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scrr

Scottish Consortium for Rural Research

formerly the Edinburgh Consortium for Rural Research

SCRR Newsletter

formerly The Bush Telegraph

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PICTURE: DAVID GENNEY, RBGE

Protecting a wonderful world

Our landscape is a precious natural resource and the work of researchers is to help look after it, says Prof Stuart Monro, scientific director of SCRR

A SONG THAT I find truly inspirational is 'It's a wonderful world', sung by Louis Armstrong. It was given fresh life and made even more meaningful when Sir David Attenborough recited the lyrics against images of the natural world from his television programmes.

Today we live in a global village where we are all affected by changes in the natural environment. The Scottish landscape is our most valuable natural resource, and is incredibly diverse thanks to the variety of geology in a very small area. That, in turn, fosters a great diversity of habitats – on land, in rivers and lochs, in the sea and in the air – each of which has its own array of plants and animals. In the pages of this newsletter we can read about how the research community in Scotland is working to understand these ecosystems and to mitigate the effects of changes in the natural environment.

Humanity, too, is part of this ecosystem – for good or ill. The legacy of previous generations leaves an imprint on the landscape, whether it is standing stones, the pattern of agricultural fields or the forest scenery. Increasingly our understanding of the ecosystem must extend from the macro to the micro and genetic techniques are opening new windows on biodiversity. Ultimately, we seek to better understand this wonderful world!

Above: the moss *Pohlia nutans* in a Scottish snowbed

This issue in initiatives

Tourism in Scotland is being promoted by the Scenic Routes Initiative – **page 2**

Habitat restoration can be helped by reseeding after non-native plants are removed – **page 3**

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Plant diversity and its benefits for agriculture are also to be investigated – **page 10**

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 on the back page.

Members' reports

SCRR; Edinburgh Napier University

SCRR Peter Wilson Lecture 2018 • February 27th, 6.30pm • Royal Society of Edinburgh

'Scotland's land: successes and failures, challenges and solutions', by Roger Crofts CBE

THE ANNUAL PETER WILSON lecture at the Royal Society of Edinburgh on February 27th, 2018 will be given by Roger Crofts, chair of the Royal Scottish Geographical Society. The title is 'Scotland's land: successes and failures, challenges and solutions'.

The talk will begin by celebrating Scotland's natural assets, then question whether all that has happened in recent times is beneficial and whether we would now have acted differently. Key inherited and current challenges will be addressed, including industrialisation of land use and ignorance of natural processes, lack of space for nature and species debates. Solutions will be set out demanding more integrated ways of planning future land use, developing a package of practical mechanisms and addressing polarisation of attitudes.

Roger Crofts trained as a geographer and geomorphologist. He worked in universities, The Scottish Office, and as CEO of Scottish Natural Heritage. He advises, lobbies, writes and talks to anybody who will listen in Scotland, Iceland and Europe on environmental strategy and policy.

Roger hopes to help people understand the Earth's heritage and environment and to care for it more effectively. He has been active in voluntary environmental and educational bodies not just in Scotland, but also in the UK and internationally. He has been chair of the Royal Scottish Geographical Society since 2013. His work has been recognised by numerous honours and awards.

To book, see www.rse.org.uk/events

Scottish Scenic Routes Initiative

Dr Kathy Velander of Edinburgh Napier University on a project to attract new visitors and sustain communities

THE SCOTTISH SCENIC Routes Initiative evolved from a conference organised by Edinburgh Napier University's Wood Studio with the aim of learning from the National Tourist Routes programme in Norway.

The resulting enthusiasm shown by landowners, politicians, public agencies and local people led to the creation of a working group consisting of 10 public agencies and funding of £1.5 million from the Scottish Government. The objectives of the initiative were threefold: to improve the physical infrastructure available to visitors along major tourist routes in Scotland; to support employment in, and help sustain, rural communities; and to create new opportunities for the best of the country's young design talent.

Below: 'The Watchers', Corgarff, in the Cairngorms

The aim was to deliver high-quality projects that would not otherwise be funded as part of conventional road or route improvements.

Nine projects have been completed and some of these have attracted extensive international interest publicity, especially in architecture and design publications and websites, as well as securing a number of important architectural awards which, in themselves, raises the profile of the location.

Work is ongoing to seek funding and development opportunities.

Contact Dr Kathy Velander, School of Applied Sciences, Edinburgh Napier University k.velander@napier.ac.uk or Peter Wilson, Timber Design Initiatives, timberdesigninitiatives@gmail.com

James Hutton Institute, Scottish Natural Heritage

PICTURE: DAVID GENNEY, SCOTTISH NATURAL HERITAGE

Native plants need help to recover after clearance of invasive species

A study by the James Hutton Institute, University of Aberdeen and SNH shows that native plants may benefit from reseeding after rhododendron removal

NATIVE PLANTS NEED a helping hand if they are to recover from invasive rhododendron, Scottish ecologists have discovered. A new study reveals that even at sites cleared of rhododendron 30 years ago, much native flora has still not returned. As a result, rhododendron eradication programmes may need to be supplemented by reseeding if the original plant community is going to re-establish.

Uninvaded Atlantic woodlands are often called the Celtic rainforest. The tree trunks host rich tapestries of diverse mosses and liverworts and in spring luxuriant carpets of bluebells cover the ground, interspersed with the fiddle-heads of diverse fern species. However rhododendron-invaded woodlands present a different vista – vast stands of this single species replacing all the diverse native flora as far as the eye can see.

Working in the Atlantic oak woodlands of Argyll, Kintyre and Lochaber on Scotland's west coast,

'Instead of dramatic displays of primroses, violets, wild garlic, ferns and grasses, only dense mats of mosses and liverworts had returned'

researchers from the James Hutton Institute, the University of Aberdeen and Scottish Natural Heritage studied plots that had never been invaded, others covered in dense rhododendron thickets, and a time-series of sites cleared of rhododendron at different periods between 1984 and 2014.

Above: Atlantic oakwood pasture, 'the Celtic rainforest'

They found that even 30 years after rhododendron removal, the native understorey normally found in Atlantic oak woodlands had not recovered. Instead of dramatic displays of primroses, violets, wild garlic, ferns and grasses, only dense mats of mosses and liverworts had returned.

The research team think that the deep shade which the invasive species casts is responsible for its impact on native plants – even decades after rhododendron eradication.

The research has important implications for rhododendron eradication efforts. The results of this study show that as well as removing rhododendron, land managers should also consider clearing mats of common mosses from the ground and reseeding with typical woodland grasses and flowering plants.

The study was funded by Scottish Natural Heritage.

Contact Bernardo Rodriguez-Salcedo
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Members' reports

Centre for Ecology and Hydrology

The benefits to society of insect pollinators – and how policy can help

Dr Adam Vanbergen, an invertebrate ecologist at CEH, reports on what the example of insect pollinators contributes to the evidence into conservation policy

'There is evidence of decline in pollinators in several regions of the world, with threats coming from changes in land-use and management intensity, climate change, pesticides, diseases exacerbated by large-scale bee management, and invasive alien species'

BIODIVERSITY UNDERPINS THE sustained functioning of the Earth system and the provision of ecosystem benefits to humankind, but it is threatened by human activities. In order to counter threats and assure the conservation, restoration and sustainable management of biodiversity and ecosystem services requires that we know the state of play.

The UN Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) was established in 2012 with a mission to 'strengthen knowledge foundations for better policy through science, for the conservation and sustainable use of biodiversity, long-term human well-being and sustainable development.' One way it achieves this is by providing scientifically credible, independent evidence assessments and options for decision-making.

A high profile example is the IPBES global thematic assessment of pollinators, pollination and food production. More than 80 experts from all regions of the world collectively analysed a large body of knowledge, including about 3,000 scientific publications. The assessment found that wild and managed pollinators provide a wide range of benefits to society by contributing to food security, farmer and beekeeper livelihoods, and social and cultural values, and by supporting wider biodiversity and ecosystem stability. It concluded that there is evidence of declines in some wild and managed pollinators in several regions of the world, with threats coming from changes in land-use and management intensity, climate change, pesticides, diseases exacerbated by large-scale bee management, and invasive alien species.

Above, bumblebee on sunflower; below, hoverfly on ragwort

However, the report also identified many policies and actions that can be effective in alleviating this problem, to safeguard pollinators and pollination services. Among these were supporting diverse farming systems, building ecological infrastructure (such as connected habitats) and moving toward a more sustainable, ecological intensification of agriculture. In 2016, the 196 government signatories, including the UK, to the Convention on Biological Diversity in Cancun, Mexico (CBD-COP13) endorsed this IPBES assessment.

This science into policy-making at the intergovernmental level is helping to steer UK and devolved government policy on pollinators and pollination. In 2014, Defra produced its national pollinator strategy and from 2015 a two-year process of engagement between the Scottish Government, SNH, scientists, conservation NGOs, Scottish Land & Estates, Scottish NFU and the wider public was undertaken. This process considered the evidence from the IPBES, Insect Pollinators Initiative and other sources and applied that knowledge to the Scottish context.

The culmination of this activity was the publication of the Pollinator Strategy for Scotland 2017-2027 (see below) which sets out the goals, the state of knowledge and an agreed series of priorities and actions to help ensure that pollinators and pollination thrive in Scotland.

The Pollinator Strategy for Scotland (2017-2027) is at www.snh.gov.uk/docs/A1835258.pdf. Contact Dr Adam Vanbergen ajv@ceh.ac.uk

Counting 14,000 seed plants in the Amazon

RBGE has published an ambitious species list for one of the planet's most biodiverse regions

ROYAL BOTANIC GARDEN EDINBURGH has published the first ever verified species list for the Amazon forests, one of Earth's biodiversity hotspots. The paper, led by Edinburgh and Brazil and co-authored by 45 botanists from across the world, was published in October in the Proceedings of the National Academy of Sciences. The published species list can now be used in conservation efforts and global models for predicting climate change response of these majestic ecosystems, as well as in macroecological and evolutionary studies aiming at understanding the origin, evolution, and ecology of the exceptional species diversity.

The study shows that the Amazon flora comprises 14,003 seed plants, of which 6,727 are trees. These figures are similar to estimates derived from non-parametric ecological models, but they contrast strongly with predictions of much higher tree diversity derived from previous parametric models.

The publication was made possible by recent advances in the study of the Amazon flora and by the digitisation of herbarium specimens, along with the hard work of hundreds of taxonomists sorting and naming these specimens over the past decades. Innovative efforts such as the ongoing Flora do Brasil 2020 and the Catalogo de Plantas de Colombia, funded by their respective governments, together with more local studies, have been key to advancing knowledge of Amazonian plant diversity.

The study demonstrates how preserved collections and the people who work on them, collaborating across countries, are essential for understanding diversity. Similar to many fields in science, we cannot work in isolation: we have to build upon the expertise of each country or institution to work towards a common goal.

The publication of all Amazonian plants is a real moment of celebration for the botanical community. It reflects hundreds of years of fieldwork and exploration and centuries of taxonomic study around the world's herbaria by countless researchers.

PICTURE: PETER MOONLIGHT

Collecting species in the Amazon forest

The publication can be found at: www.pnas.org/content/114/40/10695.abstract. Contact Dr Tina Sarkinen TSarkinen@rbge.org.uk

Members' reports

Forest Research; James Hutton Institute

Observatree project celebrates four years of citizen science

Forest Research reports on end-of-project conference

A RECENT CONFERENCE at the Royal Botanic Garden Edinburgh gave the Observatree project a chance to review its recent achievements and launch guides for engaging citizen scientists in providing evidence.

A very successful end-of-project conference was held at RBGE to review and celebrate the achievements of the EU LIFE Observatree project. Forest Research has led this four-year project to build a Tree Health Early Warning and Surveillance system through the training and deployment of volunteers, i.e. citizen scientists.

The project has been a productive partnership between Forest Research, the Woodland Trust, Fera Science Ltd, the National Trust and the Forestry Commission in Scotland and in England, with support from Defra, the Animal and Plant Health Agency, Natural Resources Wales and the EU.

Delegates were welcomed to the RBGE by Professor Pete Hollingsworth and heard a range of presentations summarising the activities of the project and how it trained volunteers; a volunteer's insights into motivations and benefits of getting involved; and international perspectives from Slovenia, Greece and Poland. Scotland's chief plant health officer, Professor Gerry Saddler, was generous in his praise of the project and how it contributes to efforts to safeguard the health of the country's plant life.

The project has produced an impressive range of outreach and training materials, and at the conference two further resources were launched. The first, titled 'Observatree explained: A layperson's report', is a brief non-technical summary of the project consistent with that produced for all 'LIFE' projects. In addition, the project has published a more detailed handbook, 'Good Practice Guidelines: An Observatree Perspective', based on experiences and lessons learned over the past four years.

Peter Crow, Forest Research's project manager, outlined plans for a phase two building on the strengths of the project and ensuring the volunteer network will continue to contribute to surveillance, not least by improving the geographic representation in areas such as the central belt of Scotland.

Further information can be found at www.observatree.org.uk/. Contact Peter Crow peter.crow@forestry.gsi.gov.uk or Chris Quine chris.quine@forestry.gsi.gov.uk

Below: the Observatree end-of-project conference at RBGE

Inspecting ectomycorrhizal fungi in roots

Study to expand k ectomycorrhizal f

With little research having taken pla provide valuable insights, explains th

RESEARCHERS AT THE James Hutton Institute and the University of Aberdeen are exploring the relationship between ectomycorrhizal (ECM) fungi and native tree species in Scotland. The study will also determine which climatic and environmental factors influence the distribution of these fungi.

ECM fungi form beneficial associations with the roots of many plant species, in particular trees: the fungi take up nutrients from the soil and pass on some of these to the host plants in return for sugars. The fungi are therefore essential components of many terrestrial ecosystems.

The data recorded from the study will contribute to the limited information currently available on the subject in Scotland. Existing records show that there are approximately 900 ECM species recorded in Scotland. This is only about one-half of the species recorded in Scandinavia.

Supported by the Macaulay Development Trust, PhD researcher Peggy Ehrlich (University of Aberdeen/ James Hutton Institute) aims to develop such records. Peggy explains: 'Scottish studies on ECM fungi have so far focused on those associated with Scots pine and on mountain shrubs.

PICTURE: JAMES HUTTON INSTITUTE

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ce previously, this project should e James Hutton Institute

'These fungi form beneficial associations with the roots of many plant species: the fungi take up nutrients from the soil and pass on some of these to the host plants in return for sugars'

Very little is known about the composition and resilience of ECM fungi in symbiosis with native hosts, except for Scots pine and mountain shrubs, and also the factors that influence their distributions.'

A combination of traditional morphological approaches as well as modern molecular analyses will be used to identify the fungi. The project will provide valuable information for forest management and woodland expansion policies.

A comparison between Scottish and Scandinavian fungal community data will also give insights into how trees and their associated ECM communities spread and developed after glaciation.

Contact Bernardo Rodriguez-Salcedo
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Orkney conference shows strengths of heritage barley

James Hutton Institute and the University of the Highlands and Islands highlight the living heritage of bere barley and its part in a more sustainable future

THE PROFILE OF bere barley, together with its potential as a source of traits for human and environmental health and as a source of living heritage, was highlighted at an event held on and around the mainland of Orkney, featuring a range of lectures, demonstrations, tours and product tastings.

Organised by the James Hutton Institute and the Agronomy Institute at the University of the Highlands and Islands (UHI) in Kirkwall, the event was supported by the Scottish Government through RESAS and the EU Northern Periphery and Arctic Programme Northern Cereals project, the Birsay Heritage Trust, Bruichladdich distillery (Islay) and Swannay Brewery (Orkney).

Sixty-eight delegates from a range of stakeholder groups including scientists, educators, funders, regulators, growers, distillers, brewers, bakers, charitable trusts, archaeologists, artists and the interested public were brought together to discover the potential of bere.

During the event, Dr Tim George of the James Hutton Institute discussed how the crop harbours useful genetic diversity, due to its adaptation to the very specific environment of Orkney for at least a thousand years. Bere has some unique traits which allow it to cope with a range of stresses and has unique abilities to cope with issues related to alkaline soils such as micronutrient metal deficiencies.

The event provided an overview of past and current uses of bere barley, plus a look at how bere got established in Orkney and how it could be used for food and drink, alternative products and as a source of genetic diversity for future barley varieties.

The scientific programme included talks by experts from the University of the Highlands and Islands, the University of Copenhagen (Denmark), the Rowett Institute and Manchester University.

Contact Bernardo Rodriguez-Salcedo
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Below: bere barley growing in Orkney

PICTURE: JAMES HUTTON INSTITUTE

Members' reports

SEFARI, RBGE, Scottish Association for Marine Science

SEFARI 'Think Tanks' and conserving genetic diversity

Professor Pete Hollingsworth of RBGE explains a new joint initiative from six leading Scottish research institutes

SEFARI 'THINK TANKS' aim to deliver insight on challenging questions of national and international importance. Think Tanks draw on the SEFARI knowledge base, but also bring in other relevant expertise. Think Tanks have considered urban food; decarbonising global agriculture; and meeting future protein needs.

One of the first Think Tank projects focused on addressing Aichi Target 13 of the Convention on Biological Diversity – conserving genetic diversity. Tackling this target has been problematic at national level as there is no consensus on how to measure genetic diversity, or how to develop scalable approaches that work effectively beyond livestock and crops.

Addressing this issue is important because the loss of genetic diversity:

• reduces fitness and elevates extinction risks of varieties, populations and species;

• reduces the genetic resources available to enhance species traits;

• impedes adaptive responses to environmental change.

The Think Tank thus focuses on developing a world-first robust national strategy for conserving genetic diversity spanning agriculture, horticulture, forestry and species of cultural and socioeconomic importance. It is doing this by bringing together a team with expertise including cultivated plants, livestock, forestry, and wild plants and animals from across SEFARI and other research institutes (e.g. the University of Edinburgh, the Centre for Ecology and Hydrology) and collaborating with key stakeholders (e.g. Scottish Government and Scottish Natural Heritage). Ultimately the aim is to:

• evaluate how different sectors approach the conservation of genetic diversity;

• develop a new approach, which combines existing best practice and new methods for a cost-effective and robust assessment of genetic diversity conservation;

• produce a model report of Scotland's progress towards the Aichi Genetic Diversity Target, including the establishment of genetic baselines.

The work is being finalised and will feed into 2018's reporting on the Aichi Biodiversity targets.

Contact Professor Pete Hollingsworth PHollingsworth@rbge.org.uk

SEFARI (Scottish Environment, Food and Agriculture Research Institutes) comprises Biomathematics and Statistics Scotland, James Hutton Institute, Moredun Research Institute, Rowett Institute, Royal Botanic Garden Edinburgh and Scotland's Rural College (SRUC). Much of the research carried out in these six internationally recognised institutes is funded by the Scottish Government. The institutes work together to deliver unique and globally distinctive multi and inter-disciplinary research. SEFARI Gateway exists to improve the flow of research findings and expertise to policy, business, and across society.

Close-up image of *Sphagnum papillosum*, a moss found in peat bogs

Genetic discovery is a breakthrough in search for disease-resistant seaweed

Research at the Scottish Association for Marine Science has identified a seaweed with unique defensive capabilities

Research conducted into the genetic make-up of a resilient red alga has taken scientists at the Scottish Association for Marine Science (SAMS) in Oban a step closer to breeding disease-resistant seaweed. The research has established the genetic code for *Porphyra umbilicalis*, a small but tough intertidal species that can tolerate a range of conditions and is among the world's most valuable commercial seaweeds.

Porphyra umbilicalis, more commonly known as laver, can adapt to conditions on different parts of the rocky shores of the UK and Ireland and is able to withstand prolonged periods of exposure to the air as well as tolerating a greater degree of wave action than most other red algae.

'*Porphyra umbilicalis*, more commonly known as laver, is able to withstand prolonged periods of exposure to the air as well as tolerating a greater degree of wave action than most other red algae'

The researchers mapped the 13,125 genes in the seaweed –

Determining the effects of salmon farming on the seabed in high-energy waters

Dr Natalie Hicks, marine biogeochemist at the Scottish Association for Marine Science, describes a new project to investigate the impact of salmon farming on the surrounding environment

A THREE-YEAR project, which sees researchers from the Scottish Association for Marine Science (SAMS) partnered with Dalhousie University in Nova Scotia, Canada, will inform the environmental monitoring and management of more exposed sites along Scotland's west coast and the Northern Isles, and potentially unlock additional capacity. Funding for the project worth £231,907 has come from Cooke Aquaculture Scotland and the Scottish Aquaculture Innovation Centre (SAIC).

Currently, the benthic impacts of salmon farming – the impact of fish waste or uneaten feed on the seabed – are monitored by industry regulator the Scottish Environment Protection Agency (SEPA) using the DEPOMOD model developed by SAMS, which is based largely on data gathered from sheltered inshore sites in sea lochs.

However, at more exposed sites such as those found off the coasts of Orkney and Shetland, where this same waste matter is dispersed more widely by strong tides and where the seabed is harder and rockier, the benthic impacts can differ significantly from those reflected in the current model.

Chris Webb, Environment and Development Manager at Cooke Aquaculture, stated that better data about the benthic footprint at these sites will provide salmon producers with information that can improve environmental monitoring and compliance, and potentially increase production – both in terms of farming existing sites and developing new sites.

Rough seas at an unsheltered coastal salmon farm

The research team, led by SAMS, will field-sample and analyse data from up to three dispersive sites around Orkney over a complete production cycle. This data will then inform the development of the NewDEPOMOD model and its use in SEPA's proposed Depositional Zone Regulation (DZR).

According to Dr Hicks, this project will ground truth the existing model (DEPOMOD), which has historically been used in more static environments, and will increase the accuracy in predicting benthic impacts in fish farms based on a model prediction. In addition it provides a great opportunity for scientists to work alongside industry partners to promote sustainability, good potential economic gains and confidence that the environmental effects are not detrimental.

Contact Dr Natalie Hicks
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a human has around 20,000 genes – to help discover what makes the intertidal species so resilient, as they aim to breed marketable seaweed that can withstand threats from common diseases.

The researchers examined the red alga's pathogen receptors – the equivalent of antibodies that recognise diseases and alert the alga to an attack – and found that the alga's defences are unlike any other plant's. Although red algae and land-based plants are related, the typical defence mechanism found in plants was not detected in porphyra. If porphyra has original pathogen detection strategies, this opens exciting new avenues of research into red algal immunity and its use in modern breeding programmes. The SAMS work has now been published and can be accessed at www.ncbi.nlm.nih.gov/pmc/articles/PMC5547612/.

The work at SAMS is part of the Global Seaweed project, a network of scientists advising on global seaweed policy funded by the UK's Natural Environment Research Council (NERC).

Contact Euan Paterson, media and communications officer at SAMS,
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Right: the red alga *Porphyra umbilicalis* tolerates a range of environmental conditions and could be key in breeding disease-resistant seaweed

Members' reports

Scottish Association for Marine Science

Cod, haddock and herring predicted to leave warming Scottish waters

Dr Natalia Serpetti, marine ecologist, Scottish Association for Marine Science, identifies potential climate change impact on Scottish sea fisheries

RESEARCHERS AT SAMS, near Oban, have predicted that by 2100 commercially important species could migrate out from this ecosystem, most likely to colder waters further north, in response to rising sea temperatures.

The findings, published in the journal Scientific Reports (see below), show that cod and herring off Scotland's west coast are already nearing the edge of their temperature tolerance range. Over the forthcoming decades these species will gradually be replaced by more abundant communities of saithe, hake and whiting. From 1985 to 2013, the population of saithe and hake off the Scottish west coast increased four-fold.

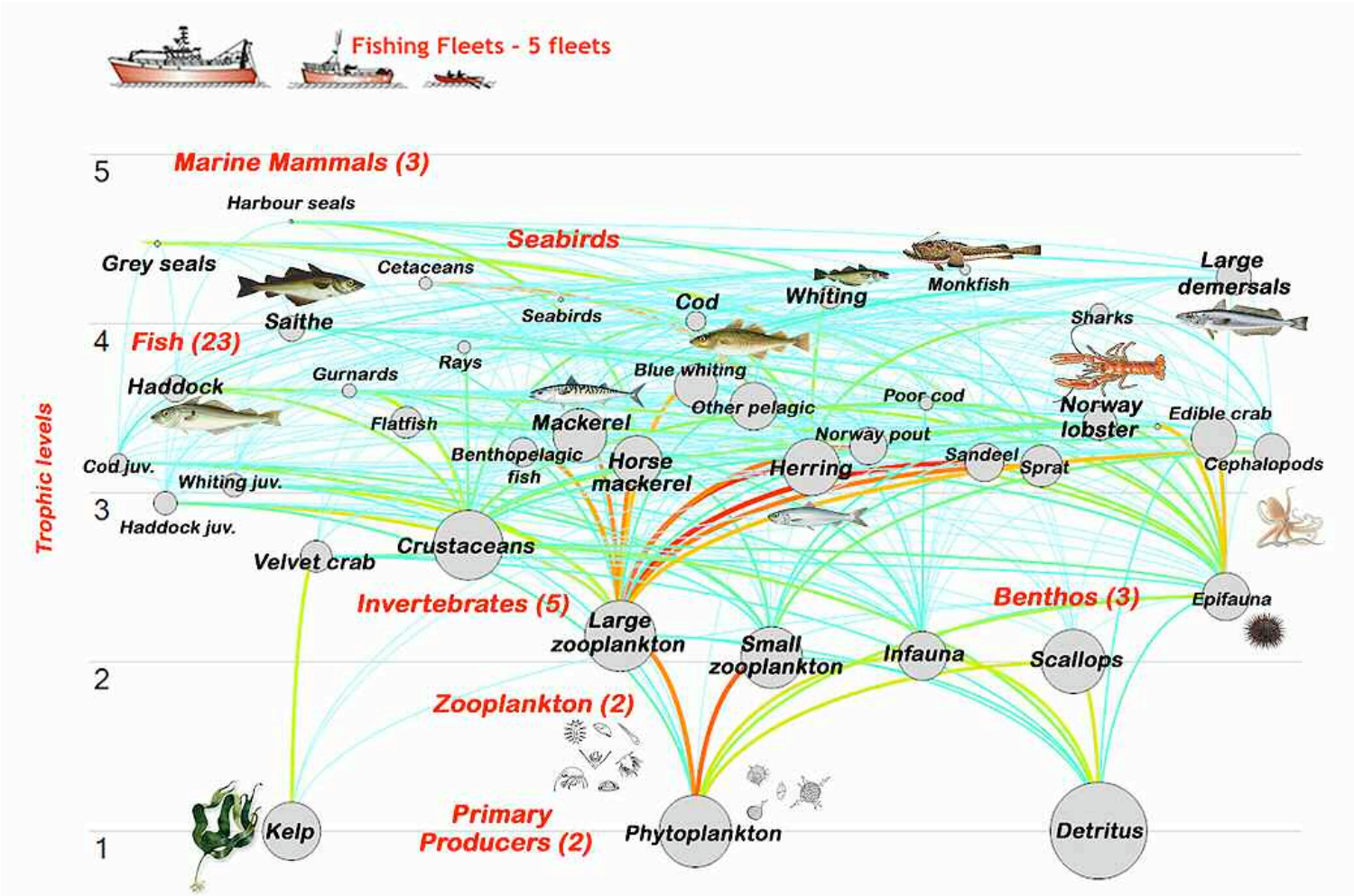
Dr Serpetti reports that these results highlight the importance of considering environmental change, as well as fishing quotas, to achieve sustainable fisheries management at an ecosystem level.

Scientists initially tested the impact of current advised fishing quotas, along with predator/prey interactions, within the ecosystem. Cod, whiting and herring stocks, which historically showed declining trends due to high fisheries exploitation and predation, recovered under a sustainable fishery management. However, when the impact of rising temperature was subsequently tested under Intergovernmental Panel on Climate Change (IPCC) climate change scenarios, and keeping fishing rates consistent with current advised maximum sustainable yields, scientists found that there would be a collapse of cold water species stocks.

The results showed that a warmer climate could jeopardise sustainable fishery management: rising temperature showed strong negative impact on cold water species such as grey seals, cod, haddock and herring, which all declined by 2100 under the worst case climate warming scenario. Even under the best case climate change scenario, cod and herring stocks were predicted to collapse off Scotland's west coast.

Dr Serpetti's research updated an existing marine model of the west coast of Scotland ecosystem, situated in the north-east Atlantic from the coastline to the edge of the continental shelf. The research is part of the Marine Ecosystem Research Programme (MERP), funded by the Natural Environment Research Council (NERC) and the Department for Environment, Food and Rural Affairs (DEFRA).

Findings at www.nature.com/articles/s41598-017-13220-7.pdf.
Contact Dr Natalia Serpetti natalia.serpetti@sams.ac.uk



The role of biodiversity in regulating the functioning of crop production systems

James Hutton Institute and SEFARI investigate why species-rich systems are more productive

SPECIES-RICH SYSTEMS often show higher productivity than monocultures, with fewer pest and disease outbreaks, improved resource capture and greater resilience to environmental fluctuations and stress. Arable crops offer a simplified production system that could capitalise on these benefits through increased species and within-species (i.e. genetic) diversity. To this end, research funded through the Scottish Government Strategic Research Programme (2016-2021) is investigating diversity-function relations in crop production systems.

A critical research challenge is to understand the mechanisms underpinning relationships between biodiversity and ecosystem function.

'The rare plant *Valerianella rimosa* germinated better in the presence of spring barley, suggesting that crops could provide the conditions needed for the establishment of these rare plants'

PICTURE: UNIVERSITY OF THE HIGHLANDS AND ISLANDS

PICTURE: JAMES HUTTON INSTITUTE, DUNDEE

Top, cornflower *Centaurea cyanus* growing amongst a crop of barley; above, monitoring an experiment looking at the impacts of barley diversity on productivity and the weed community

To improve understanding of biodiversity-function relationships, greenhouse studies have been conducted using constructed barley and arable weed communities. Findings indicate that increased plant productivity is associated with both weed species diversity and barley genotype diversity. Weed species diversity effects were largest, probably because the relationship between diversity and function is strongly regulated by plant traits and in our studies, traits varied more between weed species than between barley genotypes. However, positive effects of barley genotype diversity on productivity were due to genuine complementarity between the genotypes in their traits and associated functions, demonstrating the positive effects of crop genetic diversity on ecosystem functions.

Extending the work to consideration of crop/rare plant interactions, greenhouse studies also tested for relationships between crops and the survival of rare plants, some of which were once common weeds of arable systems. Findings show that the diversity of common weeds had negative impacts on the establishment of new plant species, in particular rare arable plants, indicating that these rare species might be inferior competitors. This may give some insight to understanding current patterns of rarity. Followed up in field trials, the rare plant *Valerianella rimosa* germinated better in the presence of spring barley, suggesting that crops could provide the conditions needed for the establishment of these rare plants. This is the subject of further investigation to examine the response of a wider range of rare arable plants to diversity in crop systems.

These two strands of research into diversity and ecosystem function have been used to help lever five million euros to fund a new EU H2020 project, coordinated by the James Hutton Institute (DIVERSify; www.plant-teams.eu). The aim of the project is to optimise the performance of crop species mixtures ('plant teams') to improve yield stability, reduce pest and disease damage, and enhance stress resilience in agricultural systems.

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The James Hutton Institute is a part of the SEFARI collective (Scottish Environment, Food and Agriculture Research Institutes – sefari.scot), responsible for delivering the Scottish Government Strategic Research Programme.

SCRR member organisations

The University of Edinburgh . . . . . www.ed.ac.uk
Moray House School of Education. . . . . www.ed.ac.uk/schools-departments/education
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Field Studies Council, Millport . . . . . enquiries.sco@field-studies-council.org
Forest Research, Northern Research Station. . . . . www.forestry.gov.uk/forestresearch
Heriot Watt University, School of Life Sciences . . . . . www.sls.hw.ac.uk
James Hutton Institute . . . . . www.hutton.ac.uk
Moredun Research Institute . . . . . www.moredun.ac.uk
National Museums of Scotland . . . . . www.nms.ac.uk
Roslin Institute, University of Edinburgh. . . . . www.roslin.ed.ac.uk
Royal Botanic Garden Edinburgh . . . . . www.rbge.org.uk
Royal Society for the Protection of Birds - Scotland . . . . . www.rspb.org.uk/scotland
Royal Zoological Society of Scotland . . . . . www.rzss.org.uk
Science & Advice for Scottish Agriculture . . . . . www.sasa.gov.uk
Scotland's Rural College (formerly Scottish Agricultural College) . . . . . www.sruc.ac.uk
Scottish Association for Marine Science, Oban . . . . . www.sams.ac.uk
Scottish Natural Heritage . . . . . www.snh.gov.uk
SNIFFER . . . . . www.sniffer.org.uk
Society, Religion and Technology Project . . . . . www.srtp.org.uk
University of Glasgow . . . . . www.gla.ac.uk
College of Medical, Veterinary and Life Sciences . . . . . www.gla.ac.uk/colleges/mvls/
College of Social Sciences . . . . . www.gla.ac.uk/colleges/socialsciences/
University of the Highlands and Islands (UHI) . . . . . www.uhi.ac.uk
Agronomy Institute, Orkney College . . . . . www.agronomy.uhi.ac.uk
Centre for Mountain Studies, Perth College . . . . . www.perth.uhi.ac.uk/specialistcentres/cms
Centre for Remote and Rural Studies, Inverness College . . . . . www.crrs.uhi.ac.uk
Environmental Research Institute, North Highland College . . . . . www.eri.ac.uk
Lews Castle College, Stornoway . . . . . www.lews.uhi.ac.uk/research
NAFC Marine Centre, Shetland . . . . . www.nafc.ac.uk
West Highland College, Fort William . . . . . www.whc.uhi.ac.uk
University of St Andrews, Earth and Environmental Sciences . . . . . www.st-andrews.ac.uk/gg
University of Stirling . . . . . www.stir.ac.uk
Institute of Aquaculture. . . . . www.aquaculture.stir.ac.uk
Biological & Environmental Sciences . . . . . www.stir.ac.uk/natural-sciences/about-us/bes/

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