

Progress Report on Strategic Research Programme Delivery



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 (KE) 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.

This report provides SRP research and allied knowledge exchange impacts covering the period between March to August 2020. Highlights include research exploring the role of tree planting to meet climate change targets; the development of new diagnostics for animal and human disease; enhancing precision livestock farming for sheep; increasing the production and consumption of pulses in Scotland; developing a new framework to measure the relationship between prosperity and poverty in delivering an economy that combines fairness and prosperity; and through a SEFARI Gateway Fellowship, examining the potential for Scotland's Highlands and Islands to engage with the Arctic Foods Innovation Cluster, with such models offering the potential to support social and economic enterprise.

This period has, however, been dominated by the COVID-19 pandemic. This has seen SEFARI core expertise and resources deployed in support of national, regional and local responses to COVID-19, as well as rapidly repurposing research to provide analysis of the ensuing societal and economic impacts of the pandemic. The SEFARI response includes the provision of an "[academic node](#)" for NHS Lothian's testing programme; developing models for understanding and tackling disease transmission; collaborating in the development of sustainable personal protective equipment from crop wastes; research exploring the impact of COVID-19 on [Scotland's food-health habits](#); repurposing research to examine impacts on Scotland's rural communities; designing and publishing [online materials](#) to support home learning and wellbeing activities during lockdown, and establishing an expert advisory group examining rural economic recovery through the lens of the Food and Drink sector.

As for so many, 2020 has been a challenging year and COVID-19 will continue to influence research and KE needs. The national and international research and KE collective response to COVID-19 has further strengthened the ties and collaborations across SEFARI, our partners and networks. Strong connectivity in sharing of knowledge and multi-sector collaboration in Scotland is a significant resource to inform actions in responding to changes resulting from the UK exiting the EU, supporting Scotland's drive towards a green recovery and a just transition on Net Zero emissions.

Very best wishes,



Director, SEFARI Gateway



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Summary

Theme 1 - Natural Assets

Funding success: There have been several significant funding successes recently that build on work funded through SRP Theme 1. Researchers in WP1.4 have been successful in winning two new EU projects, extending their impact into the global sustainable land use agenda. The projects, FRAMEwork (coordinated by the James Hutton Institute) and [IPMWORKS](#) will involve 49 partners from across Europe with a combined value of €15M, and will be working with farmers and other stakeholders to understand and promote collective approaches to land management. Researchers in WP1.1 have successfully secured funding from NERC (£1.08M) for a project ([RETINA](#)) to develop novel greenhouse gas monitoring and modelling to support policy and stakeholder decision-making. The project will provide near real-time decision support to land managers, allowing site-specific understanding of management to promote soil carbon sequestration and greenhouse gas mitigation. All these successes build on the fundamental, underpinning science previously conducted within the SRP.

Tree planting and carbon storage: Researchers in WP1.1 have shown that planting trees does not necessarily lead to a net increase in stored carbon on decadal timescales. The work demonstrated that planting birch and Scots pine trees on heather moorland resulted in a decline in the carbon stored in the soil that was greater than or equal to the increased carbon stored in the tree biomass, resulting in no net gain of stored carbon. The results are of direct relevance to current policies, which promote tree planting on the assumption that this will increase net ecosystem C storage and contribute to climate change mitigation.

You can read Theme 1 achievements in full [here](#)

Theme 2 - Productive and Sustainable Land Management and Rural Economies

Potato Blackleg: RESAS funding has underpinned a new £2.1M grant from the UK Strategic Priorities Fund led by the James Hutton Institute and with 11 other academic, industry and government partners from across the UK. The grant will fund the development of a national decision support tool for potato blackleg disease, which remains the main cause of potato seed downgrading and failures in Scotland. More information is available at the new [Blackleg Hub](#).

Diagnosing COVID-19: Building on the expertise of SEFARI scientists and the infrastructure supported by the Underpinning Capacity funding stream, Moredun Research Institute (MRI) and SRUC scientists were able to offer support to the [NHS in Scotland in their COVID-19 testing programme](#). Between the middle of June and the middle of August over 2300 samples were tested for SARS-CoV-2, although the capacity offered was much higher. Although reticent at the start, possibly due to their unfamiliarity of what could be offered, the NHS selected the MRI/SRUC hub to pilot a study looking at pooling of samples. This was based on the experience gathered during the Scottish bovine viral diarrhoea virus eradication campaign where sample pooling is the accepted norm. If successful, pooling of samples would not only save money in the longer term, but could increase the testing capacity across the country by 4-5 times.

Consuming Pulses in Scotland: Members of WP2.3 (RD2.3.8) and Soil Association (Scotland) have secured funding for a Rural Innovation Support Service ([RISS](#)) working-group on, 'Processing Pulses for Human Consumption in Scotland' with the goal of increasing pulse production and consumption. The RISS group comprises stakeholders from across the pulse value chain from farming to processing, food and drink industries, and consumer organisations. It will identify i) opportunities and barriers for the further development of a sustainable, local pulse supply chain in Scotland, ii) desirable pulse-based products and associated processing requirements, and iii) market and consumer demands. The group arose in response to challenges identified by stakeholders involved in RESAS and EU funded research to maximise the benefits of legumes in crop sequences and as intercrop components.

You can read Theme 2 achievements in full [here](#)



Theme 3 - Food, Health and Wellbeing

Crop and food waste: The valorisation of agri-waste is the focus for the development of new sustainable Personal Protective Equipment (PPE) via the Innovate UK funded project, 'Novel nanocellulosic composites as antivirals and antimicrobials for new PPE materials' ([NanocellPPE](#), [£0.5M]). The project, building on expertise within the SRP, will be delivered by a consortium including the James Hutton Institute and two Scottish SMEs, Cellucomp and Halley Stevensons Ltd, and seeks to use green chemistries and crop wastes/co-products to create completely novel absorbent antiviral and antibacterial materials of applicability to PPE. The materials should have better multiuse protection against transmissible pathogens, while reducing waste streams and lessening environmental impacts of existing fossil fuel-based products.

Theme 1 - Natural Assets

Work Package 1.1: Soils

Major Achievements

- **Novel greenhouse gas monitoring and modelling to support policy and stakeholder decision-making.** SEFARI researchers have secured funding (£1.08M from NERC) for a project to apply Dynamic monitoring, reporting and verification for implementing negative emission strategies in managed systems ([RETINA](#)). The project, involving multi-disciplinary collaboration with University of Aberdeen and Centre for Ecology and Hydrology, will combine the use of remote and proximal sensing data with modelling to provide near real-time decision support to land managers, allowing site-specific understanding of management to promote soil carbon sequestration and greenhouse gas mitigation. The research builds on work from the SRP and has received considerable press coverage ([The Courier](#), [The Press and Journal](#), [FutureNetZero](#), and [SeedQuest](#)).
- **Tree planting does not lead to a net increase in stored carbon on decadal timescales.** Tree planting is increasingly being proposed as a strategy to combat climate change through carbon sequestration in tree biomass. Using a long-term replicated experiment where pine and birch were planted on heather moorland, we calculated the total carbon stocks stored in the trees and soil 12 and 39 years after planting. We showed that tree planting did not lead to a net increase in carbon storage after planting. Plots with trees had greater soil respiration and lower soil organic carbon (SOC) than heather control plots. The decline in SOC cancelled out the increment in C stocks in tree biomass on decadal timescales. At all four experimental sites sampled, there was no net gain in ecosystem C stocks 12–39 years after afforestation – we found a net ecosystem C loss in one of four sites with deciduous birch stands; no net gain in ecosystem C at three sites planted with birch; and no net gain at additional stands of Scots Pine. Differences between sites may be due to

differences in the age of the trees. The results are of direct relevance to current policies, which promote tree planting on the assumption that this will increase net ecosystem C storage and contribute to climate change mitigation. The work has been published in [Global Change Biology](#).

Work Package 1.2: Water

Major Achievements

- **Review of managing riparian buffer strips to optimise ecosystem services.** Riparian buffer strips can provide numerous ecosystem services from pollution mitigation and provision of habitat for biodiversity to carbon storage and natural flood management. An open access [paper](#) explored how the placement, physical properties, management and vegetation structure influence the potential of riparian buffer strips to deliver a range of benefits. The review provided information for environmental managers, regulators and practitioners on how the multifunctionality of riparian buffer strips can be optimised through targeted management actions. Catchment based approaches to managing riparian areas, including through placement of multifunctional buffer strips, has the potential to help mitigate the effects of climate change.
- **A new risk-based decision support tool reveals the land use factors that determine phosphorous pollution risk.** Phosphorus pollution remains a major cause of surface water quality failures, requiring evidence-based decision-making about the effectiveness of mitigation measures and their spatial targeting.

Arctic policy: A SEFARI Gateway Fellowship examined the potential for Scotland's Highlands and Islands to engage with the [Arctic Foods Innovation Cluster](#). The final report compares and contrasts the Highlands and Islands and the Arctic region, examines official data for evidence of food and drink clusters in the Highlands and Islands and engagement with the EU's geographical indications, and analyses new primary data on the values and behaviour of food and drink entrepreneurs in the Highlands and Islands. The report has been sent to Scottish Government Arctic Policy unit stakeholders for comment and will be completed in November 2020. The Fellowship has allowed the researcher to build links with Highlands and Islands Enterprise which will result in new research opportunities, suggesting avenues for future work as part of the SRP, and will spur engagement with stakeholders working on Scotland's Arctic policy.

COVID-related activity: Theme 3 activity ranged from novel technical innovation, as in the case of the development of sustainable personal protective equipment (PPE) made from valorised agri-waste, through to membership of government policy committees and contributions to ministerial briefings. Membership of the Scottish Government's COVID-19 Stakeholder group for Rural Economy and Communities has led to the reframing of rural community research objectives for the remainder of the SRP. There have also been examples of the repurposing of research from earlier in the SRP to tackle COVID-related issues, such as effects on diet and food habits, and on food security risk assessment, and options for changes in agricultural production, trade and distribution.

You can read Theme 3 achievements in full [here](#)

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The tool was presented at the [European Geophysical Union Congress](#) and will help to target mitigation measures in high risk areas. Results from a sub-model related to the risk of phosphorus pollution from septic tanks are currently being integrated with the SEPA modelling platform [SAGIS](#) at a Scotland-wide scale through a CREW-funded project.

- **RESAS research on natural flood management (NFM) informs a UK Government POSTnote on 'Natural mitigation of flood risk'.** A [briefing](#) by the UK Parliamentary Office for Science and Technology was published recently delivering the key messages: a) NFM delivers other co-benefits, b) NFM is useful in relation to smaller more frequent floods and can be a relatively low-cost option, and c) NFM should often be used in conjunction with other approaches. The briefing included research ranging from hydro-morphology to social science.
- **A large-scale monitored river restoration project is underway.** The Beltie Burn in Aberdeenshire was channelised and embanked in the 1800s, resulting in poor habitat and floodplain disconnection. The restoration works are due to be completed by September 2020. One of the most significant river restoration projects in Scotland, the project is the subject of a high-quality monitoring study. The restoration is being led by the Dee Catchment Partnership and funded by NatureScot's Biodiversity Challenge Fund.

Work Package 1.3: Biodiversity

Major Achievements

- **Functional and ecosystem service differences between tree species: implications for tree species replacement.** Globally, tree species composition is changing due to species loss from pests and pathogens. The impact of this change on ecological functioning is rarely

tested. Using six sites across the UK, with multiple tree species at each site, we tested for functional differences between three species threatened by disease in the UK (our two native Oak species and Ash) and six other species (Sycamore, Sweet chestnut, Beech, Turkey oak, Red oak and Lime) which have previously been suggested as ecological replacement species. Differences between species were detected for all the variables measured which link to the ecosystem services of nutrient cycling, climate and water regulation. For example, decomposition was faster under Ash than Beech and three of four Oak species, the temperature was cooler under Beech than Sycamore, and Sweet chestnut bark held more water than the other tree species studied. The work highlighted which species replace diseased trees, even at the scale of single trees, and will impact on the functions and ecosystem services provided.

- **Biodiversity trends and changes across northern Europe are being driven by rising temperatures.** A Europe-wide collaboration, including SEFARI researchers, analysed 161 biodiversity time series (over 15 to 91 years duration) covering 6,200 marine, terrestrial, and freshwater species from 21 European countries. The paper published in [Nature Communications](#) showed that local trends in biodiversity often deviate significantly from global patterns. In particular, the composition of species communities has undergone extensive changes at the local level. For northern Europe, the trend is towards an increase in diversity and species numbers which could be attributed to a combination of climate change (e.g. new species adapted to warmer conditions, spread of alien species and recovery from past disturbances and pollution). The study also showed declines in insect species abundances in the Atlantic bio-geo-region (UK, France, Belgium, Spain, Denmark and Germany), corroborating recent reports of worldwide declines of local terrestrial insect communities. The study emphasised the need to standardise biodiversity monitoring schemes and to integrate long-term biodiversity and environmental monitoring data, which will allow conservation measures to be better tailored at the local level.



Work Package 1.4: Integrated Land Use Systems

Major Achievements

- SEFARI researchers have been working with farmers, allotment holders and gardeners to understand their perceptions and values in relation to biodiversity and how this interacts with their practices on their land. The work has identified the existence of three common discourses in terms of how humans, nature and the relationship between them are conceptualised, and how they connect to practices. The results also show many tensions in terms of conflicting goals and values and how to balance nature's perceived needs and other human goals.
- Work from across the SRP on land management, land use and environmental governance (e.g. this [briefing](#) and this [briefing](#)) was used to provide the Scottish Land Commission with an evidence base for their advice to Ministers on the roll-out of Regional Land Use Partnerships. The resulting 32 page report authored by WP1.4 staff was

welcomed as an important contribution to the report to ministers, providing a strong evidence base for the proposals, as well as highlighting previously unconsidered issues and pitfalls to avoid.

- Insights from WP1.2 and WP1.4 were used to complement the results of a Defra funded rapid evidence assessment of the Demonstration Test Catchment programme (2010-2018) and develop policy recommendations to assist with the advancement of the future Environment and Land Management Scheme. The findings were shared with over 80 policy makers during a webinar in June 2020.
- Economic experiments are at the forefront of recent methodological developments to evaluate and provide evidence-based policy recommendations to improve the design of agricultural policies. Researchers from WP1.4 have engaged with the Research network on Economic Experiments for the Common Agricultural Policy ([REECAP](#)) and led the organisation of the network's 2020 annual meeting held online on the 1st and 2nd of September 2020. REECAP is an EU-wide informal consortium created in 2017. It aims to bring together researchers, experts and policymakers interested in the use of economic experimental approaches to evaluate and improve the Common Agricultural Policy (CAP).

Theme 2 - Productive and Sustainable Land Management and Rural Economies

Work Package 2.1: Crop and Grassland Production and Disease Control

Major Achievements

- **Approaches to reducing potato waste by improving home storage and minimising greening:** Working with collaborators from industry and academia, SEFARI scientists have investigated ways to improve potato storage to minimise waste. In particular, new information about the genetic basis of tuber greening and wavelengths of light that can actually reduce greening have been [identified](#). By investigating the effects of different home storage regimes on potato tuber quality and sprouting, [new evidence](#) has been produced that the storage of potatoes in the refrigerator does not have serious negative effects on potato tuber quality. This information will be beneficial in reducing household potato waste.
- **Presentation at Virtual Arable Scotland:** Research was presented at the [Virtual Arable Scotland](#) event and included several videos on novel protein crops, covering the range of approaches being explored, and also a podcast on the same topic. SEFARI scientists also took part in the online debates and live events. A SEFARI Gateway Responsive Opportunity funded "A taste of plants" [film](#) highlights the KE tools and activities, and endorses SG funded research on novel crops across SEFARI was launched at the Arable Scotland event and published on [SEFARI website](#).
- **Driving Integrated Pest Management (IPM) uptake:** IPM practices are key in meeting the major biodiversity and climate change challenges faced in arable production systems. SEFARI researchers and collaborators have developed a novel metric which allows IPM practices to be quantified, revealing the measures most highly valued by farmers. In collaboration with the [Voluntary Initiative](#) and

the National Farmers Union, an [IPM Plan](#) has been developed which will be an annual requirement for the c.8000 UK crop producers under the [Red Tractor](#) quality assurance scheme. This will allow changes in practice relating to uptake of SRP research via knowledge exchange to be monitored.

- **External Funding support from the EU:** SEFARI researchers have secured funding for projects that will build on SRP research. Funding from the EU Horizon 2020 scheme will allow an MRP to expand raspberry and blueberry genomics work and germplasm enhancement through collaboration and is worth around £520K over 3 years. Further funding (£360K over 4 years) will support the [ADAPT](#) project, a consortium of 17 European academic, industry and policy partners aimed at identifying new potato breeding targets and matching potato varieties to specific challenging environmental growth conditions of the future.
- **Alternative cropping systems for sustainability:** SEFARI researchers are looking at ways to use pulses in food and feed. In collaboration with Abertay University and Arbikie distillery this has resulted in the development of [Nadar gin](#) and [Nadar vodka](#) which have a reduced carbon requirement throughout the life of production on farm, and use legumes. Based on [SRP research](#), Arbikie now have 15% legume cover on their farm compared with a national average of 1%, and this level of coverage is a suitable target for any arable farm. This work showcases the importance of adapting both the farm system and the development of products in tandem.
- **Research council funding for potato pathology:** SEFARI and Higher Education Institute collaborations have led to two new UKRI funded projects based on areas of SRP funded potato pathology research. Firstly, the role of a protein present on the eggshells of the potato cyst nematode will be investigated in detail. The protein may have a key role in a critical part of the life cycle of the nematode which allows it to remain dormant until a host is present. Secondly, an additional £1M of UKRI funding will be used to investigate the role and importance of these recently discovered novel

late blight pathogen *P. infestans* to break down plant cell walls during infection. This funding has been leveraged as a result of SRP funded research in collaboration with researchers at the University of York.

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

Major Achievements

- **New Diagnostics for animal and human (zoonotic) disease:** A number of new diagnostic tests have been developed and/or their use implemented over the last 6 months. Following the successful development of a multiplex PCR test for pathogens that cause bovine respiratory disease complex (BRDC), a similar approach has been taken for pathogens that cause abortion in ruminants. Each of the individual PCRs, that will make up the eventual multiplex, have been tested with field samples provided through the SRUC Veterinary Services surveillance team. The next phase of work will investigate the feasibility of combining the individual tests into the multiplex test. The same multiplex technology will also be applied to nematode parasites collected from a sample of 300 sheep. Once all the potential parasites have been identified, the multiplex PCR will be used to monitor parasite populations between vaccinated and non-vaccinated animals. A test for *Babesia* *infestans* has been added to the list of [tick-borne pathogens](#) that can now be diagnosed. An examination of 274 sheep samples known to be positive for Louping-ill or tick-borne fever (*Anaplasma phagocytophilum*), found only one to be co-infected with *B. infestans*, confirming that the prevalence of this parasite is probably still relatively low in Scotland. The work on Lyme Disease (performed in conjunction with scientists in WP2.3) is continuing to determine

which species of *Borrelia* are present in which habitats (upland, lowland, woodland) within Scotland.

- **Vaccine vector technology:** The success of a vaccine is often dependent on how it is delivered to the animal (or human) that is vaccinated. For some pathogens the immune response to the vaccine antigen alone can be poor and therefore the vaccine is often mixed with a carrier (an adjuvant) that helps stimulate the immune response, but these adjuvants can produce unwanted local and/or systemic side effects. WP2.2 scientists have been working on new vaccine delivery methods that involve the use of weakened or non-replicating forms of viruses to deliver the antigen of choice. Preliminary results have demonstrated strong antibody responses against the protective antigens of *Chlamydia abortus* and Louping ill virus, and in the case of the latter, stronger responses than the traditional vaccine was able to engender. The advantage of the virus vectors selected for this approach is that existing exposure of animals to these viruses does not appear to prevent them from successfully delivering the vaccine antigens.
- **Precision livestock farming for sheep:** Although readily applied in the beef and pig sectors, precision livestock farming (PLF) practises have been slower to be adopted on sheep farms. Parasitic roundworms can often go unnoticed and can cause increased costs to the farmer, due to the slower growth rate of the lambs infested by roundworms, and at market, the price paid for such lambs can be reduced due to lower carcass quality. Not only this, but the increased time to market, as well as the increased inputs, increase the relative amount of greenhouse gases produced by affected lambs. [Following on from longstanding research](#), carried out over successive strategic research programmes, on both lowland and upland research farms, which both helped to prove the principle, the PLF approach has now been tested on a commercial farm.



Using one of the QMS monitor farms, roundworm control required 40% less anthelmintic treatments, thus not only saving money for the farmer but should help to slow the development of resistance to the chemical drenches and reduce the overall reliance on chemicals for parasite control. The success of this project has helped to leverage EU Horizon2020 funding (TechCare – started in Sep 2020) to develop a method to improve welfare management in small ruminants.

- **Bringing Animal Welfare to Livestock Product Chain Assurance.** The Qualitative Behaviour Assessment (QBA) helps with the interpretation and analysis of emotional expressivity and welfare in animals which has been shown to improve animal welfare. In recent months QBA has been adopted by Waitrose as the designated indicator for animal emotional state and, in partnership with SRUC, will be rolled out across Waitrose's 'own brand' cattle, pig, broiler, hen, and duck supply chains, encompassing 640 farms (including 240 pig farms, 200 laying hens farms, 100 broiler farms, 29 duck farms, 69 dairy farms and 1 veal farm). QBA is also in routine use in the welfare programmes of the Donkey Sanctuary (since 2015, reaching 27,400 donkeys worldwide by 2020), and part of a mandatory welfare assessment in all 15 UK zoos holding captive elephants (since 2017). The world

leading work on Animal Behaviour and Welfare in Scotland and it's importance in informing and setting the policy and industry agenda can be demonstrated by two leading scientists being appointed to the recently convened Scottish Animal Welfare Commission ([SAWC](#)), which will be chaired by Professor Cathy Dwyer.

Work Package 2.3: Productive and Sustainable Land Management

Major Achievements

- **Long-term monitoring required for biodiversity indicators:** Findings from research in WP2.3 (RD2.3.9) on environmental/economic trade-offs and indicators of biodiversity for monitoring impact in agroecosystems, were accepted for publication with press releases highlighting the need for systematic, long-term monitoring of biodiversity indicators for future resilience of ecosystem services.

- **Virtual farm tours:** Members of WP2.3 (RD2.3.4, 2.3.8, 2.3.9) produced and presented a [virtual farm tour](#) of the Centre for Sustainable Cropping long-term platform, funded through the SEFARI Gateway Responsive Opportunity Fund, along with tours of Grieve's House tillage trial (also at Balruddery Farm), Craibstone and Boghall (SRUC long-term platforms) at the on-line Arable Scotland event Thursday 2nd July 2020. The virtual tour presented results from the Integrated Cropping Systems research to over 70 visitors and was followed up with an article on weed diversity for ecosystem services in *Farmers Guardian*.
- **Global Long-Term Agricultural Experiment Network (GLTEN):** Meta-data from the Centre for Sustainable Cropping platform, gathered as part of research in WP2.3 (RD2.3.9) on trade-offs in agroecosystems, were collated for the Global Long-Term Agricultural Experiment Network, a network of over 60 long-term agricultural experiments across the world which represent diverse and contrasting climate regions and environments, as well as multiple crop systems and land management schemes. The network, of which the CSC is now part, makes metadata available online under a FAIR Data Principle (findable, accessible, interoperable, and reusable), thereby adding value to individual site data in the exploration of more general global trends in cropping systems.
- **Johne's Disease in soil:** Researchers in WP2.3 (RD2.3.3) have tested the National Soil Inventory of Scotland soils (over 200 samples) for the prevalence of *Mycobacterium avium* paratuberculosis (MAP), which causes Johne's Disease in sheep and cattle. It has also been linked to Crohn's Disease in humans. The map of the prevalence of MAP is available to stakeholder upon request.
- **Leveraging the underpinning funding** in the Langhill dairy experiment, and core to many activities in WP2.3, has been a key component of plans for a Dairy Nexus included in the Borderlands Inclusive Growth Deal. The Dairy Nexus will provide a flagship facility that positions the Borderlands at the forefront of industry-

focused, rural co-innovation and knowledge exchange. It will drive transformational research and innovation to decarbonise the dairy sector and move it towards a circular bioeconomy. In doing so, Dairy Nexus will deliver significant and inclusive regional growth to underpin the rural communities that are so important to the Borderlands economy and its regional identity. This £34.2M project that requires £8.0M of capital investment will deliver £57.1 million in GVA and 739 job years (in NPV terms) in the Borderlands region. In parallel with the development of this proposal, we are pursuing funding through UKRI's flagship 'Strength in Places' fund for a project titled 'Digital Dairy Value-Chain for South-West Scotland and Cumbria'. We have recently succeeded in 'round one' of this highly competitive funding mechanism and have been awarded funds to develop a full proposal. Digital Dairy Value-Chain for South-West Scotland and Cumbria' builds on and leverages the investments proposed in 'Dairy Nexus'.

- **National Recognition of our Delivery of Data Innovations.** Prof Mike Coffey will be announced as the most recent recipient of the Royal Association of British Dairy Farmers Princess Royal Award for his outstanding contribution to the UK dairy industry. This is in recognition for the ongoing innovations in the application of world leading data and statistical science (WP2.3) and developments in genomics (WP2.2) to the understanding of the genetics of production and fitness traits in cattle - with core activities linked to Theme 2 that subsequently are delivered to Dairy farmers via [EGENES](#). Results of these evaluations are published for 95% of all dairy bulls marketed for artificial insemination in the UK and for 65% (800,000 million live animals) of the current UK milking herd every month, and inform mating decisions taking place on farms across the UK. The net value of these accelerated rates of genetic gain across the UK national cattle herd is estimated to be valued £60-80m per annum for the dairy industry.

Work Package 2.4: Rural Industries

Major Achievements

- **UKRI COVID-19:** Food and Nutrition Security during and after the COVID-19 Pandemic. This SEFARI-led and UKRI funded project is drawing on expertise from across the SRP to look at the short/medium term economic and social consequences of COVID-19 for food security, particularly the potential for disruptions to supply chains.
- **COVID-19 analytic and industry knowledge support:** During the COVID-19 crisis our scientists have contributed by providing regular support to RESAS and Scottish Government Policy officials. Regular updates on industry developments were provided during the lockdown, as consumer and industry confusion reigned. For example, support on fruit and vegetable costs, amenity horticulture, the farming calendar, etc helped provide evidence to support RESAS' Covid dashboard and inform policy during a period of significant disruption. Additionally, during the final stages of the data collection for the 2020 Rural Business Survey additional COVID-19-related questions were added and responses analysed over time for RESAS and Scottish Enterprise.
- **Agricultural Policy Development:** Our researchers have been heavily involved in supporting the ongoing evolution of agricultural policy in Scotland. This has come through direct interaction with senior policy officials, including the drafting of conceptual papers and provision of analytical support.
- **Woodland Expansion:** This project mapped the net carbon storage for 11 forestry management alternatives for new woodlands on all non-forested land in Scotland. This used the dataset of unique climate, soil and land use combinations from the SRP with the ECOSSE soil carbon model (Aberdeen University) and Ecological Site Characterisation, Forest Yield and Woodland Carbon Code datasets (Forest Research). Estimates for the above and below ground carbon were made over time and space. These highlighted the need for supplementary C tonnage as well as area targets for new woodlands. The open access journal [paper](#) was supplemented by online [mapping tools](#) both of which received favourable comment from a range of stakeholders. A regional follow up study in being undertaken and funding sought to further develop the analysis.
- **New Reports:** The [Private Water Supply](#) vulnerability to climate change (CREW) and [Cairngorm Future Snowfall](#) (CXC) reports were only possible due to underpinning SRP support. Both have been enabled by investment in the SRP on new climate and climate change datasets, bias correction/testing and indicator development. Both have been well received by their respective clients with [follow up work](#) commissioned by CNPA and the potential identified for further analysis of PWS to include other factors influencing water availability (e.g. land use change).
- **Study reveals aquaculture greenhouse gases on par with sheep industry.** In the first study of its kind, published in [Nature](#), SEFARI researchers collaborating with FAO, Cargill and WorldFish found that, in 2017, the fish farming sector generated 0.49 per cent of anthropogenic GHG emissions, or 263 million tonnes of carbon dioxide equivalent (MtCO₂e). The study quantified the emissions arising from the main cultured fish species (including shellfish) around the world. It found that, while the carbon footprints of aquaculture products vary by system, the emissions from feed production generally dominate. The research was carried out to raise awareness of how and why GHG emissions arise in aquaculture supply chains, and has received coverage in the national press ([The Scotsman](#), [The National](#)) and international [trade media](#).
- **The socioeconomic and biodiversity impacts of driven grouse moors and the employment rights of gamekeepers.** This work, commissioned by the Scottish Government, builds on the [Phase 1](#) Grouse Research undertaken through the programme. The project, led by scientists from Theme 2 with Theme 1 and 3 inputs, has provided a range of [new evidence](#) to the Scottish



Government that should help inform their response to the Grouse Moor Management Group's report and recommendations. The work generated new evidence relating to: (a) the costs, returns and employment impacts of grouse shooting and alternative moorland uses; (b) the employment rights of gamekeepers; (c) Updated and improved GIS mapping of muirburn intensity and grouse butt density along with new insights into the extent of land used for driven grouse, and (d) the impact on a selection of biodiversity species arising from different intensities of muirburn on areas associated with driven grouse. The reports have been published in November.

- **Business Resilience:** SEFARI scientists have continued to work with Scottish Government to develop approaches to understand viability and resilience in agriculture. Interest in this work, and its relation to Brexit and COVID-19 have been taken up by [trade and popular press](#). Moreover, this has been transferred through the UKRI funded [RESULTS](#) project which has enabled engagement with Scottish and wider

UK administrations but has a strong focus on [upland and island resilience](#). Additionally, we used our ScotFarm farm level model to assess how resilient Scottish dairy and beef farms are to [liver fluke infections](#), with and without climate change effects. Our analysis suggests a 12% reduction in net profit on an average dairy farm compared to 6% reduction on an average beef farm under standard disease conditions. The losses increase by two folds on a dairy farm and six folds on a beef farm when climate change effects are included with disease conditions on farms.

Theme 3 - Food, Health and Wellbeing

Work Package 3.1: Improved Food & Drink Production

Major Achievements

- **Soft fruit health benefits:** Publications identified (i) how specific polyphenolic [components of soft fruit](#) inhibit an enzyme which regulates insulin signalling, identifying the potential for soft fruit extracts in the management of type 2 diabetes, and (ii) potential genetic markers to assist with breeding of health beneficial (e.g. CVD, diabetes) [polyphenol components in blackcurrants](#).
- **Controlled environment agriculture (CEA)/vertical farming (VF):** Researchers discussed CEA/VF research with industry delegates at the BBSRC/EPSC Advanced Horticulture Workshop (Feb-20). Consortia have won 3 Innovate UK awards with a value of £1.57M: (i) nano/microbubbles in hydroponic systems to improve crop productivity through captured carbon utilisation (Hydrobubbles; £0.25M), (ii) development of varieties best suited for "high health" CEA/VF (CHOPS; £0.82M), and (iii) control architectures for CEA/VF systems and extending use to new areas e.g. microalgae and insect protein production (PROLEAFS; £0.5M).
- **BBSRC UKRI Global Challenges Research Funding:** The project 'ZIRON Pulse', draws upon SRP expertise to develop new varieties of common bean with high levels of iron and zinc, in collaboration with Kenyan academics, growers, processors and consumers, thereby addressing micronutrient deficiencies in rural communities.
- **Food safety:** Key papers build on a track record of output on food-borne toxins: (i) the dietary exposure of UK children to [multiple mycotoxins](#) from foods showing that safe levels of intake are frequently exceeded, and (ii) how different edible plants and plant extracts impact the growth response of food poisoning organisms, such as Shiga-toxicogenic *Escherichia coli* and its common [O157](#) (and less common [non-O157](#)) serotypes. An understanding of the impact of plant factors on the ability of Shiga toxin-producing *E. coli* to grow and establish is required for food safety and risk assessment. In recognition of this expertise, a

researcher joined the UK Food Standards Agency Register of Specialists: 'Food safety – chemical contaminants & additives'.

- **Crop and food waste:** SRP publications have highlighted that both intentions and habits had a relatively strong influence on consumer [behaviours leading to food waste](#), whilst the need for better coordination between [food waste and safety policies was identified](#). InnovateUK funding, underpinned by SRP expertise, is valorising agri-waste in development of sustainable Personal Protective Equipment (PPE) (Novel nanocellulosic composites as antivirals and antimicrobials for new PPE materials; NanocellPPE, [£0.5M]). The project targets absorbent materials with better multi-use protection, reducing waste streams and environment impact.

Work Package 3.2: Healthy Diets and Dietary Choice

Major Achievements

- **Stakeholder engagement and presentations:** The food-gut-brain axis is a major focus of interest in human health. Researchers gave invited talks to (i) the Royal College of Psychiatrists (Mar-20) on the food-gut-brain axis in Alzheimer's disease, and (ii) the Nutrition Society (Jul-20) on protein metabolism by human gut bacteria and impacts on health; another talk focussed on health benefits of plant-based diets on colonic microbiota and metabolites in obese subjects.
- **Funding success:** Innovate UK funding (£316k) was secured for a translational project supporting the microbiome therapeutic company, EnteroBiotix, in new product development, applying SRP expertise to microbiome modulating therapeutics.
- **Gut microbe publications:** Published work on important fibre-degrading human gut microbes: (i) [functional adaptation of subspecies of *Eubacterium rectale* and their geographic distribution](#) and

(ii) [establishment of *Coprococcus eutactus* as a beta-glucan-fermenting microbe](#), informing the development of nutritional strategies to stimulate potentially beneficial microbes in the gut.

- **SEFARI website:** Two Blogs ('[Barking up the right tree](#)' on human gut bacterial metabolism of Spruce tree gums; '[Food for thought](#)' – on Alzheimer's disease and the food-gut-brain axis) and two Case Studies ('[Protein for Life](#) – supporting healthy ageing in partnership with the food sector'; '[Modelling the effect of social networks in reducing meat consumption](#)') were published.
- **Food habits in the pandemic:** A study from earlier in the SRP was repurposed and extended to assess the impact of COVID-19 on our food habits. The study, reported in a [SEFARI blog](#), will react to the evolving situation of COVID-19 restrictions.

Work Package 3.3: Food Security

Major Achievements

- **Consumer views:** A [paper](#), 'How consumers in the UK and Spain value the coexistence of the claims low fat, local, organic, and low greenhouse gas emissions', concluded that demand for beef mince with low fat content can be increased if also labelled as 'organic' or 'low GHG'.
- **Brexit and COVID-19 affect agri-food supply chains:** Blogs for the London School of Economics Business Review attracted print and online media attention: '[What can we expect from a ban on junk food price promotions](#)'; '[Covid-19: the underlying issues affecting the UK's food supply chains](#)'; '[The UK's fresh produce supply under Covid-19 and a no-deal Brexit](#)'.
- **Leveraged COVID-19-related funding:** The 'FeedUs' model of global trade in food and

nutrition is being used in an ESRC-funded project on the impacts of COVID-19 on food security, conducting a rapid food and nutrition security risk assessment and exploring options for changes in agricultural production, trade and distribution to protect food and nutrition security.

- **Modelling food security:** Researchers contributed to a paper in the journal, [Global Environmental Change](#), modelling food security in ways that link local and global scales.
- **SEFARI Gateway Fellowship with Highlands and Islands Enterprise:** A researcher has examined the potential for Scotland's Highlands and Islands to be involved in the [Arctic Foods Innovation Cluster](#), and the ability of food clusters to offer economic and social capital benefits within rural Scotland. A draft report was sent to the Scottish Government Arctic Policy Framework Team. The project has enhanced engagement with colleagues working on the Framework and its contribution to Scotland's international relationships with the Arctic Nations.
- **Understanding how people experience food insecurity:** Researchers presented a paper 'Re-thinking the relationship between food insecurity, health and social isolation' at the Nutrition Society (Jul-20). The findings point to the importance of individuals' health and social networks in their becoming food insecure and in their efforts to regain food security.





Work Package 3.4: Communities and Wellbeing

Major Achievements

- **COVID-19:** A researcher was invited onto the SG's COVID-19 Stakeholder group for Rural Economy and Communities chaired by Fergus Ewing and Mairi Gougeon. As a result, WP3.4 researchers altered their planned work to focus on the effect of the pandemic on rural communities. Key stakeholders were interviewed, and a draft policy brief was shared with the group on 27 Aug-20. The RESAS science advisor requested responses to questions to feed into a ministerial briefing (01 Sep-20). A tool will be developed to identify where rural communities have responded with resilience and case studies will examine impacts and lessons for policy.
- **Flooding:** A researcher appeared on [BBC 'Landward'](#) in May-20 to discuss the long-term impacts of flooding on communities in NE Scotland, receiving media attention (May-20).
- **Towards Inclusive Growth:** SEFARI Gateway Responsive Opportunity funded work with

Highlands and Islands Enterprise on 'Inclusive Growth', developed a [framework](#) to measure the relationship between prosperity and poverty in delivering an economy that combines fairness and prosperity, and established a [better understanding](#) of inclusive growth in the Highlands and Islands.

- **Rural repopulation work:** A case studies [report](#) examining an [integrated approach](#) to repopulating remote areas received media coverage ([Scottish Farmer](#); [BBC Orkney](#)).
- **Health and Wellbeing:** Engaging individuals and communities in and with their natural environment has potential mental and physical health, social and economic benefits. Papers were published on (i) [nature-based interventions](#) to promote health and wellbeing through behaviour change, and (ii) what motivates people to join [citizen science conservation initiatives](#).
- **Funding:** Funding was secured (i) from SG to survey the National Islands Plan, (ii) from NERC's Valuing Nature Programme on environmental science and mental health, and (iii) from Children's Neighbourhoods Scotland to review rural poverty/ social exclusion.



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