Year 4, September 2019 to February 2020

Progress Report on Strategic Research Programme Delivery

Scottish Government
Riaghaltas na h-Alba
gov.scot

SEFARI
LEADING IDEAS
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, Innovation partnerships and underpinning capacity funding for national resources within SEFARI.

The SEFARI Gateway is the knowledge exchange and impact hub for SEFARI. The Gateway works to improve the flow of research-knowledge and expertise to and from the Portfolio to policy, industry-sector representatives and public audiences, and to improve the impacts of those activities.

The SRP progress updates within this report emphasize the breadth and depth of this interdisciplinary programme's contribution to Scotland's environment, land, agriculture, food, rural communities and economy. Key highlights include wader bird conservation; new findings on tackling soil erosion; enhancing climate change risk assessments for Scottish crop pests and pathogens; the development of a suite of tests capable of detecting the most common infections carried by ticks; new evidence on the health and economic benefits from soft fruits; and new findings for the development and adoption of healthy and environmentally sustainable diets.

For knowledge exchange and impact: 2020 is a big year for nature, the environment and agriculture, especially as we build towards the UK hosting the 26th session of the UN Climate Change Conference of the Parties (COP 26) in Glasgow. Understandably, the priorities for government, industry, and society have had to rapidly and intensively focus on the unprecedented and critical global public health crisis posed by COVID-19, and its individual, societal and economic challenges in the months and years ahead.

With us all working from home for the near future, the Gateway has moved to online working and is actively continuing to progress all current and new knowledge exchange partnerships. The Gateway will shortly launch a series of calls across the the Portfolio to SEFARI expertise to work with our stakeholders in online formats, including on urgent COVID-19-related assessments or needs.

While the national and international response to COVID intensifies, both the climate and biodiversity emergencies are and will remain at the top of the long-term political and societal agenda. The Scottish Government recently passed new legislation aiming to make Scotland Net-Zero by 2045. SEFARI Fellowship projects are continuing to provide key capacity for climate action in Scotland; e.g. through working with the National Farmers Union Scotland addressing key climate impact questions for the sector; assisting Loch Lomond & Trossachs National Park Authority to support effective woodland creation; and supporting the work of The Just Transition Commission exploring how to achieve a net-zero carbon economy that is fair for all.

The biodiversity crisis is innately intertwined with climate emergency and our earlier funded Think Tank to address Aichi Target 13 on the conservation of genetic diversity, a multi academic and agency collaboration co-led and onward funded with Scottish Natural Heritage, has been instrumental in delivering a world-first method to help understand and conserve genetic diversity in some of Scotland's most iconic wild species. This practical tool will enable other countries to assess genetic diversity and compare what has been measured in Scotland. Impacts and initiatives such as these are being assessed as a potential Gateway focus to COP26 and its aligned events.

2020 has been designated by the United Nations as the Year of Plant Health and within Scotland as the Year of Coasts and Waters, with the latter aiming to inspire people to explore and experience Scotland's shores. Both of these initiatives mark excellent opportunities for online collaboration. One of Gateway's funded responsive projects called "Waterwalls" will soon be launching a web portal for the public to submit photos and stories about their experiences of Scotland's coasts and water.

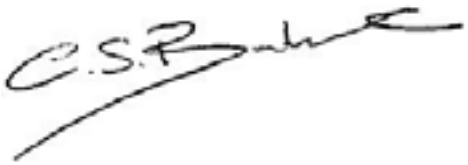
---

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

For Gateway's KE partnerships and projects in 2020, while shifting to the new realities imposed by COVID-19, we are set to deliver a range of novel knowledge partnerships, including Fellowships on innovation for environmental monitoring; better linking of agriculture by-products into the circular economy; and examining the social and economic capital delivered through farm cooperatives. Gateway has also funded a virtual Think Tank looking at the sustainable farming practices currently being used by farmers and land managers.

The road back from COVID-19 will be long and difficult. Nevertheless, despite the absolute need for social distancing to dictate where and how we work, SEFARI and SEFARI Gateway remain fully committed to ensuring that stakeholder access to Portfolio expertise and partnership working continues unabated in delivering to Scotland's National Outcomes. We are also making resources available to assist stakeholders with COVID-19 response and impacts within these unprecedented and challenging times.

Very best wishes,



Director, SEFARI Gateway

Contents

SEFARI

Scottish Government
Riaghaltas na h-Alba
gov.scot

Summary

Theme 1 - Natural Assets

WaderMap: The UK's breeding waders are in decline, due to a combination of habitat loss, unfavourable management and predation. Successful management for biodiversity, however, often needs to be done at the landscape scale. To support this, SEFARI scientists, in collaboration with the Working for Waders initiative and partners, have developed WaderMap: this tool is now being used by land-managers to develop landscape level collaborative management and to inform the development of results-orientated farm payments. WaderMap is an interactive online web app that enables stakeholders to interact with a map of management-relevant information and wader conservation initiatives. These can be shown against a number of user-selectable backdrops that, for example, show the current distribution of a species or target areas for AECS wader measures.

A toast to reduce Scotland's protein import dependency: Scotland is heavily reliant on imports for its protein requirements. RESAS-supported work to help realise more cropping of pulses (e.g. peas and beans) in Scotland, and carried out in partnership with Scottish-based SMEs, revealed that the use of home-grown peas to make gin also provided a high-protein 'co-product' for animal feed. The pea co-product can offset animal feed imports, and the two high-value products were achieved with a reduced carbon footprint (compared to conventional wheat gin). A commercial product (World's first climate-positive gin) was launched in February shortly after World Pulses Day (FAO-UN, February 10th). The beverage is fully provenanced as a sustainable Scottish product, and when purchased consumers can also be assured that they are also encouraging more-practical crop rotations at home, helping to reduce artificial fertiliser use, improve soil qualities, and, most importantly, to directly reconnect with those farmers whose aim is to demonstrate the most respectful and sustainable of food- and feed-systems. The role of consumers to lead transformative change of the food system is now widely recognised, and increasingly the evidence based for their product choices are supported by robust environmental impact assessments – as exemplified here.

Soil erosion risk maps: Soil erosion is a major problem on cultivated land as it results in the loss of soil and nutrients. Soil erosion risk maps have now been produced by SEFARI scientists for almost all the cultivated land in Scotland, at a resolution to allow land managers and regulators to assess the likelihood of damaging erosion occurring and take action to reduce the harm caused by the loss of nutrients, topsoil and carbon and potential damaging impacts on Scotland's water resources. The maps have been made available online on the SEWeb platform and have formed the basis of an economic assessment of the cost of erosion in Scotland. This work was highlighted in an article in the Scotsman to mark World soil day (5th Dec).

You can read Theme 1 achievements in full here

Theme 2 - Productive and Sustainable Land Management and Rural Economies

Climate change risk assessments for Scottish crop pests and pathogens: The ease of use and scope of the 'C4' desktop app for performing climate change risk assessments in Scottish crop locations has been enhanced. End-users can now build pest or pathogen risk models that depend on multiple as opposed to single climate variables (e.g., disease risk that depends on temperature and humidity together) and risk models can now be generated with a single button-click. The app has also been updated to use the latest UK Met. Office climate change projections (UKCP18). The desktop app is freely available to download and can be used on any Windows PC. The modelling implemented in the app has been used to produce national-scale climate change risk assessments for a wide range of crop pests and pathogens, resulting in four first-author publications in high-impact journals and numerous policy briefs for Scottish Government.

Tick-borne disease: There is growing concern that disease transmitted by ticks (TBD) could increase due to climate change. The ability to detect such infections is key to understanding the risks associated with TBD. SEFARI scientists have developed a suite of tests capable of detecting five of the most common infections carried by ticks in the UK and which can cause disease in sheep, cattle, deer, domestic animals and humans. A study of "questing" ticks (those that are actively looking to latch on to a mammalian host in order to take a blood meal) collected from Invernesshire and Aberdeenshire between 2016 and 2018 confirmed that the majority of ticks were not carrying any of the pathogens, although a significant number of those tested were carrying the bacteria that causes Lyme Disease in humans. In addition, working recently with Public Health England on a Louping-ill prevalence study, SEFARI scientists helped discover the first reported incidence of Tick-borne Encephalitis virus (TBEV) in the UK, in a deer tick in East Anglia. TBEV is a major public health concern in mainland Europe and its reported emergence here in the UK for the first time demonstrates the importance of remaining vigilant about the potential spread of new diseases to the UK from continental Europe and beyond.

You can read Theme 2 achievements in full here

Theme 3 - Food, Health and Wellbeing

Berry benefits: SEFARI has an international reputation in soft fruit crop improvement for yield, quality, resource use efficiency and pest and disease resistance; and developing close relationships with breeding and agronomy companies, government agencies and national and international stakeholders. Building on this foundation developed with long-term SG funding, work in the current SRP is applying innovative biomedical, molecular and processing technologies to identify new functional properties in berry products as well as routes to adding value to lower quality biomass. Several potentially important bioactivities of berry components, extracts or juices have been identified. A raspberry component, salidroside, has bioactivity in models of Huntington's Disease, and this finding has been followed up by the mapping of genetic markers for salidroside content, which could be used to breed high-salidroside raspberry varieties. Further work has indicated a potential role of berry polyphenols in neuroprotection, and volunteer studies in young healthy volunteers have revealed the effects of blackcurrant juice more broadly on attention, mood and brain activity. On a Europe-wide scale, nearly one sixth of the combined berry crop does not enter the retail market on grounds of quality. Major EU funding has been secured from the ERA-Net Co-fund FACCE SURPLUS (Sustainable and Resilient agriculture for food and non-food systems) for the OPTIEBERRY project ('Optimal use of by-products of berry fruit production') including SEFARI partners. The aim is to use crop waste/co-product (e.g. sustainable berry biomass, such as non-premium fruit) to develop innovative processing and biorefinery/extraction concepts leading to new food prototypes and (non)-food ingredients.

Healthy and sustainable diets: Our food system in totality accounts for 20-30% of all UK greenhouse gas emissions. Consequently, what we eat has both direct and indirect impact on our climate change commitments. Allied to technological solutions to cut emissions and decrease food waste, a move towards diets that are less resource-intense, with less associated emissions, must now be a priority. In promoting the move towards a more sustainable diet, consideration must also be given to the health consequences of such change. This is recognised in the FAO-WHO contribution to the UN Decade of Action on Nutrition whereby an international expert committee developed the FAO-WHO Guiding Principles for Sustainable Healthy Diets, published in October 2019 on World Food Day. A SEFARI scientist was an invited member of the committee and an author of the report. The high profile of SEFARI research in this arena led to invitations to contribute a keynote conference talk, a chapter in a book reviewing the latest research on healthy and sustainable food systems, and to an interview on national television.

You can read Theme 3 achievements in full here

Contact

- Theme 1: Dr Ruth Mitchell - ruth.mitchell@hutton.ac.uk
- Theme 2: Dr. Colin McInnes - Colin.McInnes@moredun.ac.uk
- Theme 3: Professor Julian Mercer - j.mercer@abdn.ac.uk
- The SEFARI Gateway - info@sefari.scot

Theme 1 - Natural Assets

Work Package 1.1: Soils

Major Achievements

- **Reducing soil erosion through prediction of erosion vulnerability**: SEFARI researchers have produced risk maps that identify areas of land most vulnerable to erosion to help land managers adjust cultivations to reduce the impacts of erosion including diffuse pollution in Scotland's rivers and streams. The maps (available on Scotland's Soils website) show how soils and landform combine to increase the likelihood that runoff from saturated soils will cause erosion resulting in the loss of valuable topsoil, nutrients and carbon. This work was highlighted in an article in the Scotsman to mark World soil day (5th Dec).
- **Soil carbon content remains stable in some agricultural soils in Scotland:** Research detailing change in soil carbon (C) concentration, soil pH and major nutrients of 37 top-soils from previous on-farm experimental sites from 1950 to 1980 in north-east Scotland has indicated no significant change in soil C concentration, despite this period coinciding with increased agricultural intensification. This contrasts with previous National Soil Inventory of Scotland resampling (approx. 25 years apart) which showed a statistically significant decrease in C concentration, but supports the CEH Countryside Survey finding of no change on soil C concentration between 1978 and 2007.
- **Impacts of zero-budget natural farming on food production:** Zero-budget natural farming differs from traditional organic farming by aiming to change the functioning of the soil–crop system so that nutrients are made available to crops without the need for external inputs such as animal manures. SEFARI scientists have been involved in the first study to provide a detailed assessment of the impacts of the farming system on the nitrogen available and soil conditions for crop growth. This has resulted in publication of a paper in Nature Sustainability, and the work has been covered by media both in India and UK.
- **Translational science in Africa:** In Jan 2020 a SEFARI researcher secured funding (GCRF NERC/BBSRC Translation Award) to continue work on optimising agronomic and crop variety selection for sustainable maize cultivation systems in southern Africa. The research project (AfricaSOIL) will apply approaches originally developed within the SRP and has a focus on trial sites and small holder farmer communities in Malawi and Zimbabwe.

Work Package 1.2: Water

Major Achievements

- **Phosphorus risk modelling:** Results of phosphorus risk modelling were presented at the SAGES 'Global Climate Challenges for a Blue Green Economy' conference (Edinburgh, 27-28 Nov 2019). SEPA have expressed an interest in extending this modelling approach to ecosystem services modelling in the Eden catchment as part of 'One Planet Choices' project.
- **Landcover change:** SEFARI scientists have been working with Scotland's National Park Authorities to assess the suitability of using currently existing remotely sensed landcover datasets to assess landcover change in the National Parks (2006-2018). 'CORINE' was found to be the most suitable dataset and landcover change was found to be increasing in both Parks. A technical report is being finalised following feedback from National Park collegues which has been presented to Scottish Governmet and a broad stakeholder audience (Jan 2020).

- **Modelling effects of in-stream wood**: A recent study reviewed approaches to modelling the hydrological and hydraulic effects of naturally formed or deliberately placed in-stream large wood, for flood risk management or river restoration. It was concluded that validation, testing different representations for different purposes and scales, alongside better accounting for model input uncertainty are needed to improve confidence in models.

- **Collaboration strengthened with applied research in Ireland:** SEFARI researchers presented multiple aspects of RESAS-funded research at the Catchment Science 2019 conference (Wexford, Nov 2019), including modelling of phosphorus sources and mitigation; the F-MAPT tool to enable placement of Flooding Measures; riparian management; water payment for ecosystem services and soil erosion work. Researchers are working closely with the Teagasc Institute and the Irish EPA in riparian and NFM allied research projects with mutual benefit for the land.

Work Package 1.3: Biodiversity

Major Achievements

- **WaderMap:** SEFARI scientists, in collaboration with the Working for Waders initiative and partners, have developed WaderMap: an online web app that enables stakeholders to interact with a map of management-relevant information and wader conservation initiatives and contribute data on their own wader conservation initiatives. These can be shown against various user-selectable backdrops that, for example, show the current distribution of a species or target areas for AECS wader measures. This tool is being used by land-managers to develop landscape level collaborative management and to inform the development of results-orientated farm payments.

- **Artificial ash tree habitat?** SEFARI researchers have investigated the bark characteristics of ash trees and other tree species that might replace ash as ash trees decline due to ash dieback disease. The work aimed to identify the bark characteristics important in supporting lichens and bryophytes on ash and hence the suitability of other tree species as replacements. The work has recently been used by students at London University's Imperial College design school to design artificial habitats similar to ash bark, that ash associated mosses and lichens could grow on.

- **Local perceptions of land management in high-value conservation sites:** Research by SEFARI social scientists has examined how residents and visitors use and place value on woodlands with a high conservation value. The research aimed to gain insight about perceptions of both biodiversity and woodland management initiatives that focus on improving biodiversity. The research found that, in addition to biodiversity and conservation, people were keen to increase the 'use' of the woodlands, often drawing on narratives of past land use and cultural histories to describe potential social and economic benefits.

- **Towards truly sustainable agri-food value-chains:** RESAS-supported research on legumes (e.g. peas and beans) was recently reported in partnership with the EU TRUE project in the outcome of an EU-wide 'consensus opinion of stakeholders' exercise. Three recommended action areas were identified to help realise more-sustainable legume-supported agri-food systems around: i) investment in agri-food and feed research and knowledge transfer; ii) preventing the use of inorganic nitrogen fertiliser; and iii) public campaigns that promote the inclusion of legumes in the human diet.

- **A toast to reduce Scotland's protein import dependency:** RESAS-supported work to help realise more cropping of pulses (e.g. peas and beans) in Scotland, carried out in partnership with Scottish-based SMEs, revealed that the use of home-grown peas to make gin also provided a high-protein 'co-product' for animal feed. The pea co-product can offset animal feed imports, and the two high-value products were achieved with a reduced carbon footprint (compared to conventional wheat gin).

A commercial product (World's first climate-positive gin) has been launched in February shortly after World Pulses Day (FAO-UN, Feb 10th).

Work Package 1.4: Integrated Land Use Systems

Major Achievements

- **Aligning policy instruments:** Work on 'Three ways to improve ecosystem monitoring and evaluation' was selected as a highlight of the year by the OPPLA newsletter and informed ALTER-Net's recommendations for the post-2020 EU biodiversity strategy submitted in Jan 2020, which identified the importance of monitoring and evaluation to inform policy but also to understand and promote the societal importance of biodiversity.

- **Measuring Scotland's natural capital assets:** SEFARI researchers have been working closely with SNH to develop Scotland's Natural Capital Asset Index (NCAI): an account of Scotland's natural capital stock and how it's potential to contribute to wellbeing changes on an annual basis. A recent joint paper highlighted the NCAI as a robust, credible and useful tool for policy making.

- **Adaptive catchment management:** Working with stakeholders from the Lunan and Leven catchments, SEFARI scientists identified factors related to ownership and a strong evidence base as important in the adoption of long-term management actions. This is being communicated to local stakeholders through the catchment management groups and national stakeholders at CREW meetings, and more widely with presentations at the TEAGASC conference on Nov 7, and a recent paper highlighting the importance social attitudes in the success of integrated catchment management schemes.

Theme 2 - Productive and Sustainable Land Management and Rural Economies

Work Package 2.1: Crop and Grassland Production and Disease Control

Major Achievements

- **Improving genetic resources in blueberries:** Whilst US blueberry breeders have found long-term success using traditional breeding approaches, SEFARI researchers believe that the incorporation of new techniques using molecular markers to identify important qualities would result in accelerated variety development, allowing breeders to select the best parent plants for crosses. In the SRP we have developed tools and technologies, including breeding populations and a genetic map, which will allow the UK to develop blueberry varieties suitable for UK conditions, more efficiently, cost-effectively and quickly than by traditional breeding. This work has advanced both fundamental and applied science with tangible outputs in terms of suitable UK adapted populations using native wild blaeberry species and tools with which growers and breeders can develop novel UK blueberry material. The benefits of the research are being realised through a commercially funded blueberry breeding programme now established in Scotland.

- **Rationalising fungicide use in spring barley:** SRP research to model the development of rhynchosporium leaf blotch epidemics (a major disease in spring barley) has identified opportunities for reducing fungicide applications according to the risk of the disease. Current practice is to make two applications of fungicide. Field experiments - to test hypotheses from the model - showed that a single fungicide application just before flowering is sufficient to maximise yield where there is little or no visible disease present in the crop at the start of stem extension and a variety with a good level of resistance is being grown. Results were presented to growers and agronomists at a series of crop events in July 2019 and January 2020.

- **Improved understanding of Scottish potato late blight populations:** SEFARI research highlighted a region of unusually high diversity in the Phytophthora infestans (causal agent of potato late blight) population in NE Scotland. This is in stark contrast to the rest of the UK where pathogen populations are much more uniform. This newly discovered area of pathogen diversity was sampled intensively and the isolates characterised for their relative ability to cause disease on potato. The results provide a new baseline for studies of P. infestans population diversity and a new understanding of the factors driving pathogen evolution. These insights are being used to inform in-field management of the threats posed by newly emerging, highly aggressive strains.

- **Genetic interactions that are important for barley grain development and yield:** SEFARI scientists have discovered how an important gene family termed 'SIX-ROWED SPIKE (VRS)' is involved in key grain developmental processes, all of which have implications for grain yield and quality and include spikelet infertility, determinacy and outgrowth. By identifying different versions, or alleles, of these genes and understanding how they interact, SEFARI scientists will be able to provide breeders with the information they need to breed better barley varieties.

- **Monitoring, predicting and managing Spotted Wing Drosophila (SWD):** SEFARI scientists have been instrumental in helping soft fruit growers respond to the potential threat from SWD. SEFARI scientists have monitored populations of this highly destructive pest of soft and stone fruits since it arrived in the UK in 2012. The data is being used to understand how the pest is spreading in UK climatic conditions, and has led to an integrated pest management tool that can be used to predict the flight activity of the pest with a very high degree of accuracy. Scottish growers have been provided with practical information on how best to monitor and sample for its presence, how to dispose of affected fruits and how manage and control the pest.

- **The informatics platform Germinate and its associated mobile applications:** Developments by SEFARI scientists have meant that Germinate can now be used to support experimental data, of use to breeders, on several additional species including cherry in Scotland and non-UK crops, including sunflower, eggplant and chickpea. The mobile applications were originally targeted towards specific Institutional data collection requirements but have a wider general application and are now used by plant researchers worldwide. The software tools have attracted external funding to help support the continued development and improvement of the platforms in crops of international importance.

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

Major Achievements

- **Animal welfare:** Recently, SEFARI scientists, working in partnership with other organisations, have been trialling ultrasound scanning as a means of diagnosing the presence of pulmonary tumours in sheep long before the signs of disease become apparent. Ovine pulmonary adenocarcinoma (OPA) is an infectious and fatal lung disease. It is caused by a virus, known as jaagsiekte sheep retrovirus (JSRV), which infects cells in the lung making them form tumours. The tumour cells produce more of the virus which can either infect new areas of the lung or be passed on to other sheep. The sheep may survive for many weeks after the signs of disease appear or may die suddenly. It is a significant disease in Scotland and the UK and in affected flocks may cause the death of 1% to 20% of the flock in a single year. It is important to note that the early stages of OPA are not apparent as the tumours are too small to cause any breathing problems even though they are able to produce virus which can infect other sheep. Although OPA was first described almost 200 years ago, methods for diagnosing and controlling the disease have been limited. The new approach using transthoracic ultrasound scanning as a means of diagnosis long before the signs of disease, allows the affected animal to be removed from the flock. A film describing this novel means of diagnosing OPA has been produced and knowledge exchange work is now underway to persuade farmers across the country to adopt this new diagnostic test. Breed societies, Livestock Health Scotland, NFU(S) and others are pushing for an assurance scheme based on this test and work is now being done to see how this might be achieved.

- **Anti-microbial resistance:** SEFARI scientists have been working on complementary projects to determine the best methods for detecting antimicrobial resistance (AMR) genes present in the environment either associated, or not, with livestock farming. In doing so they have sought

to define the abundance of different AMR genes and determine if the presence of certain genes can be correlated with the direct use of antibiotics on farm or via anthropogenic sources such as the spreading of treated human sewage on grazing pastures. In addition, investigation of AMR gene abundance and soil types, representative of the whole of Scotland, has provided a detailed geographic picture of resistance in the wider environment. Overlaying this with soil metadata and land management practices provides a view of the potential impact of agricultural practices on resistance, which in turn could be used for further modelling work on the spread of AMR.

- **Point-of-care diagnostic:** Sheep scab is a notifiable disease within Scotland. Infestation with the sheep scab mite, Psoroptes ovis, causes an intense irritation of the skin and is a major welfare concern for sheep. In affected flocks diagnosis was often not achieved until the clinical signs of disease were evident, meaning that by that stage disease had inevitably spread to other sheep and thus was more difficult to eradicate. In the previous SRP a diagnostic blood test (ELISA) was developed which allowed diagnosis before clinical signs appeared and this was rolled out to Scottish farmers as a commercial test available through the veterinary diagnostics laboratories. In the current SRP, work has concentrated on developing a point of care (POC) diagnostic that would give the farmer/vet an instant readout on the farm as to whether or not sheep were infested with the sheep scab mite. Results of a prototype POC test indicate that the presence of mites can be detected within one week of infestation, very similar to what is achieved by the laboratory test. Further optimisation is currently taking place, prior to seeking a partner for porting the test to a commercial POC platform.
- **Support for the Scottish Government BVDV eradication campaign:** Bovine viral diarrhoea (BVD) is a significant endemic disease of UK livestock with impact on animal health and production. BVD viruses (BVDV) are highly diverse but can be typed by sequencing of a short region of the genome. Understanding how BVDV change between animals is important for tracing the source of outbreaks. SEFARI scientists have collected over 5000 BVD positive samples from Scottish laboratories, representing thousands of different viral sequences. Complete BVDV genome sequences have been analysed and tools developed for BVDV strain identification. This has informed government (via EPIC) about the range and frequency of BVDV strains in Scotland and has allowed the direct analysis of new BVD outbreaks for SG and animal health industry.

Work Package 2.3: Productive and Sustainable Land Management

Major Achievements

- **Transforming food production funding:** Three large scale Innovate-UK projects commenced in 2019 addressing the Transforming food production challenge set out by the Industrial strategy challenge fund. These industry-led projects have a total value of over £2 million to SEFARI are covering topics including:

    1. Aligning farmers to consumers using modern data, decision support and precision agriculture technologies;
    2. Precision agricultural solutions to monitoring and improving productivity across the beef and dairy-beef sector;
    3. Alternative treatments in poultry to help reduce antibiotic use.

- **Leading roles for SEFARI researchers:** A SEFARI scientist has been appointed as Co-Chair of the Livestock Research Group of the Global Research Alliance. The Livestock Research Group (LRG) is an international community of experts working

together to advance research on improving livestock productivity while reducing its emissions intensity. Members collaborate to (i) extend the global knowledge base on livestock greenhouse gas emissions; (ii) develop mitigation options; (iii) Share knowledge and experiences and (iv) help strengthen the resilience of livestock farming. Another SEFARI scientist has been appointed Chair of Scotland's first ever independent Animal Welfare Commission. Announced as part of the Programme for Government, the Commission will focus on protecting wild and companion animals, while also providing scientific and ethical advice to government.

- **Innovation funding for methane reduction:** After receiving £250,000 of funding from the Department for Environment, Food and Rural Affairs (DEFRA), as part of a collaborative research project with European partners, SEFARI scientists will develop and adapt existing precision livestock farming technology to mitigate and monitor methane production. With around 90% of Scotland's cattle being outdoors for significant parts of the year, it is hoped the project will ultimately identify the best options for managing grassland and grazing animals to reduce methane emissions.

Work Package 2.4: Rural Industries

Major Achievements

- **New entrants**: SEFARI scientists are conducting empirical research into new entrants to farming that is relevant not only to Scotland, but across Europe. Analyses of case studies and the Farmer Intentions Survey indicate that new entrants to farming increase the level of innovation and global engagement within the agricultural sector. Working alongside the Horizon 2020 Project NEWBIE (New entrant networks: Business models for Innovation, entrepreneurship and resilience in European agriculture, 2018-2021), which has partners in 9 European countries, case studies were collected from Scottish new entrants as well as UK new entrants to farming. This in turn allowed representatives of the NFUS Next Generation Group and the Scottish Land Commission to visit France, supported through NEWBIE, to learn about farming incubators (support mechanisms to assist new entrants to develop and market innovative products, prior to establishing their own farms). The French experience was presented to the Farming Opportunities for New Entrants group, where it generated considerable discussion.

- **Brexit:** SEFARI scientists continue to support the Scottish Government, stakeholders and industry in considering the consequences of Brexit. Submissions and support to Lord Bew's Intra-UK Allocations Review were acknowledged in helping to formulate the final recommendations of UK-Convergence funding allocations. Scientists also supported the Scottish Government in their preparations for a no-deal scenario through input into briefings highlighting key issues for Scottish farming sectors, such as the Scottish Government commissioned research on sheep and lamb processing in Scotland.

Other Brexit themed briefings based on the analysis of the Farmers Intentions Survey continue to provide commentary on Brexit to industry and stakeholders through the trade press, Shetland Monitor Farm and SAC Consulting farm events, support for Highlands and Islands Agricultural Steering Group and the Shetland Islands Agricultural Strategy Group. Similarly, support was also given to the SRDP Farm Advisory Service on Brexit planning. Scientists took part in the Brexit- What Now? webinar where over 70 participants provided oral evidence to the Rural Economy and Connectivity Committee on the Agriculture (Retained EU Law and Data) (Scotland) Bill and participated in a Rural Enterprise Evidence workshop where Brexit issues were discussed with rural businesses and HIE.

- **Aquaculture and GHGs:** Aquaculture makes an important contribution to food security and economic development. In order to enable sustainable expansion of aquaculture, there is a need to understand aquaculture's environmental impact and how it might be mitigated. SEFARI scientists have recently published a study (Quantifying and mitigating GHG from global aquaculture) that quantifies the global GHG emissions from aquaculture. One of the conclusions of the study is that the relatively immature nature of the sector (compared to agriculture) means that there is scope to improve resource efficiency through technical innovation. Some of the data and models used in the FAO report are now being deployed to improve the efficiency of Scottish salmon farming.

- **Improved geospatial data for policy support:** Working with RESAS and RIPD, SEFARI scientists have been updating and enhancing the geospatial land use and payments datasets. These help to underpin the analysis of the 2018 Farmer Intentions Survey and its comparison with the 2013 results, advice to Ministers on options for capping payments in Pillar 1, revisions of the designation of Areas of Natural Constraint and in identifying and characterising businesses managing driven grouse. These projects also exploit capability developed within other areas of the SRP, Contract Research funding and Underpinning Capacity. New options have been tested for building light-weight demonstration tools suitable for use with policy makers, and other stakeholders as appropriate, in a workshop setting. These software tools are stand-alone packages which present policy options in a more dynamic and interactive way, highlighting the consequences of implementing particular policy choices.

Theme 3 - Food, Health and Wellbeing

Work Package 3.1:

Improved Food & Drink Production

Major Achievements

- **Primary produce and health:** New findings include a raspberry component, salidroside, with potential beneficial effects in models of Huntington's Disease, effects of blackcurrant juice on attention, mood and brain activity, and a potential role of berry polyphenols in neuroprotection. Follow-up studies are looking at traits which could be used to breed high-salidroside varieties.
- **Food production in a changing climate**: An STV documentary, 'Climate of Change', highlighted research to increase plant resilience to climate change and reduce GHG emissions. Future solutions for sustainable, high quality food included vertical farming, molecular breeding and plant-derived protein. Researchers engaged in the 'climate conversation' as part of the Scottish Government (SG) /Sustainable Scotland Network initiative - Climate Week. Pledges collected will form part of a public display highlighting how food-focussed research will contribute towards the SG's target of achieving 0% net emissions by 2045.
- **Food reformulation:** Theme scientists were interviewed for the BBC TV programme 'Great British Railway Journeys'. Highlighted SRP research targeting reformulation for developing healthier foods included work on fortification of fibre in bread and vegetable-enhanced yoghurts.
- **Food safety:** SEFARI cientists jointly organised a workshop on antimicrobial resistance, with input from RESAS, SG's veterinary adviser and Food Standards Scotland.
- **Waste reduction and valorisation:** A Theme scientist was a keynote speaker at the EAAE Seminar 'Sustainable and resilient farming systems in the European Union' (Sep-19) - talk entitled "Technological uptake and efficiency. Case studies on food waste and animal health in primary production". This was supported by the publication, 'Food waste in primary production: Milk loss with mitigation potentials'. A talk on circular bioeconomy to a regional farmers group was enthusiastically received. SRP crop waste/ co-product valorisation work secured funding from the ERA-Net Co-fund FACCE SURPLUS ('Sustainable & Resilient agriculture for food and non-food systems').

The OPTIEBERRY project (€0.92M) - 'Optimal use of by-products of berry fruit production' - targets innovative processing and biorefinery/extraction concepts to create food prototypes and (non)-food ingredients from sustainable biomass, esp. non-premium fruit.

- **Consumer perspectives on diets, health and sustainability**: Papers published in the journal Nutrients studied (i) how consumers in the UK and Spain value the coexistence of claims on low fat, local, organic, and low greenhouse gas emissions, revealing that in the UK the demand for beef mince with moderate (low) fat content can be increased if it is also labelled as "Organic" or "Low GHG" ("Local") and (ii) the importance of health claims on the adoption of new breakfast cereal products by UK consumers, where there was no clear pattern in the impact of claims.

Work Package 3.2: Healthy Diets and Dietary Choice

Major Achievements

- **Stakeholder engagement and presentations:** Theme research was showcased in (i) a SRP-wide invited talk by the DEC Advisor to the Scottish Parliament Cross Party Food Group (Jan-20) entitled 'Connecting Climate Change, Natural Capital and Health'; (ii) a keynote talk at the UK Society for Behavioural Medicine on 'Food Systems and Sustainable Diets'; (iii) teaching a key session on sustainable diets at the World Food System Summer School (Zurich); (iv) a tutorial and research talk at a summer school in Leuven on Microbial Community Modelling.

- **Publications:** Theme researchers published (i) a high profile paper on the rumen metagenome in Nature Biotechnology, which gave rise to press coverage, identifying the vital need to be able to grow more rumen bacteria types in the laboratory to help understand how to alter rumen feed conversion or methane emissions, to help tackle livestock sustainability, and (ii) an invited chapter 'Healthy and Sustainable Diets' in the book, 'Healthy and Sustainable Food Systems'.

- **Policy and public engagement:** A Theme researcher is part of a review panel supporting FSS in developing 'Dietary Guidance for Scotland', appeared on @BBCScotlandNews speaking about how the food we eat can help the environment (https://buff.ly/3aGAlFZ from 5min 30sec), and was a member of an international committee and author that developed the FAO-WHO Guiding Principles for Sustainable Healthy Diets. This brings together guidance for health, environment and food safety, while taking into account social aspects of eating. Its purpose is to be used as a guide for revising national dietary guidelines to include environmental sustainability. It was published in Oct-19 on World Food Day.

- **Funding:** A researcher was awarded a MRC Nutrition 'Hot Topic' workshop grant (£10k) on 'Reshaping the food environment: applying interdisciplinary perspectives in appetite research', to develop cross-disciplinary research ideas for future funding.

Work Package 3.3: Food Security

Major Achievements

- **Publications:** Papers in (i) Nutrients on the relationship between trading on food quality due to changes in prices and nutrition, demonstrating that increases in prices may have negative nutritional effects; and (ii) Sociologia Ruralis on community and rural policy and governance.

- **Working with stakeholders and policy:** Researchers discussed food poverty and urban

food initiatives with RESAS colleagues (Aug-19) and at the NOURISH annual conference (Nov-19), informing development of the Good Food Nation bill, and contributed to the development of a consultation on the Aberdeen local food growing strategy (Dec-19).

- **Leveraged funding**: Seed corn funding was secured for a spin off project on the potential of controlled environment agriculture to contribute to sustainable (urban) food systems.

- **Addressing meat consumption**: There was media interest in a paper stemming from the previous SRP's engagement with debate on the economic, social and environmental challenges of livestock consumption (publication in the journal Appetite featured in the previous progress report). A researcher was interviewed on BBC Radio Scotland.' Newsdrive in Dec-19, and the research was also cited in an article in The Times newspaper.

- **Understanding changing eating practices across the life-course:** A paper from the previous SRP's work on understanding food choices in Scotland was published in Food, Culture & Society, attracting media interest, and an interview on local commercial radio. This paper reveals that eating patterns acquired in childhood can shape them throughout life. Eating patterns may be more likely to change if the desire for change originates within the individual.

Work Package 3.4: Communities and Wellbeing

Major Achievements

- **Working with policy and stakeholders:** SRP research was discussed at (i) a KE event with Highlands and Islands Enterprise (HIE) in Oct-19. (ii) the Cross Party Group for Rural Policy meeting on 'Taking a place-based approach to address demographic change in rural Scotland' (Oct-19); (iii) a conference marking the 1919 Land Settlement (Scotland) Act (Sep-19); (iv) the UK Rural Policy, Practitioners and Research Group, hosted by Rural England CIC (Jan-20); (v) the National Centre for Resilience Steering Group meeting (Sep-19). Sparsely Populated Area work continues be cited e.g. in SG's "Migration: Helping Scotland Prosper" report in Jan-20.

- **Outputs:** (i) an interview on BBC Radio 4 on community land ownership and rural development (Sep-19); (ii) a workshop on rural enterprise in Scotland to consider current evidence (Nov-19); (iii) a paper on The Changing Shape of Scotland's Digital Divide.

- **The Islands Revival Workshop:** Over 30 representatives of island community groups, local government, island researchers, HIE, UHI, COSLA, the Scottish Islands Federation and the Scottish Rural Network attended a SEFARI Gateway Responsive Opportunity workshop (Aug-19), resulting in the Islands Revival Declaration. This made recommendations for how policy can support sustainable island populations and received wide media coverage. Following this, SEFARI flexible funding was awarded for the 'Research on the Edge' blog, a platform for sharing Theme research on rural and sparsely populated areas, and for stimulating discussion.

- **Policy reports and evaluation:** A draft report (from a SEFARI fellowship) to the Just Transition Commission (Dec-19) reviewed literature and policy documents, considering policies relating to 'just transition' in case study countries: Norway, Canada, the US, Peru and Germany. A report was produced for SG evaluating Scottish Rural Action, to inform future funding decision

sefari.scot

info@sefari.scot

@SEFARIscot

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

BioSS

The James Hutton Institute

Moredun

The Rowett Institute

Royal Botanic Garden Edinburgh

SRUC