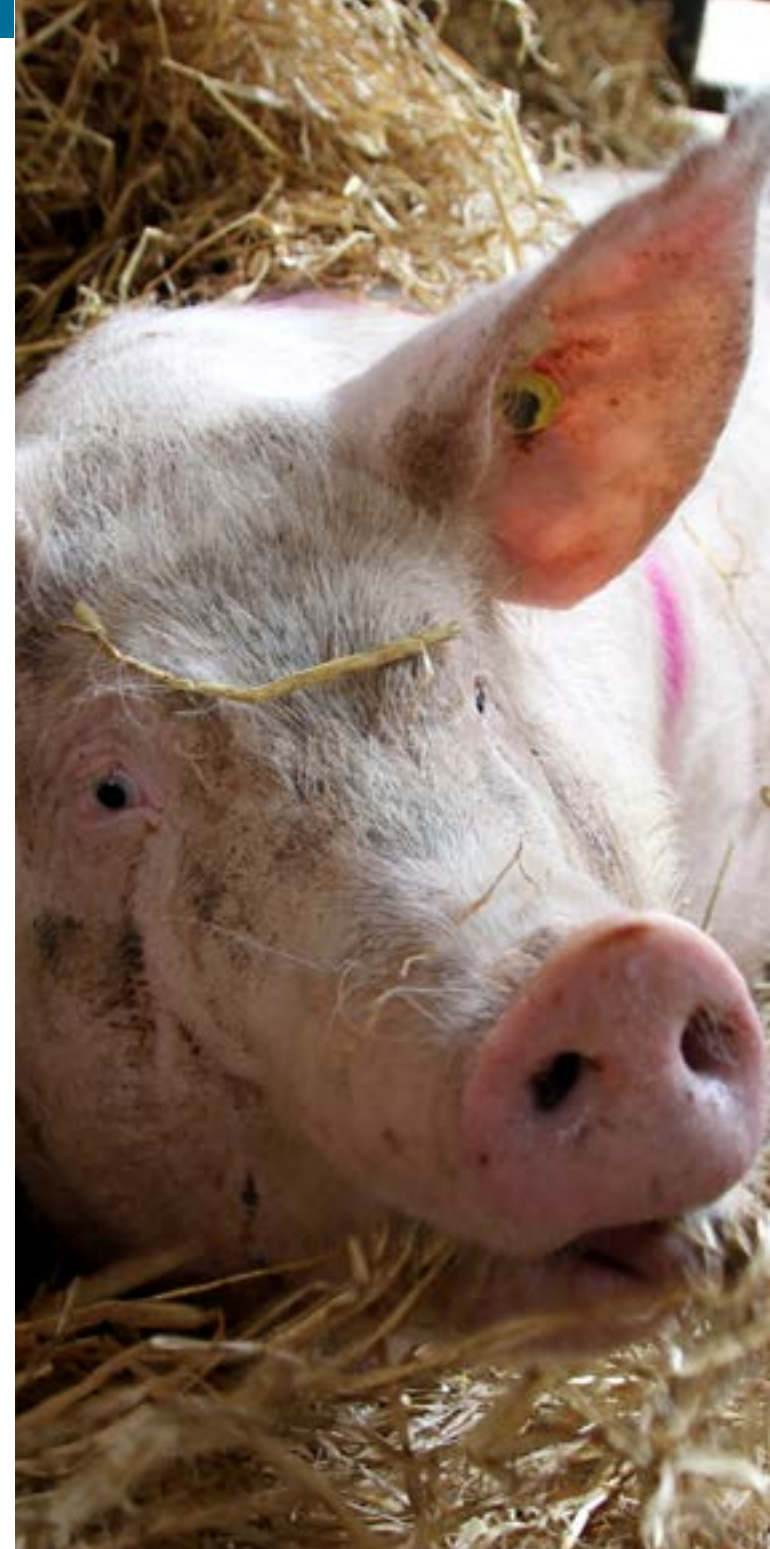
An evaluation of the impact that an exotic disease outbreak could have on British pigs was carried out. A modelling framework to explore the potential impact of diseases such as Porcine Epidemic Diarrhoea and Classical Swine Fever was developed. This enabled identification of gaps in data recording systems and mechanisms to fill these gaps.

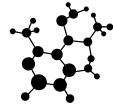
Pig Litter Sizes

RESAS-funded researchers carried out a review on the effects of selection for large litter sizes on pig welfare. Outputs of the report resulted in the Danish Pig Research Centre funding the first study on welfare of surrogate nurse sows and influenced the advice that they issue to industry on strategies to care for surplus piglets.

Free-farrowing Pigs

Collaboration between a RESAS-funded researcher and Newcastle University supported by DEFRA and the Scottish Funding Council, has resulted in the development of a website for industry: www.freefarrowing.org. It is encouraging uptake of high welfare systems for pigs, and is a much needed resource to translate research into advice for industry. The site synthesises research around free farrowing and lactation systems, much of which was carried out with RESAS funding. This web resource has also been used by governments, Non-Governmental Organisations and academics.





agriculture- livestock

New Diagnosis for Sheep Disease

Tick Borne fever, a livestock disease of sheep and goats is thought to represent a sizeable hidden cost to the livestock industry both in Scotland and further afield. Infected animals may be more susceptible to other diseases such as louping ill and respiratory diseases. RESAS-funded researchers have developed a new molecular test which can diagnose acute cases of this infection. They are now working on a test which will diagnose cases from blood samples, to enable the true prevalence of this disease in Scotland to be understood.

Supporting Higher Biology

RESAS-funded researchers collaborated with the Scottish Schools Education Research Centre to provide support to the new Higher Biology course in the areas of genomics, animal breeding and animal welfare. Resources to support the Curriculum for Excellence were developed based on feedback from an event organised for Biology Highers course leaders. 90% of attendees at this original event found the information provided very useful and all reported that they would use the information in the classroom.





agriculture – crops

Integrated Pest Management (IPM)

IPM is a way to use a whole farm approach to maximise production efficiency whilst minimising negative environmental impacts. IPM approaches are becoming increasingly topical with the inclusion of rotational and greening requirements to CAP (Common Agricultural Policy), and the loss of pesticides due to legislative change and rises in resistance. Meetings with growers and industry at roadshows throughout Scotland since 2014 promoted IPM practices and explored grower attitudes and understanding towards IPM strategies and technologies.

Promotion of IPM is a requirement of the European Union (EU) Sustainable Use of Pesticides Directive. At the request of Scottish Government policy teams a definition of IPM was provided which was submitted to the EU as the definition of IPM to include in Scotland's Rural Development Programme.

“Integrated pest management is a site specific, whole farm approach to maximising the efficiency of production whilst minimising negative effects on the environment. This should involve minimising waste and pest, weed and disease risks and includes the use of crop rotations, appropriate cultivation techniques, the use of resistant varieties, tailored and efficient use of artificial inputs such as fertilisers, pesticides and fossil fuels and the enhancement of wildlife habitats. Pest monitoring and the use of thresholds for treatment are a component in reducing reliance on pesticides.”

Fruits for the Future, Cereals in Practice and Potatoes in Practice

Fruits for the Future, Cereals in Practice and **Potatoes in Practice** are significant, annual events for demonstrating latest innovations to the agri-industry. The 2014 Cereals in Practice event highlighted the potential of disease-resistant varieties. As a result of knowledge exchange at these industry and farmer facing events there was an increased use of disease resistant cereal varieties in autumn 2014 drilling.





agriculture – crops

Working Towards Potato Late Blight Control

Potato late blight is one of the key potato diseases, responsible for widespread loss of potato crops each year. The costs to agriculture associated with chemical control exceed £3.5 billion globally each year. Controlling potato late blight requires constant identification of new sources of host resistance or chemical control. A novel disease control strategy is being developed in collaboration with an international plant breeding company. Researchers have marked strains of the potato blight pathogen to monitor the pathogen on the crop which can then be used to test the effectiveness of new disease control strategies.

In addition, RESAS-funded researchers have identified over 30 varieties of wild *Solanum* species which have resistance to potato late blight. Two genes which confer resistance have been identified and, using conventional techniques, these can now be utilised in the potato pre-breeding programme. Novel, durable resistances and markers for accelerated breeding will be established from this work.

RESAS-funded researchers are also forging national and international collaborations to advance plant health research. A memorandum of understanding between the James Hutton institute and Chinese researchers on potato late blight has enabled a joint laboratory to be set up at the Huazhong Agricultural University in Wuhan, paid for by the Chinese government, and supported by the UK's Biotechnology and Biological Sciences Research Council. This will be of benefit to both Scottish and Chinese agriculture.

Plant Health

RESAS-funded researchers contributed to UK and Scottish expert groups identifying emerging plant disease threats. These include the DEFRA-led UK Plant Health Advisory Forum, the Animal and Plant Health UK capability initiative, the British Crop Protection Council's Diseases Working Group and the Edinburgh Plant Sciences Initiative.

The UK Plant Risk register lists pest and disease risks and possible control measures and will be used by official services and stakeholders to assess risks and prioritise actions. By contributing to this RESAS-funded researchers have ensured that Scottish crop and plant health interests are heard and influence the wider UK audience.

Input from RESAS-funded researchers at the Scottish Plant Health Workshops in 2014 and 2015 contributed towards developing the scope and key principles for the new Scottish Plant Health Strategy.



agriculture - policy

Common Agricultural Policy (CAP) Reform

Scottish Government policy teams were provided with relevant and timely research which helped to influence negotiations at EU and UK level, to enable Ministers to make decisions on CAP in June 2014. Support continued during the implementation of the reformed CAP. Analysis focused on regionalisation options particularly the way in which regions were defined and how the budget was split between regions. This issue of how best to identify and exclude areas where agricultural activity fell below an appropriate minimum level was also investigated.

The financial impact of CAP reform and potential changes in farming practice was also modelled and was the subject of a large-scale survey of farmers and crofters. The modelling has informed government of the implications for viability and animal health and welfare in the Scottish beef, sheep and dairy sectors.

The European Commission's Director of Economic Analysis in the Directorate General for Agriculture, has used a diagrammatic representation of the reformed CAP developed by RESAS-funded researchers for their internal processes. This has been cited by commission staff as an example of knowledge exchange 'best practice'.

Sustainable Intensification

The goal of sustainable intensification is to increase food production whilst reducing negative environmental impacts. The Sustainable Intensification Platform is a DEFRA-funded alliance of 20 UK partners, including RESAS-funded researchers, who are developing methodologies and technologies that will encourage sustainable approaches within an applied farming context.

Measuring progress towards sustainable intensification requires metrics that can be applied on a Europe-wide scale. The EU Farm Account Data Network provides time series data on financial and physical performance of EU agricultural industries. RESAS-funded researchers are using their expertise in interrogating time-series data to develop comparative metrics of efficiency and sustainable intensification.

Agriculture Tenure

RESAS-funded researchers delivered the 'Scottish Agricultural Holdings Evidence Review (2013/14)' for the Agricultural Holdings Legislation Review Group, chaired by the Cabinet Secretary for Rural Affairs, Food and Environment. This provided evidence for the Group's 'Interim Report' (June 2014) and their final recommendations in the 'Review of Agricultural Holdings Legislation - Final Report' (January 2015). Some of the Review Groups recommendations were taken forward in the Land Reform (Scotland) Act (2016).



climate change and air quality

Committee on Climate Change

ClimateXChange (CXC), one of the RESAS-funded Centres of Expertise, and the Edinburgh Centre for Carbon Innovation, hosted the first meeting of the Committee on Climate Change (CCC) to be held outside of London. The CCC was gathering evidence for the report on 'Reducing emissions in Scotland - 2015 progress report'. A wide range of stakeholders gave evidence on the progress that Scotland is making in transitioning into a low carbon economy. This strengthened the close working relationship between CXC and the CCC.

Presenting Findings of Fifth Assessment Report

The fifth assessment report of the United Nation's Intergovernmental Panel on Climate Change (IPCC) was released in 2014. This report provides a detailed update on the state of the scientific, technical and socio-economic knowledge on climate change, its causes, potential impacts and response strategies. RESAS-funded researchers were asked to present the reports' key findings and the relevance to Scotland to senior Scottish Government officials, and also at a seminar for staff and stakeholders.

Minimising Nitrous Oxide Intensities of Arable Crop Products

RESAS-funding contributed to a collaborative project from 2009-2014 involving 23 partners from government, industry and academia, which aimed to improve estimates of nitrogen dioxide (N₂O) emissions associated with production of major UK arable crops. This was to help improve estimates of greenhouse gas (GHG) emissions reported in the UK's inventory and in carbon footprinting. The research concluded that UK agricultural emissions are 10% lower than previously thought, with 20% less GHG per tonne of UK harvested wheat than previously estimated. Research also demonstrated that choosing fertilisers with the lowest carbon footprint leads to a reduction in the GHG footprint of products, for example the carbon footprint of bread can be reduced by 7%, bioethanol from wheat by 15% and biodiesel from oilseed rape by 16%.





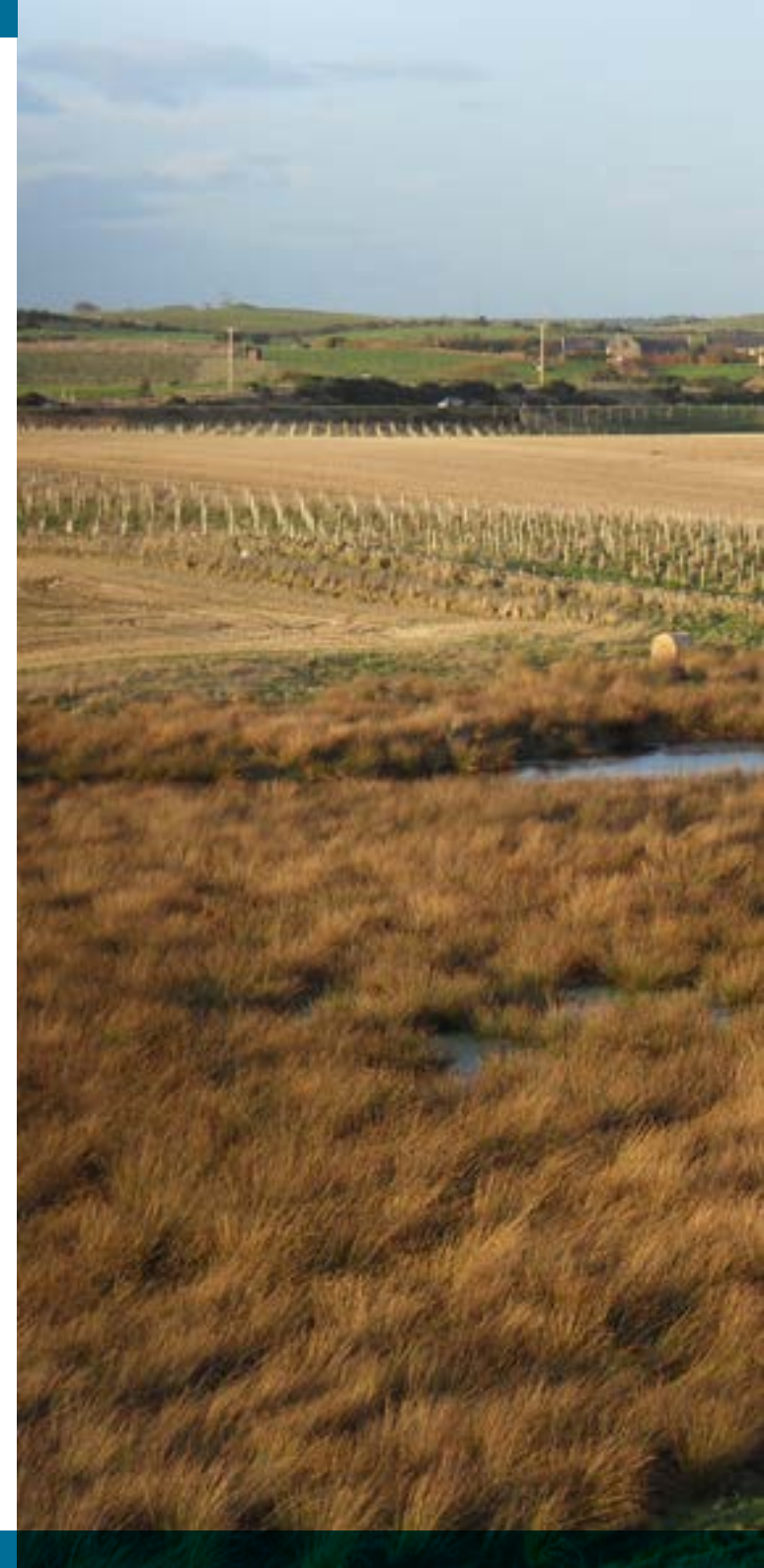
climate change and air quality

Rural Development Programmes

RESAS-funded researchers contributed to a EU project and subsequent report on 'Mainstreaming climate change into rural development policy post 2013'. This is a priority for the EU, reflected in the requirement that 20% of total EU expenditure in 2014-2020 should be climate related. This project identified how Rural Development Programmes could be more focussed on climate change, and provides technical guidance for new and innovative climate actions as well as suggestions for promoting climate action in future LEADER (Links Between Activities Developing the Rural Economy) activities. More information is available at: www.ecologic.eu/10439

Air Quality

Variations in roadside air quality were measured using mobile monitoring equipment in Glasgow city centre. The study found that mobile monitoring recorded higher concentrations of some particulates than fixed monitoring sites around the city and that some particulates had higher concentrations depending on the height above pavement. This may lead to future identification of pollution hotspots, which could result in authorities designing appropriate mitigation measures. The publication of the report was well received by the stakeholder community and was featured on BBC's 'Reporting Scotland' news programme.





water and renewable energy

Flood Risk Management at Property Level

Advances in innovative products to help protect properties from flooding have resulted in new flood risk management actions that Local Authorities, Scottish Water and individuals can take. A study was carried out to assess the flood risk management benefits of Property Level Protection (PLP) in Scotland, to raise awareness and promote the wider use of PLP. The research found that PLP can provide a more effective means of limiting the impact and consequences of flooding than can be provided with sandbags. The results have been presented to Local Authorities in a webinar. Where Local Authorities have implemented schemes the evidence shows that barriers to delivery can be overcome through appropriate planning assessments, engagement, maintenance and administration of schemes.

Informing Scottish Rural Development Programme (SRDP)

The current SRDP (2014-2020) includes options for biodiversity, climate change and improving water quality and reducing flooding. RESAS-funded researchers reviewed evidence on the effectiveness of the proposed water options and ran a joint workshop to get technical and on the ground advisory input to the guidance for these water options. Guidance around these options, aimed at farmers and landowners applying for SRDP funding, was produced and is available on the SRDP website www.gov.scot/Topics/farmingrural/SRDP.





water and renewable energy

Natural Flood Management Compensation

Natural Flood Management (NFM) refers to techniques that restore or use the natural processes within a catchment to reduce flood risk through slowing the flow of flood water, retaining water in the floodplain. RESAS-funded researchers assessed the suitability and implications of a range of financial mechanisms which could be used by public bodies to compensate land managers for implementing NFM measures on their land.

A separate guidance document for public bodies will assist Local Authorities with the process of negotiating with land managers when implementing NFM measures. The findings have been discussed and developed with Local Authorities at a workshop, with the aim of helping them successfully negotiate an affordable solution with land managers, thereby encouraging uptake of NFM.

Building Partnerships with China

An Asia-Europe Meeting (ASEM) on Water, co-hosted in Scotland by RESAS-funded researchers and the Centre for Environment and Hydrology (CEH), was followed by an invitation to visit China to develop a research proposal and provide training for Chinese scientists. This has led to a training and collaboration network for preparing a management plan for a key source of drinking water in Hunan province and training has been delivered to Chinese scientists on lake and catchment management sciences.

Septic Tanks

RESAS-funded researchers have been active in increasing awareness of the potential for pollution from tanks. The detergents used and the maintenance carried out can affect pollution from tanks. A septic tank leaflet was redesigned and distributed across the UK by the Dee Catchment Partnership, and household surveys and sampling visits were carried out in target pollution study catchments.

A collaboration with Agri Food and Biosciences Institute, Northern Ireland, is researching the contribution of septic tank wastewaters to the pollution load of the catchment. Source tracing approaches developed by RESAS-funded researchers use effluents such as artificial sweeteners and caffeine to trace the contribution that septic tanks make to the phosphorus concentrations compared to other catchment sources, such as agriculture.



water and renewable energy

Benefits of Private Water Supply Grants

Private water supply grants aim to improve the quality of drinking water from private water supplies. This project assessed whether the grants had been effective in meeting this aim. Some benefits were found at specific properties, however improvement in the national level of compliance with the Drinking Water Directive was not achieved. A lack of suitable data before and after grant award makes assessment challenging, but many potential improvements were identified. These research findings will inform the future development of the grant scheme.

Freshwater Pearl Mussel Habitat

The Spey Catchment Initiative requested an assessment of water quality impacts on the Spey Freshwater Pearl Mussel population. New lower phosphate targets and improvements in the limits of detection were recommended. These have been taken forward by Scottish Environment Protection Agency and Scottish Natural Heritage in their assessments of water quality targets for sites designated for Freshwater Pearl Mussels.

Future Resilience of Scotland's Hydropower

Researchers produced a review of 'Scotland's hydropower: current capacity, future potential and the possible impacts of climate change'. This included recommendations on how to increase the resilience of new hydropower installations, for example by: (i) including possible future and historic flow regimes in preliminary site assessments, and (ii) considering oversized or multi-turbine solutions to achieve greater operational flexibility in a more variable climate.





water and renewable energy

Community Renewable Energy in Scotland

To inform how the Scottish Government's targets for community renewable energy are delivered, the current and projected economic benefits of the expansion of community and local owned renewables were reviewed. The report was cited in the Scottish Government's Community Energy Policy Statement.

Community Engagement on Wind Farms

A review of best practice for engaging with local communities on wind farm developments has been carried out. Several important factors were identified in the study, including wide-ranging and innovative methods of engaging and facilitating dialogue, and ways of measuring engagement through all stages of wind farm development. The study was referenced in the Scottish Government's Good Practice Guide on public engagement for Sub-20MW Wind Turbine Proposals.





food and drink

Food and Drink Commission

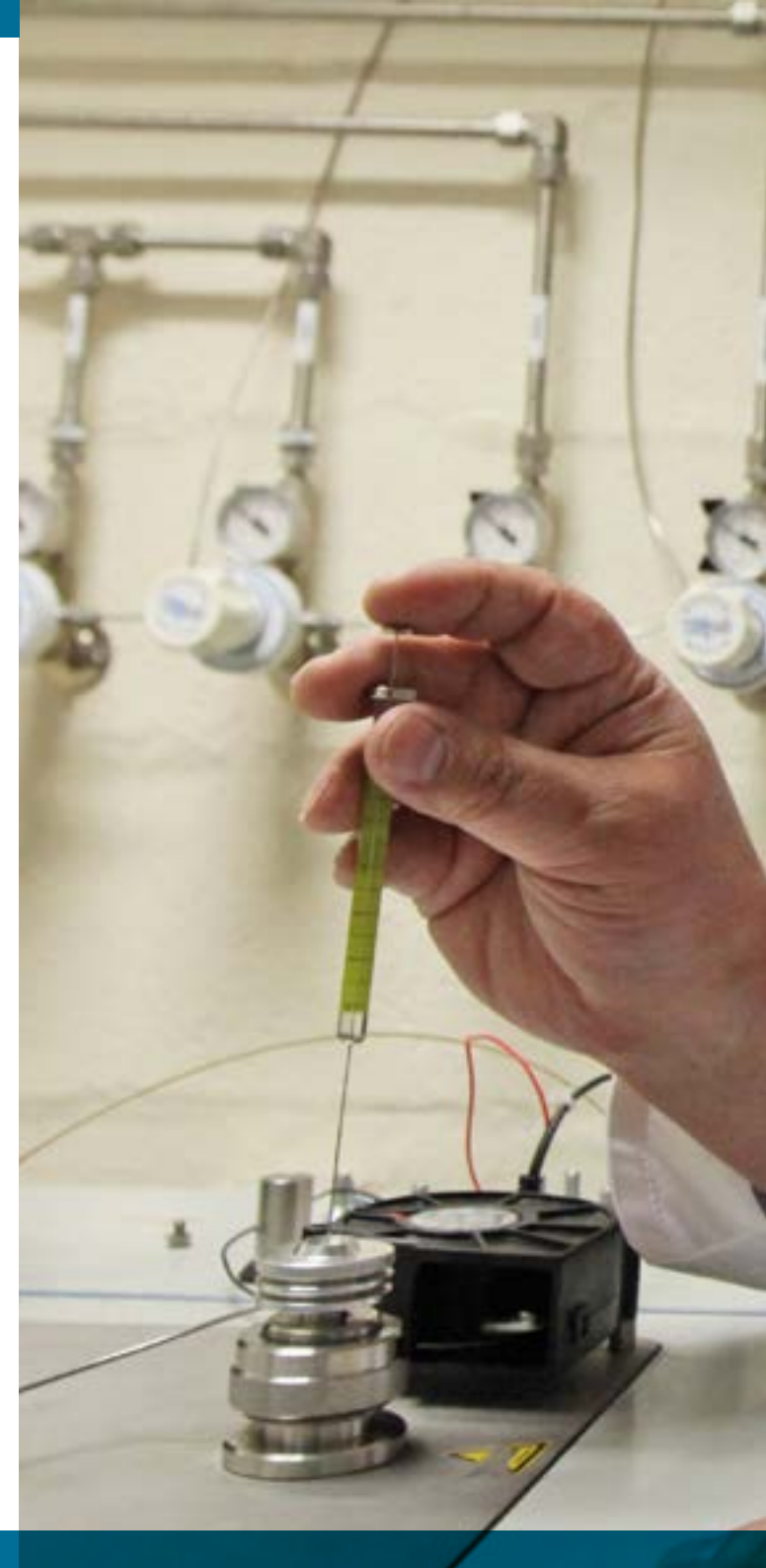
A new Food Commission for Scotland was established in 2014. Reflecting the importance of RESAS funding to food and drink research in Scotland, two MRP directors have been appointed to the Commission, one as Vice-Chair. The Commission is providing advice to Ministers and will address challenges facing Scotland's food culture and advocate the importance of good food to Scotland's health and wellbeing, environment and quality of life.

Changing Behaviours in Food and Drink

A workshop led by RESAS-funded researchers on 'promoting behaviour change in food and drink production and consumption', was a key step in planning the implementation of the 'Good Food Nation' agenda. The research highlighted at the workshop helped identify what is necessary to enable behaviour change. This is now informing a range of activity across health, education, the environment, access and affordability. This work will provide the Food Commission with evidence on how to negotiate the existing supply and demand model.

Authenticating Whisky

Counterfeiting is a growing problem for the drinks industry. The Scotch Whisky Association handles around 70 cases of whisky fraud at any one time. RESAS-funded researchers have tested the use of Total Refraction X-Ray Fluorescence to differentiate between genuine and counterfeit whiskies, based on their trace element profiles. The tests successfully differentiated genuine and counterfeit whiskies from each other and were able to differentiate whiskies by region. Further work is ongoing to enable future uptake by industry. The technique is quick, uses a drop-sized sample and is potentially portable.





food and drink

Sustainable Oat Production and Utilisation

RESAS funding has contributed to a successful programme to study oat genes and their functions, which as a result has developed molecular marker technology to enable selection of key genetic traits. The project identified genes associated with yield, economic competitiveness and quality, which will enhance the value of oats as a low input cereal crop. The technology is now being integrated into an oat breeding programme.

Nil By Mouth

'Nil By Mouth' was an interactive art event held at the Scottish Parliament. It was the culmination of a series of collaborations between Scottish artists, RESAS-funded researchers and food producers across Scotland. The art explored issues surrounding sustainable food production including farming practices, soils, and nutrition. The project, funded by Creative Scotland, resulted from collaboration with the Crichton Carbon Centre and the environmental art charity Wide Open. It has resulted in an award from the Leverhulme Trust for an artist-in-residency with a RESAS-funded researcher.

Tackling Spotted Wing Drosophila

Spotted Wing Drosophila (SWD) is a fly which originated in Asia and is now found worldwide, and is an important pest of soft and stone fruit crops. It was first detected in Scotland in 2014. Through workshops and meetings RESAS-funded researchers highlighted the arrival of SWD in Scotland and advised growers how to mitigate against and control SWD, resulting in changes in industry practice.





food and drink

Making Meat Safe

Toxoplasma gondii is an infection frequently found in pigs. Cysts of *Toxoplasma* can cause health problems in humans, and the disease can be contracted by eating undercooked meat. RESAS-funded research has shown that a commercial vaccine can be used in pigs which reduces the cyst burden, making the meat much safer for human consumption.

Novel Pro- and Pre-Biotics

Probiotics are microorganisms which are introduced into the body for their beneficial qualities. A multi-partner project has been funded by a Danish multinational company to identify novel probiotics. RESAS-funded researchers will investigate the bacterial culture collections built up in part through RESAS funding, which will help identify the next generation of functional probiotics.

Prebiotics are food ingredients that promote the growth of beneficial microorganisms in the gut. A collaboration between RESAS-funded researchers and a Swiss firm will test a new prebiotic on human volunteers to assess its effect on gut microbiota.





food and drink

Blueberries

Blueberries are an increasingly popular fruit in the UK, and with less than 10% of the fruit consumed being UK grown, there is room for an increase in production. Blueberries are a North American crop which favour warmer climates, so work is underway to identify cultivars of blueberries which will thrive in the cooler and wetter Scottish climate and to characterise the potential health benefits of consuming these fruits.

Blueberries are tetraploids, organisms with four copies of each chromosome. A new technique to map tetraploids, developed by RESAS-funded researchers for potato (another tetraploid), has led to the first genetic map of blueberries. This will be utilised to enable the breeding of varieties that are better suited to Scottish conditions.

A range of blueberry cultivars have now been characterised for UK production and the first tools for marker assisted blueberry breeding have been created. A blueberry variety factsheet for UK production has been produced, and funding from Innovate UK will further develop blueberry cultivars.

Blackcurrants

Blackcurrant breeding programmes have produced a portfolio of new varieties with enhanced fruit quality and environmental resilience. Many of these varieties are in commercial trials, and are showing good cropping consistency and quality traits.

The adaptation of blackcurrants to climate change, through controlled dormancy, is the focus of a large grant with industry partners. This project will also model chilling responses, to optimise dormancy-breaking treatments.

RESAS-funding also contributed to a project which developed key components of an Integrated Pest and Disease Management programme for blackcurrant crops. Priority was given to alternative, biological methods, particularly those which can help reduce effects of Botrytis, leaf midge and sawfly. Key outputs include that laboratory screening for Botrytis infection is now included in the selection process for the commercial blackcurrant breeding programme. The leaf midge is now deemed no problem for established bushes, meaning targeted sprays are no longer required. A sawfly pheromone trap has also been developed which will reduce the need for preventative sprays, and enable more targeted spraying.





marine

Hydrodynamic Modelling

A hydrodynamic model was developed using openly available software called the Scottish Continental Shelf Model. The model covers all of Scottish shelf waters out to 200 nautical miles and simulates the hydrodynamic conditions in three dimensions. The model provides at least 1km resolution with higher resolution in four case study areas, the Pentland Firth and Orkney Waters, Loch Linnhe, Lewis and Harris, and Shetland. The model is contributing to our understanding of sea lice dispersal, informing both management and mitigation measures. It is being used to help predict wave resources around Scotland and evaluate the impacts of offshore renewables development. The model will continue to be maintained and updated by Marine Scotland.

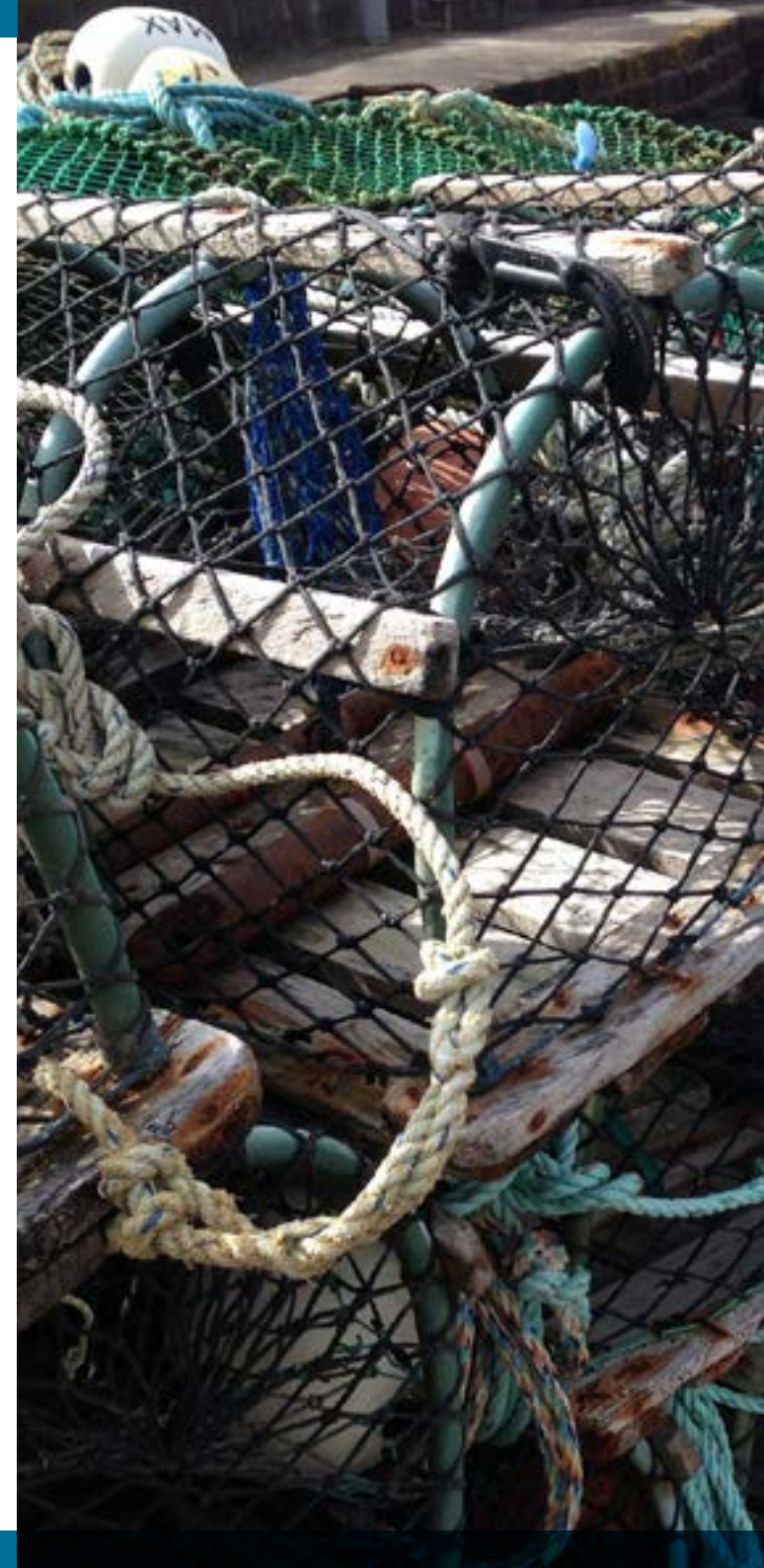
Assessing options for change in management on Scottish Inshore Fisheries

This research examined the potential economic impact of possible new management measures in Scottish inshore waters. In particular the application of restrictions on the use of mobile fishing gears within one and three nautical miles of the shore. The results indicate that gear restrictions out to

three nautical miles would result in a reduction in jobs in the short run for the fishing sector but these would be outweighed by new jobs related to recreation over the longer term. These findings are useful in supporting policy development but further work is required to underpin any future changes to inshore management.

Sustainable Healthy Fish

Aquaculture products, including oily fish such as salmon, are important components of a healthy diet. However, the increasing replacement of marine-derived ingredients in salmon feeds by more sustainable vegetable-derived materials has important implications for the health giving properties of the fish that is ultimately produced. RESAS-funded research has determined the effect of consuming such salmon and will provide knowledge on how the consumption of such fish and fish products relate to current dietary recommendations.





rural communities

Rural Socio-Economic Performance (SEP) Index

RESAS-funded researchers have developed a multivariate index of socio-economic performance (SEP index) for rural and small town Scotland. This index has been used to provide an evidence-based mechanism to support decisions on targeting of funding and was used as a basis for allocation of Scottish LEADER funding to the Local Action Groups.

Scottish Rural Parliament

The first Scottish Rural Parliament was hosted in Oban in November 2014. RESAS-funded researchers presented their work in a dedicated exhibition space. Researchers also facilitated several workshops, including one on Land Reform attended by the Cabinet Secretary and the Scottish Government's Land Reform policy lead.

Evaluation of Community Right to Buy (CRtB)

This research built a logic model to investigate the short and medium-term outcomes from CRtB. It identified that the short-term outcomes, including improving community participation, had largely been met. The medium-term outcomes, such as overall community cohesion, had a more mixed picture. The evaluation identified recommendations over developing a monitoring framework for the CRtB policy. Its overall findings showing generally positive outcomes helped to underpin the community land policies which were a key part of the drivers for the Land Reform (2016) Act.

Linking Communities and Estates

RESAS-funded research on the potential for partnerships between communities and estates was presented at a meeting of the Cairngorms National Park Authority (CNPA) Land Management Forum in April 2014. Following on from this workshops run by the CNPA Local Action Group were facilitated to find out how the LEADER Local Development Strategy can best support businesses.

Scottish Enterprise Rural Group

A two way flow of information to encourage ideas between industry and RESAS-funded research and to ensure research findings are heard in the Scottish rural sector included the hosting of the Scottish Enterprise Rural Group by RESAS-funded researchers. There was a particular interest on the impact that the LEADER programme has had on community resilience.



land use

Implementing Soil Protection Policy

A RESAS-funded researcher was invited to outline the development of the Scottish Soils Framework at the International Workshop on Soil Degradation Risks in Planted Forests held in Bilbao. The positive interactions between stakeholders were emphasised. The Scottish approach to soil protection (i.e. the approach of the Scottish Soil Framework) was referred to by a senior European Commission officer as an exemplar for other European regions and countries.

Sediment Fences

The use of sediment fence technology to prevent soil erosion in fields following harvest has been evaluated and promoted by RESAS-funded researchers. A useful side-effect of these trials is to increase awareness of the issues around soil erosion, which has led to better practice to prevent soil mobilisation. This research led to the Environment Agency funding three trials in Cornwall with bulb growers. The use of sediment fences in agricultural systems is now promoted in the Good Agricultural and Environmental Condition guidelines. International interest from New Zealand, Poland and China, has resulted in large scale trials on orchard land in Hunan province, China.

Nitrate Modelling

Nitrate Vulnerable Zones (NVZs) are areas where the concentrations of nitrate in water exceed, or are likely to exceed, acceptable levels. The source of nitrates in water is primarily from agricultural fertilisers, so legally binding rules are put in place in NVZs to reduce nitrate loss from agricultural land. Scottish Environment Protection Agency led a 2013 Nitrates Directive Review to develop a new methodology to designate NVZs. Nitrate loadings to groundwater, modelled by RESAS-funded researchers, were used as one strand of evidence. As a result of this review the boundaries of the NVZs were revised in 2015, which resulted in a decrease of 2,700 km² of land under NVZ designation in Scotland.





land use

Land Use Strategy Pilot

RESAS-funded researchers collaborated with Aberdeenshire Council to deliver one of two Regional Land Use Strategy pilots which ran until March 2015. The Aberdeenshire pilot was focused on issues of rural land use change. The aim is to create a framework which summarises policy and environmental information for users and indicates where particular types of land use change might be beneficial or detrimental in line with policy goals and climate change mitigation/adaptation.

The final product Aberdeenshire Rural Land Use Pilot, a web-based decision support tool, was launched in 2015 with a series of roadshow events. Workshops also enabled people from a diverse range of organisations to interact and explore the complexities of future land use change, and to find points of agreement. rlup.hutton.ac.uk/

Search Tools

Combining Scottish spatial data on soil, vegetation and surface features has resulted in a process which can reduce search areas for assisting with search operations. The toolset developed enables the spatial data to be interrogated and mapped in Geographic Information Systems (GIS). This process is being used in response to police enquiries and was featured on the BBC4 series 'Catching History's Criminals'.





ecosystems and biodiversity

Revising the Natural Capital Asset Index

The Natural Capital Asset Index (NCAI) is a measure developed by Scottish Natural Heritage to help assess the sustainability of Scotland's economic growth over coming years and to ensure Scotland's natural assets are managed in a sustainable way. RESAS-funded researchers undertook an evaluation of Scotland's NCAI. As a result of the recommendations of the evaluation the Index was revised and re-published.

Ecosystem Health Indicators

RESAS-funded researchers are members of the Scottish Biodiversity Strategy Indicator sub-group. This group is developing Ecosystem Health Indicators for Scotland, particularly with regards to soil health and function. This has led to improved collaborations with researchers at Centre for Ecology and Hydrology and other organisations, and supports Scotland's Biodiversity Route Map 2020.

State of Nature Scotland

A RESAS-funded researcher presented the opening keynote speech by at the 2015 State of Nature Scotland conference. The conference set out the challenges to nature in Scotland, potential responses and highlighted success stories. This was followed up by an interview for BBC Radio Scotland's 'Out of Doors' programme.

Perceptions of Peatlands

Workshops were run by RESAS-funded researchers to understand how the public perceive peatlands. Many benefits were recognised by the public, but there were also negative associations around danger and wastelands. The findings from the workshops have been used by Scottish Natural Heritage to help inform their work on restoration of peatlands.

In addition, collaboration between RESAS-funded social and natural scientists has enabled the development of a decision support tool 'WISE Peatland Choices' which provides an assessment of the suitability of peatland sites for restoration.





ecosystems and biodiversity

Understanding the Risks of Beaver Reintroduction

A qualitative risk assessment which assessed the risks to public health from beaver reintroductions to Scotland was conducted in collaboration with Health Protection Scotland (HPS) and Scottish Water. The assessment concluded that any reintroduction of beavers would pose a low risk to public health through contamination of water supplies. The links made with HPS have enabled conversations around future 'one health' approaches to solving animal/human disease problems.

Working Towards the Sustainable Development Goals

The Copenhagen Consensus Center addresses how best to use limited budgets to do the most good for the most people. The Post-2015 Consensus project brought together experts to establish the most effective targets for the UN's post-2015 development agenda. A RESAS-funded researcher was invited to carry out a cost-benefit analysis of the proposed Sustainable Development Goals with respect to forest protection. A subsequent review of all analyses identified 19 targets that represent the best value-for-money in development over 2016-2030, offering \$15 back on every \$1 invested.



D



measuring the difference





policy and practice

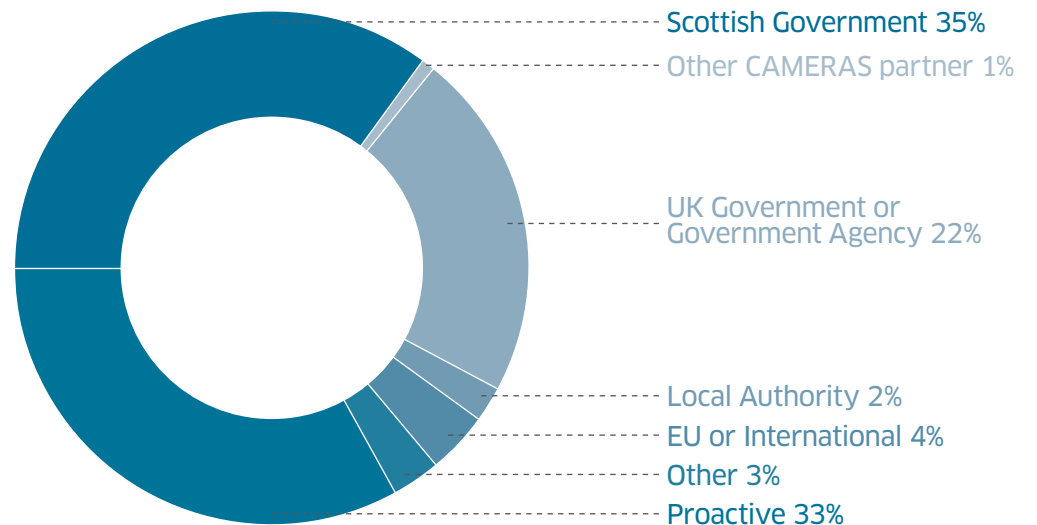
Scottish Government-funded research contributes to shaping policy by providing a knowledge and evidence base to help inform decisions. Much of the funded research is longer term and strategic, rather than directed to immediate policy needs. However, the expertise and capacity available also means that policy makers can seek advice as and when they need it. RESAS encourage that briefs are written in response to specific requests from policy, thus ensuring they are relevant to policy needs and end users.

186
policy outputs were produced from the total research portfolio in 2014-15

25%
increase in reactive policy outputs since the start of the programme in 2011

Reactive outputs now make up
67%
of all policy outputs

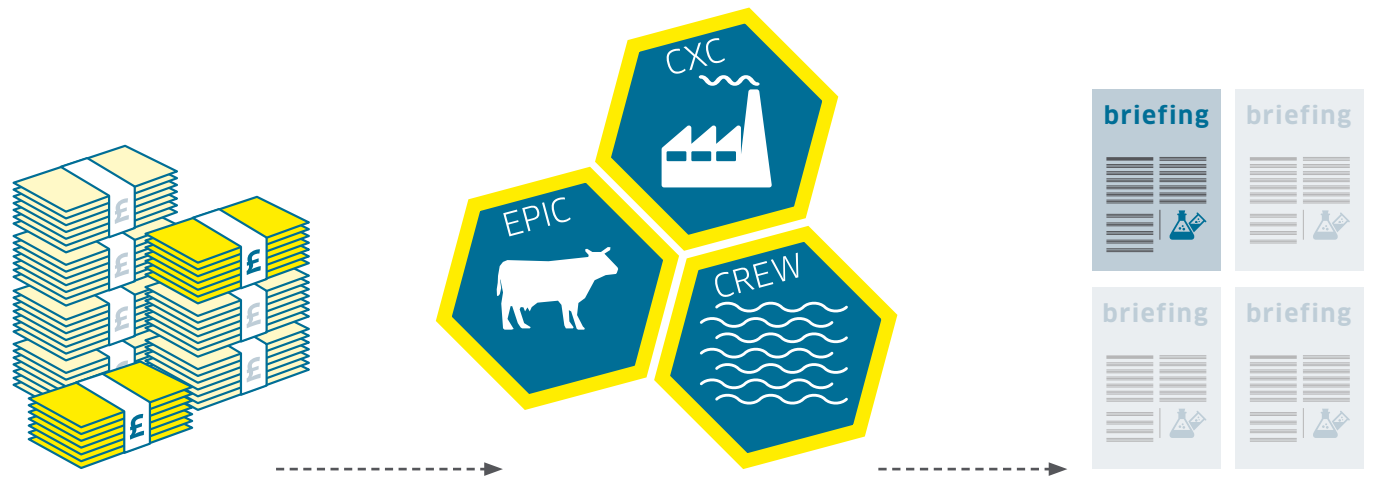
Of those requests 35% of them came from the Scottish Government, and 22% from the UK Government or Government agencies.





policy and practice

Our Centres of Expertise (CoEs) allow policy makers more direct and rapid access to research and evidence. These centres undertake research within the themes of Animal Disease, Climate Change, and Water and Renewable Energy, and continue to be a highly valued resource.



13%
of total portfolio
funding received by
three CoEs in 2014-15

Centres of Expertise

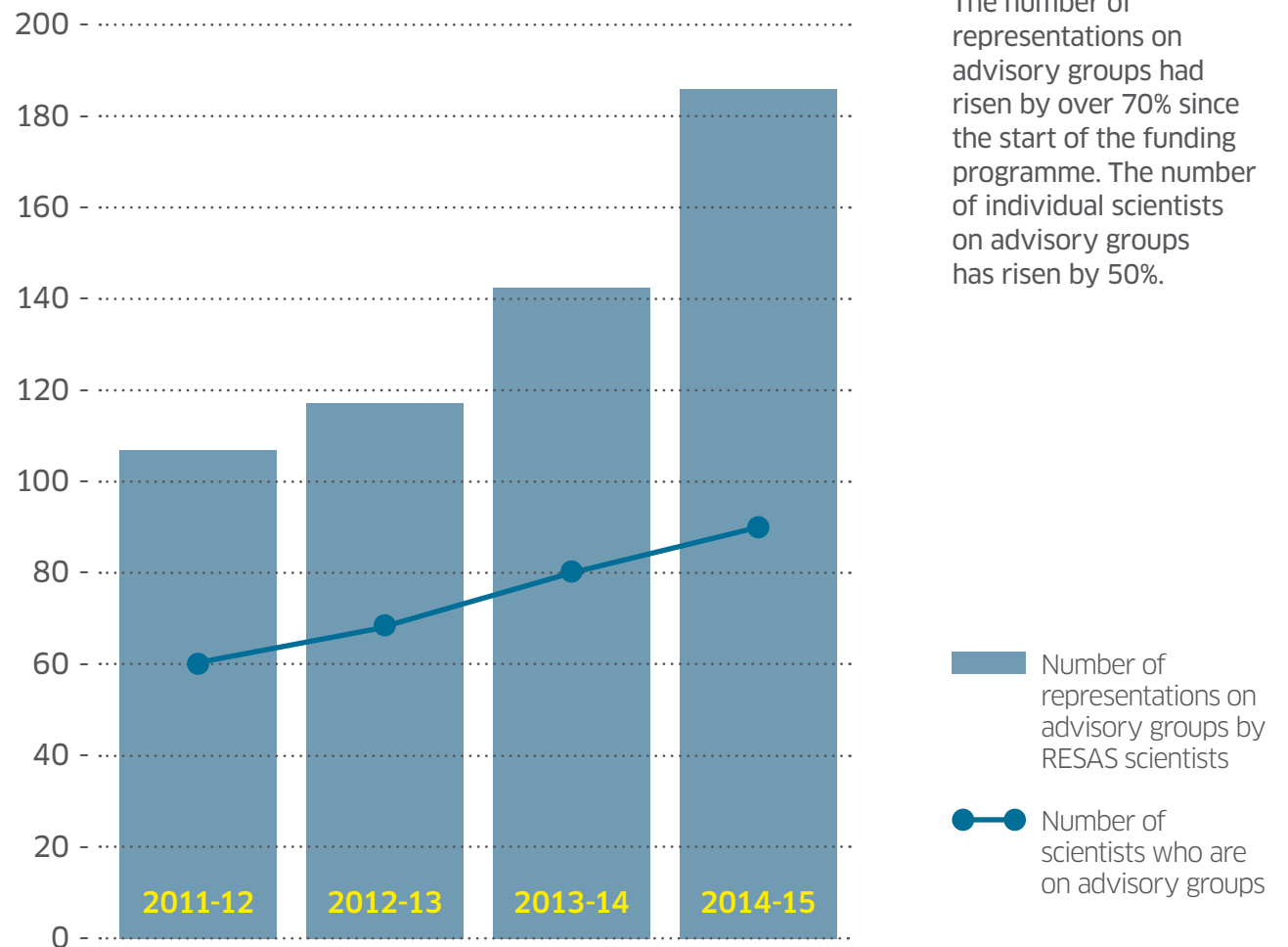
37%
of the policy output
was produced by
the three CoEs

CXC ClimateXChange
EPIC Centre of Expertise on Animal Disease Outbreaks
CREW Centre of Expertise for Waters



policy and practice

As well as producing briefs and reports which influence policy, a number of RESAS-funded researchers also sit on committees or are members of advisory groups which can provide an opportunity to influence policy. In 2014-15, there were 185 representations on government or agency advisory groups by 90 RESAS-funded scientists and researchers. These include representations at Scottish Government, UK Government, EU and UN levels. Researchers are members of a wide range of committees and advisory groups including IPCC (Intergovernmental Panel on Climate Change) working groups, EU European Innovation Partnership focus groups, European Food Safety Authority working groups, DEFRA Antimicrobial Resistance co-ordination group, DEFRA UK Plant Health Forum, and SNH Science Advisory Committee.

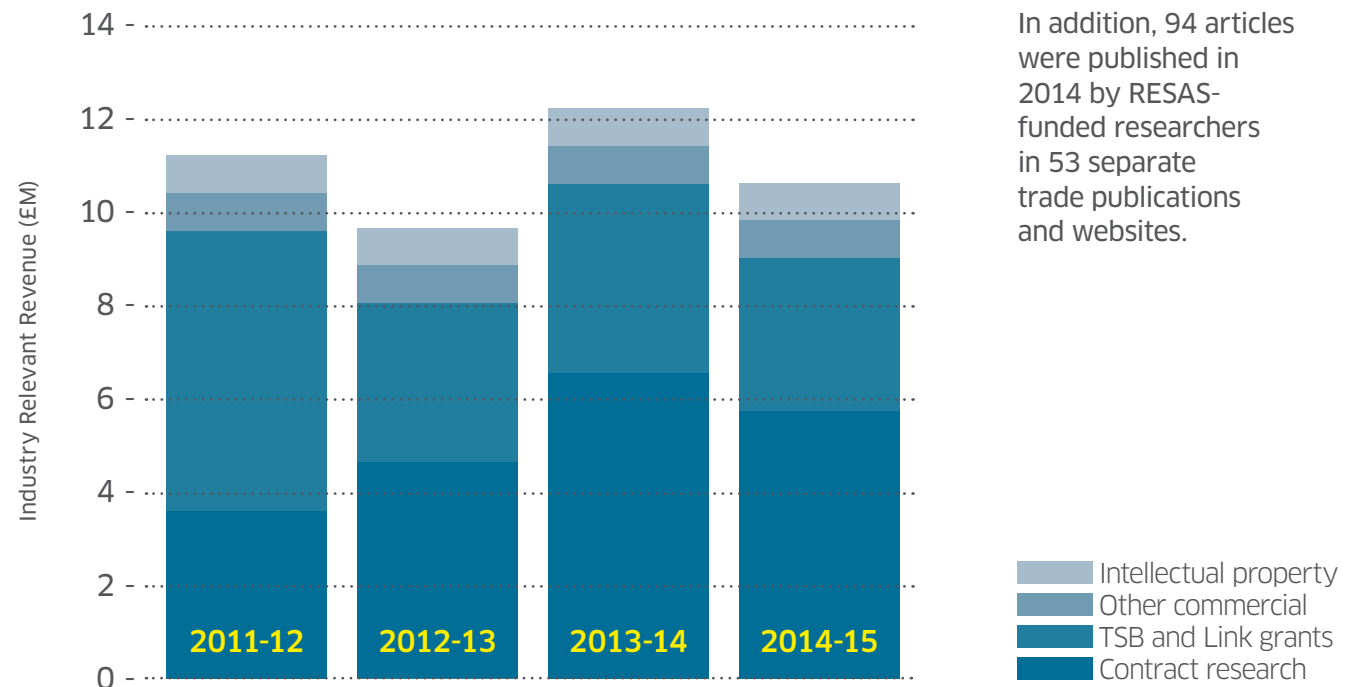




trade and industry

New tools and technologies developed as a result of RESAS-funded research can be of benefit to industry. Ten spin out companies formed since 1999 are still trading. Seven new patents on five innovations were granted in 2014-15, two of which are already licensed. Nineteen new licences were granted in 2014-15, for a range of topics including diagnostic tests for diseases and for raspberry and strawberry varieties.

An important source of additional funding for RESAS-funded researchers is leveraging in money from industry to support their needs and for specific projects, consultancies and collaborations. This industry relevant income has fluctuated between c. £10-12 million in each year since the start of the programme. £10.5 million of industry relevant income was generated in 2014-15.





scientific resilience

RESAS-funded research is reported in a wide range of international scientific journals. Researchers collaborate with other MRPs to produce this work as well as collaborating with academics outwith MRPs - both nationally and internationally.

Over 550 peer-reviewed articles were published in 2014 by RESAS-funded researchers. Of these, 67% were co-authored with researchers outside the MRPs, 37% were co-authored with international researchers and partners.

A RESAS funded researcher (Professor Philip White (Plant and Animal Sciences)) was listed in the Thompson Reuters list of highly cited researchers for 2015.

Between 2011-14 55 highly cited papers were published by RESAS-funded researchers. Highly cited papers are defined as a paper which received enough citations to place it in the top 1% of its academic field based on a highly cited threshold for the field and publication year.

Highly-cited papers published in 2014 cover a wide range of programme research including cattle genetics, gut microbiology, soil microbiota, plant pathology and knowledge exchange. They are featured in a wide range of high-impact journals including Science, Ecology Letters, Plant Cell and BMC Biology.



53%

of all peer-reviewed articles in 2014 were published in journals with an impact factor of 3 or greater, and

15%

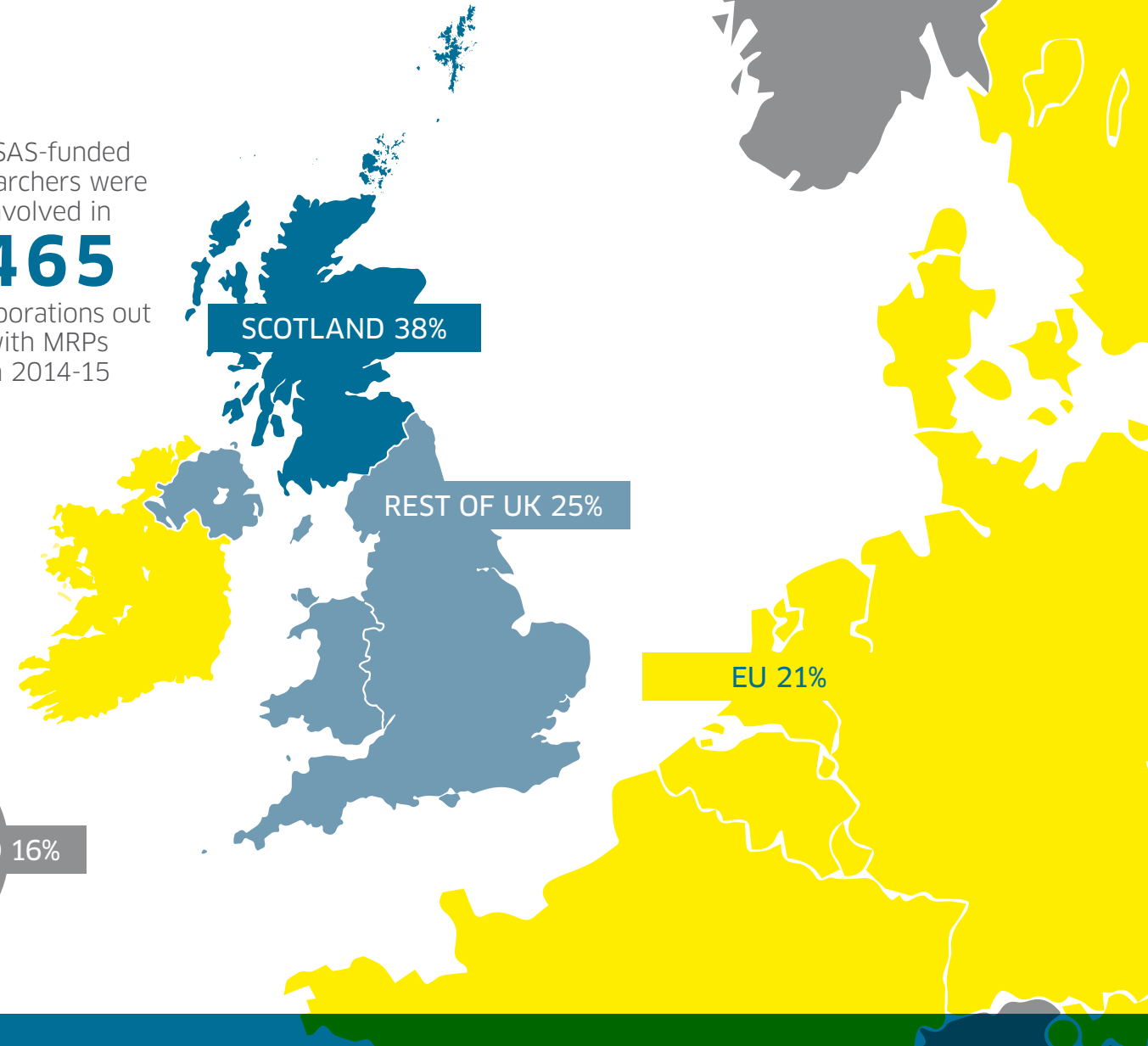
in journals with an impact factor of 5 or greater

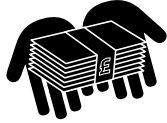


scientific resilience

As well as producing scientific papers, RESAS-funded researchers are involved in a wide range of collaborative scientific projects - both within Scotland and further afield. These collaborations can help to ensure that RESAS-funding contributes towards world-leading research.

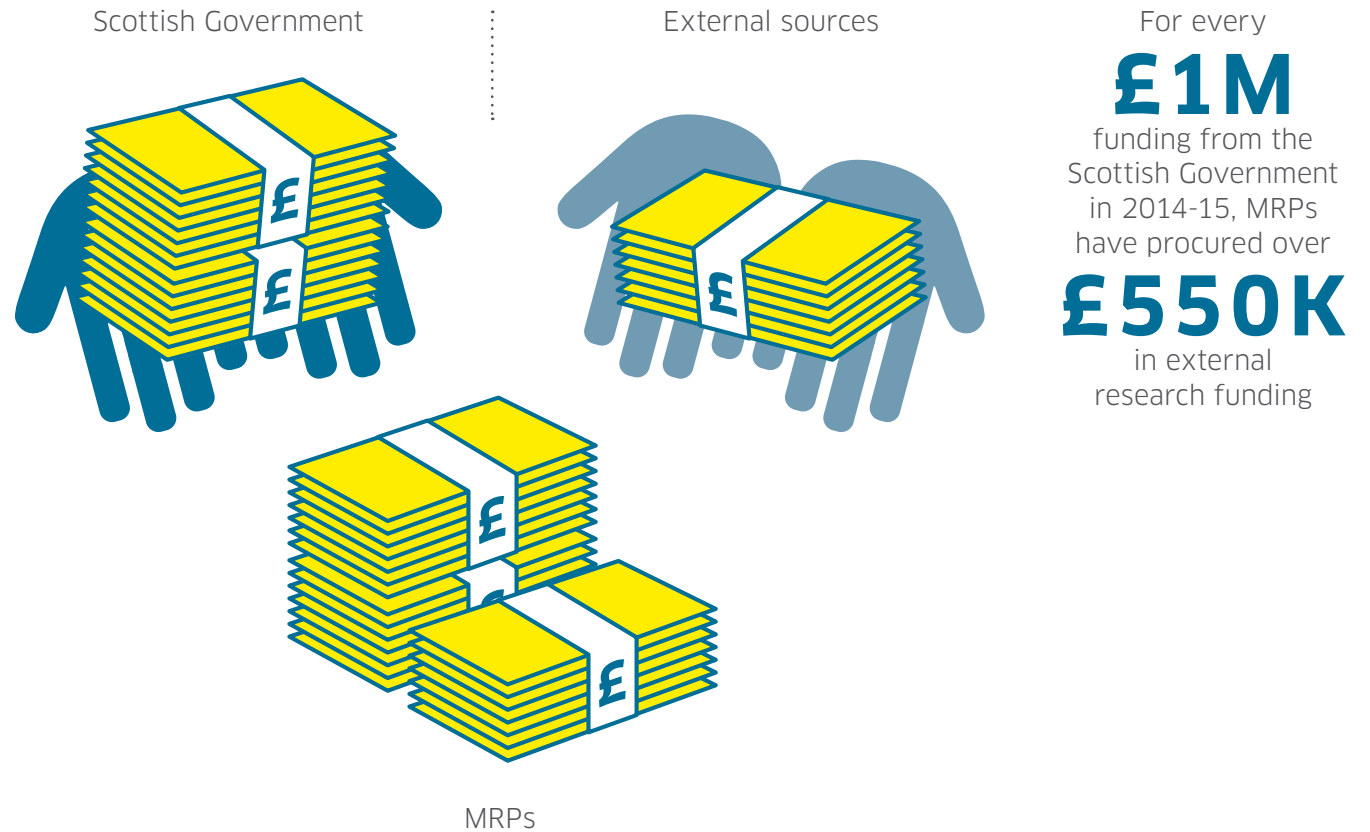
RESAS-funded
researchers were
involved in
465
collaborations out
with MRPs
in 2014-15





scientific resilience

90% of RESAS funds go to MRPs. In addition to providing direct support to scientific research, the funding also helps the MRPs raise additional money from sources including the EU, the UK Research Councils and DEFRA, which can then be fed back into research.





Scottish Government
Riaghaltas na h-Alba
gov.scot

© Crown copyright 2016

OGL

This publication is licensed under the terms of the Open Government Licence v3.0 except where otherwise stated. To view this licence, visit nationalarchives.gov.uk/doc/open-government-licence/version/3 or write to the Information Policy Team, The National Archives, Kew, London TW9 4DU, or email: psi@nationalarchives.gsi.gov.uk.

Where we have identified any third party copyright information you will need to obtain permission from the copyright holders concerned.

Images supplied by and are copyright to: crown copyright, Marine Scotland, SASA, Scotland's Rural College, James Hutton Institute, Moredun Photo Library, CREW, SNH, SEPA, Matthew Hepburn.

This publication is available at www.gov.scot

Any enquiries regarding this publication should be sent to us at
The Scottish Government
St Andrew's House
Edinburgh
EH1 3DG

ISBN: 978-1-78652-599-4 (web only)

Published by The Scottish Government, December 2016

Produced for The Scottish Government by APS Group Scotland, 21 Tennant Street, Edinburgh EH6 5NA
PPDAS36631 (12/16)

W W W . g o v . s c o t