Year 3, September 2018 - February 2019

Progress Report on Strategic Research Programme Delivery

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FOR BETTER LIVES

SEFARI, the Scottish Environment, Food and Agriculture Research Institutes, are responsible, with Higher Education Institute partners, for delivering the Scottish Government (Rural and Environment Science and Analytical Services, RESAS) funded Strategic Research Portfolio on environment, food, agriculture, land and communities.*

The Portfolio includes the Strategic Research Programme 2016-2021 (SRP), the Centres of Expertise (CoE), Innovation partnerships and underpinning capacity funding for strategically important projects and resources. SEFARI Gateway (herein referred to as the Gateway) exists to improve the flow of research, knowledge and expertise to and from the Portfolio to policy, industry & society sector-representative organisations and public audiences – and to improve the impacts of those activities.

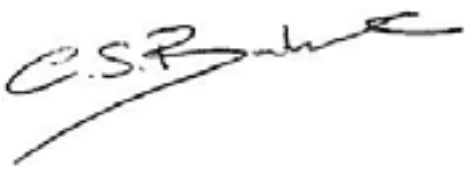
Here we provide highlights from the SRP for the period of September 2018 to February 2019, as presented to the Operational Group of the Strategic Advisory Board for RESAS Science.

This is the second time we have distributed the progress update in this report format. We would welcome feedback on these highlights, including whether you wish to receive them in this way in the future. We will also be happy to expand on any of the research featured and place you in conversation with the appropriate researchers regarding any of the presented highlights, as well as with any of the disciplines across the SRP.

The Gateway provides a range of opportunities through our Fellowships, Think Tanks and Responsive Opportunity programmes to enable experts from the Strategic Portfolio to engage and work directly with stakeholders. We are now expanding both the number of and stakeholder-need focus of our Gateway-funded programmes (in particular we seek to build partnerships via co-funding). A key feature for all Gateway schemes and interactions is genuine co-construction with the stakeholder(s) to ensure a priority need is addressed. We want to build strong partnerships for the benefit of environment, food, agriculture, land use and communities.

Contact details for research-specific and Gateway enquiries are provided at the end of these SRP highlights and we look forward to hearing from you.

Very best wishes,



Interim Director, SEFARI Gateway

* You can find more information about the structure of the Strategic Research Portfolio and the partners involved (SEFARI, SEFARI Gateway and CoEs) here.

Contents

Theme 1 - Natural Assets

Work Package 1.1 - Soils

Major Achievements

- **Plant biodiversity and nitrogen deposition:** Large scale survey data from the James Hutton Institute, in combination with other data resources from across the UK, has enabled SEFARI scientists and UK collaborators to propose that a thirty-year moving window of cumulative nitrogen deposition is the most relevant measure to represent impacts on plant communities for application in science, policy and ecosystem management. Such a metric allows long-term impacts of nitrogen deposition to be included, while allowing for the impact of declining deposition to also be taken into account – something that cumulative deposition does not allow for as this will always increase.

- **Soil carbon research:** SEFARI scientists presented an overview of work on soil carbon sequestration in relation to land use at a workshop on UK Soil Organic Carbon Data and Modelling, CEH Lancaster in February. The aim of the workshop was to begin developing metadata from previous work to aid development and validation of new models and to develop a consortium to bid for UKRI funding. Research on the potential for carbon storage in Scotland's agricultural soils was presented at Climate Week 2018 in Victoria Quay, Edinburgh, 1-5 October and an article on the potential to pay farmers for carbon sequestration, the impact of increasing soil carbon on water retention, on increased resilience to erosion and on soil biodiversity was published in the Scotsman on World Soil Day.

- **Agency and policy interaction:** Prior to publication of a consultation on their Crop Production Sector plan, SEPA approached the SEFARI Sector Lead for Soils and Crops and funding was obtained via a SEFARI Gateway Spark (stakeholder priority-need targeted Think Tank) call to hold a workshop of stakeholders and policy makers (Centre for Carbon Innovation, Edinburgh, 4th March 2019) to further discuss content and implementation of the SEPA Crop Production Sector Plan.

Work Package 1.2 - Water

Major Achievements

- **Research on warming rivers:** A study on long term river temperature warming trends was published in Science of the Total Environment (Pohle et al. 2019) and presented to the American Geophysical Union Fall Meeting 2018. A related film informs about river temperature and its relevance for Scottish environment and rural economy.

- **Scottish river physical restoration cited amongst international case studies**: The Bowmont catchment research has been recently summarised in a chapter of an international book published by the US Army Corp of Engineers, emphasising the international relevance of SRP research. The book is called "Engineering with Nature: An Atlas" and gives an overview of natural flood management measures including tree planting and use of novel wooden structures in the Bowmont catchment.

- **Developments in nutrient modelling:** Phosphorus pollution modelling continues with development of a catchment-scale prototype for the Lunan catchment and wider modelling is being supported by numerous collaborations (international team Marie-Curie Training Network bid submitted; Walsh fellowship PhD won; new water quality sensor funding won; EPSRC project submitted on the top of the river Ganges) and a special session on modelling led by Miriam Glendell at European Geophysical Union, Vienna, April 2019. An international review paper 'Challenges of Reducing Phosphorus Based Water Eutrophication in the Agricultural Landscapes of Northwest Europe' has been published in Frontiers in Marine Science.

- **Evidence presented on water policy integration:** Theme Research considering how river basin management and flood risk management plans interact was an invited presentation to European Commission's Working Group F's review of the Water Framework Directive in 2019 and published

as part of a wider review (Carvhello et al., 2019), with leads giving evidence to a WFD Fitness Check meeting, which inspired a blog by the European Environment Agency asking for better policy integration to deliver the WFD in future.

Work Package 1.3 - Biodiversity

Major Achievements

- **Evolving for mixture benefits:** Concepts developed through our crop mixtures work (RD1.3.1 and RD2.3.8) concerning the beneficial interactions between neighbouring species have contributed to delivery of a new research paper by Schöb et al. 2018 (Nature Ecology and Evolution). This study shows for the first time that some of the effects which help to deliver benefits from crop mixtures evolve best in a species rich plant community. Importantly this work demonstrates how higher diversity helps promote ecosystem functions, and that breeding for crop mixtures (a potential sustainable production approach) may need novel trait combinations which only emerge in species-rich systems.
- **CaperMap:** An engagement and communication tool to facilitate capercaillie conservation in multiuse woodlands was presented to stakeholders at a training event held at the Hutton at the beginning of this year. CaperMap is now assisting conservationists, local communities, and other stakeholders (e.g. SNH) to better understand how woodland can be managed to benefit outdoor users and capercaillie.
- **Establishing landraces as living heritage:** SEFARI scientists in collaboration with Archaeologists from University of Sheffield have identified and confirmed the origins of barley landraces in the archaeological record using morphometrics and genetics, helping to establish its status as living heritage and helping secure its commercial future through providing the grain with heritage credentials that can be used in marketing of products.
- **Ancient barley landraces adapted to marginal soils demonstrate exceptional tolerance to micronutrient limitation:** SEFARI scientists in collaboration with University of Copenhagen and University of Highlands and Islands, Orkney have identified a unique Mn efficient phenotype in Bere landraces that can be potentially used to cope with micronutrient deficiencies seen in crops grown in marginal calcareous soils in the western

and northern isles of Scotland and in many of the cereal producing lands on a global scale.

Work Package 1.4 - Integrated Land Use Systems

Major Achievements

- **How can we enhance the role of local land and water users in delivering catchment scale water ecosystem services?** This was the question addressed for the Lunan Water in a presentation at Scotland's Biennial Land Use and Environment Conference, Edinburgh, 28-29 November 2018 - this conference was part-funded via the SEFARI Gateway Responsive Opportunity Fund. The presentation identified barriers to implementation of innovative water management, including demonstrating technical feasibility, the thin spread of benefits across users, long term management/ legal issues, lack of clear champions and lack of precedence for Payments for Ecosystem Services.
- **Maps of land use data and ecosystem services:** A report has been produced summarising collation of maps/spatial datasets on land use and ecosystem services for case study locations of Scotland's two National Parks and Aberdeenshire River Dee. These maps have been produced through work on agricultural land use and its impacts and on mapping ecosystem service indicators and are intended for analysis at the whole river catchment scale or smaller.
- **Review of Environmental Monitoring:** A review of how monitoring of EU Natura 2000, Water Framework Directive and agri-environment schemes under CAP across 9 European cases has been published (Waylen et al., 2019). It found that whilst current approaches do not fit with best practice for adaptive management, there were many good practice examples that could be built upon from sharing across policy regimes. These lessons will be drawn on in responses to the Scottish Government's consultation on Environmental Governance (16th Feb – 11th May 2019). The results will be presented as an invited paper at the ALTERNET conference in May 2019.
- **Aligning Policy Instruments:** A review of how to ensure Scottish government policy instruments align both vertically and horizontally was presented at the Scottish Biennial Land Use and Environment Conference, sparking interest from Scottish Government Agriculture and Rural Development policy makers. This has been complemented by a review of 'market-based' instruments which was presented at Ecosystem and Land Use Stakeholders Engagement Group, sparking requests for follow up discussions from SNH, SEPA, SWT and RESAS; and complements the focus of the Scottish 'One billion pound challenge' initiative launched in February 2019. These lessons will be drawn on in responses to the Scottish Government's consultation on Environmental Governance (16th Feb – 11th May 2019).

Theme 2 - Productive and Sustainable Land Management and Rural Economies

Work Package 2.1 - Crop and Grassland Production and Disease Control

Major Achievements

- **Supporting the barley sector with Ramularia knowledge:** Research into the epidemiology, detection, host pathogen interactions and control of Ramularia leaf spot was presented by SEFARI researchers at an International workshop in October, 2018. Ramularia disease control and integration of elicitors into Integrated Pest Management programmes was demonstrated at the CropTec event.

- **Insights into host-pathogen interactions:** New research papers show that virulence factors from the potato late blight pathogen Phytophthora infestans work in combinations, and in multiple ways, to enable successful infections (1, 2). The mechanism by which a P. infestans virulence factor exploits links between plant hormone signalling and disease susceptibility to promote disease has been revealed; a target to be exploited for disease control.

- **Understanding causes of ear sterility in wheat:** SEFARI research has contributed to reporting of physiological and genetic influences on seed set in wheat. This research is helping an ongoing study into causes and control of environmentally induced ear sterility which can result in significant yield loss in Scottish wheat crops. The AHDB Report considers risk factors contributing to poor seed set, including wheat breeding material that could be used in future crop improvement.

- **New insights in to how roots affect soil condition:** SEFARI scientists have contributed to the identification of key components of plant root exudates which impact the soil physical conditions in the rhizosphere (1, 2, 3, 4). This discovery has important implications for our understanding of the dynamics of nutrients and water and dictate the environment in which plant soil interactions take place. The group has used this information to model the rhizosphere.

Work Package 2.2 - Livestock Production, Health, Welfare and Disease Control

Major Achievements

- **Greenhouse Gas mitigation:** GHG emissions remain a major challenge for Scotland's ruminant industry and ensures a research focus on mitigation options across SEFARI members. Work is using state-of-the-art respiration chambers and feeding facilities, as well as cutting-edge techniques to understand the microbial processes and organisms involved. Other studies are developing biomarkers and proxies for breeding programmes to reduce emissions intensity (GHG per unit milk or meat produced) - both by reducing emissions and improving technical efficiency factors such as feed conversion efficiency. This work has recently been profiled in two video presentations produced by Reuters TV and Scottish Government social media team.

- **Parasite control:** SEFARI scientists have previously developed an effective prototype recombinant vaccine to control Teladorsagia circumcincta, the primary cause of parasitic gastroenteritis in small ruminants in temperate regions worldwide. The vaccine prototype comprised eight proteins produced separately in bacterial or yeast systems but the complexity of the expression and purification steps made this vaccine unattractive for commercial exploitation. Using a meta-analysis of trial data gathered over seven years using the eight-protein vaccine a strategy was developed to simplify this vaccine. Based on this analysis, a two-component prototype vaccine was tested in a direct comparison with the original eight-protein vaccine and performed as well as, if not better than, the original vaccine. The findings were the 'Editors choice' in the International Journal for Parasitology.

- **Tackling Antimicrobial Resistance (AMR):** SEFARI scientists are putting the corner pieces into the complex One Health jigsaw that is AMR. Their work in areas of AMR in the environment, food chain, livestock and wildlife populations was showcased to relevant stakeholders and researchers at a recent

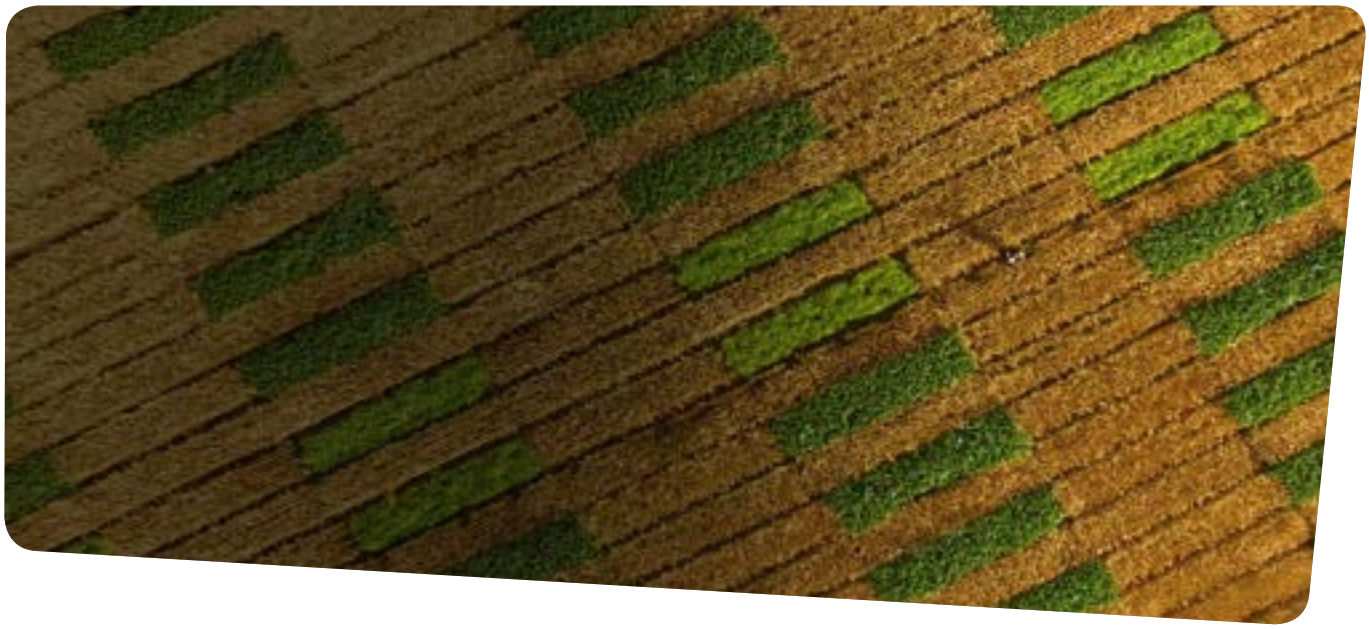
SEFARI Gateway Responsive Opportunity funded event. This research will assist Scottish policy makers to prioritise action to meet commitments to the new UK Action plan for AMR and so contribute to the realisation of the UK vision for AMR.

- **Pig supply chain interest in 3D camera technology to predict tail biting:** SRP research led to two successful Innovate UK grants. Early results from the first of these (3D Tails), showed that machine vision algorithms could detect low tail posture from overhead 3D camera images, which is an early warning sign of a tail biting outbreak. These results and the continuation of this research to develop a farm-ready prototype (TailTech project) have led to considerable interest across the pig (Pig World, Pig Progress, Pig Health Today,), farming (Farmer's weekly, Farming UK), regional (Press and Journal, The Courier) and engineering/technology press (IEEE spectrum, Vision Systems Design), as well as a radio interview (BBC Radio 4 Farming Today). Furthermore, interest in this technology from across the pig supply chain and from agri-technologists, has led to invitations to speak or demonstrate at BBSRC Animal Welfare Research Network (Birmingham, July 2018), Sainsbury's farming conference (London, December 2018), at BBSRC's innovation hub at the Oxford farming conference (January 2019), food supply company Winterbotham Darby's Animal Welfare conference (Bristol, March 2019), UK Agri-tech centres showcase event (Newcastle, March 2019) and The Royal Agricultural University's "Agritech and the Future of British Farming" event (Cirencester, April 2019).

Work Package 2.3 - Productive and Sustainable Land Management

Major Achievements

- **International partnerships on nitrogen in agriculture:** SEFARI researchers contribute to Legumes Translated, a Horizon 2020 Thematic Network supporting innovation in grain legume-supported cropping systems and value-chains by linking sources and users of quality-assured knowledge. Also, SEFARI researchers are part of the UKRI GCRF's new 'South Asian Nitrogen Hub'. This ambitious new Hub brings together partners from the UK and South Asia; together 32 leading research organisations. The Hub seeks to improve nitrogen management in agriculture, saving money on fertilizers and making better use of manure, urine and natural nitrogen fixation processes.



- **Industry partnerships driving application of machine learning in agriculture:** Machine learning is the focus of two recently commenced SEFARI research projects. The first, with the University of the West of England, uses advances in machine vision and machine learning to automatically detect and monitor key affective states in individually identified pigs and measure performance traits using only the face. Involving industry partners the project offers the potential to realise low-cost, non-intrusive and practical means to both biometrically identify individual animals and assess and record their condition daily using only the face and help monitor animal welfare state and performance. The second, uses machine learning to predict TB status of dairy cows from mid infrared analysis of routine milk sampling. Again involving industry partners the project, if successful, will create new and novel services to assist dairy farmers in managing animal disease. Recording also allows monitoring bTB prevalence and so the efficacy of disease control strategies.
- **SEFARI success in Sweden:** A SEFARI researcher has been awarded the prestigious Wallenberg Professorship. Presented by HRH Crown Princess Victoria in a ceremony in January 2019 the visiting position will explore areas related to the sustainability of future agricultural production systems. The position will help to further grow research and education links between SEFARI activity and work in Sweden.

Work Package 2.4 - Rural Industries

Major Achievements

New databases: Significant new databases have been generated through WP2.4 to provide insights into the agricultural and wider rural business base were generated through two major telephone surveys in the autumn and winter of 2018. Building on the 2013 and 2015 surveys (funded under the 2011-16 SRP) the 2018 Farmers Intention Survey was co-designed with Scottish Government analysts and policy leads to provide information on a wide range of important policy topics that can support post-Brexit policy development: motivations, household income, reliance on support, plans for the future, sources of advice, global engagement, new entrants, seasonal lets, Brexit, etc. About 2,500 businesses engaged in this telephone survey and the results from the survey are starting to emerge. The 2018/19 Rural Business Survey was co-designed with Scottish Government officials and Scottish Enterprise to help improve policy knowledge on issues such as: business performance and outlook; employment and family labour; Brexit; export and imports activity; links to the land-based sector, business constraints and training/advice needs. About 1,200 businesses form Aberdeenshire, the Borders, Tayside and Dumfries and Galloway engaged in the telephone survey and the results, building on the findings of the 2017/18 Rural Report, are now emerging and will provide new rural economy insights to officials.

Theme 3 - Food, Health and Wellbeing

Work Package 3.1 - Improved Food & Drink Production

Major Achievements

- **Raspberry research:** Research on raspberry bioactive compounds and health won a prize for the best poster on novel bioactives at the 2nd International Conference on Food Bioactives and Health. A published book chapter identifies both direct health benefits of consumption and opportunities for use of bioactives from soft fruits.
- **Microbiological environment in vertical farming:** SEFARI scientists have secured Innovate-UK KTP funding with Intelligent Growth Solutions seeking to control the microbiome within the growing environment in vertical farming systems and reduce the need for crop sanitisation.
- **'Scotland 2030: Our Food Future':** SEFARI research including the protein content and nutritional aspects of wild vs cultivated vegetable species, and related food waste streams, as potential dietary sources was presented at a Scotland's Futures Forum entitled "Scotland 2030: Our Food Future" co-hosted by Nourish (Sep 18; see video highlights here). Chaired by Claudia Beamish MSP, and well attended by policy and wider stakeholders, this seminar used Nourish Scotland's vision of a sustainable food system to kick-start a discussion on food in Scotland. The work was also highlighted at the 'Nutritionists in Industry' meeting (Sept-18) to over 100 nutritionists working across the private sector, at the European Microbiome Congress (Nov-18), and in a keynote address to a new European network on plant-based diets (Jan-18).
- **Ministerial Summit on Reformulation:** A SEFARI scientist joined the panel at the 'Reformulation for a Healthier Future - challenges, opportunities and support' summit (Jan-19) convened by the Minister for Public Health, Sport and Wellbeing, Joe FitzPatrick MSP, and supported by FDF Scotland, Scottish Funding Council and Scottish Enterprise. The event featured contributions from government, industry and academia. Publications on reformulated and innovative foods with enhanced health properties providing healthy reformulation options for the food and drink sector have used salal and blackcurrant to reformulate yogurt, with products showing antidiabetic and antioxidant properties.
- **Food waste:** A SEFARI scientist gave an invited presentation on food waste behaviour at the 168th EAAE Seminar "Behavioural Perspectives in Agricultural Economics and Management", Feb-19 (Toma et al., Household food waste behaviours – a causal analysis of cohort data), material summarised in briefing format. Stakeholder workshops (Group Model Building) focussed on incentives to reduce food waste along supply chains: (i) causes and solutions for food waste/loss reduction in the fruit and vegetable supply chain linked to pest control (Feb-19) – attended by farmers/processors, ZWS, SG, SEPA, SNH, Buglife Scotland, NFUS, Soil Association and LEAF; (ii) incentives to reduce milk loss in dairy primary production linked to reduced use of antimicrobials on farm (Oct-18) – attended by WRAP, NFUS, AHDB, Soil Association, SG, SEPA, dairy industry and SAOS.

Work Package 3.2 - Healthy Diets and Dietary Choice

Major Achievements

- **Global Challenges Research Fund (GCRF) Hub grant award:** SEFARI scientists are key members (incl. the deputy lead) of and bring knowledge and expertise acquired through the SRP to a 5-year GCRF Hub grant led by the London International Development Centre (LIDC) and the London School of Hygiene & Tropical Medicine (LSHTM). The new £19.76m UKRI GCRF 'Action against Stunting Hub' (including →£1m to SEFARI research in epigenetics and microbiota) brings together an interdisciplinary team from 18 institutions to tackle the problem of stunting in children. It aims to reduce child stunting

by up to 10% across communities in India, Indonesia and Senegal, and it will also support new regional platforms on maternal and child nutrition proposed by UNICEF, linking the work of the Food and Agriculture Organisation, The World Bank, and the World Health Organization at the country level.

- **Sustainable Diets task force:** As an example of international leadership within the SRP, a Theme scientist has joined a new international task force on Sustainable Diets assembled by the International Union of Nutritional Sciences (IUNS). The Task Force will contribute to the development and standardisation of nutrition indicators and methodologies for characterising and promoting environmentally sustainable diets, provide a communication forum for multisectoral and multidisciplinary activities, and provide a stable framework for organisation of scientific symposia on sustainable diets.
- **Maternal and Infant Nutrition:** SEFARI research on the perinatal programming of food preferences was presented at a Maternal and Infant Nutrition Event hosted by SG (Jan-19.) The event, for stakeholders and practitioners from across SG, NHS Health Scotland and Food Standards Scotland, with an interest in early years, reflected on what works for both prevention and early intervention, to address childhood obesity at its earliest point. SRP research was discussed, as one of only two case studies presented, and highlighting how an intervention study from the Theme aims to provide evidence and proof of concept to underly future public health advice.
- **Highly cited research:** Three SEFARI scientists in microbiota research were included in the 2018 Clarivate Analytics Highly Cited Researchers list of scientists 'who have demonstrated significant influence through publication of multiple highly cited papers during the last decade'.

Work Package 3.3 - Food Security

Major Achievements

- **Research funding:** SEFARI scientists were awarded a RESAS contract for additional work on dairy contracts ('The impact of mandatory written dairy contracts in European countries and their potential application in Scotland'). Evidence will be collected on the implementation and impact of mandatory contracts in Europe, and the potential impact of Brexit. Additional contract funding examines sheepmeat processing in Scotland and potential impacts of Brexit.
- **Local community engagement:** A SEFARI scientist presented to the Environment Group at Aberdeen City Council (Nov-18) as part of a collaboration between citizen social scientists and SEFARI researchers working on local food growing, community benefits and supply chains. Scientists also attended a workshop/networking event (Nov-18) on the role of local community food initiatives in tackling food poverty and other social issues
- **Publications:** (i) Community Development Journal ('Community resilience and narratives of community empowerment in Scotland'), analysing the current Scottish policy framework and aspirations for community empowerment; (ii) Regional Environmental Change ('Stochastic cognitive mapping to build common ground for selecting cases in research projects').

Work Package 3.4 -Communities and Wellbeing

Major Achievements

- **Working with policy:** A SEFARI researcher has joined a SG Expert Advisory Group considering the implications for Scotland of the UK Migration Advisory Committee's recommendations for post-Brexit migration policy. Their report will be launched in Mar-19 in the Scottish Parliament by the Minister for Europe, Migration & International Development, Ben MacPherson MSP. The report will contain sections which relate directly to WP3.4 research.
- **Presentations:** SEFARI researchers presented at the Rural Planning Summit in Sep-18, the SG's Resilience Conference in Oct-18, the SG seminar 'Inequalities in use of the outdoors' in Dec-18, and ran a workshop 'What is place-based rural policy, and what evidence base does it need?' at the

Scottish Rural Parliament 2018 in Nov-18. Scientists also attended the North Alliance meeting on Education, and a meeting of the Board of a new research centre on Fragile Territories, in Milan in Jan-19, discussing their work on sparsely populated areas.

- **Research funding:** SEFARI scientists will evaluate the outcomes for local people of the 'Creating Natural Connections in Cumbernauld' project, applying social research methods developed in the SRP. The National Lottery Heritage Fund has provided £1.3m to improve ecosystems, access and community engagement in greenspace. Resilience ideas from SEFARI scientists have contributed to National Centre for Resilience funding on "Hot Spots and Not Spots", which looks at areas of resilience across Scotland, and the EU H2020 project "Digitisation: Economic and Social Impacts in Rural Areas" which begins in April/May 2019.
- **Place-based policy blogs:** Three blogs were published (SEFARI Gateway & SEGS) relating to place-based policy research and the Scottish Rural Parliament workshop: "What Exactly is Place Based Rural Policy"; "Do we have the evidence to support place based policies"; and "Big data, small places: building a better evidence base".

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SEFARI works across six Research Institutes who deliver
the Scottish Government funded Strategic Research Programme.

BioSS

The James Hutton Institute

Moredun

The Rowett Institute

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