

The Scottish Environment, Food and Agriculture Research Institutes' (SEFARI) responses to COVID-19



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Foreword

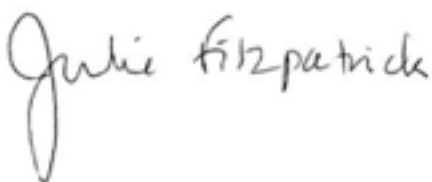
The Scottish Environment, Food and Agriculture Research Institutes (SEFARI*) have produced this synopsis of their current actions and combined capability available to assist national and regional strategies in dealing with the extreme public health and wider societal crisis posed by the COVID-19 (SARS-Cov-2) pandemic.

SEFARI enshrine over a hundred years of expertise, facilities and datasets within the environment, food, agriculture and rural community sectors, providing a national research capability focused on delivering [Scotland's National Outcomes](#). This interdisciplinarity is informed through SEFARI's enduring partnerships across public agencies, sector representative and civic society organisations. Such capacity is the result of sustained and ongoing financial support from Scottish Government (RESAS) to provide policy-relevant mid to long term strategic research and which also underpins leverage of income from UK, EU and international research funders, including from commercial companies. Collectively this has endowed SEFARI with extensive regional, national and international partnerships that build on and enhance institutional and collective research capability.

SEFARI offer a range of [expertise](#) of direct and immediate relevance for COVID-19 including: core facilities for working on infectious agents; disease modelling and epidemiology, virology, diagnostic testing; high-performance computing and data analytics. SEFARI also has significant capability to respond to the web of challenges caused by and related to the COVID-19 pandemic, such as expertise on understanding and developing responses to the economic and societal impacts that will be present during and beyond the immediate response to COVID-19.

Throughout their history SEFARI have responded to various emergencies and extreme events, and helped Scotland to be more resilient. The current focus on COVID-19 is unprecedented. SEFARI are doing everything possible to support efforts against COVID-19 and, in learning from both immediate and long-term needs, will continue to build relevance to future outbreaks of emerging, re-emerging and novel infectious agents of plants, fish, and livestock, and the outbreaks, epidemics and any pandemics these may cause.

Very best wishes,



Professor Julie Fitzpatrick,
Chair, SEFARI Directors Executive



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

Executive Summary

- SEFARI encompasses over a hundred years of expertise, facilities and datasets in the environment, food, agriculture and rural community sectors, providing a national interdisciplinary, strategic and responsive research capability.
- SEFARI's combined capability and expertise is available to assist national and regional strategies dealing with the COVID-19 pandemic.
- SEFARI's enduring partnerships with public agencies, sector representative and civic society organisations across Scotland and the UK enable SEFARI to form multi-stakeholder research partnerships directed to priority needs.
- SEFARI has core facilities and expertise to assist with COVID-19 response including:
 - A CL3 pathogen containment facility
 - CL3 laboratories
 - Biological testing and processing technologies
 - High Performance Computing
 - Vaccine technologies
 - Virology
 - Disease surveillance
 - Biological (molecular) diagnostics
 - Modelling and epidemiology
 - Bioinformatics
- SEFARI are supporting individuals and communities during lockdown through online educational and wellbeing resources.
- Staff at both professional and personal levels are volunteering and working in their communities to assist the NHS, key workers and vulnerable individuals.
- SEFARI expertise is being deployed and made available to support current wellbeing, societal and economic analysis and recovery strategies, with expertise including:
 - Community resilience
 - Individual and societal behaviours
 - Rural business
 - Agri-food innovation
 - Supply chains and networks
 - Nutrition and wellbeing
- SEFARI is developing new research and national and international collaborations in response to COVID-19.
- SEFARI (Gateway) is providing rapid, bespoke knowledge exchange to assist new and ongoing strategic needs of stakeholders.

SEFARI offer a range of expertise which are being deployed and may assist in understanding and responding to the immediate, and longer-term web of challenges caused by, and related to, the COVID-19 pandemic. These include core facilities for working on infectious agents; experience in epidemiology, virology, diagnostic testing and (animal) vaccine development, through to expertise on understanding and developing responses to the economic and societal impacts that will be present during and beyond the immediate response to the COVID-19 pandemic. The remainder of this briefing will provide more information in these areas.

SEFARI expertise and knowledge relevant to COVID-19 analysis and testing

Virus surveillance & virological support

The Virus Surveillance Unit (VSU) at the Moredun Research Institute combined with SRUC's centralised diagnostic facility with its high throughput diagnostics for livestock disease and the equipment needed for DNA/RNA extraction and PCR diagnosis, provide a major virological capability. A range of highly sensitive quantitative tests to detect and identify a range of viral pathogens including for bovine coronavirus have been developed. The VSU holds a bank of virus isolates to enable monitoring for changes to existing and newly emerging viruses. The unit's staff provide specialist support to Scottish Government and veterinary laboratories nationally.

SRUC also provides UKAS quality assured (UKAS ISO 17025 certification) veterinary laboratory testing and specialist advice to veterinary surgeons throughout the UK in the farm animal sector. These facilities, staffed by veterinary surgeons with a broad knowledge of animal health, supported by laboratory scientists and technical staff, undertake national livestock disease surveillance, conduct livestock health schemes as well as veterinary clinical pathology/pathology UK-wide services, which could be incorporated into assistance for COVID-19 response.

Specialist research and containment facilities

SEFARI collectively have a long track record of working on a range of plant and animal pathogens important in agriculture and nature, and have high level containment facilities for this research. Moredun Research Institute's laboratory and animal facilities operate up to containment level 3 (CL3) and have extensive experience of working with pathogens up to Hazard Group (HG) 3 level. Both of these capabilities would be required for working with COVID-19. The Institute's staff are also trained for working within the National Network Laboratory for the Home Office for handling HG3 and Schedule 5 pathogens (pathogens as subject in the Anti-terrorism, Crime and Security Act 2001). The Institute's animal disease models are also useful for research into human pathogens such as COVID-19.



Surveillance, modelling, molecular epidemiology, bioinformatics and gene sequencing

SEFARI has extensive experience of developing spatial, ecological and epidemiological modelling, disease-surveillance, forecasting and molecular epidemiology through the James Hutton Institute, SRUC, Moredun Research Institute and BioSS, and in more recent years including our work in and through the Scottish Government's (RESAS-funded) Centre for Expertise (CoEs) on Animal Disease Outbreaks ([EPIC](#)) and Plant Health Centre ([PHC](#)). The benefits from this partnership approach are recently discussed by EPIC with regard to [modelling](#) for pandemic preparedness. Examples on in-state expertise and capacity include from SRUC which, through roles in EPIC, the Crop Clinic, and the Edinburgh Genetics Evaluations Solutions (EGenes), has vast expertise in the development of databases for a research (national and international) service provision. BioSS has specific expertise on statistical inference for models of epidemic spread using available data, e.g. case reports. This can be used to estimate model parameters that determine epidemic progress and facilitate design of control strategies.

Overall, the expertise within SEFARI and through its CoEs and wider partnerships combined with advanced data analytics and statistical modelling deploying: [high-performance computing](#), (bio-) informatics, machine learning and artificial intelligence, provide a strong opportunity to aid understanding of current to future disease transmission and its wider impacts.



Antibody testing

Moredun Research Institute and SRUC have experience in developing and running serology based assays to detect antibodies to pathogens. This would be very useful in the current COVID-19 pandemic, as antibodies last longer in patients and are an indicator of exposure to the virus (even in the asymptomatic) aiding with understanding of the potential and longevity of acquired immunity. Moredun Research Institute and SRUC have the potential to run thousands of serological tests a day manually and this capacity could be increased substantially by applying robotic technology. BioSS also has research and [consultancy-oriented expertise](#) in assay evaluation, specifically evaluation of tests in field conditions in the absence of a 'gold standard'.

Behavioural and social science

SEFARI has a track record of policy targeted social science research on understanding drivers of actions within networks e.g. food supply chains (SRUC, Rowett Institute, James Hutton Institute) and food health behaviours (Rowett, SRUC, James Hutton Institute, BioSS). This includes developing models of attitudes/perceptions and behaviours to a range of stimuli (e.g., climate change, animal welfare/health, water quality, food waste, healthy eating) and other policy instruments (e.g. agricultural policies, food taxation, health, & inequalities). In addition, there is social science expertise in rural community resilience and the mental and physical importance of interactions with nature. Both are topic areas of high relevance in the immediate and longer term response to COVID-19. Across SEFARI, research skills that underpin behaviours research include agent-based modelling and survey work (targeted questionnaire surveys, phone interviews) with potential to run online focus groups where appropriate. This could help to understand the social implications of the COVID-19 measures at individual, regional and population levels.

Institute facilities and expertise registered as available for use and equipment being relocated to support COVID-19 response

Across the SEFARI institutes, facilities are available to aid understanding and responses to COVID-19-related challenges, and these extend from high-tech specialist equipment through to laboratory space and personal protective equipment (PPE).

Institute core facilities available to aid COVID-19 testing and analyses

- Institutes have the capacity to complete high throughput biological testing, and all have registered expertise, facilities and resources with the NHS to assist in various testing regimes for COVID-19, if required.
- Moredun Research Institute, James Hutton Institute, SRUC and Rowett Institute, have extensive experience of running diagnostic real-time RT-PCR assays, which are currently the preferred testing system for COVID-19 (using patient swabs), along with a range of other PCR based diagnostics. These institutes also have the required Thermo Fisher PCR machines to process samples.
- Diagnostic test capacity is supported by a range of sample processing technology (e.g. robotic liquid handling) and other PCR based diagnostics.
- State of the art High Performance Computing (HPC), for processing what is often referred to as "big data" and integrating multiple and complex data sets, is a key capability within specific Institutes. The sharing of this expertise has recently been extended across SEFARI by a Gateway [Responsive Opportunity Project](#).
 - HPC at the James Hutton Institute

is central to multiple aspects of the Institute's research, allowing tackling data analysis at scale for Next-Generation Sequencing, environmental and remote sensing data sets, or running complex climate and weather models.

- Databases and associated informatics at SRUC are underpinned by a suite of HPC for handling large and complex datasets and advanced statistical models. This includes high capacity servers for high demand computing to be undertaken on very large data sets and/or highly complex datasets. In particular the Nvidia DGX station is expressly designed for machine learning for 4 GPUs and 20,000 500-cores.
- These facilities are suited to use for understanding pandemic epidemiology. The James Hutton Institute has recently made facilities available to international research groups investigating COVID-19.



Institute facilities, experts and administration already deployed to aid COVID-19 response

- Three automated, high throughput extraction systems from the James Hutton Institute and Rowett Institute have been loaned to NHS Highland, NHS Lanarkshire and NHS Grampian to assist COVID-19 testing and DNA sequencing.
- The Rowett Institute has loaned: two ThermoFisher Applied Biosystems 7500 Real Time PCR machines and one Qiagen QIAcube sample processing unit to NHS Grampian, which will significantly increase clinical labs testing throughput. Additional equipment availability has been identified but has not been requested by NHS Grampian yet.
- The James Hutton Institute has supplied reagents and consumables to the new

testing facility at Edinburgh University through the central coordination hub for the NHS.

- The Rowett Institute is ideally placed to provide assistance to the NHS due to its site co-location with Aberdeen Royal Infirmary and main regional clinical testing labs. The institute also has existing clinical contacts working with NHS Grampian departments on the secondment of expertise and the processing of volunteers from its staff, including the completion of an NHS 'snap survey' to capture required technical and clinical lab skills.
- The Rowett Institute is providing administrative support for a new training centre for redeployed and retired NHS workers, which has been created in the University of Aberdeen Clinical Skills Suttie Centre at Foresterhill, Aberdeen.

Staff volunteering and supporting PPE provision

Laboratory work requires PPE and SEFARI have variously donated these to local NHS sites, care homes and charities, and with SRUC also donating equipment for use as ventilators.

SEFARI have been more than encouraging and supportive of staff wishing to volunteer during the pandemic, not only through their expertise but also more general volunteering within local communities and helping those in need and at risk.

- The Rowett Institute's staff have volunteered as part of the University of Aberdeen NHS COVID-19 testing response.
- The James Hutton Institute, using employee, family and local network connections, are supplying clear acetate sheets to NHS Tayside's Orthopaedic and Rehabilitation Technology Services Centre and the Men's Shed in Westhill, Aberdeenshire, to help produce face shields to replenish

PPE stocks for frontline workers.

- James Hutton Institute members of staff have produced close-fit face masks that are being provided to a local women's refuge centre in Dundee.



New projects applied for or instigated to support COVID-19 response and recovery

SEFARI has immediately responded to a range of research calls on COVID-19, including from the Chief Scientist's Office (CSO) in Scotland and the UK's Royal Society. Given the rapidly developing calls and initiatives, multiple projects are now under application variously covering approaches to testing, disease modelling and impacts on communities or sectors of the economy. Progress as to these and new applications will be updated regularly.

Collaborative use of pathogen research and containment facilities

In response to the CSO Scotland call, more than 12 collaborative research proposals have been established with Moredun Research Institute, involving many of the HEIs across Scotland as the planned research requires access to CL3 labs and trained staff for appropriate health and safety.

Disease modelling, epidemiology and testing (national and regional scales)

- SRUC have made a collaborative application to CSO Scotland for research on machine learning to predict COVID-19 status from saliva swabs.
- BioSS is a member of the [Scottish COVID Response Consortium](#) (SCRC), along with EPIC and the Boyd Orr Centre for Population and Ecosystem Health (and other staff) at the University of Glasgow. Additional expertise is being leveraged from SRUC and Heriot-Watt University.
- The SCRC submission to the Royal Society's Rapid Assistance in Modelling the Pandemic (RAMP) call was successful and has been adopted as a hub/workpackage, one of only three chosen from over 1800 applications. The Royal Society have linked SCRC with HPC and coding experts in C++,

Java and Julia programming from UKAEA (Atomic Energy Authority), who will hopefully be able to help run models at scale. SCRC are working on projects relating to the repurposing of models of epidemic spread, and the development of inferential methods for coronavirus models.

- Funding is being sought from the CSO Scotland for applying mathematical modelling of COVID-19 spread to look at how resources for surveillance and control can be best deployed to give the most effective suppression of the epidemic within the Scottish context; this is a BioSS joint application with Heriot-Watt University.

Future novel capacity for vaccine development

- Moredun Research Institute has developed novel vaccines for multiple livestock pathogens responsible for impacting various aspects of food production and animal welfare over the decades. The Institute has the capacity to undertake proteomics, transcriptomics and bioinformatics which allow the identification and testing of protective vaccine antigens. Recent vaccine development includes targeting viruses which are zoonotic (pass between animals to humans) and also include using viruses as part of vaccine delivery protocols. Facilities allow testing of viral vaccines up to CL3 level.
- Plant science research and facilities (e.g. novel controlled plant growth containment) at the James Hutton Institute offers the future potential for large scale Good Manufacturing Practice compliant use of plant systems as "factories" to synthesize protein-based products, such as biosafe non-infectious [virus-like particles \(VLPs\)](#) for use as vaccines.

This technology, which does not use genetically modified plants, has the potential to deliver high yields of candidate proteins and in a manner that is arguably safer, cheaper and more scalable than many traditional vaccine production systems. This is exemplified by a few companies using somewhat different plant vaccine technologies to the James Hutton Institutes e.g. KBP/Mapp Biopharmaceutical's production of the first testable and deployable Ebola virus vaccine (ZMapp). Moreover, Medicago has successfully used plants to produce COVID-19 VLPs as a candidate vaccine 20 days after receiving the virus coat protein sequences.

Proposals to aid PPE use

Amongst its series of applications to CSO Scotland, SRUC has led a collaborative application on the development of recyclable bio-film plastics for PPE.

Surveying and modelling impact on business, agriculture and horticulture

- Researchers at SRUC are surveying rural businesses with specific COVID-19-related questions and analysis for Scottish Government and Scottish Enterprise to assess business confidence levels. There is potential to extend this survey to assess the impacts of COVID-19 to aid with policy decisions.
- Through the PHC, SEFARI scientists are contributing to work to understand: (a) where increased risks to plant health occur due to the outbreak (e.g. online sales, reduced inspection), (b) where plant health capacity could help in future public health outbreaks and (c) mapping the networks by which information flows in the plant health sector and identifying potential pinch points for intervention.
- BioSS are seeking funding from the "Data-Driven Innovation" initiative of the Ed-

inburgh City Deal for a project concerning the understanding of the impact of COVID-19 in Scotland's livestock sector, jointly submitted with the Roslin Institute. If funded, the project would take a risk-based approach to policy prioritisation and communication. It aims to improve understanding of how farmers in Scotland are affected by the implementation of COVID-19 mitigation activities, and to measure objectively how the implementation of COVID-19 mitigation activities impact on the trade of live animals in Scotland. This relates specifically to live cattle and sheep movement networks, and how this links to reported farmer-led responses.

Understanding the impact on food supply and nutritional health

The pandemic involves an immediate (and potentially long term) element of disruption to food systems and food culture, and there are concerns about how dietary choices can rapidly shift at the population level to affect health and wellbeing. SEFARI has expertise in understanding and advising on disruption to supply chains, routinely advising growers and producers around adapting to extreme events and advising government on agricultural policy.

- SRUC and James Hutton Institute have provided assessment focused primarily on policy positions on fruit, vegetables and potatoes, as well as ornamental horticulture.
- SRUC have published a report on opportunities for [boosting agricultural productivity](#), during external pressures of trade and policy, and the current COVID-19 outbreak.
- SRUC has undertaken initial assessment of the impact of Covid-19 on the food system for the most vulnerable (e.g. [Covid-19 and UK food supplies](#)) which is being developed further in a new proposal.

- The Rowett Institute is developing a proposal on assessing the impact of the COVID-19 crisis on food supply, consumer behaviour and consumption.

Aligned with advising on food production and supply, expertise on nutrition and diets provides an important resource for public and business alike.

- The [Human Nutrition Unit](#) team at the Rowett Institute have created new recipes to support affordable healthy eating during lockdown. These recipes, available on their web site, focus on [home-store cupboard ingredients](#) and have generated interest across social media platforms.
- A series of health focused [seafood recipes](#) have also been developed working with a North East Scotland food producer.

Understanding impact on community resilience

The COVID-19 outbreak and consequent “lockdown” has far reaching implications for the resilience of communities and individuals. Through the work of the strategic research programme, James Hutton Institute and SRUC researchers offer expertise in social science and are well networked within rural and remote rural communities and their associations. They are thereby well placed to facilitate joined-up working across different local contexts to overcome related challenges.

- Findings from SEFARI’s ongoing strategic research on [community resilience and wellbeing](#) in rural areas have significant potential to benefit future policy development to aid the needs of social and economic recovery post COVID-19.
- SRUC’s [Rural Policy Centre](#) has a record of synthesising and analysing international policy approaches. This could focus on rapid assessment to enable learning from

international responses to COVID-19.

- A range of new research applications are being submitted by James Hutton Institute and SRUC. These proposals are linked to community resilience, illustrating key facets of expertise that can inform our understanding of and strategies for post COVID-19 recovery efforts. These include: to use of James Hutton Institute expertise in community engagement and digital technologies to assist NHS and community care workers to manage health and well-being in remote and rural communities with the University of Highlands and Islands; to use SRUC expertise within epidemiological modelling of COVID-19 spread and control measures in Highlands and Islands, including its tourism implications, and understanding the behavioural drivers of COVID-19 restriction measures on rural communities, including front line workers.

Supporting mental wellbeing

Recognising the important mental health benefits from connection with nature during social isolation, RBGE has launched '[Virtual Spring](#)'.



New online films, images of the four Gardens in bloom, blogs and daily updates are all being produced behind-the-scenes during the temporary closure of the garden. This has been extremely popular (e.g. #VirtualSpring video footage of *Magnolia campbellii* in bloom reached an audience of over 300,000, generated 91,200 views and 28,800 engagements). In total the Virtual Spring has now reached an audience of 1.12 million, 102.4k engagements, and 241.5k video views.

Colleagues in EPIC have also showcased mindfulness videos on social media, featuring tranquil aspects of nature. The SEFARI Gateway funded Responsive Opportunity project [Waterwall](#) has been launched (led by the James Hutton Institute in collaboration with Scotland's Centre for Expertise in Waters ([CREW](#)), RBGE, Moredun Institute and BioSS) collating images of rivers, lochs and coasts around Scotland and placing them on an interactive map of Scotland.

Home learning and educational support during lockdown

SEFARI undertakes an extensive range of school-age engagement, providing both a physical and an electronic window into the strategic and wider research within SEFARI. Much of this is directly relevant to the school curriculum and is usually co-designed with and for teachers.

During the COVID-19 crisis SEFARI have quickly adapted activities to produce materials to support home learning.

- RBGE are developing high-quality virtual [learning experiences](#) for primary school pupils, early year learners and those with additional support needs.
- A pre-COVID-19, cross-SEFARI educational project, led by the Rowett Institute on the role of food and food production in healthy and sustainable diets ([Diet Detectives](#)) has rapidly restructured its approach to provide online materials.

- Staff across the institutes e.g. at SRUC have also been offering up their personal expertise to aid colleagues who are home-schooling, by creating videos and sharing informative weblinks.

A SEFARI Gateway cross-Institute working group is corralling the full spectrum of and developing new SEFARI [educational resources](#) to support teachers and parents with at-home learning during lockdown, and to showcase wider SEFARI eLearning resources that will continue to provide fun and interactive learning as COVID-19 restrictions ease.

Working internationally

SEFARI institutes are collaborating internationally on COVID-19 and offering support to countries overseas.

- The James Hutton Institute are facilitating the use of HPC capabilities to Colombian researchers to help authorities analyse data and understand the epidemiology of the pandemic in their country.
- BioSS have partnered with the University of Victoria, Canada, in order to further develop the [Viral Bioinformatics Research Centre](#) (VBRC), a collection of tools to interactively annotate and analyse viral sequences. A coronavirus-dedicated page and database has been recently added to the VBRC webpage, together with information and pointers to other resources about the virus. VBRC is very popular among virologists, and BioSS are seeking funding to update and expand it.
- BioSS are also in discussions on developing a partnership with the University of British Columbia in order to develop methods to precisely define the antigenic sites of COVID19, as well as a partnership with the Centre for Genomic Regulation (Barcelona) to make the computational pipeline available to a larger number of scientists and apply it to the assembly and analysis of a large number of COVID-19 viral samples provided by local hospitals.

- Moredun Research Institute has initiated a collaboration with scientists at the University of Pisa, Italy, in the area of COVID-19 serology with virus neutralisation assays.

Contributing to new and maintaining existing knowledge networks

Active dialogue across all our stakeholders engaged in the delivery of Scotland's National Outcomes is being undertaken to identify COVID-19 priorities and provide support where needed. SEFARI Gateway has set its Knowledge Exchange strategy to support (and to fast track priorities) opportunities for Scottish Government funded scientists within SEFARI and across partners in the Strategic Portfolio to address stakeholder COVID-19 priority response needs. This includes directly working with stakeholders in the development of SEFARI Think Tanks, placement of individual SEFARI experts (Fellows) with key stakeholders and prioritizing our responsive KE-project calls to COVID-19, in particular for input into post-COVID-19 recovery needs. Examples include input into the Royal Society for the encouragement of Arts, Manufactures and Commerce-Food, Farming and Countryside Commission; working with Highlands and Islands Enterprise on regional and sectoral recovery needs, also with Scotland Food and Drink and local food hubs. In each case, Gateway KE mechanisms are offering bespoke adaptation to need.

Conclusion

The COVID-19 crisis will have far-reaching health, societal and economic impact at local, regional, national and international scales for many years after the threat of COVID-19 infection has receded. SEFARI sees its response in both the immediate and the long-term and this demands that we continue to develop our national scale (and its underpinning of our international reach) approaches and innovations to answer the ongoing and vital long term challenges of animal and plant diseases, climate, biodiversity, land use, food and rural community resilience across Scotland and in a world which will undoubtedly have been changed by COVID-19.

In the immediate crisis, SEFARI researchers and Institutes offer expertise and resources that are relevant to the direct fight against COVID-19. This capacity is founded from sustained Scottish Government (RESAS) strategic and underpinning support for SEFARI research and facilities. SEFARI, working with our research partners, such as CoEs, are rapidly making information and resources accessible to Scottish and UK Governments, NHS and wider stakeholders. At a personal level in both professional and private capacities, staff across SEFARI are volunteering and seeking to contribute wherever they can, in what is a hugely dynamic crisis.

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

