

**BiGGAR Economics**

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# Economic Impact of the Strategic Research Programme 2011-2016

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A report to the  
**Scottish Government**

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# 1 EXECUTIVE SUMMARY

Between 2011 and 2016 the Scottish Government's Rural and Environment Science and Analytical Services Division (RESAS) invested £246 million, an average of over £49 million per year (2011-2016), in a portfolio of strategic research and related activities. In 2016 BiGGAR Economics was commissioned to assess the economic impacts generated by this investment. This report summarises the findings of the analysis.

There are two main types of economic impact associated with the 2011-16 Strategic Research Programme (SRP): operational impacts generated directly as a result of the funding provided and wider economic benefits realised as a result of the research supported by the funding.

In collaboration with the Scottish Government and the Main Research Providers (MRPs), a framework to identify the wider economic impacts of the SRP was developed. Where possible, these benefits have been quantified and are discussed in Section 1.1 below. The funding provided through the 2011-16 SRP has also helped to generate a variety of wider economic benefits that cannot be fully quantified. These benefits include benefits to human health, the efficiency of public expenditure and the sustainability of rural communities. The 2011-16 SRP has also generated an even wider range of wider, non-economic benefits that are outwith the scope of this report.

For many areas of activity considered in this report the funding provided through the 2011-16 SRP enabled researchers to leverage in additional research funding from elsewhere, by providing match funding and underpinning research capacity. For this reason it is reasonable to attribute all of the benefits of levered research to the 2011-16 SRP and this is the approach taken in this report.

## 1.1 Wider Economic Benefits

The 2011-16 SRP was used to fund research that has stimulated a broad range of wider economic benefits. Uncertainty about the future value and long-term duration of each benefit means that it is appropriate to measure these benefits as an annual contribution realised in 2016. **It was estimated that the wider economic benefits associated with the 2011-16 SRP contributed a total of £151.8 million GVA to the Scottish economy in 2016 and supported around 1,460 jobs.**

These wider economic impacts included:

- **Commercialisation benefits of £1.6 million GVA and more than 50 jobs.** These benefits included activity supported within spin-out companies that were established between 2011 and 2016 based on research supported by the SRP. These benefits also include the activity associated with license agreements reached between 2011 and 2016 that allow intellectual property based on research funded by the SRP to be used for commercial purposes.
- **Animal health benefits of at least £3.0 million GVA.** These benefits relate to the cost savings realised as a result of improving the control of Bovine Viral Diarrhoea, an important livestock disease. These impacts were underpinned by animal health research but realised as a result of funding provided through the 2011-16 SRP. These figures are however based on an illustrative examples rather than the full range of animal health research undertaken by

the MRPs. This full impact of this area of activity is therefore likely to be significantly higher than the figure above.

- **Plant health benefits of at least £16.6 million GVA.** These benefits relate to the cost savings realised as a result of improvements in the control of three important crop pests and diseases: Late Blight, Potato Cyst Nematodes and Ramularia. These impacts were underpinned by research undertaken in previous funding cycles but realised as a result of funding provided through the 2011-16 SRP. As the 2011-16 SRP funding also supported research on a various other pests and diseases this estimate of impact is likely to be conservative.
- **Genetic improvement benefits of £35.9 million GVA and supporting around 260 jobs.** These benefits related to genetic improvements in livestock and food crops that were underpinned by important genetic resources that were funded through the 2011-16 SRP. These benefits are permanent so the cumulative value of these impacts will increase over time. Due to the time-lag between research effort and commercial application it is also expected that the annual value of this impact will increase over time.
- **An increase of £3.3 million GVA within the food and drink sector, which supported around 140 jobs.** This impact was realised as a result of support that the MRPs provided to companies within the sector to develop new products and market opportunities. This impact was underpinned by research findings generated during previous funding cycles but the MRPs ability to support the companies involved in commercialising the benefits was directly supported by the 2011-16 SRP.
- **Environmental benefits estimated to be worth £71.7 million GVA to the Scottish economy and to have supported around 620 jobs.** This impact is a measure of the annual value of the contribution that the MRPs are able to make to Scotland's system of environmental protection as a result of the funding they received through the 2011-16 SRP. Methodological challenges<sup>1</sup> mean that this estimate should be regarded as illustrative of the potential order of magnitude of the economic value of this work, rather than a definitive value; however, there is some justification for believing that the estimate is likely to be conservative.
- **Exports worth £19.4 million to the Scottish economy and which supported around 390 jobs.** This impact related to the Scottish potato seed export sector, the continued success of which is largely attributable to on-going research funded through the 2011-16 SRP.
- **Workforce productivity benefits of £0.2 million.** This impact related to the additional earnings that PhD graduates whose studies were funded by the 2011-16 SRP could expect to earn over the course of their working lives.

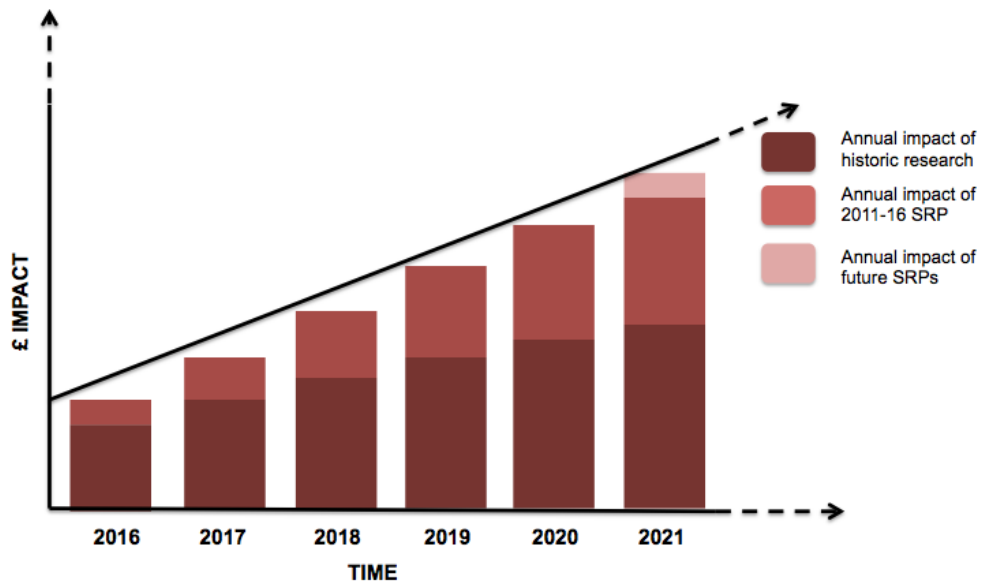
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<sup>1</sup> The methodological challenges are discussed in more detail in Chapter 10 of this report. Benefits of environmental research can be wide ranging including preservation of natural resources (a benefit in its own right and underpinning sectors of the economy that depend on natural resources), avoidance of re-instatement costs and realising value from non or under exploited resources. The challenges include the difficulties of valuing environmental quality and of quantifying costs avoided. This estimate is based on one example of an environmental benefit, based on published research on the social and economic implications of nitrogen in the environment.

## 1.2 Future Expected Benefits

Research is a long-term activity the benefits of which frequently require many years to realise. For this reason the value of the wider economic benefits associated with the 2011-16 SRP that were realised in 2016 will almost certainly increase over time and some of the benefits realised in 2016 will be partially attributable to research undertaken before 2011. A visual representation of this process is provided in Figure 1-1.

Figure 1-1 – Annual impact of SRP over time



Source: BiGGAR Economics. \*For presentational reasons the annual impact of the SRP has been depicted until 2021. In subsequent years there would continue to be annual impacts of future SRPs.

Uncertainty about the future value and long-term duration of each benefit means that for most of the benefits described above it is not possible to fully assess the expected future benefits of the 2011-16 SRP. This report has however identified some evidence relating to the future potential benefits of animal health research and research on livestock and crop genetics. Based on this evidence it was estimated that **within 10 years the annual impact associated with the 2011-16 SRP will have increased from £151.8 million GVA now to at least £157.8 million GVA/year and around 1,470 jobs.**

As this impact does not consider the future impact of the other areas of activity considered in this report it is almost certainly an underestimate.

## 1.3 Operational Impacts

Operational impacts are those that are generated as a result of the daily operations of the institutions considered. These impacts are proportionate to expenditure and arise immediately after expenditure has occurred. Operational impacts include:

- direct impacts – the wealth generated and employment supported directly by the MRPs;

- supplier impacts – economic activity within businesses that supply the MRPs with goods and services;
- staff spending impacts – economic activity supported by the expenditure of staff employed by the MRPs and the businesses within their supply chains;
- capital spending impacts – economic activity supported within the Scottish construction sector as a result of capital projects undertaken by the MRPs.

It was estimated that the total value of the operational impacts supported by the funding provided through the 2011-16 SRP amounted to £282.6 million Gross Value Added (GVA) and that, on average, this activity supported more than 820 jobs annually between 2011 and 2016.

Over the period 2011 – 2016 the MRPs were also able to leverage £148.5 million in additional research funding from industry and public sources as a result of the funding provided through the SRP. The total value of the operational impacts supported by this funding was estimated at £186.2 million GVA between 2011 and 2016. It was estimated that this activity also supported around 560 jobs annually<sup>2</sup>.

**In total the operational impacts associated with the 2011-16 SRP amounted to £468.9 million GVA between 2011 and 2016 in Scotland. This activity supported a total of almost 1,380 Scottish jobs.**

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<sup>2</sup> Throughout this report, employment is measured in terms of headcount jobs supported.

## 2 INTRODUCTION AND APPROACH

Between 2011 and 2016 the Scottish Government's Rural and Environment Science and Analytical Services Division (RESAS) invested £246 million, an average of over £49 million per year (2011-2016), in a portfolio of strategic research and related activities. This programme of activities had the following purpose:

*“The SG’s RAE investment in scientific research provides a foundation for the sustainable use of our natural resources, the productivity and profitability of our agricultural sector and rural businesses, the prevention and effective management and control of animal and plant diseases and our ability to respond effectively to global challenges such as food security and climate change. The funding also helps maintain Scottish-based scientific capability of international standard and associated infrastructure at the Government’s Main Research Providers (MRPs).”*

Source: Scottish Government Rural Affairs and the Environment Strategic Research Strategy 2011 – 2016, <http://www.gov.scot/Publications/2014/02/8714>

In August 2016 BiGGAR Economics was commissioned by the Scottish Government to assess the direct and indirect economic impacts of this programme. This report presents the findings of the analysis.

### 2.1.1 Scope of Analysis

The overarching objective of this analysis was to consider the **economic** impacts arising from or associated with the 2011-16 SRP. Although economic impact has been broadly defined, it is important to acknowledge that the research supported by the 2011-16 SRP has generated a wide range of other, non-economic benefits. These benefits have been extensively considered within previous studies<sup>3</sup>, which interested readers are encouraged to refer to.

## 2.2 Sources of Impact

Broadly speaking there are two main types of economic impact associated with the 2011-16 SRP: wider economic benefits realised or expected as a result of the research supported by the funding and operational impacts generated as a result of the funding provided. This report considers both types of impact.

### 2.2.1 Wider Economic Impacts

The 2011-16 SRP supported a very wide range of activity, which has generated a vast array of economic (and other) benefits. It would have been impractical to attempt to assess the benefits of all of this activity within a single report so to overcome this it was necessary to develop a framework for the analysis that made it possible to reflect the diversity of the impacts supported in a concise and structured manner.

This framework identified all the different types of economic benefit that the 2011-16 SRP might have been expected to generate. These benefits were identified by

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<sup>3</sup> Meagher L (2014), Review of the impact of the Scottish Government rural and environment strategic research portfolio on policy and practice (unpublished). See also, RESAS Strategic Research Highlights, Available at: <http://www.gov.scot/Publications/2016/12/8280> and <http://www.gov.scot/Resource/0047/00474715.pdf>

undertaking a desk-based review of the end of programme reports for the SRP and the annual Spotlight and Highlight publications produced by the MRPs and the Scottish Government. This initial framework was then shared with the Directors and other key staff from each of the MRPs to ensure that no important areas of impact had been overlooked.

The areas of impact identified through this process were:

- **Commercialisation impacts** – including the wealth generated and employment supported by spin-out companies and license agreements based on research supported by the 2011-16 SRP.
- **Animal health benefits** – including the cost savings associated with reduced livestock mortality, morbidity and treatment costs and the increase in farm gate prices realised as a result of improved livestock productivity.
- **Plant health benefits** – including the cost savings associated with reducing crop losses and damage due to disease, reduced expenditure on crop protection, increased farm gate prices and benefits to food processors that use the affected crops as inputs in the production process.
- **Major disease threats** – the cost savings associated with mitigating the risk of major disease outbreaks.
- **Efficiency of agricultural production systems** – including cost savings arising from the reduction of agricultural inputs (such as fertilisers) and productivity improvements associated with improvements in the management of agricultural land.
- **Sustainability benefits** – improvements in farm business productivity and profitability that help to support jobs and sustain livelihoods in rural areas.
- **Biodiversity benefits** – including the value of natural resources protected, cost savings associated with averting reinstatement costs, the value of carbon savings realised and increases in the value of ecosystem services.
- **Human health benefits** – including the cost savings realised as a result of avoiding pathogens entering the human food chain, the economic benefits associated with developing more effective treatments for diseases and the cost savings associated with the prevention of disease.
- **Policy efficiency benefits** – cost savings (and better outcomes) associated with improvements in the efficiency of public expenditure.
- **Benefits to the food and drink sector** – including the development of new products and market opportunities and improved product value.
- **Genetic improvement benefits** – increases in the market value of agricultural output arising from genetic improvements in livestock and crops.
- **Research skills benefits** – improvements in the future productivity of the research skills base arising from the training provided by the MRPs to PhD students.

In collaboration with the MRPs a long-list of case studies was then identified that could be used to help illustrate each type of benefit. This list was then refined in



order to identify those examples that could potentially be quantified. These quantifiable benefits are described in Chapters 4 to 11 of this report.

Where sufficient evidence was not available to enable a type of benefit to be quantified then it was assessed qualitatively. These qualitative assessments are presented in Chapter 12.

### 2.2.2 Operational Impacts

The operational impacts associated with the 2011-16 SRP include both those generated by the 2011-16 SRP funding and those generated by funding that was leveraged as a result of the 2011-16 SRP funding provided. These impacts include:

- **direct effects** – i.e. the number of jobs and value of economic activity directly supported by the funding;
- **supply chain effects** – i.e. economic activity supported by each MRP purchasing goods and services to undertake the research funded;
- **employee spending effects** – i.e. economic activity supported by the expenditure of staff whose positions were supported by the funding;
- **capital investment effects** – i.e. jobs and activity supported in the Scottish construction sector and sectors that provide capital equipment to the MRPs.

These impacts are quantified in Chapter 13 of this report.

### 2.2.3 Additionality

Best practice dictates that in assessing the economic impact of an initiative or organisation it is important to consider not just what happened but also what might have happened anyway, even if the organisation or initiative in question did not exist – i.e. the extent to which impacts are “additional”. In order to do this it is necessary to take account of the following effects:

- **Leakage** – the proportion of activity that might occur outside the study area (e.g. the economic contribution that SRP funded research makes outwith Scotland);
- **Displacement** – the extent to which activity generated might replace existing activity elsewhere in the study area (e.g. the extent to which the Scottish Government might deter the private sector from investing in R&D by funding R&D publicly through the SRP).

In general leakage has been taken account of based on the proportion of total relevant agricultural activity (e.g. livestock population, crop acreage) that occurs in each study area. These assumptions were based official statistics and are discussed in the relevant section.

The starting point for assessing the additionality of impacts generated by SRP funded research was the general principle that public funding is generally only provided to support research that would not otherwise be undertaken by the private sector. Usually this is because the research in question is an early stage of the technology readiness scale and would therefore be of limited commercial interest. This principle is discussed with specific reference to some of the

individual impacts described in this report in the relevant chapter but as a general rule it implies that displacement would not occur.

Best practice also dictates that it is important to take account of **multiplier effects**, i.e. the indirect impacts of each area of activity. (e.g. purchases made by suppliers to the MRPs in order to produce the goods and services used to undertake research). These effects were accounted for by applying appropriate multipliers, which were taken from the input/output tables published by the Scottish Government and are specific to different sectors of the Scottish economy.

## 2.3 Funding Leverage

For many areas of activity considered in this report the funding provided through the 2011-16 SRP enabled researchers to leverage in additional research funding from elsewhere (a description of the value of leveraged funding is provided in section 13.2). This means that for many of the areas of activity considered in this report the funding provided through the 2011-16 SRP represented only part of the total research investment. It could therefore be argued that a proportion of the impact associated with this activity should be attributed to the other funding providers.

Consultation with the MRPs however suggests that the funding provided through the 2011-16 SRP was critical to securing additional research funding. In some cases this may have been because it enabled the MRP's to fulfil match funding requirements. In other cases it was because the funding provided through the 2011-16 SRP underpinned research capacity that was essential to securing and/or realising an impact from the additional funding.

This means that if the 2011-16 SRP funding had not been available then the MRPs would have been unable to secure the full amount of funding required to support these areas of research or realise the associated benefits. For this reason it is reasonable to attribute all of the benefits of such research to the 2011-16 SRP and this is the approach taken in this report.

## 2.4 Impact Time-scales

Some of the activity supported by the 2011-16 SRP (and the additional funding leveraged as a result of this funding) generated economic benefits immediately. The total value of these operational benefits over the 2011-16 period are quantified in Chapter 13 of this report.

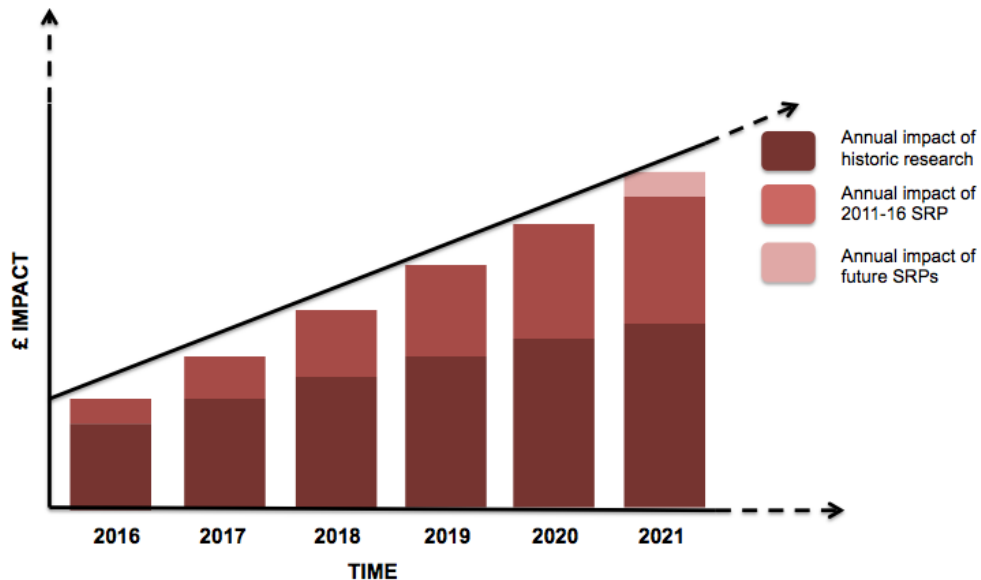
In general however research is a long-term process where there is a significant time-lag before significant benefits are realised. This has two important implications for this analysis.

- many of the wider economic benefits realised between 2011 and 2016 were (at least partially) underpinned by research undertaken in previous funding cycles and can therefore only be partially attributed to the 2011-16 SRP;
- many of the wider economic benefits associated with the research funded by the 2011-16 SRP had not yet been realised at the time of writing.

All of the wider economic benefits considered in this report represent long-term (if not permanent) economic improvements. This means that once the benefit has been realised it will be realised again and again in subsequent years. The

cumulative value of these benefits will therefore increase over time. Furthermore, because of the time-lag between research effort and economic impact, the annual value of benefits will also grow over time. A visual representation of how this impact has, and will continue to develop over time is provided in Figure 2-1.

Figure 2-1 – Annual impact of SRP over time



Source: BiGGAR Economics

Ideally, in order to estimate the impact of the 2011-16 SRP it would be necessary to estimate the total value of each area of activity (i.e. all of the pale red boxes in the chart above) and then attribute a proportion of this total benefit to each funding round. In reality this is not possible because of uncertainty about the future value and long-term duration of each benefit. To resolve this issue this analysis therefore uses the annual value realised in 2016 (i.e. the bar on the far left of the chart) as a proxy measure of the economic impact of the 2011-16 SRP. As illustrated by the figure above this is likely to under rather than overestimate the full value of the impact.

The time-frame associated with each of the areas of activity considered in this report is discussed in further detail in the relevant chapters. Where possible estimates of the total value realised between 2011-16 are also provided.

## 2.5 Report Structure

The remainder of this report is set out as follows:

- Chapter 3 describes the strategic background and context for the 2011-16 SRP, the structure and objectives of the strategic research portfolio and each of the MRPs;
- Chapter 4; describes the benefits that have been generated by spinout-companies established and license agreements reached during the 2011-16 period;
- Chapter 5 highlights the economic benefits associated with improvements in animal health delivered (at least in part) as a result of funding provided through the 2011-16 SRP;

- Chapter 6 describes the economic benefits associated with improvements in plant health delivered (at least in part) as a result of funding provided through the 2011-16 SRP;
- Chapter 7 quantifies the value of genetic improvements in livestock and crops delivered (at least in part) as a result of funding provided through the 2011-16 SRP;
- Chapter 8 considers the contribution that research supported by the 2011-16 SRP has made to maintaining the value of Scotland's exports;
- Chapter 9 describes the contribution that funding provided through the 2011-16 SRP has made to the development and growth of Scotland's food and drink sector;
- Chapter 10 quantifies the economic value of the contribution that research funded by 2011-16 SRP has made to Scotland's environment;
- Chapter 11 describes the additional productivity benefits associated with the research training provided by the MRPs that was funded by the 2011-16 SRP;
- Chapter 12 explores the wider economic benefits of the 2011-16 SRP; and
- Chapter 13 quantifies the core operational impacts generated by the funding provided through the 2011-16 SRP;
- Chapter 14 presents our summary and conclusions.

BiGGAR Economics is grateful to all of the individuals who contributed to this study without whom this report would not have been possible. A full list of those consulted is provided in Appendix A.

## **3 BACKGROUND AND CONTEXT**

This chapter describes the strategic background and context for the 2011-16 SRP. It also describes the structure and objectives of the strategic research portfolio and summary information about each of the MRPs.

### **3.1 Strategic Context**

#### **3.1.1 Scottish Government Policy Environment**

For several years the Scottish Government has been very clear in its commitment to achieving sustainable and equitable economic growth. The Government has been equally clear in the important role that it expects Scotland's research community to play in achieving these objectives.

The latest version of the Scottish Government's economic strategy identifies four key strategic priorities: investment, innovation, inclusive growth and internationalisation. The commercialisation of research and development is identified as a key objective under the innovation priority.

#### **3.1.2 Strategic Research Strategy 2011-2016**

The Strategic Research Portfolio (SRP) within the Rural Affairs and Environment (RAE) Portfolio supports a Greener, Smarter and Wealthier Scotland and contributes towards the achievement of a number of national outcomes<sup>4</sup> including:

- We value and enjoy our built and natural environment and protect it and enhance it for future generations;
- We reduce the local and global environmental impact of our consumption and production;
- We are better educated, more skilled and more successful, renowned for our research and innovation.

In seeking to deliver these higher level aims, the research strategy sets out the wider strategic context for the Government's research investment in the Rural Affairs and Environment (RAE) portfolio, the research priorities for the 2011 – 2016 research programme and the approach to knowledge exchange<sup>5</sup>.

#### **3.1.3 Rural Affairs and Environment Objectives**

Our Rural Future published in 2011 set out the Government's vision for Rural Scotland:

*"We want to see a rural Scotland that is outward looking and dynamic – with a diverse economy and active communities. Rural prosperity will increase in ways which make best use of all of our resources – our people, as well as the land, seas, rivers and wildlife. Our rural communities will grow in confidence and diversity, taking control of local assets and providing local services to generate income and employment. Our young people will have the opportunity to build*

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<sup>4</sup> Scottish Government's Rural Affairs and the Environment Strategic Research Strategy 2011-2016 <http://www.gov.scot/Publications/2014/02/8714>

<sup>5</sup> A copy of the strategy is available here: <http://www.gov.scot/Resource/0044/00443642.pdf>

*careers and prosperous futures in the area where they grew up. Services of the highest possible quality and with the greatest possible choice will be accessible to the whole community. Our world-rated natural, cultural and built environments will be managed sensitively to balance development requirements with the vital need to manage our precious natural assets sustainably. We want to see rural Scotland participating fully in the global exchange of ideas and culture, with the right connections to make this happen, including high speed broadband and appropriate transport infrastructure. Rural businesses will make best use of local assets to become more competitive and enterprising”.*

The Scottish Government’s 2011 Spending Review set out six priorities to support this vision, including: developing the rural economy; supporting agriculture to deliver public benefits; building up a world class food and drink industry; empowering rural communities; making best use of Scotland’s natural assets; and tackling climate change.

The SRP portfolio supports the delivery of these priorities.

### **3.1.4 Wider Science Alignment**

The RESAS scientific research portfolio operates within the broader UK strategic science funding environment. The Research Strategy points out that in addition to working with UK Research Councils, Defra and other UK and EU networks to co-ordinate and ensure best use of research funding and to maximise the value of Scottish Government research investment, the portfolio is aligned with other programmes such as the Living with Environmental Change partnership (LWEC), led by the Natural Environment Research Council (NERC) and the UK Global Food Security programme, led by the Biotechnology & Biological Sciences Research Council (BBSRC).

## **3.2 Strategic Research Portfolio Objectives and Structure**

There were three strategic priorities for the SRP 2011-2016:

- Supporting policy and practice;
- Supporting innovation and the economy; and
- Scientific resilience.

These were underpinned by two further supporting priorities:

- Scientific excellence; and
- Collaboration and multidisciplinary working.

To deliver these objectives, the strategic research portfolio supported:

- Applied research to address current and emerging challenges (e.g. climate change, food security, natural resource scarcity), to meet short and medium term policy needs and to enhance productivity and economic growth (with a particular focus on agriculture, the food and drink industry and animal life sciences);
- Longer-term strategic research to understand change and enhance resilience to future threats (e.g. plant and animal disease);

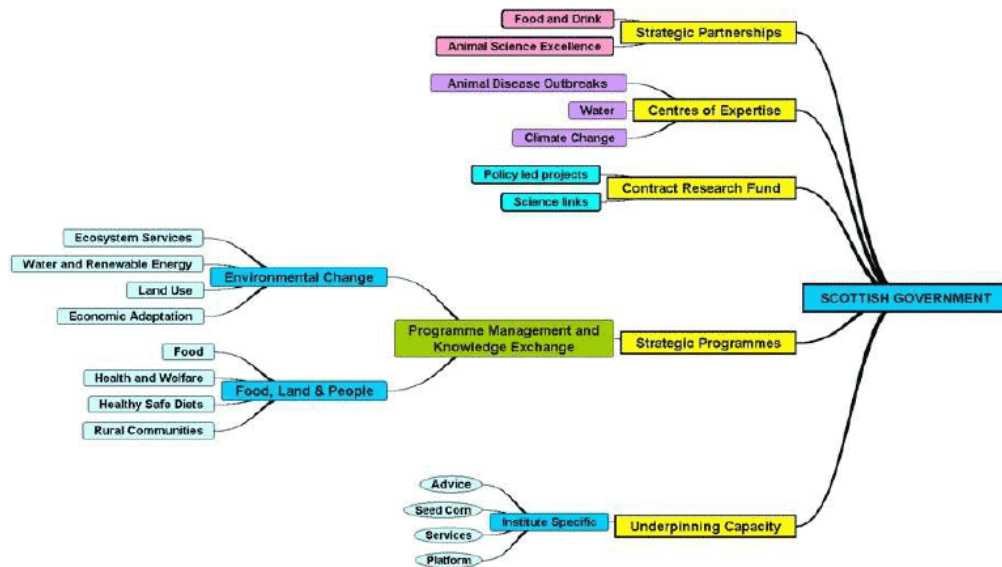
- Maintenance of critical infrastructure and research assets including facilities, collections and databases; and
- Development of future research capacity and capability (e.g. funding PhDs and post-doctoral opportunities).

These strategic priorities were delivered through a wide portfolio of research activity, summarised in Figure 3.1 below, comprising:

- Two five year multi-disciplinary programmes of strategic research – environmental change and food, land and people;
- Three “policy-facing” Centres of Expertise covering climate change, animal disease and water;
- Two “industry-facing” Strategic Partnerships focused on animal science and food and drink;
- Investment in underpinning capacity to support Scotland’s strategic rural and environmental science base.

The area of specific focus for this study is the Strategic Programmes (containing two streams - Environmental Change and Food, Land and People), alongside the investment in underpinning capacity provided to the MRPs. The funding and resources devoted to these areas are described in Section 4.2.

Figure 3.1: Strategic Research Portfolio 2011-2016 - Component Parts



Source: Scottish Government Rural Affairs and the Environment Strategic Research Strategy 2011 - 2016

### 3.2.1 Strategic Programmes

The Strategic Research Programmes were intended to provide evidence to inform policy through collaboration across scientific disciplines and between Main Research Providers (MRPs), as well as through partnership working with other



UK funders of research. The Programme Research was structured into eight research themes across the two programmes, shown in Figure 3.1 above<sup>6</sup>:

- Environmental Change (Local Responses to Global Change)
  - Theme 1: Ecosystem Services
  - Theme 2: Strong and resilient sources and supply chains for water and energy (Water and Renewable Energy)
  - Theme 3: Technologies and management tools to deliver greater benefits from rural land use and increased resilience to change (Land Use)
  - Theme 4: A rural economy resilient to global and local change (Economic Adaptation)
- Food, Land and People (Optimising the Potential of Scotland's natural assets)
  - Theme 5: Efficient and resilient supply chains for food (Food)
  - Theme 6: Animal/plant health and disease and animal welfare (Health and Welfare)
  - Theme 7: Healthy safe diets (Diet and Health)
  - Theme 8: Vibrant rural communities (Rural Communities)

### 3.2.2 Underpinning Capacity

RESAS funding to underpin capacity covered<sup>7</sup>:

- Advice – ensuring that an appropriate level of advice, guidance and background information was provided to policy;
- Seedcorn – designed to enable investment in new science, e.g. PhD studentships and investment in more speculative science;
- Platform – promoting scientific and financial sustainability, for example by assisting a Main Research Provider to accept research grants from a funder at less than full economic price; and
- Services – discrete activities that maintain key collections or attributes of the Scottish science base recognised as of national or international importance. This includes:
  - Maintenance of key long-term data sets of national significance;
  - Maintenance of potato germplasm collections;
  - Maintenance of Rubus (Raspberry) and Ribes (Blackcurrant) high health stock collections;
  - Maintenance and development of the barley collection;

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<sup>6</sup> Source: <http://www.gov.scot/Topics/Research/About/EBAR/StrategicResearch/future-research-strategy/Themes>

<sup>7</sup> This activity is 'Non Programme Research Activity', further details: <http://www.gov.scot/Topics/Research/About/EBAR/StrategicResearch/future-research-strategy/nonprogramme>



- Provision of Biomathematical & Statistical services;
- Maintenance of pathogen and pest collections;
- Maintenance of the National Soils Archive;
- Maintenance and operation of a Scottish Soils Database and Website;
- Maintenance of a responsive and reactive capacity to develop diagnostic tests.

### **3.3 The Main Research Providers**

The research portfolio described above is largely carried out by the Scottish Government's Main Research Providers (MRPs):

- Biomathematics and Statistics Scotland (BioSS), which is part of the James Hutton Institute and provides support and research to the other MRPs;
- The James Hutton Institute (JHI);
- The Moredun Research Institute (MRI);
- The Rowett Institute of Nutrition and Health (RINH), which is part of the University of Aberdeen;
- Royal Botanic Garden in Edinburgh (RBGE); and
- Scotland's Rural College (SRUC).

#### **3.3.1 Biomathematics and Statistics Scotland**

Biomathematics and Statistics Scotland undertakes research, consultancy and training in mathematics and statistics as applied to agriculture, the environment, food and health<sup>8</sup>. In terms of its governance, BioSS is formally a part of the James Hutton Institute. BioSS employs over 30 people distributed across its five locations.

#### **3.3.2 The James Hutton Institute**

The James Hutton Institute was formed in 2011 with the merger of the Macaulay Land Use Research Institute and Scottish Crop Research Institute. Today, the James Hutton Institute is comprised of its research functions and a commercial subsidiary, James Hutton Limited, which provides consultancy and analytical services for research and commercial purposes.

The organisation combines strengths in crops, soils, land use and environmental research to work towards making major, new contributions to the understanding of key global issues, such as food, energy and environmental security, and delivering evidence-based solutions to these global challenges.

#### **3.3.3 The Moredun Research Institute**

The Moredun Group was established in 1920 as the Animal Diseases Research Association by farmers dedicated to improving the health of their livestock.<sup>9</sup>

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<sup>8</sup> Source: <http://www.bioss.ac.uk/>

<sup>9</sup> Source: <http://www.moredun.org.uk/>

Moredun continues to undertake scientific research to improve animal health and welfare through the prevention and control of infectious diseases of livestock.

In particular, research is focused on achieving a greater understanding of disease pathogenesis, developing diagnostic tests and the creation of novel vaccines. The commercial scientific arm of the organisation, Moredun Scientific, provides contract research and biosafety testing services supporting the animal health, pharmaceutical and biotechnology industries.

### **3.3.4 The Rowett Institute of Nutrition and Health**

The Rowett Institute is part of Aberdeen University's School of Medicine, Medical Sciences and Nutrition, focussing on nutrition and human health and also on animal health and nutrition<sup>10</sup>. Scottish Government funded research at the Institute aims to address issues such as food inequalities, food security and obesity, as well as the sustainable development of Scotland's food industry.

### **3.3.5 Royal Botanic Garden, Edinburgh**

Royal Botanic Garden Edinburgh is a Non Departmental Public Body (NDPB) sponsored and supported through Grant-in-Aid by the Scottish Government's Environment and Forestry Directorate (ENFOR)<sup>11</sup>.

Its mission is "to explore, conserve and explain the world of plants for a better future". It works to conserve plant biodiversity in the face of global environmental change and mass extinction; provide baseline botanical data and; understand the evolutionary processes that have given rise to the botanical diversity that exists.

### **3.3.6 Scotland's Rural College**

Scotland's Rural College was formed in 2012 from the merger of Barony, Elmwood and Oatridge College and the Scottish Agricultural College (SAC). It delivers comprehensive skills, education and business support for Scotland's land-based industries, through a focus on research, education and consultancy<sup>12</sup>.

SRUC's research centres and teams are based in seven locations across Scotland including sites in Inverness, Edinburgh, Aberdeen and Ayr. Research at SRUC is focused on Animal & Veterinary Sciences, Crops & Soils, Land Economy & Environment and Future Farming Systems.

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<sup>10</sup> Source: <http://www.abdn.ac.uk/rowett/about/index.php>

<sup>11</sup> Source: <http://www.rbge.org.uk/home>

<sup>12</sup> Source: <http://www.sruc.ac.uk/>

## **4 COMMERCIALISATION**

The MRPs are a vital source of technological innovation through the commercialisation activities they undertake. This includes the creation of new spin-out companies and the licensing of intellectual property based on SRP funded research.

### **4.1 Spin-out Companies**

Over the period 2011-16 three spin-out companies were created by the MRPs based on research that was funded, at least in part, by the SRP. As the intellectual property upon which these companies were founded was funded by the SRP (at least partially), it is reasonable to conclude that they would not have existed if the SRP funding was not available and that the benefits they have subsequently generated are therefore attributable to the SRP funding. The counterfactual scenario would therefore be that these companies would not exist.

The three new spin-out companies make an economic contribution through the people they employ and the turnover they generate.

One of these companies, ArxBio, has developed a new platform technology for bacterial vaccines based on SRP funded research. This technology will allow the development of novel and effective vaccines against important bacterial diseases of livestock. The animal health market is a global multi-million pound industry and this new technology is well placed to make a significant impact by generating novel products to prevent and control animal disease.

Arxbio and the research scientists involved from the MRP won first prize in 2012 in the Converge Challenge, a national competition to find the best new business start-up based on innovative scientific research. Arxbio received £25,000 cash and a further £25,000 in support from the Converge Challenge to help establish the company with the aim to have market approved products in the next 3-5 years.

Other SRP-funded research has led to the successful development of the first vaccine in the world for a worm parasite of sheep. The Barber's Pole worm, (*Haemonchus contortus*), is the most important roundworm parasite of sheep and goats in the world. Worm infections have traditionally been treated using anthelmintics and although very effective, resistance is increasing with drug resistant strains commonplace in countries like Australia. The vaccine is being successfully sold in Australia through a spin-out company, Wormvax. The first batch of vaccine, consisting of 300,000 doses, was sold within 10 days of the vaccine's launch. Wormvax provides an excellent example of the global influence and impact of SRP funded research. Although based in Australia, the net profits of the company will flow back to the MRP thereby increasing research resources and supporting further research in Scotland.

A third company, GT Biologics, was also spun-out based on SRP funded research and is described in further detail in the case study below.

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**Case Study 4-1 – GT Biologics**

GT Biologics was spun-out in 2008 based on research directly funded by the SRP. There are trillions of bacteria in the human gut performing a variety of functions that go beyond the digestion of food. Through SRP funding, MRP researchers identified the bacteria responsible for triggering inflammation in the lower gut and the potential for the development of therapeutics. They have been able to identify novel compounds derived from the bacteria that naturally colonise the gut of healthy individuals and have been demonstrated to exhibit potent anti-infectious and anti-inflammatory properties.

GT Biologics was spun out to develop new drugs and other therapies based on the use of these live bacteria for the treatment of inflammatory bowel diseases, such as Crohn's disease and ulcerative colitis and other autoimmune conditions, including multiple sclerosis. GT Biologics initially received support and seed investment from the University of Aberdeen, the Genomia fund and Scottish Enterprise. This was later followed by major investment from the biopharmaceutical company, 4D Pharma.

Under the banner of 4D Pharma, further product research and development has taken place, with the lead product (derived from SRP supported research) shortly about to begin Phase 1 human trials. Following the successful completion of this, much larger Phase 2 and Phase 3 studies will be undertaken and potentially phase 4 studies to provide the basis of dossiers that will be assessed by regulators before the therapeutic can be sold. Drug discovery and development has long lead times with the first sales being generated after many years of clinical development and regulatory approval. The impact of the therapeutic itself will therefore take many years to realise.

However, the company continues to maintain a presence in Aberdeen, occupying 10,000 sq. ft of lab and office space and employing approximately 30 people at the site. In this way, the company makes a contribution to the Scottish economy estimated at **£1.6 million GVA and 54 jobs annually**, and a contribution to the UK economy of **£1.7 million GVA and 59 jobs**. This includes the impacts of the company's turnover and employment as well as supply chain and staff spending impacts. Although GT Biologics has now become part of 4D Pharma, SRP funding underpins the research that led to the spinning out of GT Biologics and therefore this economic impact can be entirely attributed to the SRP. GT Biologics was established based on research undertaken in the previous SRP and received major external investment in 2012 propelling it to its current success. As illustrated through the example of GT Biologics, the establishment and development of spin-out companies is a long term process. The impacts of spin-out companies from the current SRP will therefore not be realised yet and GT Biologics has therefore been included by way of illustration of the potential future benefits of this area of activity.

*Source: BiGGAR Economics based on Consultation*

## **4.2 License Agreements**

Research supported by the 2011-16 SRP has also enabled some of the MRPs to reach license agreements with commercial clients. These agreements give companies the legal right to use intellectual property (IP) developed by the MRPs to generate commercial gains. In return, companies pay royalties to the MRPs.

As with spin-out companies, the IP that these licence agreements relates to was created by research that was funded by the SRP. If the SRP funding was not available then these agreements would therefore not exist. The counterfactual scenario would therefore be that the impact associated with these agreements would not have been generated.

Between 2011 and 2016 the MRPs have made 28 license agreements with commercial companies for intellectual property based on research funded (at

least in part) by the 2011-16 SRP. These agreements generated a total of around £11,700 in royalty payments.

In order to estimate the economic impact associated with these agreements it is first necessary to estimate how much additional turnover they might enable the license holder to generate. This was done based on the findings of a study from 2002<sup>13</sup>, which found that royalty rates typically represent around 5% of sales from products embodying a patented technology.

This assumption was used to estimate that technologies licensed from the MRPs enabled license-holding businesses to generate around £0.2 million additional turnover between 2011 and 2016. This turnover was then converted into GVA and employment impacts using appropriate economic ratios and multipliers. In this way it was estimated that technologies licensed from the MRPs that were based (at least in part) on research funded by the 2011-16 SRP enabled Scottish businesses to generate £0.2 million GVA and support 1 job between 2011 and 2016. (The annual value of this impact fluctuated significantly from year to year reflecting the profile of royalties payments received).

### 4.3 Impact Time-Scale

The impacts described in this section were all realised during the 2011-16 period but establishing a spin-out company or finalising a license agreement generally represents the culmination of years of research effort so these benefits did not arise entirely as a result of the 2011-16 SRP. Research funded by the 2011-16 SRP did however contribute to the development of each of the companies and agreements considered in this chapter. The 2011-16 Programme can therefore be considered necessary but not sufficient for their existence.

It is important to note that the impacts quantified in this chapter almost certainly represent an underestimate of the true value of the commercialisation activity underpinned by research funded through the 2011-16 SRP. This is because:

- The spin-out companies and license agreements are expected to continue to generate wealth and support employment beyond the 2011-16 period.
- The spin-out businesses and license agreements established during the 2011-16 period are still at a relatively early stage of development. It is likely that as the businesses involved continue to develop the value of the commercial returns to the research that underpins them will increase. As a result, the annual impact considered in this chapter is likely to increase in subsequent years.
- It is likely that research supported by the 2011-16 SRP will one day help to underpin further spin-out companies and license agreements that are not yet currently envisaged. Just as the commercialisation impact realised in 2011-16 is partially attributable to historic research effort, some of the commercialisation impact that will be realised after 2016 will be attributable to research funded through the 2011-16 programme.

As the future value of commercialisation benefits supported by the 2011-16 SRP are not yet known, the impact of commercialisation activity *realised* between 2011 and 2016 therefore provides a reasonable (if conservative) approximation of the commercialisation benefits *generated* by research funded by the 2011-16 SRP.

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<sup>13</sup> Goldscheider (2002), Use of the 25% rule in valuing IP, les Nouvelles.

## **5 ANIMAL HEALTH**

The livestock and wider agri-food sector is of fundamental importance to the Scottish economy. In 2016 the total value of livestock production in Scotland was estimated at around £1.6 billion<sup>14</sup>. Scotland has approximately 18% of the UK's cattle and 20% of the UK's sheep. A stable and secure food supply underpins all other sources of economic activity and is therefore critically important to the entire economy.

Animal diseases are one of the main threats to the livestock sector and have economic impacts on the agricultural and livestock sector as well as the wider economy. By way of illustration, an outbreak of foot and mouth disease in 2001 cost the UK between £6.0 and £9.0 billion, with £91.0 million paid in compensation to farmers<sup>15</sup>.

### **5.1 Contribution of the 2011-16 SRP**

The MRPs play an important role in tackling animal diseases and preventing disease outbreaks. They do this by undertaking research to improve understanding of disease pathogenesis. With greater understanding and awareness of the diseases, the MRPs are then able to develop successful approaches for their improved control and prevention. This includes the development of diagnostic tests and the creation of novel vaccines with the ultimate aim of reducing livestock mortality and morbidity and/or reducing the cost of treatment and control of diseases.

Scientists funded by the 2011-16 SRP have been at the forefront of tackling Bovine Viral Diarrhoea (BVD). The case study below describes this work and quantifies the contribution it has made to the Scottish economy.

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<sup>14</sup> Scottish Government (2016), Statistics - Farm Livestock, Available at: <http://www.gov.scot/Topics/Statistics/Browse/Agriculture-Fisheries/agritopics/alllivestock>

<sup>15</sup> BBSRC (2016), Bioscience Facts and Figures



Case Study 5-1 – Bovine Viral Diarrhoea

Bovine Viral Diarrhoea (BVD) is a major contagious endemic disease of cattle in Scotland. The main disease occurs when susceptible pregnant animals become infected with the virus, which can cross the placenta infecting and causing disease in the developing foetus. Once these calves are born, they are persistently infected with the disease and provide the major route of spread for this virus. They often appear normal but are shedding the virus throughout their lives.

Many livestock farms have BVD among their highest economic and welfare concerns. BVD results in major economic losses for the cattle industry, through abortions, infertility and reproductive problems, deformed offspring and permanently infected animals.

Due to the hidden nature of BVD and the wide variety of disorders it causes, a key challenge for the MRPs was to assess the extent of the damage it does at farm level and make this apparent to farmers and vets in order to implement the best prevention and control responses. MRP researchers combined epidemiological and economic computer models to explore the relationship between disease spread and the actions of farmers (e.g. vaccination, removing persistently infected individuals) that might influence such spread. The economic aspects of the model compared these costs at whole farm level with the likely benefits. Although focused on farmers actions, this work helped to highlight the value of tackling BVD collectively.

SRP funded MRP research has led to and underpinned the establishment of a BVD eradication programme in Scotland. MRP research made the economic case for eradication at farm level, improved understanding of the epidemiology, transmission and host response to the virus and provided scientific evidence on how the disease can be prevented and controlled. From 2014 onwards, control measures to reduce the spread of infection have been introduced, including a ban on knowingly selling or moving infected cattle, requirements to declare a herd's BVD status before sale and restrictions on untested herds and animals.

The SRP funded research found that eradicating BVD could save the dairy industry about £38 million a year and reduce prices for consumers by an additional £11 million. This amounts to a total cost of £49 million over the period of a ten-year eradication programme. This implies that the annual benefit might be around £4.9 million. The total potential benefits of eradicating the disease have been attributed to the SRP because without the critical role played by SRP funded research policy makers and farmers would not understand the real costs of BVD, and it is therefore unlikely that the BVD eradication programme would have been established.

To date the eradication scheme has successfully reduced the proportion of herds with negative status from 28% in 2010/11 to 11% in 2016, so 61% of the annual impact has been achieved. This suggests that the impact of this work in 2016 could be worth **£3.0 million** each year to the Scottish economy and **£16.3 million** to the UK economy. However, the full effects of this research have not yet been fully realised.

Research at the MRPs is continuing in order to develop methods for tracing the source of the remaining infection so that the disease can be completely eradicated in Scotland.

*Source: BiGGAR Economics*

## 5.2 Expected Future Benefits

The nature of this type of research is that it takes significant time and several funding rounds to understand disease pathogenesis and to identify the most suitable potential solution. Vaccine development and approval, should it be the preferable course of action, is also a lengthy process. Therefore, one round of SRP funding supports continued development and progress in disease understanding and management but is unlikely to yield final solutions for all of the diseases being studied.

One example of this is SRP funded research on sheep scab, which has led to the development of an early diagnostic test for the disease and was launched commercially in 2015. Although it is too early for the impacts to have been realised, the diagnostic test will play an important role in early detection of the disease thereby helping to limit its spread as described in the case study below.

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#### Case Study 5-2 – Sheep Scab

Sheep scab is the most important ectoparasitic disease of sheep in the UK, is now endemic in the UK and is a notifiable disease in Scotland. Sheep scab is highly contagious; it is estimated that in affected flocks over 90% of sheep may be infested. It is therefore a major concern for Scottish producers with economic consequences resulting mainly from the costs of treatment, prevention, damage to wool and reduced quality of sheepskins.

SRP funded research at one of the MRPs has led to the development of a diagnostic test capable of accurately detecting sheep scab in infected animals, including in the pre-clinical stages. The test is therefore useful in identifying recently infected flocks before the infection is able to spread and cause production losses. In addition, the test can accurately detect that an infection is due to the scab mite and not another ectoparasite.

This test is therefore highly useful in the rapid detection and treatment of infection thus limiting the spread of disease.

The sheep scab diagnostic is being offered free of charge throughout Scotland and strategic use of the diagnostic is helping to maximise impact. For example, the sheep scab diagnostic is being used to maintain freedom of disease on the islands of Mull and Iona. The way it is deployed means that only a relatively small number of tests have been performed (less than 200), but by strategic application of the test it is actually protecting 110 flocks of sheep on the islands. More widely, vets are using the new diagnostic blood test to determine whether or not flocks have scab, saving farmers money by enabling the targeting of treatments and avoiding losses from clinical and subclinical disease.

A report published by the Scottish Government estimated the current cost of sheep scab in Scotland at £0.6 million/year and the current cost of measures used to control the condition at £5.1 million/year, giving a total cost of £5.7 million. It was assumed, based on consultation with the MRPs that SRP supported research could reduce this cost by 50% and that 50% of this benefit may be attributable to the SRP. This suggests that the potential impact of this work could be worth as much as **£1.8 million/year** to the Scottish economy and **£8.8 million/year** to the UK economy. SRP funded research in this area is continuing in order to develop a vaccine.

*Source: BiGGAR Economics*

### 5.3 The Counterfactual

The case studies presented above demonstrate that addressing these diseases has the potential to deliver significant economic returns to the farmers concerned. It might therefore be argued that this would provide an incentive to the market to provide a solution and that the research funded by the SRP is simply displacing research that would otherwise be undertaken by the private sector.

Consultation with scientists undertaken as part of this exercise suggest that there is little justification for this argument. Developing a vaccine or control programme for any disease is a long-term process that generally requires years of development work. At the early stages of this process, when results (and potential commercial returns) are highly uncertain, there is little incentive for private companies to invest in the research. This early stage research is however essential because it provides the intellectual underpinning for future advances.



Rather than displacing private investment, the funding provided through the SRP therefore actually enables this type of research by addressing the market failure that would otherwise deter private investment. For this reason the impacts of this work can be considered additional.

Added to this it should also be noted that in order to generate a benefit, the vaccine and control solutions developed by the MRPs must first be adopted by the farmers concerned. Achieving this often requires behaviour change at an industry wide level, which is not something that the private sector would have the incentive – or capacity – to deliver. Research supported by the SRP plays an important role in delivering this behaviour change by enabling researchers to spend time engaging with farmers and influencing industry wide patterns of behaviour.

## 5.4 Summary of Benefits

Table 5-1 summarises the benefits described in this chapter. It has been estimated that SRP funded research on BVD supported £3.0 million GVA in Scotland and £16.3 million GVA in the UK in 2016. Once the impact of this research has been fully realised and once the future expected benefits of sheep scab research are realised the economic impact could increase to £6.7 million GVA in Scotland and £35.7 million GVA in the UK.

Table 5-1 – Annual impact of animal health improvements - GVA (£ millions)

	Scotland	UK
<b>2016</b>		
Bovine Viral Diarrhoea	3.0	16.3
Sheep Scab	-	-
<b>Total</b>	<b>3.0</b>	<b>16.3</b>
<b>2026</b>		
Bovine Viral Diarrhoea	4.9	26.9
Sheep Scab	1.8	8.8
<b>Total</b>	<b>6.7</b>	<b>35.7</b>

Source: BiGGAR Economics

Research into animal diseases and the development of appropriate control and prevention measures is a long-term process. In addition, the benefits of the research take several years to realise as it takes time for widespread adoption of control and prevention measures. The impacts of BVD research described in this section were realised during the 2011-16 period but is a result of years of research effort so these benefits did not arise entirely as a result of the 2011-16 SRP. The sheep scab diagnostic has been developed directly through 2011-16 SRP funded research although the benefits will be realised in subsequent years.

It is also important to note that the two case studies highlighted in this chapter represent only a very small proportion of the research in animal diseases undertaken by the MRPs. The MRPs undertake research into a number of the most economically important and most widespread animal diseases, including:

- liver fluke in sheep;

- Johne's disease;
- enzootic abortion in sheep;
- intestinal parasites in sheep; and
- respiratory disease in cattle.

The impacts of SRP supported research into animal diseases at the MRPs will therefore be much greater than those described above.

## 6 PLANT HEALTH

The economic consequences of crop pests and diseases include:

- the value of crops lost or damaged as a result of outbreaks of pests and diseases; and
- the cost incurred by farmers to try to prevent and control pests and disease.

Around the world plant pests and diseases are estimated to be responsible for losses ranging from between 20% to 40% of global production<sup>16</sup>. Protecting crops from disease therefore has the potential not only to make a very significant contribution to global food security but also to the value of agricultural output.

This chapter considers the contribution that scientists funded by the 2011-16 SRP have made (and continue to make) to limiting the damage of plant pests and diseases in Scotland.

### 6.1 Contribution of the 2011-16 SRP

According to statistics produced by the Scottish Government the total value of crops produced in Scotland in 2015 amounted to £820.7 million.<sup>17</sup> Two crops accounted for around 45% of this output: barley (£198.1 million) and potatoes (£167 million). Although scientists funded by the 2011-16 SRP are engaged in research on a variety of pests and diseases research on pests and diseases that affect these two crops was a particularly important focus.

In recent years one of the most important diseases effecting barley in the UK (and elsewhere) has been Ramularia. Scientists in the 2011-16 SRP have been at the forefront of tackling this disease. The case study below describes this work and quantifies the contribution it has made to Scottish agricultural output.

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<sup>16</sup> Savary et al. (June 2012), Crop losses due to diseases and their implications for global food production losses and food security.

<sup>17</sup> Scottish Government (2016), Economic Report on Scottish Agriculture 2016 Edition, Table A1

Case Study 6-1 – Tackling Ramularia

In the late 1990s barley growers in Scotland began noticing symptoms of an unrecognised disease that reduced yield and resulted in thinner grains. Plant pathologists based in one of the MRPs identified that these symptoms were being caused by a pathogen that had not previously been recorded in Scotland and applied for funding from the Scottish Government to help tackle the emerging threat.

The first phase of the research was to identify the disease and the best control measures (fungicides) for controlling it. The next stage was to develop a diagnostic test to enable growers to identify the disease before symptoms emerge.

After the initial research was completed the fungus that causes Ramularia developed resistance to the fungicide that had been identified to control it, forcing scientists to identify an alternative. In the years since the original research was undertaken the fungus has continued to evolve, which has created an on-going need to monitor fungicide sensitivity so that alternative measures can be identified and adopted as necessary. This on-going monitoring has been a key focus of research funded by the 2011-16 SRP and has enabled scientists at the MRP to develop best practice guidance on the control of Ramularia that has been widely adopted across the UK.

In the absence of proper control measures it has been estimated that losses due to Ramularia would (on average) equate to 0.5 tonnes/hectare. Implementing the best practice control strategies developed by the MRP reduces these losses (on average) to a maximum of 0.2 tonnes/hectare. Based on the current average yield of 6.6 tonnes/hectare, this represents an improvement in yield of around 4.5% on unprotected crops.

This implies that crop yields have improved by around 0.3 tonnes/hectare as a direct result of work undertaken by the MRP. By applying this estimate to the actual amount and value of barley produced in the UK in 2015 it was estimated that the value of this output was **£37.5 million GVA**. Using the same method it was estimated that Scottish growers could accrue around **£9.0 million GVA** of this value.

Ramularia first emerged in central Europe but it has now spread to all major barley growing regions around the world. The expertise developed as a result of this research means that the advice of scientists at the MRP is now much sought after by barley growers all over the world. With authorities in Europe estimating that Ramularia could reduce yield by up to 20% and authorities in South America estimating losses of up to 70% this means that the global implications of this work could be very substantial indeed.

*Source: BiGGAR Economics based on Consultation with MRP staff*

Accounting for 20% of the total value of Scottish crop production potatoes are Scotland's second most valuable crop. The two most important pathogens affecting potatoes in the Scotland are late blight and potato cyct nematodes (PCN). It has been estimated that these pathogens together cost the UK economy a total of £81 million/year<sup>18</sup>. Scotland currently accounts for around 30% of the value of the UK potato crop so this implies that these diseases are likely to cost the Scottish economy in the region of £25 million/year.

Scientists funded through the 2011-16 SRP have been particularly active in addressing these pathogens and helping to contain their cost to the Scottish economy. The funding has for example been used to develop an empirical model that can be used to project the risk of PCN in 36,000 crop locations around the UK. An understanding of such risks is of fundamental importance to the decisions farmers make about when and how much fungicides to apply to their crops, which can significantly reduce the cost of crop damage and losses. Funding from the

<sup>18</sup> Potato Council (May 2009), Pesticide availability for potatoes following revision of directive 91/414/EEC: impact assessments and identification of research priorities

2011-16 SRP has also been used to sequence the genome of one of the most damaging species of PCN, which is expected to be key to future control efforts.

Direct evidence about the economic benefits of this research is not readily available but can be estimated based on recent experience in barley production.

As discussed in the case study above, research funded by the 2011-16 SRP has resulted in an increase of around 4.5% in the yield of barley across the UK. It is not unreasonable to expect that the research undertaken on important potato pathogens would have resulted in a similar level of improvement within the potato crop. By applying this to the volume and value of potato production in Scotland in 2015 it was possible to estimate that the value of agricultural production was around **£7.6 million** higher than it otherwise would have been as a result of this research. Using the same approach it was estimated that the benefit to the UK economy as a whole amounted to **£24.9 million** in 2015.

## 6.2 The Counterfactual

The benefits described in this chapter can be considered additional to the Scottish economy for the same reasons described in section 5.3: public funding is necessary to overcome the risks associated with uncertain returns to early stage research. Without this funding there would be a market failure and the private sector would not undertake this type of research.

## 6.3 Summary Benefits

By adding together the two sources of benefit considered in this chapter it was estimated that research funded by the 2011-16 SRP reduced the cost of important crop pests and diseases to the Scottish economy by £16.6 million GVA in 2015. Across the UK as a whole the value of this benefit was estimated at around £62.3 million GVA. These impacts are summarised in the table below.

Table 6-1 – Annual impact of plant health improvements - GVA (£ millions)

	Scotland	UK
Ramularia	9.0	37.5
PCN & Late Blight	7.6	24.9
<b>Total</b>	<b>16.6</b>	<b>62.3</b>

Source: BiGGAR Economics

### 6.3.1 Impact Time-Scale

The impacts described in this chapter are underpinned by many years of research evidence but the nature of plant pests and diseases means that it is appropriate to include these impacts as part of this analysis. This is because, although expertise and understanding of particular pathogens may be based on historic research, the methods used to predict and control them are constantly evolving.

Like the plants they affect, plant pests and diseases evolve continually. As soon as a new control method is implanted the pathogen involved starts changing in order to circumvent it. The challenges presented by these pathogens have also been compounded in recent years by the withdrawal of some of the most effective chemical control treatments on environmental grounds.

This means that tackling pests and diseases is an on-going battle where standing still is not an option and the benefits of previous advances are quickly eroded, as in the case of the study above where the fungus that causes Ramularia developed resistance to the fungicides used to control it.

Research supported by the 2011-16 SRP has enabled scientists to continue to develop new and improved control strategies, thereby helping to avoid the benefits of previous scientific advances being eroded. It is therefore appropriate to attribute the value of these benefits to the 2011-16 SRP.

## **7 GENETIC IMPROVEMENT**

For many years funding from the SRP (and predecessor programmes) has been used to support research and research infrastructure that has delivered genetic improvements in crops and livestock.

Genetic improvements are permanent and cumulative. This means that gains realised in one year will continue to be realised in subsequent years as economically advantageous traits are expressed in each new generation. Ongoing research means that the ability to select for desirable traits is continually increasing, which causes the total cumulative impact to increase each year. In order to estimate the total impact of genetic selection in 2016 (or any other given year), it is therefore necessary to consider both the cumulative benefits associated with historic research as well as the marginal additional benefits generated by research supported by the 2011-16 programme.

This chapter considers both aspects of this impact.

### **7.1 Livestock**

Since the early 1960s, consumption of milk per head in developing countries has almost doubled, meat consumption has more than tripled and egg consumption has increased by a factor of five. This increase has been achieved by increasing both the number and the productivity of animals reared. Improvements in livestock productivity, particularly in developed countries such as the UK, have largely been attributed to genetic selection. These productivity improvements arise because genetic selection helps to:

- bring about general productivity gains resulting from animals displaying desirable genetic traits – such as increased milk yield or carcass weight;
- reduce incidence of disease within a population of animals – thereby reducing losses to farmers from mortality and reduced productivity; and
- improve feeding efficiency by increasing the weight of meat that can be produced per kilo of feed.

While genetic selection has long been a feature of the livestock industry, traditionally this was based on visual inspection rather than scientific analysis. In recent decades traditional techniques have increasingly been replaced with more efficient statistical methods for estimating the genetic merit of animals.

In the UK the development and application of statistical genetic selection techniques within the dairy, beef and sheep industries has been driven largely through Edinburgh GENetic Evaluation Services – EGENES, which is delivered by one of the MRPs.

#### **7.1.1 EGENES**

EGENES uses performance and pedigree data recorded by farmers, breeders and other industry players to produce routine genetic evaluations for all dairy cattle and sheep in the UK and for the UK's biggest beef breeds. The evaluation outputs are then made freely available to the industry through a variety of sources including industry websites, trade publications and the popular agricultural press.

The EGENES unit is closely linked with industry and uptake of the outputs from the service within the UK livestock industry is high. This is reflected in the fact that much of the work of the unit is funded directly by industry. SRP funding has however been instrumental in enabling the Unit to leverage in this commercial funding. It is therefore appropriate to consider the impact associated with EGENES as part of this analysis.

### **7.1.2 Underpinning Capacity**

The work undertaken by EGENES is underpinned by research that is made possible by genetic resources and research infrastructure that are managed by the MRPs.

The Langhill Herd for example is a pedigree herd of dairy cows that has been carefully selected since the 1970s – making it the world’s longest running large animal experiment. It includes a group of “high genetic merit” animals and a control group that has been selected to reflect the average genetic value of dairy cattle in the UK.

The herd provides a valuable genetic resource that enables scientists to undertake controlled experiments on various aspects of animal nutrition, fertility, productivity and welfare that would not be possible on a commercial farm. The results of this research directly inform the work of EGENES.

These genetic resources and the research farms on which they are based are funded directly through the SRP, which provides further justification for considering the benefits associated with these resources as part of this analysis.

### **7.1.3 Benefits Realised to Date**

The economic benefits of genetic selection are measured by comparing the performance of individual animals within a contemporary group with the average of other animals in that group. The UK dairy industry for example uses a measure called “Profitable Lifetime Index” (PLI), which is a measure of the additional profit a bull with a high PLI is expected to return from each of his milking daughters over her lifetime compared to an average bull.

Using this measure it is estimated that genetic improvement in British dairy cattle over the last 20 years has been worth £2.4 billion, of which at least £408.0 million (17%) is directly attributable to EGENES. It is also estimated that genetic improvement has added around £500 million in additional value to the UK beef herd. Assuming that a similar proportion of this benefit can be attributable to EGENES suggests around £83 million benefit can be attributed to work supported by the SRP.

In both cases these impacts were measured over a 20 year period, which implies that the annual value of these benefits to the UK dairy industry is around £20 million/year while the annual value to the UK beef industry is around £4.2 million. Scotland accounts for around 9% of the UK dairy herd and 28% of the UK beef herd, which implies that these improvements are worth £1.9 million to the Scottish dairy industry each year and £1.2 million to the Scottish beef industry.

In addition to these benefits research funded by the SRP has also led to the widespread adoption of new genetic selection indexes for dairy cattle. These indexes have increased the average productive lives of dairy cattle from 3.4 years in 2004 to 4.3 years in 2009), reduced the average calving interval from 431 days



in 2008 to 423 days in 2012 and improved milk yield. It is estimated that the value of these benefits to the UK dairy industry amounted to £634 million between 2008 and 2013, which equates to an annual impact of £126.8 million across the UK and £11.8 million in Scotland.

Research supported by the SRP has also enabled genetic improvements worth £17.8 million to be realised across the UK sheep breeding industry. These benefits were realised over 10 years so the annual value of this improvement was around £1.8 million across the UK. Around 20% of sheep in the UK are in Scotland so it is reasonable to assume that £0.4 million of this benefit has accrued to sheep farmers in Scotland.

Taken together these benefits were worth a total of £152.7 million to the UK livestock sector in 2016 and £15.2 million to the Scottish livestock sector.

## **7.2 Crops**

Funding from the SRP (and predecessor programmes) has also been invaluable in supporting genetic improvement in several food crops that are important to the Scottish economy, in particular soft fruit, barley and potatoes. These improvements have been realised as a result of research findings being used to support the development of new varieties of crops that:

- produce greater or more reliable yields;
- are more resistant to disease; and/or
- exhibit characteristics such as improved taste, texture, nutritive value or appearance, which are desirable to consumers and/or food processors.

As with livestock breeding, genetic selection in crops is not new but research supported by the SRP has led to the development of new tools and techniques that have helped to make the process considerably more efficient.

In the past there was a considerable amount of trial and error involved in plant breeding because plant breeders had to breed a new variety and then wait until it reached maturity to see whether or not it would express the desired trait. The development of modern genetic selection techniques has removed much of this uncertainty and made it possible for breeders identify whether the desired trait will be present at a much earlier stage – thus making the whole process much more efficient.

### **7.2.1 Underpinning Capacity**

The MRPs act as the custodian of three globally important collections of genetic material: the Commonwealth Potato Collection, the UK Rubus (raspberries), the Ribes (blackcurrants) Germplasm Collection and a 10,000 line barley mutant collection.

The Commonwealth Potato Collection is the UK's genebank for potatoes and contains around 1,500 samples from more than 80 different species of potato. It is one of a network of international potato genebanks and provides the basic genetic resource for the improvement and adaptation of this important food crop.

One of the MRPs is also the only organisation in the UK that is authorised to produce pathogen tested Rubus and Ribes nuclear stock to enter the UK Plant Health Certification Scheme. The Scheme operates to ensure that the soft fruit

industry in Scotland (and the rest of the UK) has access to high-health plants for propagation.

Together these collections mean that researchers in Scotland (and elsewhere) have access to a huge variety of genetic resources. These resources are invaluable for developing new varieties that are better suited to changing environmental conditions or that better meet consumer requirements.

These resources also fit the traditional definition of a public good in that they are both non-rival and non-excludable. They are non-rival because the genetic material for producing plants can be reproduced and therefore its use by one individual does not stop someone else from using it. They are non-excludable because once a genetic improvement has been made plant breeders all over the world are quickly able to take advantage of it. These characteristics mean that there would be little incentive for the private sector to maintain these types of resources itself, which implies that displacement is unlikely to be a concern.

### **7.2.2 Impact to Date**

Research funded by the SRP (and its predecessors) has led to the development of multiple new varieties of potatoes, soft fruit and brassicas. Research commissioned by one of the MRPs showed that the total market value of crops grown from these varieties in the UK in 2014 was around £125 million<sup>19</sup>.

Not all of this value can be attributed to the MRPs however, some of it is attributable to crop growers and other individuals who contribute at other stages of the supply chain. Furthermore, if these varieties did not exist then other alternative varieties are available. In order to estimate the economic contribution of varieties developed by the MRPs it was necessary to come to a view on the “additionality” of these varieties, i.e. the extent to which they enable growers to improve their performance relative to the next best variety available.

The research referred to above estimated that these varieties generated £44.5 million *additional* gross value added for the UK economy each year and supported almost 890 jobs. In Scotland it was estimated that this impact amounted to £12.9 million GVA and around 260 jobs.

As well as developing new varieties researchers supported by the SRP have also worked closely with seed developers to develop new varieties of barley that have delivered significant improvement in yield and other economically important characteristics. These improvements have enabled farmers in the UK to increase the average yield of barley by around a third from 4.95 tonnes/hectare in the mid-1980s to 6.6 tonnes/hectare in 2015<sup>20</sup>.

The 2016 research referred to at the start of this section estimated that in 2015 these improvements added £6.5 million to the value of the Scottish barley crop, £23.2 million to the value of the UK barley crop and £152.4 million to the European barley crop.

The new varieties developed by – or in collaboration with – the MRPs have also generated significant benefits for food processors. For example, by improving the reliability of raw inputs or helping to reduce waste in the production process. The same research referred to elsewhere in this section estimated that these benefits

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<sup>19</sup> BiGGAR Economics (December 2016), Economic impact of the James Hutton Institute

<sup>20</sup> Brassley P (2000), Output and technical change in twentieth-century British agriculture.

were worth £14.2 million GVA/year to the UK economy, of which £1.4 million GVA was generated in Scotland. It was also estimated that this economic activity supported around 220 jobs across the UK.

By adding together the impacts considered in this section it can be estimated that historic research supported by the SRP has resulted in genetic improvements in crops worth £20.8 million GVA/year to the Scottish economy (and £109.2 million across the UK). It was also estimated that this economic activity supported at least 260 Scottish jobs (and more than 1,100 across the UK as a whole).

### **7.3 Impact Time-Scale**

The benefits described in this chapter are underpinned by many years of research effort. Although research funded by the 2011-16 SRP has contributed to the realisation of these benefits it represents only a proportion of the total investment in this area of research. Despite this caveat it is appropriate to consider these benefits as part of the present analysis.

Realising breeding gains is a long-term process that requires close collaboration between industry and academia. This type of collaboration requires strong professional relationships based on mutual trust and respect. An important factor in developing such relationships is a long-term commitment by both parties.

The long-term nature of the funding provided through subsequent SRP funding rounds helps to provide confidence to industrial partners of the MRPs long-term commitment to this area of research. Without this commitment then the future gains of the research would be uncertain and there would be little incentive for industry to participate. SRP funding therefore plays a vital role in helping to overcome the market failure that would otherwise deter private investment in this type of research. For this reason the impacts associated with this area of activity can be considered additional.

One important practical reason for this is that the 2011-16 SRP has provided funding to support essential underpinning capacity, without which none of the benefits described in this chapter could have been realised. Examples include the Langhill Herd, which provides the genetic resource for achieving breeding gains in the dairy sector, and the Commonwealth Potato Collection, which has provided the genetic resources required to support genetic improvement in potatoes.

For this reason, although some of the benefits described in this chapter were underpinned by historic research, it would not have been possible to realise them without the long-term commitment embodied by the 2011-16 SRP.

### **7.4 Expected Future Benefits**

Whether in plants or animals genetic improvement is a long-term process the benefits of which take several years to realise. The impacts described above therefore represent the annual impact of historic genetic research that was realised in 2016. As genetic improvement is permanent and cumulative the value of this annual impact will be realised again in subsequent years. The value of this annual impact will also increase year on year as the improvements made as a result of research funded by the 2011-16 programme begin to be realised.

The expected value of the additional genetic improvements realised as a result of the 2011-16 programme are explored in the two case studies below.

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**Case Study 7-1 – Ribena blackcurrants**

For the past 25 years one of the MRPs has been responsible for delivering the fruit breeding programme for the manufacturers of the iconic British soft drink, Ribena. In recent years one of the most important challenges facing the breeding programme has been the effect of warmer winters on blackcurrant crops in the UK and research funded through the SRP has played an important role in addressing this challenge.

Blackcurrants need a certain level of winter chilling to set fruit so a warmer winter can seriously reduce the volume of crops the following autumn. In the mild winter of 2015/16 for example some growers lost 40% of their crop.

The MRP has responded to this challenge by releasing a new variety of blackcurrant onto the market that performs well in milder winters. Although this variety has been released through the commercially funded Ribena breeding programme, the selection of the variety was informed by research on winter chilling effects that was funded by the 2011-16 SRP.

The manufacturer of Ribena expects that the new variety could save growers in the UK around £2 million/year and protect around 40 jobs. As Scotland accounts for around 28% of the value of soft fruit produced in the UK this implies the research could be worth around £0.6 million/year to Scottish producers and safeguard around 11 Scottish jobs.

An important consequence of this will be to ensure that the manufacturer of Ribena can continue to source all of its blackcurrants from UK producers, which is extremely important to the provenance of the product and ultimately its brand value. In addition to this, securing a more reliable supply of raw ingredients should help company to maintain high levels of efficiency. Ultimately this will support the continued competitiveness of the company and help to ensure that it maintains a strong market position in a highly competitive global market.

Research commissioned by the MRP in 2016 estimated that the producer benefits associated with the breeding programme (i.e the benefits to the Ribena manufacturer rather than blackcurrant producers) was worth £27.3 million GVA to the UK economy and supported around 220 jobs. Research supported by the SRP will play an important role in maintaining the value of this contribution in the future. The extent of this contribution is a matter of judgement but of the ten varieties of blackcurrants used in Ribena today, nine were bred by the MRP so it would be reasonable to attribute around 10% of future benefits to the new variety whose selection was informed by SRP funded research.

By adding together the producer and processor benefits considered in this case study it can be estimated that research funded by the 2011-16 SRP can be expected to safeguard £4.7 million GVA for the UK economy and more than 60 jobs. Of this around £0.6 million GVA and 11 jobs could be in Scotland. This is an annual impact that will occur again in subsequent years. The value of this annual impact is also likely to increase over time as uptake of the new variety increases.

*Source: BiGGAR Economics*

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**Case Study 7-2 – Maintenance Index for dairy cows**

Milk yield is an important focus for genetic improvement in the dairy industry but prolonged selection for this trait has resulted a gradual increase in the size of dairy cows. Larger animals have higher nutritional requirements but as feeding regimes were not adjusted to account for increased size fertility gradually declined.

To help address this, scientists funded by the 2011-16 SRP published a breeding value relating to the cost of keeping dairy cows. The index was constructed based on the genomic feed intake records for the Langhill herd and will enable farmers to select bulls who will produce daughters who are capable of maintaining high milk yields without growing overly large.

This is expected to have significant implications for the UK dairy industry by enabling dairy farmers to maintain milk output while reducing feed costs. The extent to which feed costs could be reduced has not yet been formally evaluated but academics involved in the project suggest an estimate of 1% would be reasonable.

On average dairy farmers in the UK spend between 7-8 pence/litre on purchased feed. By multiplying this by the total volume of milk produced in the UK in 2015 (15bn litres) it estimated that the cost of purchasing feed for the UK dairy industry in 2015 was around £1.1 billion. Reducing this cost by 1% would therefore represent a total saving of £11.4 million across the UK industry. Around 9% of the UK's dairy herd are located in Scotland so this implies that £1.1 million of this saving could be realised in Scotland.

The figures above relate only to savings in purchased feed and do not take account of the opportunity cost to dairy farmers of growing feed on-site. For this reason this impact almost certainly underestimates the true value of this research.

*Source: BiGGAR Economics*

The impact arising from the two case studies described above will increase the future value of the annual impact of genetic improvement to the Scottish economy. By adding together the future expected impacts considered in the two case studies above the annual value of this future benefit was estimated at £16.1 million GVA across the UK (£1.6 million in Scotland) and more than 60 UK jobs (including around 11 in Scotland).

It is important to note that this as an annual impact this impact will be realised again in subsequent years. The annual value of this impact will also continue to increase year on year as the benefits of future research are realised. As such the cumulative value of this research will continue to grow over time in perpetuity.

## **7.5 Summary Genetic Improvement Benefits**

In total, it was estimated that the current total annual impact of research into plant and animal genetics delivers £36.0 million GVA in the Scottish economy, and £237.3 million GVA in the UK economy. It is expected that when the economic value of research funded by the programme is fully realised, that the total benefit of research will be £38.3 million GVA in Scotland and £254.5 million GVA in the UK.

Table 7-1 – Annual impact of genetic improvement (£ million GVA)

	Scotland	UK
<b>2016</b>		
Livestock	15.1	152.7
Crops	20.8	84.6
Total	36.0	237.3
<b>2026</b>		
Livestock	17.0	167.9
Crops	21.4	86.6
Total	38.3	254.5

Source: BiGGAR Economics. Note, totals may not sum due to rounding

## 7.6 Future Potential Benefits

The case studies above describe the additional annual impact *expected* to arise as a result of research funded by the 2011-16 SRP. These impacts *could* however be much higher than this as the case study below illustrates.

### Case Study 7-3 – UK grown blueberries

In 2015 the value of the blueberry market in the UK expanded by 25% to £237 million (compared with £56m a decade ago)<sup>21</sup> but it is estimated that only 1-3% of this demand is currently met by UK producers<sup>22</sup>. With demand expected to continue to grow this represents a potentially lucrative opportunity for soft fruit growers in the UK.

One of the main barriers preventing producers from exploiting this opportunity is that the leading varieties of blueberry imported from elsewhere are often unsuitable for the UK growing season. Research supported by the 2011-16 SRP is helping to address this by informing the development of new varieties that are better suited to the UK climate.

If such new varieties were to be successfully introduced to the market then the proportion of UK blueberry demand that could be met by UK producers could increase to around 50%. This represents a potential contribution of around £111 million/year to the UK economy (£31 million in Scotland) and more than 2,200 jobs (600 jobs in Scotland).

Although there is still considerable uncertainty about the magnitude and time-scale of this benefit, the history of the Scottish raspberry industry provides a strong past precedent.

In the 1990s the raspberry industry in Scotland was in crisis due to cheap imports and the effects of disease on existing plantations. From 1993 funding provided (in part) by the Scottish Government was used to develop new varieties that were more resistant to disease and could be grown in polytunnels. These varieties enabled growers to significantly improve productivity and start producing higher quality fruit suitable for the fresh market (prior to this most fruit was used in relatively low value products such as jam).

If the new varieties had not been developed the Scottish raspberry industry would have had to continue to producing fruit primarily for the processing market. If this had happened then it is highly likely that the sector would by now have been largely replaced by competition from cheaper imports from Eastern Europe.

Source: BiGGAR Economics

<sup>21</sup> Produce Business UK (16<sup>th</sup> September 2016), Blueberry growers in Peru respond to UK retail requirements

<sup>22</sup> Knowledge Scotland (18<sup>th</sup> July 2011), Developing a British Blueberry Industry



## **8 EXPORTS**

This chapter considers the contribution that research supported by the 2011-16 SRP has made to maintaining the value of Scotland's exports.

### **8.1 Seed Potatoes**

In 2015 Scottish farmers produced more than 1.0 million tonnes of potatoes of which just over a quarter were seed potatoes and almost 79,000 tonnes of these seed potatoes were exported. Seed potatoes are a particularly high value component of the potato crop, generating between £240 and £250/tonne compared to around £140/tonne for main crop potatoes.

By multiplying the average value/tonne of seed potatoes grown in Scotland by the total volume of seed potatoes exported it was estimated that seed potato exports generated a total of £19.4 million for the Scottish economy in 2015/16. By dividing this by a turnover/GVA ratio for the agricultural sector it was estimated that this activity also supported around 388 jobs in Scotland.

The continued success of the seed potato industry in Scotland is wholly dependent on Scotland's reputation for producing high health plants. In order to maintain this high health status it is vital that growers in Scotland are able to respond quickly and effectively to new and evolving disease threats. Their ability to do this depends strongly on the research and underpinning capacity funded by the SRP.

In part this benefit arises as a result of the on-going research on important potato diseases undertaken by the MRPs (see chapter 6 for further details). This helps to ensure that growers in Scotland are in a position to respond appropriately to new disease threats as and when they emerge.

The benefit is also supported by the plant breeding work undertaken by the MRPs (see section 7.2 for further information), which has led to the development of new varieties of potato with improved resistance to important diseases. As discussed in the previous chapter, these genetic improvements are made possible by the genetic resources available through the Commonwealth Potato Collection, which is hosted by one of the MRPs and supported by funding provided through the 2011-16 SRP.

#### **8.1.1 Counterfactual**

The continued success of Scotland's seed potato industry is entirely dependent on Scotland's reputation for producing high health plants and Scotland's ability to breed new varieties that are resistant to diseases. Sections 7.2.1 and 6.2 describe why the benefits of these areas of work are attributable to the funding provided by the SRP. The same rationale can therefore also be used to justify why the benefits discussed in this chapter would not be realised without SRP funding.

## **9 FOOD AND DRINK**

Scotland's food and drink industry was identified in Scotland's Economic Strategy as one of the growth sectors in which Scotland can build on existing comparative advantage and increase productivity and growth. In 2014, the food and drink sector<sup>23</sup> generated a turnover of £14.4 billion and a GVA of £5.3 billion for the Scottish economy in 2014.<sup>24</sup> The sector is therefore of fundamental importance to the Scottish economy.

### **9.1 New Product Development**

SRP funding supports research and development in the food and drink sector as well as facilitating knowledge transfer. This supports the development of new and reformulated food products. As well as addressing public health targets these products contribute to the success of individual companies and the success of the sector as a whole.

One example of this is the role of one of the MRPs as a core partner in the Food & Health Innovation Service (FHIS) programme, which ran over the period 2010-15. The investment made by the SRP and its commitment to the research undertaken at the MRP created a platform of knowledge and capability that made the MRP a natural partner for the £4.5 million programme. The programme provided practical support to over 500 Scottish food and drink companies. The aim of FHIS was to help businesses realise growth opportunities in the healthy food and drink products marketplace. The programme therefore provided easy access to a group of companies who were likely otherwise not to have had access to expertise. Of the 500 companies supported, around 250 companies benefitted from support of some kind from the MRP partner in the programme.

An initial evaluation of the project forecasted a £40 million GVA impact<sup>25</sup> by 2016 from the programme. The core expertise and competence provided to businesses came as a direct result of the long-term commitment from SRP to support the research of the MRP in question. This long-term commitment enabled the MRP to undertake early-stage, pre-commercial research that would have been of limited interest to industrial partners and would therefore not have otherwise have been funded. The GVA impact of the programme can therefore be attributed in part to the SRP – i.e. it can be considered additional. A further example of how SRP funding has supported product development and generated economic benefits for the food and drink sector is the relationship between one of the MRPs and the major British retailer Marks & Spencer. This is described in more detail in the case study below.

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<sup>23</sup> The food and drink sector, as defined by the Scottish Government, encompasses: crop and animal production; fishing and aquaculture; manufacture of food products; and manufacture of beverages.

<sup>24</sup> Scottish Government (December, 2016), Growth Sector Statistics Database.

<sup>25</sup> Scotland Food and Drink, Food and Health Innovation Service (2012), Good Practices on Regional Research and Innovation Strategies for Smart Specialisation



Case Study 9-1 – Balanced for You

The Balanced for You food range (formerly known as Fuller Longer) was developed by Marks & Spencer (M&S) with expertise from one of the MRPs. Product development was based on SRP funded research into the efficacy of high protein and mixed carbohydrate diets for sustained appetite control and weight loss. The research partnership with M&S took the research findings of protein-induced satiety from the laboratory through to the marketplace. Together the development of a new range of calorie controlled food products was undertaken.

Obesity and its associated health issues are a major public health concern. The development of the Balanced for You range provides consumers with a way to make sensible meal choices in order to manage their weight. The range has a menu plan which features a carefully calculated balance of proteins and carbohydrates for calorie-counted meals and snacks to achieve sustained weight loss.

This industry-academia partnership to develop a food range based on scientific input, was a first for M&S, and has led to one of the UK’s most popular retail healthy-eating food ranges. M&S has 20 million weekly customers and figures for one week’s sales in January 2012 indicate it was the number one food diet brand in M&S in healthy meals.

As the underpinning research was funded by the SRP the economic contribution from the annual sales of the Balanced for You range can be attributed in part to the SRP. As well as contributing economically to the success of the overall food and drink sector, the Balanced for You range provides a practical and convenient way for people to manage their weight.

Source: BiGGAR Economics

In order to quantify the annual economic impact of the FHIS, a proportion of the FHIS's forecast GVA impact was attributed to the SRP. Annual sales information provided by Marks & Spencer was used to estimate the turnover from the Balanced For You range. Appropriate economic ratios and multipliers were then applied in order to estimate the direct and indirect effects.

By adding together the impacts considered in this section it can be estimated that research in the food and drink sector supported by the SRP has resulted in an economic contribution worth **£3.3 million GVA** and **143 jobs** to the Scottish economy. At the UK level this was estimated to be worth **£11.2 million GVA** and **441 jobs**.

Table 9-1 – Annual impact of SRP research in the Food and Drink sector

	Scotland		UK	
	GVA (£m)	Jobs	GVA (£m)	Jobs
<b>Annual impact of SRP research</b>				
Food & Drink	3.3	95	11.2	441

Source: BiGGAR Economics

The impacts described in this section were all realised during the 2011-16 period and represent annual impacts. However, these impacts would not be possible without previous rounds of SRP funding creating the research strength and underpinning capacity of the MRP in question. For example, the MRP partnership with the FHIS programme would not have happened were it not for previous SRP investment in research creating the core competence and expertise at the MRP.

It is also important to note that the impact on the food and drink sector of SRP funding will grow in the future. Research supported by the 2011-16 SRP will underpin future economic benefits, as described in the following section.

## **9.2 Development of New Market Opportunities**

The Scottish food and drink industry aims to increase the sector's turnover from £14.4 billion in 2014 to £16.5 billion by 2016. The food and drink industry performance review highlights investment in R&D as one of the key components for driving growth in GVA and turnover in the sector. SRP supported underpinning research therefore has an important role to play in the development of new varieties and new markets as well as supporting Scottish businesses to maximise these opportunities.

One example of this is the potential market for UK grown blueberries. Blueberries account for 17% of fruit sales in the UK but it is estimated that only 1-3% of the blueberries purchased in the UK are grown here. MRP researchers have been undertaking research to develop new varieties of blueberries which are better suited to the Scottish climate. This research opens up the possibility for Scottish growers to capture a share in a growing market, as discussed in Section 7.6.

MRP researchers have also been working in conjunction with Interface Food and Drink to promote collaboration between food and drink companies. For example, one of the MRPs has been working with small to medium sized rapeseed oil enterprises in Scotland to establish a common interest group. The Scottish Rapeseed Oil group comprises all eight Scottish rapeseed oil manufacturers. The MRP has been working with the group to help establish a unique selling point for Scottish rapeseed oil against other UK manufactured and imported oils.

Rapeseed oil the fastest growing oil type, growing at 21% year on year and increasing its share to 2.6% of the total UK oils market. This is largely due to rapeseed oil being considered a healthier alternative to olive oil due to its higher levels of omega 3 and half the saturated fat. The UK market value of rapeseed oil is £7.2 million and retail sales in Scotland amount to £479,699.<sup>26</sup> In order for Scottish producers to gain a larger market share it is important that they are able to differentiate themselves from other regions and brands by communicating what makes them, their sourcing, taste profile, nutritional profile or manufacturing process different or better.

MRP scientists have been working with the Scottish Rapeseed Oil group in conjunction with a number of universities to understand the regional and environmental factors affecting the composition of the oil. Developing a research based USP for Scottish rapeseed oil will help Scottish SMEs realise new market opportunities and accelerate their growth.

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<sup>26</sup> Scottish Enterprise and HIE (2013), The UK Retail Edible Rapeseed Oil Category

## **10 ENVIRONMENTAL BENEFITS**

Approximately 30% of the resources provided through the 2011-16 SRP were allocated under the “Environmental Change” programme. Although the principle aims of this research were environmental, the research will also have important economic effects. These effects arise when research leads to the:

- preservation of natural resources that are valuable in their own right or help to underpin the activities of important sectors of the Scottish economy;
- avoidance of environmental reinstatement costs and (potentially) fines associated with illegal damage to the environment; or
- realisation of the commercial value of previously unexploited or underexploited natural resources (such as oil or water for example).

In most cases these effects arise indirectly as a result of research being used to inform the development of public policy or industry practice and often the benefits of the research are intangible and difficult to quantify.

### **10.1.1 Economic Impact of 2011-16 SRP Environmental Research**

The 2011-16 SRP has helped to deliver a wide range of environmental benefits. It is beyond the scope of this report to identify these benefits but interested readers are referred to the end of programme reports produced for each of the two main research themes and in the annual Spotlight and Highlight publications produced by the MRPs and the Scottish Government.

It is likely that many of the environmental benefits realised through the 2011-16 SRP will have benefited the Scottish economy in some way but the indirect nature of the benefits means that in most cases quantifiable evidence of this is not readily available. This report therefore focuses on just two areas where it is possible to identify tangible economic benefits:

- reductions in emissions; and
- avoiding the costs associated with species translocations.

Both of these examples are considered in the case studies below.

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**Case Study 10-1 – Reducing greenhouse gas emissions**

In 2009 the Climate Change (Scotland) Act established a legally binding target for the Scottish Government to reduce greenhouse gas (GHG) emissions by at least 80% (from 1990 levels) by 2050. Agriculture is currently the third largest source of GHG emissions in Scotland, accounting for nearly 23% of total Scottish emissions in 2014. To help achieve the targets set out in the Act, the Scottish Government has therefore set a specific target to reduce GHG emissions from agriculture by 10% by 2020. Funding provided under the 2011-16 SRP has enabled the MRPs to engage in various projects that have made – or have the potential to make – a significant contribution to achieving this target.

Scientists funded by the 2011-16 SRP have for example contributed directly to the development of the Scottish Government's **Beef Efficiency Scheme**. The Scheme uses data collected from farmers about the performance of their herds to develop new approaches to genetic selection and management practice that will help farmers to improve herd efficiency. Improving herd efficiency will not only improve overall profitability but will also reduce emissions from beef production. Although the full impact of the Scheme will not be realised for several years it has been estimated that the scheme could reduce GHG emissions by the equivalent of 270,000 tonnes of CO<sub>2</sub> over a 10 year period.

Scientists funded through the 2011-16 SRP have also contributed directly to the development of a **GHG budget for the agricultural sector**. This research identified approximately 10 Mt CO<sub>2</sub> equivalent that, under ideal conditions, could be mitigated from the agricultural sector by 2022. The research findings provided a basis for developing a voluntary target of around 3 Mt CO<sub>2</sub> equivalent that was agreed between DEFRA and the agricultural sector. The potential value of this saving is significant. Using the UK Government's Department for Business Energy and Industrial Strategy benchmark carbon values, the scientists responsible for the research have estimated that it could be equivalent to £250 million worth of avoided climate damages.

Source: BiGGAR Economics

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**Case Study 10-2 – Conservation translocations**

MRP scientists have played a leading role in developing national and international guidelines for conservation translocations. Conservation translocations involve the deliberate movement and release of plants, animals or fungi into the wild for conservation purposes. They are particularly important given that human induced habitat loss and degradation have caused population size reductions and local extinction in many species. As well as this, climate change is leading to environmental conditions becoming unsuitable for many populations in their current locations and conservative translocations can serve to offset these losses.

However, moving species has a number of potential risks. Translocation can create problems for other species or habitats, for example through competition, disease transmission or genetic swamping. There can also be negative effects for humans if the translocated populations cause health problems or negative impacts on livelihoods and leisure. It is estimated that 20-30% of all introduced species worldwide cause a problem.

In particular, non-native species can have a direct cost to the economy, through control and eradication costs, structural damage to infrastructure or loss of production. For example, Scotland's natural environment supports the game and fishing industry, provides a unique destination for tourists and is the source of high-quality food and clean water supporting the food and drink sector. Any threat to Scotland's natural environment therefore has the potential to cause production losses across all of these sectors.

To promote best practice and to maximise the benefits while minimising the potential harm of conservation translocations, MRP scientists co-authored the 2013 International Union for the Conservation of Nature's (IUCN) Guidelines for Reintroductions and Other Conservation Translocations. These guidelines have become the international standard and were used as the basis for the Council of Europe's Conservation Translocations under Changing Climatic Conditions recommendations. The MRP involved then led the authorship of The Scottish Code for Conservation Translocations, the first national implementation of the new IUCN guidelines. By developing best practice for conservation translocations, the MRP has created an international, and national, standard for translocations helping to minimise the potential risks and associated economic costs whilst maximising the potential benefits.

This research was published in 2013 so the benefits it is likely to generate are unlikely to have been fully realised yet. To illustrate the potential scale of research in this area it is however instructive to consider that it has been estimated that the total loss to the world economy as a result of invasive non-native species is around 5% of annual production (i.e. the total value of the goods and services produced)<sup>27</sup>. By contrast, the cost of invasive non-native species to the Scottish economy has been estimated at around 0.2% of total Scottish gross domestic product (GDP).

*Source: BiGGAR Economics*

## **10.2 The Value of Scotland's Natural Environment**

The two case studies in the previous section highlight two areas in which research funded through the 2011-16 SRP has made a direct contribution to protecting Scotland's natural capital and the ecosystem services it provides. Assessing the value of ecosystem services in monetary terms is inherently difficult because most are not traded on the open market. There is however a clear consensus that ecosystem services are vital for human development and play a key role in underpinning the economy.

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<sup>27</sup> Williams et al (2010), The Economic Cost of Invasive Non-Native Species on Great Britain.

Over the past 15 years there have been two major studies that have attempted to quantify the value of Scotland's natural environment and the ecosystem services it provides.

The first was undertaken in 2002 by SEPA and sought specifically to estimate the value of ecosystem services in Scotland. This research found that while it is impossible to put a monetary value on some ecosystem services, those that could be measured were worth around £17.2 billion/year. This work was updated in 2012 in order to produce a revised estimate of between £21.5 and £23 billion/year to the Scottish economy<sup>28</sup>.

The second major study was commissioned by Scottish Natural Heritage in 2008<sup>29</sup> and attempted to quantify the value of Scotland's natural capital by considering the role that a high quality natural environment plays in supporting various sectors of the Scottish economy. This research showed that 11% of Scotland's total economic output depends on sustainable use of the environment, which was worth £17.2 billion a year to the Scottish economy (coincidentally the same value estimated by the earlier work published by SEPA in 2002). This study also estimated that the natural environment supported one in seven of all full time jobs in Scotland.

Although not directly comparable, the magnitude of the impacts described in the two studies serves to illustrate just how valuable Scotland's natural environment is to the country's economy. Given that Scotland's natural environment is such a valuable economic resource efforts to protect it must therefore also have an economic value.

Responsibility for designing, implementing and enforcing the policies that make up Scotland's system of environmental protection rests with the Scottish Government, which funds the various public agencies tasked with protecting Scotland's natural environment. The policies, regulations and procedures implemented by these agencies are in turn underpinned by research evidence, much of which is provided by the MRPs. The MRPs therefore play a key role in ensuring that appropriate measures are in place to protect Scotland's natural environment.

### **10.3 Assessing the Benefits of Environmental Research**

Assessing the economic benefits of environmental research is challenging for a number of reasons, not least of which is that the benefits of environmental research are often indirect and may occur over a very long period of time. Much environmental research is also focused on delivering outcomes that simply cannot be quantified in monetary terms – such as greater biodiversity or improved environmental quality.

The challenges of measuring the economic returns to environmental research are widely recognised in the economics literature and there is no clear consensus about the best approach for doing this. In attempting to assess the benefits of environmental research supported by the 2011-16 SRP a number of alternative approaches were therefore considered.

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<sup>28</sup> Williams E (2012), Preliminary exploration of the use of ecosystem service values in a regulatory context

<sup>29</sup> Scottish Natural Heritage (2008), The economic impact of Scotland's natural environment



### **10.3.1 An Insurance Based Approach**

The first approach considered was an insurance-based approach.

In many ways Scotland's system of environmental protection can be regarded as a kind of insurance policy: by investing in this area the Scottish Government is in guarding against the costs of environmental damage that might otherwise be incurred. Economic theory suggests that the premiums paid for an insurance product should be equal to the expected value of the compensation that would be received in the event of the insured-against event. Put another way this implies that the amount that the Scottish Government is prepared to invest in environmental protection is a direct reflection of the cost of the environmental damage that it expects might otherwise occur.

Analysis of information on the Scottish Government's website suggests that in 2015/16 the Scottish Government spent £16.2 million procuring research designed to support environmental protection through the SRP. Following this logic to its natural conclusion would suggest that this therefore represents the economic value of this environmental research to the Scottish economy.

The insurance policy analogy does however have an important limitation in that the market for environmental protection is not competitive because the Scottish Government is the only customer. Unlike most insurance markets this means that the Scottish Government has a very high level of market power and can in effect determine the price of the "premium" it pays. This means that the amount invested in environmental research almost certainly underestimates the true value that this research generates for society. For this reason £16.2 million should be regarded as the minimum value that this area of research contributes to the Scottish economy.

As this method was likely to considerably underestimate the value of environmental research to the Scottish economy it was therefore rejected.

### **10.3.2 Comparisons with Other Countries**

The second approach involved considering the economic costs of environmental damage incurred by other countries that do not have as well developed systems of environmental protection as Scotland. Specifically this approach involved developing a counterfactual scenario based on the Chinese experience and the proportion of Chinese GDP that is currently devoted to efforts to remedy damage made possible by a lack of environmental regulation. The logic for this approach was based on the assumption that if Scotland did not have its current system of environmental protection in place then it too would need to spend a similar proportion of its GDP on environmental restoration.

Using this approach it was estimated that the environmental benefits of research supported directly and indirectly through the 2011-16 SRP were worth £96.7 million GVA/year to the Scottish economy.

There are however important and significant differences between the Scottish and Chinese economies, which make this approach problematic so it too was rejected.

### 10.3.3 Potential Scale of Return on Investment

An alternative approach to estimating the economic value of environmental research is to consider the return on investment that has been realised by environmental research undertaken elsewhere. Evidence on the economic returns to environmental research is limited but two helpful sources include:

- research published by the European Commission<sup>30</sup>, which considered the economic benefits of environmental policy across the EU; and
- a study published by the Natural Environment Research Council (NERC) that considered the economic benefits of natural science<sup>31</sup>.

The first of these studies considered various ways in which environmental policy in the EU has generated tangible economic benefits. One of the areas considered that is particularly relevant to the present analysis was the role of environmental policy in helping to strengthen the natural capital base. The specific policy area considered in relation to the stock of natural capital was the EU wide network of Natura 2000 sites, which exist to protect the most seriously threatened habitats and species across Europe. The study considered the economic and social value of the natural capital base (e.g. providing food, cultural and leisure resources, distinctiveness and sense of place) and how Natura 2000 sites policy had helped to safeguard that natural capital base.

The research suggests that the total cost implementing this policy area is around €6.1 billion/year and that this investment is expected to generate (direct and indirect) quantifiable benefits of around €5.2 billion/year for the EU economy and support around 207,400 jobs. This equates to a benefit/cost ratio of 0.9 and a cost/job of around £26,300.

Understanding and protecting Scotland's natural capital and biodiversity is an important focus of much of the environmental research supported by the SRP, which provides some justification for using the findings of this section of the report in the present analysis.

It would not be good practice to be overly reliant on a single piece of evidence (albeit one published by the European Commission) so a further search was undertaken to identify further research that might provide further justification for this approach. This search identified the second of the studies highlighted above, which considered the economic benefits associated with a variety of different areas of research supported by the NERC.

One of the areas considered was the economic benefits of the Global Nitrogen Enrichment programme, which focused on how nitrogen from fertilisers, livestock farming and fossil fuels moves through the environment. Understanding and identifying ways of tackling issues relating to nitrogen use and pollution from agriculture is another important focus for research funded by the 2011-16 SRP, which provides some justification for using the findings of the report to inform the present analysis.

The report suggests that NERC's investment of around £6 million in this area of work has generated economic benefits of between £7 million and £48 million for

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<sup>30</sup> Rayment et. al. (2009), the economic benefits of environmental policy

<sup>31</sup> PricewaterhouseCoopers (2006), Economic benefits of environmental science



the UK economy. This implies that the benefit cost ratio of this type of research could be between 1.2 and 1:8.

So as to avoid relying exclusively on just one source of evidence the two return to investment ratios described were then combined to produce an average ratio. This ratio implied that the economic return to environmental research might – on average – be of the order of 4.43. That is to say, each £1 invested in environmental research might be expected to generate around £4.43 of economic benefits.

As discussed above, the Scottish invested around £16.2 million in environmental research through the 2011-16 SRP in 2015/16. Applying the ratio above to this expenditure suggests that this research could have generated an annual economic benefit of around £72 million for the Scottish economy. Applying the cost/job estimate described above suggests that this research could also have supported around 620 Scottish jobs.

It is however important to use caution when interpreting this result. The methodological challenges associated with estimating the impact of environmental research mean that it very difficult – if not impossible – to provide a definitive assessment of the true economic contribution of this area of research. This estimate should therefore be regarded as illustrative of the potential order of magnitude of this benefit rather than a definitive value.

That said, there is some justification for suggesting that the estimate provided above could be conservative. This is because, as discussed in section 13.2, MRP scientists have been very successful at using the funding provided through the 2011-16 SRP to leverage additional research funding. Undoubtedly a proportion of the additional funding leveraged will have related to environmental research. This means that the true value of environmental research supported by the SRP, and by extension the economic benefits associated with this research, could well be higher than estimated above.

It is also important that this substantial benefit is understood in the context of the overall value of the natural environment to Scotland’s economy. The information presented above helps provide this. As discussed above, ecosystem services in Scotland are have been estimated to be worth between £21.5 and £23 billion/year. The figures presented in this chapter suggest that the research supported by the 2011-16 SRP might account for less than half of 1% of this value. Understood in this context the impact presented in this chapter appears conservative.

The impact described in this section is summarised in the table below.

Table 10-1 – Impact of research to protect the natural environment

Assumption	£m	Jobs
Impact of environmental research	71.7	617

Source: BiGGAR Economics

## 11 RESEARCH TRAINING

The 2011-16 SRP funding also enabled the MRPs to train PhD students, who will be future generations of researchers, by allowing staff members to devote time and resources towards mentoring and developing them. In addition, MRPs are able to have access to the latest tools, techniques and databases, which young researchers can learn to use.

Once they have entered the labour market the skill and approach that these researchers will have developed provide them with the ability to contribute more productively to future employers, and to generate greater value in the economy than they may otherwise have been able to. This additional productivity will predominantly be represented by additional remuneration accruing to the researchers, and the additional profits generated by employers.

The additional profit that graduate employers can expect to generate is not a subject that has been well researched but information on the earnings premium that graduates receive is readily available, and can be used to provide a measure of the economic contribution that graduates make to the economy each year.

The graduate earnings premium was the subject of a research paper published by the Department for Business, Innovation and Skills in 2011,<sup>32</sup> which analysed Labour Force Survey data covering the period 1996-2009. Although the primary focus of the research was the earnings premium of undergraduates, it also considered postgraduates, comparing their after-tax earnings to undergraduates. The direct and indirect costs were then subtracted from the graduate premium for each degree to give the net graduate premium.

The study found that the completion of a PhD was associated with a lifetime earnings premium of £62,395 compared to an undergraduate, and that completion of a Masters degree was associated with a premium of £55,720 compared to an undergraduate. As an estimated 39% of PhD students have previously completed a Masters degree<sup>33</sup> the additional premium associated with completing a PhD was estimated at £6,675.

By applying this assumption to data provided by the Scottish Government on the number of PhD students supported it was estimated that the researcher training supported by the 2011-16 SRP funding generated a productivity benefit of around £1.3 million in Scotland, and £2.0 million in the UK. In 2016, researcher training was estimated to support a productivity benefit of £0.2 million in Scotland, and £0.3 million in the UK.

Table 11-1 – Annual impact of research training

	Scotland	UK
Total GVA (£m)	0.2	0.3

Source: BiGGAR Economics

This benefit will be generated over the course of the researchers working lives and will therefore help to increase the annual value associated with the 2011-16 SRP in the future.

<sup>32</sup> Department for Business, Innovation and Skills (2011), The Returns to Higher Education Qualifications

<sup>33</sup> HEFCE (2011), PhD Study: Trends and Profiles 1996-97 to 2009-10

## **12 WIDER ECONOMIC BENEFITS**

This chapter describes some of the wider economic benefits associated with the 2011-16 SRP that it has not been possible to quantify.

### **12.1 Human Health**

SRP funding supports research related to human health in two main ways. MRP researchers undertake research into the prevention and control of pathogen access to the human food chain. This includes pathogens such as *E. coli*, *Cryptosporidium* and *Campylobacter*. As well as this the MRPs are involved in functional foods and nutraceuticals research which aims to help people manage or avoid disease.

#### **12.1.1 Functional Foods**

The global nutraceuticals market was valued at \$182.6 billion (£150.5 billion) in 2015. Figures for the UK market were not available, however by way of illustration, the vitamin supplement industry is worth around £675 million to the UK.<sup>34</sup> There are further significant economic benefits through the public health implications of disease prevention and improved disease management.

Previous SRP funding led to the development of Fruitflow, a tomato extract which can help with healthy blood flow. MRP research found that biologically active constituents in tomatoes inhibit blood platelet aggregation; a known cause of heart attack, stroke and venous thrombosis. An MRP spin-out Provexis was launched in 1999 to market and sell the product and the company was later listed on the Alternative Investment Market. In 2009 Fruitflow was the first food ingredient to meet the requirements of the European Food Safety Agency for products with a specific health claim. In 2010 the company entered into a long-term Alliance Agreement with DSM Nutritional Products and now has more than 50 healthcare brands (food, drink and nutraceuticals) across the globe, which incorporate Fruitflow. In 2016, Provexis concluded a collaboration agreement with By-Health, one of China's largest health products manufacturers. The agreement aims to target the creation of new products for the estimated 230 million people in China with cardiovascular problems. The total cost of coronary heart disease in China has been estimated to be £14.0 million<sup>35</sup> each year and Fruitflow could therefore generate significant benefits. Although it is not possible to quantify the economic contribution of Fruitflow, it nevertheless provides an example of successful functional food product development and commercialisation founded from SRP funded research.

Although not yet generating impact, the current SRP has been funding research into the effects of berry extracts on diabetes management. MRP scientists have shown that the ingestion of a concentrated bilberry extract in a capsule gives a significantly reduced glucose response in volunteers with Type 2 diabetes who are controlling their diabetes by diet and lifestyle alone. Current research is focused on adipose (fat) tissue responses to blueberry phytochemicals and on investigating the effects of berries on fat and protein in food, to assess whether they can be used as natural additives. Although this area of work is currently in the research phase there are significant potential economic benefits, should a

<sup>34</sup> BBSRC (2016), Bioscience Facts and Figures

<sup>35</sup> Le, C. et al. (2014), Economic burden and cost determinants of coronary heart disease in rural southwest China: a multilevel analysis, *Public Health*, Volume 129, Issue 1, 68 - 73

product be developed and commercialised. Type 2 diabetes is the most prevalent form of diabetes affecting 2.5 million people in the UK (about 5% of the population). It is becoming increasingly prevalent with incidence of Type 2 diabetes expected to double in the next 20 years. The total cost (direct care and indirect costs) associated with Type 1 and Type 2 diabetes in the UK currently stands at £23.7 billion and is predicted to rise to £39.8 billion by 2035/36.<sup>36</sup> The research currently being undertaken at the MRPs could therefore have significant economic benefits.

### 12.1.2 Prevention and Control of Zoonoses

Zoonoses are diseases or pathogens transmitted between animals and people and may involve a wide range of infectious agents. Around 62% of all known human pathogens and 75% of emerging diseases are zoonotic and pathogens may be transmitted by direct contact or through contaminated food or water supplies.

These pathogens can have very damaging economic consequences. This includes direct impacts on economic productivity, for example because people affected need to take time off work and/or direct healthcare costs. There are also indirect impacts linked to wider effects on the food supply chain, such as losses resulting from contamination. SRP funding supports research into several zoonotic pathogens including *E. coli*, Cryptosporidium, Campylobacter, toxoplasma and chlamydia in sheep.

*E. coli* cases are relatively rare but has been the cause of a number of large and serious foodborne outbreaks, which typically involve lengthy public enquiries and considerable cost to the public purse and food supply chain. Most outbreaks are associated with the consumption of contaminated meat or dairy products as cattle are the main reservoir for the transmission of *E. coli*. Consequently MRP research is focused on the development of a vaccine for cattle. Research is also being undertaken into the different strains of *E. coli* in order to understand which strains are more likely to transmit infections.

Campylobacter is the most common cause of food poisoning in the UK and is responsible for an estimated 280,000 cases of food poisoning each year. Around four in five cases of campylobacter poisoning in the UK come from contaminated poultry. The Food Standards Agency estimates that Campylobacter causes more than 100 deaths a year and costs the UK economy about £900 million. MRP research is focused on characterising Campylobacter in order to differentiate strains and assess their pathogenic potential.

*Toxoplasma gondii* is a parasite that causes abortion in ewes. Humans can become infected by eating lightly cooked meat that contains Toxoplasma tissue cysts or following contact with oocysts in cat faeces or by contact with infected sheep and lambs at lambing time. Toxoplasma can cause serious disease in pregnant women and immunocompromised people, such as AIDS patients. Infection in pregnant women may kill the unborn child or lead to severe disability. Although incidence of Toxoplasma in humans is low the costs of the relatively small proportion of cases with severe disease make toxoplasmosis one of the most costly of gastro-intestinal infections. The research focus of the MRPs is on whether or not the current vaccine is able to reduce the number of Toxoplasma

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<sup>36</sup> Diabetes UK (Oct 2016), Facts and Stats

cysts found in edible cuts of meat therefore reducing the potential of transmission to humans.

Although it is not possible to quantify the potential economic impacts of MRP research into these pathogens, MRP research into the pathogen *Cryptosporidium* provides a case study demonstrating the potential reduction in harm achievable by MRP research into zoonoses.

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#### Case Study 12-1 – *Cryptosporidium*

*Cryptosporidium* is recognised as a major contaminant of drinking and recreational waters and is very difficult to control due to its resistance to standard water disinfection processes. Symptoms of cryptosporidiosis include mild to severe diarrhoea, abdominal pain and nausea. In individuals with impaired immune systems, such as AIDS patients, the symptoms can be more severe. Cattle, and in particular neonatal calves, are seen as the main reservoirs of this parasite, the oocysts (infective stage) of which are resistant to current chemical treatments used by the water industry causing problems for control.

As a result of SRP funded research into *Cryptosporidium*, one of the MRPs collaborated with Scottish Water when it was noted that one public water supply in Glenlivet had a historical and current record of *Cryptosporidium* contamination. There had been numerous cases of human illness, and at least one hospitalisation, as well as high costs to the water provider associated with these outbreaks and to the farms through veterinary treatment and losses in cattle production due to cryptosporidiosis.

In order to identify the source of the *Cryptosporidium* and find an effective solution water samples were collected and the results from these were compared to those obtained for livestock and wildlife, with the hope of teasing out the transmission routes of the parasite through the catchment. The particular strains of *Cryptosporidium* present in the catchment illustrated that the parasites detected were predominantly of the same strain indicating that the parasite was transmitted between livestock and deer in the catchment and into the water. This illustrated that all livestock and wildlife tested potentially had a role to play in contamination of the water sources and that transmission of the parasite was evident between livestock and wildlife, due to shared access to hill and enclosed grazing. MRP researchers advocated improving the catchment above the public water supply in order to prevent transmission and disseminated this information through meetings and an on farm event held locally for both the water and livestock farming industries.

Following the intervention the incidences of *Cryptosporidium* fell from 21 raw water positives in the 6 months before to 2 water positives in the 2 years after, a decline of 90%.

*Source: BiGGAR Economics*

## 12.2 Sustainable Rural Communities

The SRP also focuses on supporting rural communities to make them more economically and environmentally sustainable. The research in this area aims to boost farm business productivity, reducing costs and ensuring that more money stays in the local area, and protect livelihoods in traditional industries, such as crofting.

These aims not only improve the economic outcomes of the individuals affected, but also build capacity in the local areas, creating wider opportunities. This ultimately makes rural communities more economically sustainable by attracting new people to the area and providing young people with options that mean they don't have to leave in search of work.

In addition, the research often provides communities with the knowledge and resources to become more environmentally sustainable. Often, reductions in

costs can be achieved by managing land better, or by using less resources, which reduces the carbon footprint of rural areas, and ensures that the land maintains its level of productivity.

Farming for a Better Climate, which is administered by one of the MRPs, is a scheme designed to improve the environmental sustainability and profitability of farms throughout Scotland. It provides practical support to benefit farmers and reduce the impact on the climate.

The principal way that research is undertaken is through volunteer Climate Change Focus Farms, which, aided by specialists, experiment with practical measures to improve farm profitability and reduce carbon output. Meetings are then organised to disseminate the findings of this research.

For example, Glenkilrie, a 1,000 hectare beef and sheep farm in Perthshire, volunteered as a climate Change Focus Farm. After implementing changes advised by MRP specialists, it managed to save £11,000 and reduce its carbon footprint by 10%. The Farming for a Better Climate initiative organises its focus into five key areas, which can benefit most farms, including Glenkilrie:

- using electricity and fuels efficiently – at Glenkilrie they replaced an petrol quad with an electric one, reduced the unnecessary operation of the feed mixer wagon, and matched the machinery better with task at hand;
- developing renewable energy – considered installing a biomass boiler, and considered the scope to invest in other forms of renewables;
- locking carbon into the farm;
- making the best use of nutrients – regular soil sampling instituted to highlight areas that have low potassium and pH, including GPS-based soil analysis, and considered increased use of farm yard manure and slurry storage to maximise nitrogen value; and
- optimising livestock management – condition scoring animals to optimise feeding, analysing silage to enable more efficient feeding of lambs, screening livestock to identify diseases and unproductive cows early, calving earlier, and replacing straw with recycled wood chip.

### **12.3 Efficiency of Public Expenditure**

The MRPs also contribute towards effectively allocating funding towards the areas where it will generate the most impact. For example, MRPs were intensively involved with how the Scottish Government allocates the European Union's Common Agricultural Policy (CAP) funding.

As the 2014-20 round of CAP funding was devolved from the EU for the first time, this presented an opportunity to increase the efficiency of its allocation. In order to achieve this one of the MRPs developed a regionalisation model as well as several other funding models to compare results. This was aided by graphical presentations of the data, and the overall approach was complimented by other member states.

In addition, the MRPs has been instrumental in explaining the impact of the proposed changes, especially to individual farms. For example, one of the MRPs developed a CAP Payment Calculator, which they have deployed with over 1,500



clients, and another MRP helped to explain the reforms and their consequences to a wider variety of stakeholders, including the National Farmer's Union Scotland, Scottish Natural Heritage and Forestry Commission Scotland. A Farmer Intentions Survey was also carried out, which will serve as a baseline for farmers' views on the CAP.

This and other similar research has also increased understanding of the relative advantage and disadvantage of rural areas within Scotland. The work undertaken on changes to the CAP has also increased the level of experience in the MRP.

Additionally, one of the MRPs developed a socio-economic index for rural communities, which combines 20 indicators for about 2,000 data zones in Scotland. As well as being used to allocate Links Between Activities Developing Rural Economies (LEADER) funding, this data has been used by a wide range of organisations, such as NHS Highland and the Church of Scotland, to better target resources.



## 13 CORE ECONOMIC IMPACTS

This section describes the economic impacts that the Scottish Government's SRP generates through its funding, as well considering funding that has been leveraged based on Strategic Research, including:

- the direct impact of the programme including the staff that are employed and the value it adds directly to the economy;
- the impact of expenditure on goods and services related to the funding;
- the impact of expenditure by staff supported; and
- the impact of capital investment related to the funding.

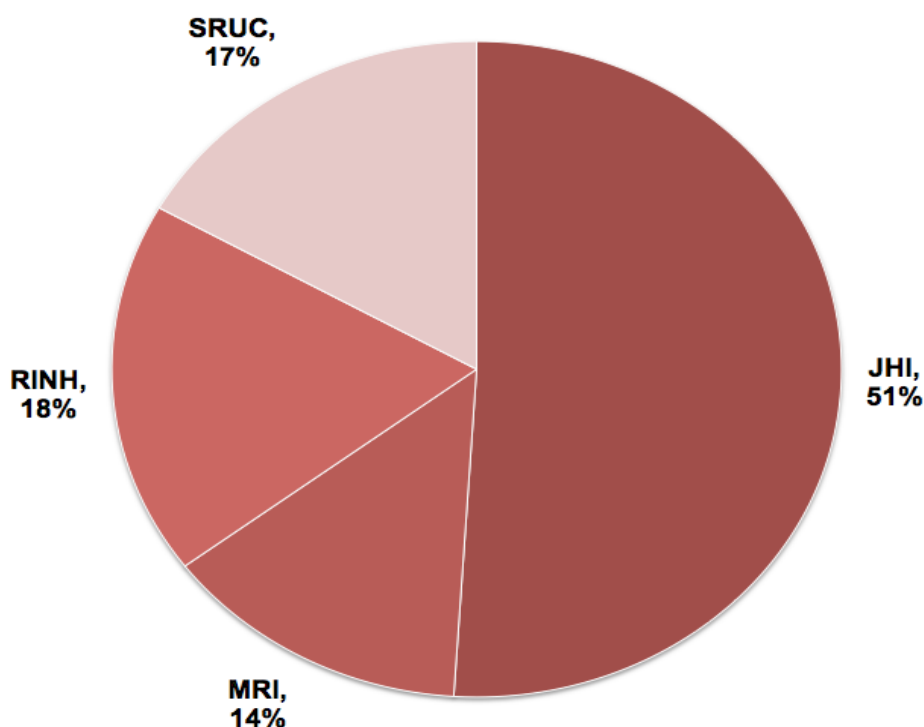
### 13.1 Direct Impact

The direct impact of any organisation or programme to the economy is the value it adds to the economy and the direct number of jobs it supports. Direct GVA is calculated by subtracting expenditure on goods and services from total income.

The total income of the MRPs from the SRP in the period between 2011/12 and 2015/16 was £246.0 million. This represents an average income of £49.2 million over the five year period and £47.5 million in 2015/16. Over the period the Scottish Government allocated £189.1 million funding to the strategic research programmes, £51.0 million to support the underpinning capacity of the MRPs and a further £5.9 million to support capital investment by the MRPs.

As can be seen in Figure 13.1, about half of the funding over the total period has gone to the James Hutton Institute (this includes the income of Biomathematics and Statistics Scotland, and its impact is included as part of the James Hutton Institute's throughout Chapter 4), followed by the Rowett Institute (18%), Scotland's Rural College (17%) and the Moredun Research Institute (14%). The Royal Botanic Garden did not receive any direct funding over this period.

Figure 13.1 – Strategic research funding by institution



Source: Scottish Government

Based on supplier spending and SRP funding as a proportion of total income, which were either sourced from annual accounts or from the institutions directly, it was possible to estimate the supplier spending at each institution supported by the SRP. Over the period of the programme this supplier spending amounted to £91.8 million, and was equal to £17.7 million in the most recent year.

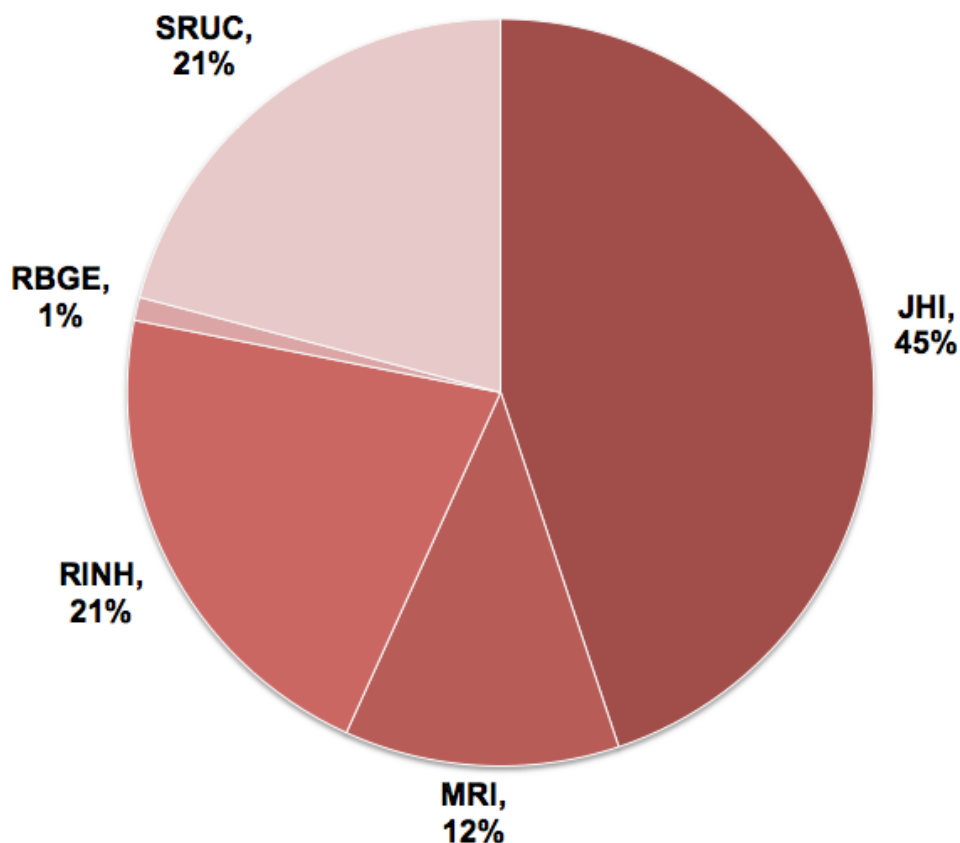
Over the period of the programme, the average level of employment supported by the SRP was 390 jobs, falling from 411 in 2011/12 to 374 in the most recent year. A break-down of the type of staff posts supported is provided in Table 13-1. This shows that more than half the posts funded were associated with the Food Land and People Programme and around 18% related to underpinning capacity. It also shows that almost half of the posts funded (48%) were natural scientists, 44% were for technical and support staff and 8% were social scientists.

Table 13-1 – Staff posts supported

	Environmental Change Programme	Food, Land & People Programme	Underpinning Capacity	Total	% of Total
Natural scientists	54.5	82.9	37.3	174.7	48%
Social scientists	12.3	14.5	3.3	30.0	8%
Technical & support staff	42.8	93.5	24.3	160.6	44%
Average*	109.6	190.9	64.8	365.4	
% of total	30%	52%	18%		

The James Hutton institute was responsible for 45% of the average employment supported, while Scotland’s Rural College and the Rowett Institute were responsible for 21% each, the Moredun Research Institute 12%, and the Royal Botanic Garden 1%.

Figure 13.2 – Strategic research employment by institution



Source: Scottish Government

Therefore, it was estimated that over the period of the programme, GVA was equal to £154.2 million GVA and the average employment was 390 jobs supported annually, as shown in Table 13-2.

Table 13-2 – Direct impact (2011-16)

	Scotland	UK
Direct GVA (£m)	154.2	154.2
Direct Jobs (average)	390	390

Source: BiGGAR Economics Calculations

### 13.2 Funding Leverage

Over the period 2011-2016 the MRPs used the funding they received through the SRP to leverage in £94.3 million of further research funding from other sources. This funding was either directly related to RESAS research or was provided to support research that built on research previously funded by the Scottish Government. A summary of the sources of this funding is provided in Table 13-3.

Table 13-3 – External research funding leveraged

	2011/12	2012/13	2013/14	2014/15	2015/16	Total
Research Councils	2.2	3.0	4.0	5.2	5.1	19.4
EU	6.9	6.6	4.7	5.2	5.7	29.2
DEFRA	4.1	2.5	1.7	1.9	0.9	11.2
Other Scot. Gov.*	2.4	1.8	2.0	1.8	1.2	9.2
Other	4.3	4.5	5.4	5.9	5.2	25.3
Total	19.9	18.4	17.9	20.0	18.1	94.3

Source: Scottish Government \* Includes RESAS Contract Research Fund

The MRPs also generated £54.2 million revenue from industry that was either directly related to RESAS research or was provided to support research that built on research previously funded by the Scottish Government. A summary of this revenue by source is provided in Table 13-4.

Table 13-4 – Industry funding leveraged

	2011/12	2012/13	2013/14	2014/15	2015/16	Total
Contract Research	3.6	4.5	6.4	5.8	5.3	25.7
Intellectual property income	0.5	0.6	0.6	0.7	0.6	3.0
Innovate UK/TSB and Link grants	3.5	2.4	1.9	1.6	2.3	11.7
Other commercial activity	3.5	2.5	3.2	2.5	2.1	13.8
Total	11.2	9.9	12.1	10.6	10.4	54.2

Source: Scottish Government

In total, over the period 2011 – 2016 the MRPs were able to leverage £148.5 million in additional research funding from industry and public sources as a result of the funding provided through the SRP. This implies that for every £1 that the MRPs received in SRP funding, they were able to leverage in a further 60p in additional research and industry funding. This is summarised in Table 13-5.

Table 13-5 – Funding leverage

	Total 2011 - 2016
Total SRP funding	246.0
Total additional funding leveraged	148.5
Leverage ratio	0.60

Source: Scottish Government

By considering the income leveraged by each institution, and the respective funding/staff and funding/expenditure on goods and services ratios it was possible to estimate the direct impact of this additional income. This was estimated using the same method as outlined in Section 13.1.

In this way it was estimated the direct impact of this leveraged funding totalled £86.9 million GVA and supported an average of 220 jobs over the period 2011-16 (Table 13-6).

Table 13-6 – Leveraged Funding Impact (2011-16)

	Scotland	UK
Direct GVA (£m)	86.9	86.9
Direct Jobs (average)	220	220

Source: BiGGAR Economics Calculations

### 13.3 Supply Chain Effect

The Scottish Government's programme funding also has an impact on the economy through the purchases of goods and services that the funding supports, as this generates turnover and employment in the companies that supply the MRPs. The level of supply expenditure was estimated based on the level of supply spending as a proportion of all income, then multiplied by the income MRPs received from the SRP.

In order to calculate the economic impact of this spending it was also necessary to establish from which sectors of the economy supplies were being purchased. Each industry has different levels of productivity and staffing requirements, therefore the same level of turnover can have different GVA and employment impacts. As BiGGAR Economics has recently undertaken studies for the James Hutton Institute and the Moredun Research Institute, and is currently undertaking an analysis of Scotland's Rural College, the average proportions of supply spending in each industry from these institutions were applied the level of supply spending supported. The average across all of the institutions was then applied to the Rowett Institute to provide an estimate of the impact of the Institute's spending on supplies.

Expenditure in each of these industries will then represent an increase in turnover of the businesses involved. The economic impact of this increased turnover was estimated by dividing total turnover in each industry by the appropriate turnover/GVA and turnover/employee ratios.

The level of supplier spending in Scotland and the UK was also adapted from the previous and on-going economic impact studies undertaken. The indirect economic impact of this expenditure was then estimated by multiplying the GVA and employment supported by the appropriate GVA and employment multipliers.

Therefore, impact of supported expenditure on goods and services was estimated to have contributed £49.5 million GVA over the period of the programme and 157 jobs annually in Scotland, and £85.9 million GVA and 268 jobs annually in the UK.

In order to estimate the economic impact supported by the leveraged funding the GVA/income and jobs/income ratio were applied. In this way it was estimated that the leveraged impact would be £33.2 million GVA and 105 jobs in Scotland, and £57.6 million GVA and 180 jobs in the UK.

Table 13-7 – Supplier impact from MRP expenditure (2011-16)

	Scotland	UK
<b>Direct Funding</b>		
Total GVA (£m)	49.5	85.9
Jobs (average)	157	268
<b>Leveraged Funding</b>		
Total GVA (£m)	33.2	57.6
Jobs (average)	105	180

Source: BiGGAR Economics Calculations

### 13.4 Staff Spending Effects

In order to calculate the economic impact of staff expenditure it was first necessary to estimate the level of staff spending supported by the SRP. This was estimated by considering the ratio of staff costs to income at each institution and then multiplying this by the funding provided by the programme. At institutions where data on staff costs was not available, it was estimated based on the average percentage of income spent on staff salaries.

It was then assumed, based on previous BiGGAR Economics studies, that all members of staff would live in Scotland. Based on Scottish input-output multipliers, it was also assumed that staff would spend 74% of their salaries in Scotland and 93% in the UK, and that 8% of staff spending would go towards VAT.<sup>37</sup>

As staff spending would increase turnover in businesses across the economy, the economic impact was estimated by applying turnover/GVA and turnover/employee ratios to staff spending, and the indirect impact was estimated by applying the appropriate GVA and employment multipliers. Over the period of the programme it was estimated that staff spending generated a total of £73.6 million GVA and, on average, supported 263 jobs annually in Scotland, and £104.1 million GVA and 368 jobs in the UK.

In order to estimate the impact from leveraged funding it was necessary to calculate the GVA/income and jobs/income ratio supported by the direct funding. After applying these ratios it was estimated that the leveraged funding generated £62.8 million GVA and supported 224 jobs in Scotland, and generated £88.8 million GVA and supported 314 jobs in the UK.

<sup>37</sup> European Commission (2013), A Study on the Economic Effects of Current VAT Rates Structures

Table 13-8 – Staff Spending Impact (2011-16)

	Scotland	UK
<b>Direct Funding</b>		
Total GVA (£m)	73.6	104.1
Jobs (average)	263	368
<b>Leveraged Funding</b>		
Total GVA (£m)	62.8	88.8
Jobs (average)	224	314

Source: BiGGAR Economics Calculations

### 13.5 Impact of Capital Investment

Capital expenditure supported by the SRP also has an impact on the economy, generating additional turnover in the manufacturing and construction sectors. Capital expenditure support from the programme was estimated to average £1.7 million annually, based on the ratio of capital expenditure to income at the institutions for which there were data.

Based on information from the institutions, and the average where this was not available, it was estimated that 84% of capital spending occurred in Scotland and 93% occurred within the UK. It was also calculated that the 39% of capital spending is spent in the construction industry, and 61% is spent on equipment, of which half was assumed to be spent in the manufacturing industry and half in the wholesale industry.

In order to capture the direct effects of increased turnover in these industries, turnover/GVA and turnover/employee were applied. It was then necessary to apply GVA and employment multipliers to capture the indirect effects.

In this way it was estimated that capital spending supported by the programme contributed £5.3 million GVA over the period of the programme and supported an average of 11 jobs annually in Scotland, and £6.1 million GVA and 14 jobs annually in the UK.

The leveraged funding made possible by the Scottish Government research also makes additional capital spending possible. By applying the ratio of GVA/income and jobs/income it was possible to estimate that over five years this funding supported £3.2 million GVA and an average of 7 jobs in Scotland, and £3.7 million GVA and an average of 8 jobs in the UK.



Table 13-9 – Capital Spending Impact (2011-16)

	Scotland	UK
<b>Direct Funding</b>		
Total GVA (£m)	5.3	6.1
Jobs (average)	11	14
<b>Leveraged Funding</b>		
Total GVA (£m)	3.2	3.7
Jobs (average)	7	8

Source: BiGGAR Economics Calculations

## 13.6 Summary

When the impact associated with the Scottish Government's direct funding, and the impact associated with the leveraged funding are summed, the total impact over five years is estimated to be £468.9 million GVA and an average of 1,377 jobs in Scotland, and £587.3 million GVA and an average of 1,763 jobs in the UK.

Table 13-10 – Core Impacts (2011-16)

	Scotland	UK
<b>GVA (£m)</b>		
Direct Funding Impact	282.6	350.2
Leveraged Funding Impact	186.2	237.1
Total	468.9	587.3
<b>Jobs (average)</b>		
Direct Funding Impact	821	1,040
Leveraged Funding Impact	556	722
Total	1,377	1,763

Source: BiGGAR Economics. Note, totals may not sum due to rounding

## 14 SUMMARY AND CONCLUSIONS

This chapter summarises the economic impacts considered in this report and presents the conclusion of the analysis.

### 14.1 Wider Quantifiable Economic Impacts of 2011-16 SRP

In addition to the operational activity directly supported by the funding the 2011-16 SRP also helped to stimulate a wide range of wider economic benefits. It was estimated that these wider economic benefits generated a total of £151.8 million GVA for the Scottish economy in 2016 and supported around 1,460 jobs (Table 14-1)..

Table 14-1 – Wider economic benefits of 2011-16 SRP realised in 2016

	GVA (£millions)	Jobs
Commercialisation	1.6	54
Animal health	3.0	n/a
Plant health	16.6	n/a
Exports	19.4	388
Genetic improvement	35.9	257
Food and drink	3.3	143
Environment	71.7	617
Research training	0.2	n/a
<b>Total</b>	<b>151.8</b>	<b>1,459</b>

Source: BiGGAR Economics. Note, totals may not sum due to rounding

It is expected that the research supported by the 2011-16 SRP will result in the annual impact described above increasing over time. Based on the evidence available it was estimated that within 10 years the annual impact associated with the 2011-16 SRP will have increased to at least £157.8 million GVA/year and 1,470 jobs. This increase is attributable mainly to benefits associated with animal health research and genetic gains in livestock and plants that are expected as a result of research undertaken during the 2011-16 period but not yet realised. It is also likely that the impacts associated with many of the other areas of activity considered in this report will also increase over the next 10 years but limitations in the availability of evidence means that it is not possible to quantify these benefits at this stage.

### 14.2 Operational Impacts of 2011-16 SRP Expenditure

The funding provided through the 2011-16 SRP directly supported activity within the MRPs and within the businesses and organisations in their supply chains. The funding also enabled the MRPs to leverage additional research funding from other organisations, which supported further activity within the MRPs and their supply chains.

In total over the period 2011-2016 this activity generated £468.9 million for the Scottish economy and supported around 1,377 jobs (Table 14-2).

Table 14-2 – Core impacts (2011-16)

	Direct funding	Leveraged funding	Total funding
<b>GVA (£m)</b>			
Direct impact	154.2	86.9	241.1
Supplier impact	49.5	33.2	82.7
Staff spending effect	73.6	62.8	136.5
Capital investment	5.3	3.2	8.5
<b>Total</b>	<b>282.6</b>	<b>186.2</b>	<b>468.9</b>
<b>Jobs (average number of fte positions supported over period)</b>			
Direct impact	390	220	610
Supplier impact	157	105	262
Staff spending effect	263	224	487
Capital investment	11	7	18
<b>Total</b>	<b>821</b>	<b>556</b>	<b>1,377</b>

Source: BiGGAR Economics. Note, totals may not sum due to rounding

### 14.3 Unquantifiable Economic Impacts of the 2011-16 SRP

The funding provided through the 2011-16 SRP has also helped to generate a variety of wider, unquantifiable economic benefits. These benefits include:

- Human health** – scientists funded by the 2011-16 SRP are engaged in a variety of research designed to prevent pathogens such as Cryptosporidium and Campylobacter from entering the human food chain and contain such outbreaks when they do occur. They are also contributing to the development of a variety of functional foods and nutraceuticals that have the potential to play an important role in reducing the incidence and cost of managing human diseases such as diabetes and cardiac disease. These illnesses and diseases represent a considerable cost burden for both public health authorities (in terms of treatment costs) and UK industry (in terms of absence due to ill health). Although it is not possible to quantify the contribution that research funded by the 2011-16 SRP has made to reducing these costs the magnitude of the costs involved means that even a small contribution is likely to have significant economic impacts.
- Sustainable Rural Communities** – research supported by the 2011-16 SRP funding has also made a significant contribution to the sustainability of rural communities by helping to reduce costs and improve the productivity of farm businesses. Although it is difficult to quantify this contribution it has played an important role in helping to maintain the financial sustainability of rural businesses and protect livelihoods in traditional industries, such as crofting.
- Efficiency of Public Expenditure** – Scientists funded by the 2011-16 SRP have also been closely involved in the reformation of a number of important areas of public policy, such as the CAP. This work has helped to improve the efficiency with which important components of public expenditure are allocated, enabling the government and other agencies to achieve greater outputs for the same level of input.

## APPENDIX A – LIST OF CONSULTEES

BiGGAR Economics would like to thank all those who contributed to the study, who are listed in Table A1 below.

Table A1 - List of consultees

Name	Role/Department	Organisation
Dr. Charles Bestwick	EC Programme Advisor	Rowett Institute of Nutrition and Health
Dr. Katie Crosley	Programme Grant Administrator	
Prof. Peter Morgan	Director	
Diane Mutch	Accounts Manager	
Dr. Alan Rowe	Food and Drink Industry Specialist	
Prof. Julie Fitzpatrick	Scientific Director	Moredun Research Institute
Prof. Lee Innes	Principal Scientist and Director of Communications	
Dr. Colin McInnes	Head of Vaccines and Diagnostics	
Dr. Rebecca Artz	Researcher, Ecology and Ecosystems	James Hutton Institute
Lesley Beaton	Senior Commercialisation and Licensing Manager	
Prof. Colin Campbell	Chief Executive	
Prof. Lorna Dawson	EC Programme Advisor	
Prof. Derek Stewart	Head of Enhancing Crop Productivity and Utilization	
Prof. David Elston	Director	Biomathematics and Statistics Scotland
Dr. Chris Ellis	Head of Cryptograms	Royal Botanic Gardens Edinburgh
Prof. Mike Coffey	Team Leader, Animal Breeding and Genomics	Scotland's Rural College
Dr. Neil Harvis	Team Leader, Crop Protection	
Prof. Wayne Powell	Principal and Chief Executive	
Liam Kelly	Strategic Science Lead	Scottish Government
Richard Murray	Senior Economist and Head of Rural Analysis	
Eilidh Totten	CAP Reform & Agri-Environment	



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