

BiGGAR Economics

Economic Impact of the James Hutton Institute

A final report to



The James
Hutton
Institute

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1 EXECUTIVE SUMMARY

The main findings of the report are that in 2015/16 the James Hutton Institute generated a total of £447.9 million gross value added (GVA)¹ and supported around 3,280 jobs around the world. This impact included:

- £54.7 million GVA and more than 900 jobs in the local areas in which the Institute operates;
- £211.8 million GVA and around 2,130 jobs in Scotland; and
- £318.5 million GVA and around 3,280 jobs across the UK; and
- £447.9 million GVA at the global level.

The analysis has also demonstrated that the economic impact generated by the James Hutton Institute is substantial relative to its scale, supporting:

- £11.98 in economic benefit across the UK (£7.97 across Scotland) for each £1 generated through its direct operations;
- 5.6 UK jobs (3.6 in Scotland) for each person directly employed; and
- £12.75 in economic benefit across the UK (£8.48 in Scotland) for each £1 that the Institute receives in funding from the Scottish Government.

By any measure these impacts are substantial.

Analysis of these figures shows that 18% of the economic activity that the James Hutton Institute generates around the UK and just over a third of the jobs it supports are associated with the operational activities of the Institute – i.e. the people it employs, the money it spends on goods and services and the expenditure of its staff. The vast majority of the impact generated by the Institute is therefore associated with the research activity undertaken by the scientists who work there. This impact arises through their contribution to protecting and enhancing the natural environment, their development of new sustainable land use methods, and their contribution to agricultural production.

1.1 Sources of Impact

The Institute's research focuses on the cross-cutting themes of improving food and environmental security while also enhancing community wellbeing and resilience. As a result much of the benefits of the research are interconnected and interdependent. This interconnectedness is a distinct strength of the Institute.

The Institute's research to support sustainable land use for example has wide ranging benefits both for the environment and the economy. These benefits are particularly challenging to quantify but two examples highlighted in the analysis have made a direct contribution of at least £3.4 million GVA to the UK economy. What cannot be quantified is the role that this research plays in underpinning the wider contributions of the Institute.

¹ Gross Value Added is a commonly used measure of economic impact. It is the total value of output in an economy less the value of intermediate consumption (i.e. the value of the goods and services consumed as inputs in the production process). It measures the contribution that an individual producer, industry or sector makes to gross domestic product.

For example, research to understand agricultural pests and diseases and to support the development of more efficient production systems plays a key role in underpinning the wider contribution that the Institute makes to food production. In 2015/16 it was estimated that this contribution amounted to £175.4 of GVA across the UK and around 1,330 jobs.

The Institute's research has impact across the agricultural sector but is particularly apparent in three areas of agricultural production: soft fruit, potatoes and barley. The Institute's long-term support for the Scottish raspberry industry has for example been critical to the survival of an industry that generates more than £15 million/year for the Scottish economy while the Institute's expertise in barley breeding plays a key role in supporting the continued competitiveness of the Scotch whisky industry.

Similarly, by helping to reduce dependence on chemical fertilisers and support the development of more sustainable production systems, research on sustainable land use also plays an important role in underpinning the contribution that the Institute makes to Scotland's natural capital.

The agri-food sector, like many other sectors of the Scottish economy, is highly dependant on the high quality of Scotland's natural environment for its continued success, a national asset that has been valued at £17.2 billion. The James Hutton Institute plays an important role in supporting this by undertaking research to further the understanding of Scotland's natural environment. It also generates economic benefit by enabling Scotland to realise the full potential of valuable natural resources. It was estimated that in 2015/16 the James Hutton Institute's contribution to enhancing and preserving Scotland's natural capital was worth £63.8 million to the Scottish economy and supported around 630 Scottish jobs.

The James Hutton Institute also provides a range of commercial services for public agencies and industry including analytical services for multinational oil and gas and pharmaceutical companies and contract research for a wide range of different industries. It was estimated that in 2015/16 these activities generated £14.3 million GVA for the UK economy and supported around 120 jobs.

Of course research only generates economic impact when it is adopted and applied. The scale of the impacts considered in this report are therefore a testament to the success of the Institute's approach to knowledge exchange. In addition to their contributions to science and academia, scientists at the Institute take part in a variety of committees and advisory boards and produce various outputs for policy and other stakeholder audiences. Amongst other things, these improve how the Government and other organisations manage natural resources and contributes to the development of policy that will have direct effects on land use, natural resources and rural wellbeing.

One of the reasons that the James Hutton Institute has been so successful in influencing agricultural and environmental policy is because it fosters a trans-disciplinary approach in which natural scientists and social scientists work together and alongside policy makers and other stakeholders. This means that recommendations and advice are based not only on what is scientifically possible but also on what is likely to be socially, economically and politically acceptable.

The knowledge exchange activity undertaken by the Institute enables it to deliver many of the benefits described in this report but also helps to generate economic activity in its own right. In an effort to quantify the direct contribution of this activity this report has considered the amount of time that scientists at the institute devote to this type of activity and the expenditure of visitors who attend the various

conferences and events hosted by the Institute each year. It was estimated that in 2015/16 this activity generated £4.5 million for the UK economy and supported 60 jobs.

1.2 Wider Benefits

Despite the scale of the numbers presented above there are many areas of activity that cannot be fully quantified. One example of this is the Institute's work on soil. Soil is fundamental to agriculture so any improvements in human understanding of soil are likely to result in improvements to agricultural productivity. Although the Institute has particular strength in soil sciences, which has almost certainly helped to improve agricultural productivity, quantifiable evidence of this is not readily available. It is however readily apparent that work in this and other areas has played an important role in underpinning many of the other benefits that have been quantified in this report.

Some of the research undertaken at the James Hutton Institute can also have benefits that may not occur until long after it has been undertaken. Research carried out for the oil industry underpinned decades of more efficient drilling and made an important contribution to helping Scotland to continue to realise the full potential of its oil reserves. Similarly, the Institute has expertise in the area of water management, which underpins growth in several industries and is likely to become an increasingly valuable resource in the future.

The Institute has also generated significant but unquantifiable benefits by:

- supporting the development of a successful life sciences sector in the Dundee and Aberdeen City regions and supporting the competitiveness of institutions with which it regularly collaborates such as the Universities of Dundee, Aberdeen and St Andrews;
- contributing to the regeneration and sustainability of local communities throughout Scotland;
- enhancing Scotland's brand value and helping to make the country more attractive to potential investors; and
- improving the understanding of wellbeing, which is widely recognised as an important driver of economic prosperity and development.

1.3 Global Contribution

Although the primary focus of this analysis has been on the economic impact of the James Hutton Institute in the UK, the Institute's research and policy experience also influence the wider world in a number of different areas. For example, the Institute has led or contributed to numerous projects aimed at reducing soil degradation, improving water management and disease control and targeting aid to counter malnutrition in Africa and elsewhere.

It is also making an important contribution to global food security, notably through its work with potato breeders in China. In addition, the Institute works with companies from around the world in developing agricultural products and new varieties of plants. The magnitude of these benefits can be illustrated by considering the contribution that the Institute has made to agricultural productivity in Europe through its influential work on barley breeding. It is estimated that the value of this impact alone in 2015/16 was £152.4 million.

Although substantial, this impact does however relate only to one area of activity. Much of the global contribution made by the James Hutton Institute simply cannot be quantified. It is for example almost impossible to assess the economic value of clean water to rural African communities but scientists at the Institute are making an important contribution to delivering this through their work on boreholes in Malawi. There are many other similar examples that could be highlighted to demonstrate how the James Hutton Institute is helping to improve the natural resources of the areas it is involved in and in turn the lives of the citizens who live there, all of which are equally difficult to quantify.

1.4 Conclusion

The overarching conclusion of this analysis is that the James Hutton Institute delivers a substantial economic impact and an impressive return on investment for its funders. Despite the scale of these numbers this report does not pretend to have captured the economic value of the Institute in its entirety. In part this is because there are simply too many different areas of activity to capture within a single report and in part it is because some areas of activity have simply proved too difficult to quantify. For these reasons the figures presented are likely to underestimate the true economic value of the James Hutton Institute's contribution to the UK economy.

An important theme throughout this report is the important contribution that the Institute makes to underpinning the success of many sectors of the Scottish economy. Of particular importance is the work that scientists at the Institute undertake to understand, protect and preserve Scotland's natural capital. While this work is important in its own right, it also plays a key role in supporting the continued success of many important sectors of the Scottish economy, not least of which is the agri-food sector.

Another important theme has been the interrelated nature of many, if not most, of the impacts considered. The Institute is a repository for a diverse range of multi-disciplinary expertise and a vehicle that makes it possible to bring this expertise together in ways that generate multiple and substantial benefits both in Scotland and elsewhere in the world.

2 INTRODUCTION

This report presents the findings of a study undertaken by BiGGAR Economics in autumn 2016 on the economic impact of the James Hutton Institute. The study quantifies the economic contribution of the James Hutton Institute to the local, Scottish, UK and global economies. The economic impacts described in this report are for 2015/16.

2.1 Background and Context

The James Hutton Institute is a world-leading specialist research organisation situated across two main sites in Aberdeen and Dundee. The Institute was formed in 2011 with the merger of the Macaulay Land Use Research Institute and Scottish Crop Research Institute, both of which have extensive histories. 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 purposes².

The Institute's vision is to be *'at the forefront of innovative and transformative science for the sustainable management of land, crop and natural resources that supports thriving communities.'*

The organisation combines strengths in genetics, genomics, biochemistry, crop breeding, plant pathology and epidemiology, soil sciences, economics, social sciences, water, land use, bio-informatics, biodiversity and analytical chemistry. It uses these strengths 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.

Research is carried out for a range of clients including the Scottish and UK Governments, the European Union and other organisations worldwide including industry. The Scottish Government invests significantly every year into a portfolio of strategic research to ensure that Scotland remains at the forefront of advances in agriculture, food and the environment. The James Hutton Institute is one of the Scottish Government's six Main Research Providers (MRPs) in rural affairs, food and the environment. The research undertaken by the MRPs is used to build an evidence base to support policy needs.

The Institute also hosts research resources that have global importance and are valuable assets for other researchers, such as seed banks that have worldwide importance for the science of genetics and genomics. Examples include the Commonwealth Potato Collection, which is the UK's genebank of landrace and wild potatoes and is one of a network of international potato genebanks. A further example of international significance is the Scottish National Soils Archive housed at the Aberdeen site contains more than 43,000 air-dried soil samples collected from 13,000 locations around Scotland.

2.1.1 Scientific Challenges

Having this diversity within a single institute is unusual and means that the James Hutton Institute is particularly well placed to deal with global challenges, which are often multi-faceted and require expertise from a range of different disciplines.

² This report considers the impacts of both research functions and James Hutton Ltd, which are hereafter together referred to as "the James Hutton Institute".

Reflecting this ambition and breadth, research is structured and centred around three cross-cutting fundamental Scientific Challenges³:

- **scientific challenge 1** – develop new crops and production methods that help deliver food security while better protecting the environment;
- **scientific challenge 2** – protect and enhance the resilience of ecosystems for multiple benefits; and
- **scientific challenge 3** – deliver technical and social innovations that support sustainable and resilient communities.

2.2 Approach

This study aims to demonstrate how the activities of the James Hutton Institute create benefits and impact for the economy. Quantifiable economic effects were assessed using two widely accepted measures of economic impact:

- Gross Value Added (GVA) – which measures the monetary contribution that an organisation adds to the economy through its operations; and
- employment – which measures the total number of jobs supported (unless stated otherwise).

2.2.1 Type of Impacts Covered

The focus of this report is specifically on the economic impacts generated by the James Hutton Institute rather than wider benefits it generates for society or the environment. As far as possible the report has attempted to quantify the value of these benefits in monetary terms. Inevitably this has influenced the selection of examples used to illustrate benefits with the result that the focus of much of the analysis is on those benefits that generate the largest quantifiable benefits. This should not however be taken to imply that those benefits that cannot be quantified are less valuable.

It is also the case that the quantitative impacts described in this report are likely to underestimate the full value of the contribution that the James Hutton Institute and its research make to the economy. This is because:

- the data for monetisation of many benefits is at an early stage of research;
- not all economic value can be converted into monetary value;
- monetary value does not capture aspects such as quality and equality;
- monetary value is static and does not capture the dynamic activities that drive economic and social impact; and
- the value of research and contribution to knowledge is often more than economic value.

2.2.2 Study Areas

This study considers the economic contribution that the James Hutton Institute makes to:

³ James Hutton Institute (2016), Transformative Science 2016-2021

- local areas – Dundee City Region and Aberdeen City Region⁴;
- Scotland;
- the UK; and
- elsewhere in the world.

Throughout the report impacts within the smaller study areas are incorporated within the larger study areas. Thus the UK impact includes the impact in Scotland and the Scottish impact includes the impact in the local areas.

Limitations in data availability mean that it has not been possible to assess the value of every impact within every study area. For example, it was not possible to estimate how much of the James Hutton Institute's contribution to preserving Scotland's natural environment benefited different localities within Scotland. Impacts are therefore presented for the study areas for which data are available.

2.2.3 Impact Time-Frame

Some of the activity undertaken by the James Hutton Institute generates economic activity immediately (e.g. purchases made by the Institute generate activity amongst the Institute's suppliers almost straight away). Much of the activity undertaken by the Institute however does not generate immediate economic effects. For example, the impact of research undertaken by scientists at the James Hutton Institute may be generated several years after the initial research was undertaken. The impact generated in 2015/16 will therefore be the cumulative impact of historic activity.

In an effort to reflect the full extent of the contribution made by the James Hutton Institute this report considers the impact that this historic activity generated in 2015/16 alongside the effects of the Institute's operational expenditure in 2015/16.

2.2.4 Methodology

The starting point for assessing each source of impact was the scale of activity undertaken, such as the scale of the Institute's expenditure on supplies or the scale of contract research. Where possible data on the scale and location of the activity was sourced directly from the James Hutton Institute.

In some cases it was necessary to supplement this data with assumptions to help quantify the scale of each type of activity, such as the location of certain agricultural markets. Where this data was not available it was necessary to make appropriate assumptions. These assumptions were based on publicly available information and BiGGAR Economics' previous experience of assessing similar activity elsewhere. Where assumptions have been made in the report, they have been clearly identified as such and referenced accordingly.

Each area of impact has a direct and indirect impact on the economy. The direct impact was estimated by applying ratios of turnover/GVA and GVA/employee for the appropriate sectors of the UK economy to the total value of expenditure

⁴ Dundee City Region includes North Fife and the local authority areas of Dundee, Angus and Perth and Kinross. Aberdeen City Region is defined as the local authority areas of Aberdeen City and Aberdeenshire.

associated with each source of impact. These ratios were obtained from the UK Annual Business Survey.⁵

Each area of activity also generates indirect and induced impacts further down the supply chain. These impacts arise as a result of purchases made by the businesses that benefit directly from expenditure by the Institute (and its staff and students) or by staff employed by these businesses. These effects were captured by applying appropriate GVA and employment multipliers.

These multipliers were based on the latest Type 2 GVA and employment multipliers published by the Scottish Government.⁶ This source was used because it is more up to date than equivalent information published about the UK economy as a whole and because it also provides multipliers for different sectors, which enables greater accuracy within the analysis.

These multipliers were then adapted for each of the study areas to reflect the comparative size of the economy in each and account for leakage. For example, to reflect the scale of the UK economy in relation to the Scottish economy, these multipliers were increased by 20%.

The economic ratios and multipliers for each industry ensure that economic activity at point of sale and along the supply chain are allocated to the appropriate study areas thereby taking account of where goods are produced.

2.3 Report Structure

The remainder of this report is structured as follows:

- chapter three quantifies the operational impacts of the James Hutton Institute;
- chapter four considers the James Hutton Institute's contribution to protecting and enhancing Scotland's natural capital;
- chapter five describes the Institute's contribution to sustainable land use;
- chapter six quantifies the economic value of activity undertaken at the James Hutton Institute to enhance food production;
- chapter seven describes the benefits of commercial services delivered by the Institute, including commercial research contracts and analytical services;
- chapter eight describes the James Hutton Institute's approach to knowledge exchange and quantifies the contribution of this activity to many areas of policy and practice across Scotland and beyond;
- chapter nine considers the wider economic benefits associated with the James Hutton Institute including the contribution it makes to local regeneration and competitiveness, how it helps to support Scotland's international profile and the contribution it makes to the efficiency of public policy;
- chapter ten summarises the findings and conclusions of the analysis; and
- the appendix contains a list of those consulted as part of this exercise.

⁵ ONS (2016), UK Annual Business Survey 2014 Revised Results

⁶ Scottish Government (2016), Scottish Supply Use and Analytical Input-Output Tables, 1998-2013

3 CORE OPERATIONAL EFFECTS

This chapter considers the economic impacts that the James Hutton Institute generates through its daily operations, including:

- the direct impact of the Institute including the staff it employs and value it adds directly to the economy;
- the impact of expenditure by the Institute on goods and services;
- the impact of expenditure by staff and students; and
- the impact of capital investment made by the Institute.

3.1 Direct Impact

The direct economic impact of any organisation to the economy is the value it adds to the economy and the number of jobs it supports.. Gross value added (GVA) is estimated by subtracting expenditure on goods and services from total income.

The total income for the James Hutton Institute in 2015/16 was £39.0 million and total expenditure on goods and services was £12.5 million. Therefore, it was estimated that the direct GVA of the Institute was £26.6 million. In 2015/16 there were 626 people employed directly by the Institute, which was equivalent to 583 full-time equivalent (fte) staff. This impact is summarised in Table 3.1.

Table 3.1 – Direct Economic Impact

	Local Areas*	Scotland
GVA (£m)	25.0	26.6
Jobs	548	583

Source: BiGGAR Economics *Local impact is smaller than the Scottish impact because some staff are based outwith the two main campuses

3.2 Supply Chain Effects

The James Hutton Institute also has an impact on the economy through its purchases of goods and services, as this generates turnover and employment in the companies that supply it. In 2015/16 the Institute spent £12.5 million on goods and services.

In order to estimate the GVA and jobs impact that this expenditure had on businesses in the supply chain it was necessary to establish the different industries represented in the supply chain and the level of expenditure in each, as each industry has different levels of productivity and staffing requirements.

Expenditure in each of these industries represents an increase in the turnover of businesses in the supply chain. The direct economic impact of the increased turnover in each of the industries was therefore estimated by dividing total expenditure in each industry by the turnover/employee and turnover/GVA ratios for the industry.

It was also necessary to consider the effects of the Institute's expenditure on goods and services on each study area. The economic ratios and multipliers for each industry ensure that economic activity at point of sale and along the supply

chain are allocated to the appropriate study areas thereby taking account of where goods are produced. It is therefore only necessary to consider the location of the Institute's suppliers. The Institute estimated that 25% of supplies were sourced from the Dundee City Region (DCR), 15% from the Aberdeen City Region (ACR), 60% from Scotland and 95% from the UK. The direct economic impacts were estimated based on this geographical distribution.

The indirect economic impact of this expenditure was estimated by multiplying the resulting GVA and employment impacts by multipliers for each of the industries. By summing the direct and indirect impacts in all sectors it was possible to estimate the total impact.

In this way it was estimated that the Institute's expenditure on goods and services contributed £2.5 million GVA and supported almost 50 jobs in the local areas in which it is based, £5.2 million GVA and almost 100 jobs across Scotland and £9.0 million GVA and 170 jobs across the UK. This impact is summarised in Table 3.2.

Table 3.2 – Supply Chain Impact

	Local Areas	Scotland	UK
GVA (£m)	2.5	5.2	9.0
Jobs	48	98	170

Source: BiGGAR Economics

3.3 Expenditure Effects

The Institute also has an economic impact as a result of the expenditure of its staff and students.

3.3.1 Staff Spending

In order to estimate the impact of staff spending in each of the study areas it was first necessary to understand where staff live. According to data provided by the James Hutton Institute 93% of staff salaries were paid to staff in the local area, and the remainder were paid to staff in other parts of Scotland. Total staff costs in 2015/16 were £25.6 million.

The level of spending in each of the study areas depends on where employees spend their salaries. The assumptions used for the proportion of their salaries that staff spend in each of the study areas is given in Table 3.3. For example, it was assumed that staff spend 45% of their salaries in the region where they live and a total of 74% in Scotland.

These assumptions are based on analysis of the Scottish input-output tables, which indicate that people living in Scotland spend 74% of their expenditure within Scotland. Reasonable assumptions were then made for other study areas. Where staff spend their salaries is not the same as where the goods and services that people buy are produced. These assumptions only take account of where staff live, the economic multipliers take account of where goods are produced.

Table 3.3 – Staff Spending Matrix

	Local Areas	Scotland	UK
Percentage of staff wages	93%	100%	100%
Where staff spend their salaries			
Where staff live	Local Areas	Scotland	UK
Local area	45%	74%	93%
Rest of Scotland	10%	74%	93%

Source: BiGGAR Economics Assumptions

Using these assumptions it was possible to estimate that staff spent £10.9 million in the local areas, £19.0 million in Scotland, £23.8 million across the UK⁷.

As staff expenditure will cover a wide range of goods and services, the direct GVA and employment impacts of this expenditure were estimated by dividing the increased turnover by the turnover/GVA and turnover/employee ratios for the whole economy. The indirect GVA and employment impacts were estimated using multipliers for the whole economy, and adjusted for the size of the economies of each study area.

In this way it was estimated that the expenditure of staff at the James Hutton Institute generated £14.0 million GVA for the Scottish economy and supported almost 260 Scottish jobs. A break-down of this impact for each of the study areas is provided in Table 3.4.

Table 3.4 – Staff Spending Impact

	Local areas	Scotland	UK
Staff Spending (£m)	10.9	19.0	23.8
GVA (£m)	5.1	14.0	19.8
Jobs	97	258	361

Source: BiGGAR Economics

3.3.2 Student Spending

Staff at the Institute supervise a large number of students undertaking postgraduate studies. The students generate economic activity in the economy by spending money on goods and services. As with members of staff, in order to estimate this impact it was first necessary to know where students live. This is shown in Table 3.5.

Table 3.5 – Student Spending Assumptions

	Local areas	Scotland	UK
Number of students	110	123	135

Source: James Hutton Institute

An estimate of the amount of money that students spend was based on a survey of student spending undertaken by the Department of Business, Innovation and

⁷ To account for the effect of taxation it was assumed that VAT at 20% would apply to this expenditure

Skills,⁸ which provides the average yearly student spend, broken down by category. As this survey was undertaken in 2011/12 the figures were adjusted for 2015/16. It was assumed that undergraduate and postgraduate expenditure would be the same. The annual student spend is shown in Table 3.6.

Table 3.6 – Student Annual Spend

	Value
Food	2,119
Personal items	2,003
Entertainment	1,244
Household goods	379
Non course travel	1,781
Other living costs	39
Housing costs	4,213
Travel	408
Books and equipment	485
Total	12,671 ⁹

Source: Department for Business, Innovation and Skills

It was assumed that all students stay in private accommodation, and that they primarily spend their money in the area where they live. The direct economic impact of student expenditure was estimated by applying the turnover/GVA and turnover/employee ratios for the sectors in which the expenditure occurs to the total value of each type of expenditure. For example, it was assumed that expenditure on food, personal items and other living costs would occur within the retail sector and that expenditure on entertainment would occur within the arts and entertainment sector. The indirect impacts were then estimated by applying multipliers for the appropriate sectors.

In this way it was estimated that in 2015 student spending contributed £1.1 million GVA to the Scottish economy and supported 20 Scottish jobs. A break-down of this impact for each of the study areas is provided in Table 3.7.

Table 3.7 – Student Spending Impact

	Local areas	Scotland	UK
GVA (£m)	0.7	1.1	1.2
Jobs	14	20	24

Source: BiGGAR Economics

⁸ Department for Business, Innovation and Skills (2013), Student Income and Expenditure Survey 2011/12

⁹ The minimum value of a doctoral stipend in the UK in 2015/16 was £14,057, slightly higher than the estimate of student expenditure used in this section. The more conservative assumption of £12,671 was used because it relates directly to student expenditure (rather than income) but for this reason this impact should be considered as conservative.

3.4 Capital Investment

The capital expenditure of the James Hutton Institute has an impact on the economy, supporting manufacturing and construction sectors. Although the James Hutton Institute spent £0.9 million on capital projects in 2015/16, in order to control for large differences in capital spending in different years, an average was taken of actual and projected expenditure between 2011/12 and 2020/21. This generated an annual average expenditure of £1.3 million.

Based on information provided by the Institute it was assumed that 90% of the capital suppliers were located in the local areas in which the Institute operates¹⁰.

Table 3.8 – Capital Spending Assumptions

		Value
Capital spending in 2015/16		£866,000
Average Capital Spending from 2011/12 to 2020/21		£1,256,000
	of which spent on equipment	75%
	of which spent on construction	25%
By location		
	Dundee City Region	55%
	Aberdeen City Region	35%
	Scotland	90%
	UK	90%

Source: James Hutton Institute

As 75% of capital spending was on equipment this was assumed to generate additional turnover in the wholesale goods sector, as most of the machinery is sourced from abroad. The remainder was assumed to be in the construction sector. The economic impact of capital expenditure was estimated by applying turnover/GVA and turnover/employee ratios to the increased spend for the appropriate sectors. The indirect impacts were estimated by applying the multipliers for the appropriate sectors to the direct impacts.

In this way it was estimated that capital investment by the James Hutton Institute generates around £0.3 million GVA/year for the Scottish economy and supports around 3 jobs. A break-down of this impact for each of the study areas is provided in Table 3.9.

Table 3.9 – Capital Spending Impact

	Local areas	Scotland	UK
GVA (£m)	0.3	0.5	0.5
Jobs	3	4	4

Source: BiGGAR Economics

¹⁰ It is noted that a significant proportion of capital expenditure would relate to the procurement of equipment, much of which would be manufactured overseas and appropriate multipliers and ratios have been used to account for this.

3.5 Summary

By adding together each of the impacts considered in this section it was estimated that the James Hutton Institute generated a total of £47.4 million GVA for the Scottish economy in 2015/16 and supported more than 960 jobs in Scotland as a result of its core operations. A break-down of this impact for each of the study areas is provided in Table 3.10.

Table 3.10 – Core Impact

	Local areas	Scotland	UK
Direct Impact	25.0	26.6	26.6
Supplier Impact	2.5	5.2	9.0
Staff and Student Spending	5.8	15.1	21.1
Capital Spending	0.3	0.5	0.5
Total	33.7	47.4	57.2
Jobs			
Direct Impact	548	583	583
Supplier Impact	48	98	170
Staff and Student Spending	111	278	385
Capital Spending	3	4	4
Total	710	963	1,142

Source: BiGGAR Economics

4 CONTRIBUTIONS TO NATURAL CAPITAL

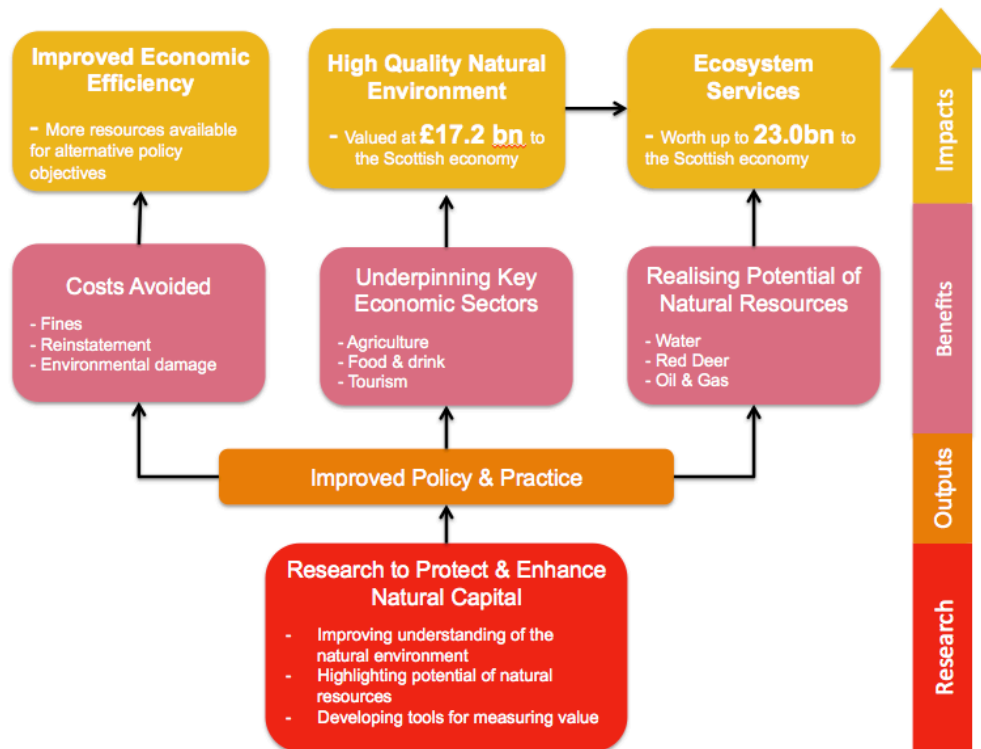
Mankind depends on the natural environment for a range of resources and processes ranging from food and clean drinking water to waste decomposition and climate regulation. Collectively these benefits are known as “ecosystem services”. Since the late 1970s, as global population growth has put increasing pressure on finite natural resources, interest in valuing ecosystem services has increased.

Valuing ecosystem services is inherently difficult because most are not traded on the open market. As a result, the methods for valuing ecosystem services are constantly evolving and there is no clear consensus on the best approach. There is however a clear consensus that ecosystem services are vital for human development and play a key role in underpinning the economy.

The James Hutton Institute has made a significant contribution not only to preserving and enhancing Scotland’s natural capital but also to developing methodologies for its valuation - an important step toward securing its continued preservation. In order to fully assess the economic impact of the institute it is therefore necessary to consider this contribution.

The economic importance of the James Hutton Institute’s research on natural capital is described in this chapter and illustrated in Figure 4-1.

Figure 4-1 – Economic Value of Research to Preserving and Enhance Natural Capital



Source: BiGGAR Economics

4.1 Valuing Ecosystem Services

Research undertaken at the James Hutton Institute has helped to raise awareness about the value and importance of various ecosystem services. By way of illustration it is helpful to consider the example of the work researchers at

the Institute have undertaken to highlight the role of Scotland's peatlands as a carbon store. This example is considered in Figure 4-2.

Figure 4-2 – Ecosystem Services: Peatlands

Peatlands are a distinctive feature of the natural landscape of Scotland, accounting for nearly a quarter of the Country's land area. It is estimated that Scotland has approximately 13% of the world's blanket bog with the Flow Country and the Lewis Peatlands probably representing the largest contiguous areas globally.

Historically, peatlands have been seen as wasteland and various efforts, including draining, burning, afforestation and grazing have been made to make them more productive. As a result it is estimated that more than 80% of Scotland's peatlands are now degraded.

Peat is however a significant carbon store, with the potential to play an important role in enabling Scotland to realise its climate change objectives. Until recently this potential was not recognised but research undertaken by scientists at the James Hutton Institute has been instrumental in changing this. In June 2015 the Scottish Government explicitly recognised this potential in its new routemap for Scotland's biodiversity¹¹, which identified the restoration of peatlands as top priority project.

Since then scientists at the James Hutton Institute have continued to provide expert advice to the Scottish Government to ensure that it has the scientific understanding it requires to ensure that the restoration efforts are as effective as possible. Scientists at the Institute have also developed a decision support tool to help the government and other agencies decide exactly where to focus restoration efforts.

Source: James Hutton Institute¹²

Researchers at the Institute have also helped to deliver important advances in the valuation of ecosystem services. For example research undertaken by the James Hutton Institute resulted in an important change to the Water Resource Scotland Act 2012, which should mean that decisions regarding the use of water resources should take account of a much broader spectrum of interests than would otherwise have been the case. The Water Resource Scotland Act places an obligation on the Scottish Government to maximise the value that it obtains from Scotland's water resources but as originally formulated "value" was defined narrowly in relation to the monetary value directly associated with the resource.

Researchers at the James Hutton Institute proposed that the value of water resources should instead be assessed using a much broader definition that takes account of the value of all water ecosystem services including non-market benefits such as recreational benefits for communities. The subsequent adoption of these proposals has meant that public agencies have to take account of a much broader spectrum of issues when making decisions on the use of Scotland's water resources, which should ultimately help to protect the wider social and cultural value of these resources.

4.1.1 The Economic Value of the Natural Environment

The continued success of many of the most important sectors of the Scottish economy is critically dependant on Scotland's high quality natural environment. The Scotch whisky industry for example, which generates around £5 billion/year

¹¹ Scottish Government (June 2015), Scotland's biodiversity, a route map to 2020

¹² R Artz and Steve Chapman (2016), Peatlands: a summary of research outputs supported or facilitated by the environmental change programme of the Scottish Government's portfolio of strategic research 2011 - 2016

for the UK economy¹³, relies heavily on supplies of high quality fresh water and barley and a major driver for the tourism industry is Scotland's landscapes and the opportunities they provide for outdoor recreation. Any significant deterioration in the quality of Scotland's natural capital could therefore be expected to have serious consequences for Scotland's economy.

In 2008 Scottish Natural Heritage published research¹⁴ that attempted to quantify the value of Scotland's natural environment 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 and that this is worth £17.2 billion a year to the Scottish economy and supports 1 in 7 of all full time jobs.

Other research has 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 can be measured are worth between £21.5 and £23 billion/year to the Scottish economy¹⁵.

In addition to this, efforts to restore the natural environment once it has become damaged can be very costly. These costs can include not just the cost of implementing any restoration measures necessary but also the payment of any fines that might be incurred by whoever caused the damage. This type of expenditure represents an opportunity cost for the economy because these resources could potentially have been used for other, more productive purposes. An example of this is provided in the case study below.

Figure 4-3 – Nitrate Vulnerable Zones

Nitrate Vulnerable Zones are areas designated as being at risk of nitrate leaching from agricultural nitrates applied as fertilisers to boost crop yields. Nitrate contamination can present a risk for drinking water supplies, especially private supplies, and can also cause eutrophication. This is the process through which the oversupply of nutrients, like nitrates, causes explosive growth of plants and algae in a water body. When these organisms die they are broken down by bacteria, which use up the available oxygen in the water. It is therefore important to be able to identify and monitor areas where there is potential for this to happen and for appropriate regulations to be put in place for farmers in these areas.

The European Union Water Framework Directive (WFD) created a duty to assess a broad range of risks to the quality of groundwater, including those from nitrates produced by agricultural activities. When the Directive was established, the James Hutton Institute was asked by the Scottish Government to create a way of identifying which areas are vulnerable to nitrate leaching. The Institute developed a modelling approach using Soil Survey of Scotland data, to model and identify those areas of groundwater most at risk of contamination by nitrates. The James Hutton Institute model has been used to predict nitrogen water loads for the Scottish Environment Protection Agency (SEPA). Had the Institute not developed an approach to dealing with the WFD, a £50 million fine would have been levied on the government. Although not all of this amount can be claimed to be a saving as a result of the Institute, it serves to demonstrate the importance of the Institute's role.

Source: BiGGAR Economics based on consultation with JHI staff

As Scotland's natural environment is such a valuable economic resource efforts to protect it must therefore also have an economic value. The following section

¹³ 4 Consulting (January 2015), the economic impact of Scotch whisky production in the UK

¹⁴ Scottish Natural Heritage (2008), the economic impact of Scotland's natural environment

¹⁵ Scottish Government (2013), 2020 Challenge for Scotland's Biodiversity

describes some of the many ways in which Scientists at the James Hutton Institute help preserve Scotland's natural environment and section 4.2.1 attempts to quantify the contribution that this work makes to the Scottish economy.

4.2 Contributing to Scotland's Natural Capital

The James Hutton Institute is particularly well placed to support efforts to protect and enhance Scotland's natural capital because of the depth and breadth of the experience of its staff and the unique research assets located there.

The most fundamental building blocks of Scotland's natural environment include soil, water and biodiversity all of which perform a wide range of essential environmental, social and economic functions. Staff at the James Hutton Institute have particular expertise relating to each of these areas as well as issues relating to the management and governance of natural resources. It would be impossible to identify all of the ways in which staff at the James Hutton Institute contribute to understanding the natural environment but particularly important areas of expertise include:

- biodiversity;
- wildlife;
- landscapes,
- land use;
- tourism and recreation;
- rural communities;
- soils; and
- pests and diseases affecting animals, plants and humans.

Staff at the James Hutton Institute are closely involved in providing advice and research support relating to these areas to the various public agencies tasked with maintaining the natural environment. That this advice and support is highly valued is illustrated by the following comment:

“The James Hutton Institute has particular expertise in translating policy requirements into research objectives and research findings into policy recommendations. This has helped the Institute to build a strong and enduring relationship with the Scottish Government and enabled it to act as an effective broker between the Government and Scotland's research community.”

Jon Rathjen, Water Industry Team, Scottish Government.

The James Hutton Institute is also responsible for coordinating the Centre of Expertise for Waters (CREW) on behalf of the Scottish Government and plays a major role in the other Centres of Expertise relating to climate change (ClimateXChange) and livestock disease (EPIC). These Centres exist to enhance engagement between academic researchers and policy makers within the government and its agencies.

As an example of the societal relevance of this type of work, CREW's research programme is directed by a series of steering groups, each of which has

representation from key stakeholder groups such as Scottish Water and the Scottish Environment Protection Agency (SEPA). CREW helps the steering groups to define research question and then identifies the most appropriate expertise, either from within the James Hutton Institute or from other university or research institute partners or a mixture of both. In this way CREW plays an important coordinating role between universities, companies and other research providers and helps to ensure that policy makers are able to access and make best use of available science.

The Institute also makes a major contribution to the CXC Centre of Expertise by providing advice and expertise to the Scottish Government policy teams working on climate change. Scotland has ambitious targets to reduce greenhouse gas emission reductions by 42% by 2020 and by 80% by 2050 and researchers at the Institute are contributing to achieving these targets. Researchers at the Institute have also made significant contributions to the Low Carbon Scotland Report on Policies and Proposals (RPP) and the Scottish Climate Change Adaptation Programme. For example, James Hutton Institute analysis of the contribution of peatland restoration to enhancing carbon sequestration from the atmosphere resulted in its inclusion into the Second Report (RPP2).

The James Hutton Institute is also home to a number of important research assets, that provide invaluable insight into Scotland's natural environment. One such asset is the National Soils Archive, an extensive and comprehensive collection of representative soil samples from all over Scotland that dates back to the 1930s. The Archive currently contains 4.8 metric tonnes of soil samples and associated soil DNA samples, which can provide valuable insight into the state of Scotland's soils and be used to monitor changes in soil over time. The resource is used by a variety of different agencies to help develop effective approaches to pollution control and other important policy areas.

One of the reasons that the James Hutton Institute has been so successful in influencing environmental policy is because it fosters a trans-disciplinary approach in which natural scientists and social scientists work together and alongside policy makers and other stakeholders. This means that recommendations and advice are based not only on what is scientifically possible but also on what is likely to be socially, economically and politically acceptable.

It would be impossible to list all the ways in which staff from the James Hutton Institute have contributed to the protection and enhancement of Scotland's natural capital but by way of illustration it is helpful to consider how the Institute has helped to support the work of SEPA. A case study of this work is provided below.

Figure 4-4 – Modelling Phosphorus Dynamics

Phosphorous is a naturally occurring element but if too much of it enters the environment then watercourses can become polluted, which can have major consequences for both human health and the economy. Phosphorous occurs naturally in rocks and other mineral deposits but can also be released into the environment by a variety of man-made activities including the discharge of partially or untreated sewage, run-off from agricultural sites and the application of some lawn fertilisers. Identifying the source of phosphorous contamination is therefore an important priority for public authorities.

Scientists at the James Hutton Institute developed the first land use models that made it possible to identify the potential sources of phosphorous in a given catchment area. The model helped to bring about a step-change in the management of phosphorus pollution.

The model was quickly adopted by the Scottish Environment Protection Agency (SEPA), which used it to establish the source of phosphorus pollution in catchment areas around Scotland. By providing clear evidence about the relative importance of different sources of pollution the model enabled SEPA to have more informed discussions with the individuals responsible and made it easier to reach agreement on any remediation that might be necessary. The model also provided the evidence that SEPA required to be certain that any remediation measures that they did propose were likely to deliver the intended outcomes, thereby helping to improve the efficiency of public spending.

Source: BiGGAR Economics based on consultation with JHI staff and SEPA

4.2.1 Quantifying the Benefits of Environmental Protection

The starting point for assessing the value of effective environmental protection is to consider the scenario that might exist if no such protection existed. One way of doing this is to look at the experience of other countries where protection of the natural environment has not been regarded as an important policy priority. Perhaps the most obvious example of this is China where the need to maintain high levels of economic growth to support a rapidly growing population has meant that environmental protection has long been a low priority for policy makers.

The widespread environmental damage caused by China’s rapid industrialisation has been well documented but evidence of the economic costs of this damage is much less readily available. The Chinese Government is understandably reticent on this issue but has published figures suggesting that the costs of dealing with pollution now account for around 3.5% of Chinese GDP¹⁶. Many commentators believe that the Chinese Government still spends far too little on environmental protection so this assumption is likely to be a conservative estimate of the true cost of an adequate environmental protection system.

In 2016 the comparison between China and Scotland may seem extreme but it is only necessary to look back a few decades to see how such a scenario could have arisen. The dual forces of poverty and disease in rural areas and massive demand for labour in industrial centres such as Glasgow and Dundee meant that Scotland was not only one of the first countries in the world to industrialise but also one of the quickest. By the 1970s it was clear that such rapid industrialisation had taken a heavy toll on Scotland’s natural environment.

Since the 1970s a huge amount of resources have been devoted to cleaning up this damage. Although the scars of industrialisation (and deindustrialisation) are still apparent in many parts of Scotland there is no doubt that the quality of Scotland’s natural environment is now far superior to China’s. In large part this can be attributed to Scotland’s system of protecting its natural capital.

¹⁶ Chinese Council on Foreign Relations (January 2016), China’s environmental crisis

Responsibility for designing, implementing and enforcing the policies that make up this system ultimately rests with the Department of Rural Affairs, Food and the Environmental (DRFE) within the Scottish Government. This is a diverse portfolio that has responsibility for protecting and enhancing Scotland's environment and for developing rural Scotland by working with industries and communities. This department funds the various public agencies tasked with protecting Scotland's natural environment and is also responsible for allocating funding under the Common Agricultural Policy (CAP).

In 2015/16 the DRFE spent a total of £492 million on activities directly related to environmental protection. This included funding for agencies such as the Forestry Commission, SNH, Scottish Water and SEPA and "greening payments", which are paid under the CAP to farmers who use farmland more sustainably and care for natural resources as part of their everyday work.

Although the Scottish Government is the main agency responsible for environmental protection in Scotland, it is not the only one. For example Police Scotland employs dedicated officers to tackle wildlife crime, the Scottish courts system incurs costs for prosecuting those responsible for illegal pollution and local councils help to support national parks and scenic areas. In addition to this there are various charities and even private companies that support environmental work. It would be impossible to estimate the total expenditure of all of these agencies on environmental protection so to avoid over estimating the James Hutton Institute's contribution it was assumed that the combined expenditure of these agencies equals that of the Scottish Government.

This implies that the cost protecting Scotland's natural environment currently amounts to around £984 million/year, or around 0.7% of Scotland's GDP. In contrast, the Chinese experience suggests that the cost of dealing with inadequate environmental protection if this system did not exist could be at least 3.5% of GDP. It could therefore be argued that the benefits of Scotland's environmental protection system represents 2.8% of Scotland's GDP (around £3.7 billion GVA).

In order to estimate what proportion of this benefit could reasonably be attributed to the James Hutton Institute it was necessary to establish:

- the role that research has played in helping to realise this benefit; and
- the contribution that researchers at the James Hutton Institute have made to this research effort.

Like any area of public policy, to be effective it is vital that environmental policy is based on high quality research evidence. To provide this evidence DRFE procures research and analytical services from various research providers. In 2015/16 DFRE spent around £19.7 million on research directly related to the environment. This represents around 4% of the total amount spent by the Government on environmental protection in Scotland. Assuming that other organisations devote a similar proportion of the money they spend on the environment to research It could therefore be argued that around 4% of the total benefits associated with Scotland's system for protecting its natural capital could be attributed to the research and analysis that underpins it.

In order to estimate how much of this impact might reasonably be attributed to the James Hutton Institute it was necessary to consider the extent of the Institute's contribution to the research effort. In 2015/16 data from the Scottish Government shows that the James Hutton Institute secured around 73% of the environmental

related research funding available from the Scottish Government. Analysis of the Institute’s income for 2015/16 suggests that around 30% of the income that the Institute receives from sources other than the Scottish Government might have been for environmental related research. Taken together this implies that the Institute’s expenditure on environmental research accounted for around 43% of the total amount spent on environmental related research in Scotland.

By applying these two assumptions to the total value of the benefits of effective environmental protection estimated above it was estimated that the James Hutton Institute’s total contribution to Scotland’s natural capital amounted to £63.8 million GVA. Using appropriate ratios from the SNH study referred to above, it was estimated that this activity supported around 630 Scottish jobs. This impact and the assumptions used to estimate it are summarised in Table 4-1.

In arriving at this estimate it was necessary to make a number of assumptions. The basis of these assumptions was naturally a function of professional judgement but the general approach was to err on the side of caution and adopt conservative assumptions where possible. As a result, it is likely that the estimate below underestimates the true contribution of the James Hutton Institute.

Table 4-1 – Impact of Research to Preserve the Natural Environment - Assumptions

Assumption	Value
Cost of ineffective environmental protection (as proportion of Chinese GDP)	3.5%
Cost of effective environmental protection	0.7%
Value of effective environmental protection (in GVA)	£3.7bn
Research contribution (research as % of DRFE environmental expenditure)	4%
Research effort attributable to JHI (% of environmental research secured)	43%
Scottish Impact (£m)	63.7
Scottish impact (jobs)	630

Sources: Chinese government, Scottish Government draft budget for 2016/17, JHI annual accounts and Strategic Research Programme expenditure figures from Scottish Government

4.3 Realising the Potential of Scotland’s Natural Resources

As discussed above, various studies have attempted to place a value on Scotland’s natural environment and the value of ecosystem services in Scotland. That each of these studies has estimated a different value reflects not just the difficulties in measurement but also the fact that the value of ecosystem services and the economic potential of natural capital evolves over time. Research undertaken at the James Hutton Institute has made an important contribution to this by improving understanding of Scotland's natural resources and thereby helping to increase the potential value of these resources.

4.3.1 Enhancing the Value of Scotland’s Natural Capital

The James Hutton Institute has helped Scotland to realise the potential of its natural resources in various ways. For example, for many years researchers at the Institute have provided advice and support to private estates and the Red Deer Commission (now part of SNH) on the management of red deer populations.

Research¹⁷ commissioned by the SNH estimates that red deer stalking contributes £70.4 million/year to the Scottish economy and that deer management supports around 2,520 jobs. Any improvements in deer management practices are therefore likely to have direct and significant economic benefits.

The James Hutton Institute's long-standing engagement with the oil and gas industry has also enabled it to play an important role in enabling Scotland to realise the full potential of its oil and gas reserves by helping companies to identify where to focus drilling efforts. This contribution is explored further in section 7.1.

In the future it is anticipated that the Institute could play an important role in helping Scotland to realise the potential of another increasingly important natural resource: water. Indeed according to the Scottish Government...

"In the future the James Hutton Institute's ability to provide rapid access to a broad range of knowledge and expertise will be very important to realising the full social and economic potential of Scotland's water resources."

Jon Rathjen, Water Industry Team, Scottish Government.

This potential is considered further in the case study below.

Figure 4-5 – Realising the Economic Potential of Scottish Water

Scotland has the wettest climate in the UK and 90% of the UK's inland surface water. While Scotland's abundant water resources are often regarded as an inconvenience, they also represent an important economic opportunity. The James Hutton is playing an important role in helping Scotland to realise this opportunity.

Scotland's abundant water resources mean that it has significant expertise in managing water. As the world's population continues to grow, the need to manage water effectively becomes ever more important (particularly in parts of the world where clean water is a scarce resource), and the demand for such expertise is likely to increase significantly

The Scottish Government has recognised this potential and is keen to maximise it for the benefit of the nation. In 2013, the global market for water and wastewater technology was estimated to be worth £51.2 billion¹⁸. The UK's share of this market is currently estimate to be worth around £1.5 billion (or 3% of the total) but it is believed that there are opportunities to expand the UK's global market share to at least 10% (£8.8 billion) by 2030. The Scottish Government estimates that Scotland's share of the water technologies industry could therefore be worth around £900 million each year.

The James Hutton Institute has played a vital role in creating awareness of the potential of Scotland's water resources. The Institute has for example played an instrumental role in developing the Scottish Government's Hydro Nation strategy, which sets out the Government's commitment to maximising the benefits to the Scottish economy through the economic development and effective stewardship of Scotland's water resources.

The Institute (through CREW) has also played an important role as an "early broker and builder of confidence" in facilitating entry for Scottish companies into a number of global water technologies markets through its contacts with international research institutes.

Discussion with policy makers at the Scottish Government confirms that the has already played a crucial role in creating awareness of the global potential of Scotland's water resources and helped to ensure that this potential is recognised by policy makers. Although the value of this contribution cannot yet be quantified, the size of the potential market means that the future benefits could be very substantial indeed.

Source: BiGGAR Economics based on consultation with JHI staff and SEPA

¹⁷ Putman, R. (2012), Scoping the economic benefits and costs of wild deer and their management in Scotland, Scottish Natural Heritage Commissioned Report No. 526

¹⁸ UKWRIP (2014), HTechO: Tapping the Potential: A Fresh Vision for UK Water Technology

4.4 Summary Contribution to Natural Capital

This chapter has estimated that in 2015 the James Hutton Institute's contribution to Scotland's natural capital was worth £63.8 million to the Scottish economy and supported around 630 Scottish jobs. This estimate should be regarded as conservative. In addition, this section has also demonstrated how work undertaken by the Institute is helping to increase the total value of Scotland's ecosystem services and enabling the nation to realise the full potential of its natural resources. As a result, it would be reasonable to expect that the impact of this area of activity could increase considerably in the future. This impact is summarised in Table 4.2.

Table 4.2 – Contribution to Natural Capital

Scotland	
GVA (£m)	63.8
Jobs	631

Source: BiGGAR Economics

5 SUSTAINABLE LAND USE

According to figures published by the UK Government, the combined value of UK agricultural production and food and drink manufacturing in 2014 was £52.7 billion¹⁹. This chapter and the following chapter considers the contribution that researchers at the James Hutton Institute make to the productivity and sustainability of this hugely important sector.

5.1 Pathways to Impact

Researchers at the James Hutton Institute are engaged in a number of different but complementary areas of research that together play an important role in supporting and enhancing the productivity of the agri-food sector. Together these areas of research enable the James Hutton Institute to:

- breed **new varieties of plants** that produce greater or more reliable yields that are more resistant to disease or exhibit characteristics such as improved taste, texture nutritive values and appearance, which are desirable to consumers;
- design **effective treatment and control strategies** for managing and countering threats from pests and diseases; and
- develop **production systems** that increase yield, make agriculture less resource intensive and more economically, socially and environmentally sustainable.

The benefits of these activities for producers include:

- increased and/or more reliable yield – i.e. the ability to produce more crops on a given area of land, the same amount of crops on a smaller area of land or to sustain a more reliable yield under changing environmental conditions;
- lower costs of production – i.e. the capacity to maintain production while reducing expenditure on agricultural inputs such as fertilisers and pesticides;
- reduced crop losses – i.e. as a result of preventing or mitigating the damage caused by pests, outbreaks of disease and climate change; and
- enhanced crop value – i.e. because the crop is more desirable because of traits such as yield stability, appearance, texture, taste or nutritional value.

These activities also help to generate benefits further down the production chain for food and drink processors. These benefits include:

- more reliable supplies, which is very important for maintaining output in an integrated supply chain;
- better quality inputs, which supports long-term competitiveness; and
- new products, for example the novel use of crops in new food products.

By supporting the development of efficient agri-businesses that are both profitable and socially and environmentally sustainable, these improvements ultimately help

¹⁹ Department for Environment Food and Rural Affairs (21st March 2016), British food and farming at a glance

to ensure the long-term sustainability of agricultural production, which directly benefits society as a whole.

The ability of the James Hutton Institute to deliver the benefits described above is underpinned by a number of important factors including:

- the unique collections of genetic resources housed within the Institute;
- the skills and experience of staff;
- its trans-disciplinary approach to research; and
- facilities that enable researchers to provide practical demonstrations of improved processes and new crop varieties.

5.1.1 Genetic Resources

One important factor in the James Hutton Institute's strength in crop related research is the fact that the Institute is the repository for three globally important collections of genetic material: the Commonwealth Potato Collection and 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 for what is the third most important food crop in the world in terms of human consumption²⁰.

The James Hutton Institute 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. It therefore plays a fundamental role in underpinning the continued success of an industry that generates more than £15 million/year for the Scottish economy²¹.

Together these collections mean that researchers at the Institute 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.

5.1.2 Skills & Experience

One area of expertise that has been particularly important to realising the benefits from crop related research is genomics technology. The ability to identify specific genes that cause agronomic traits in crops (e.g. yield, processability or consumer preference) or determine the pathogenicity of plant diseases is of fundamental importance to many areas of research at the James Hutton Institute. To support this key area of work the Institute maintains dedicated genomics labs with the capacity to undertake genomic sequencing, genotyping and high-throughput gene expression.

²⁰ International Potato Centre website, accessed via <http://cipotato.org/potato/facts/> in October 2016

²¹ Scottish Government (2016), Economic report on Scottish agriculture

In recent years this capability has enabled researchers at the James Hutton Institute to play an important role in defining the genome for a number of important food crops including barley, potatoes, tomatoes and raspberries. This is important because it enables breeders to identify whether or not a particular characteristic (e.g. disease resistance) is present in a particular variety, which makes the plant breeding process much quicker and more efficient.

Whereas in the past plant breeders would have had to grow a plant to maturity and then wait to see whether it exhibited a particular trait, now they can simply check for the presence of particular genetic markers. This has important implications for agricultural productivity at a global level.

Of course the James Hutton Institute's contribution to agricultural productivity extends beyond the genomics expertise that exists within the Institute. The James Hutton Institute (or its predecessors) has been engaged in crop research for almost 100 years and many of the researchers who work in the Institute today have decades of experience in their respective fields.

By bringing together researchers from a wide variety of different but complementary disciplines the Institute contributes to improvement in agricultural productivity in a variety of different ways. For example, by identifying ways of increasing the efficiency and long run sustainability of input use, reducing losses through pests and diseases, improving cropping systems and by enhancing the uptake of new innovations.

Expertise on pests and diseases has for example been instrumental in enabling the Institute to develop crop varieties with better resistance to disease while understanding of Scotland's natural environment is currently proving invaluable in efforts to develop varieties of blueberries that better suited to Scotland's climate. Consultation with one of the Institute's major industrial clients, Lucozade Ribena Suntory, confirms that the multi-disciplinary expertise available within the Institute is of central importance to the continued success of the breeding programme.

5.1.3 Demonstration Facilities

To deliver tangible economic benefits it is essential that the outputs of research undertaken at the James Hutton Institute are taken up by industry. To encourage this the Institute maintains a number of facilities around the country that can be used to provide practical demonstrations of new processes and varieties.

These facilities include around 270 hectares of arable land that is used to conduct a wide range of agricultural, horticultural and environmental trials. An expert service is provided for land preparation, sowing, drilling, harvest and clearance of residues. As well as annual crops such as potatoes, brassicas and cereals, field staff also maintain around ten hectares of perennial soft fruit trials and three research farms and stations: Balruddery Research Farm in Angus, Glensaugh Research farm in Aberdeenshire and Hartwood Research Farm in Lanarkshire.

To help support this type of work the James Hutton Institute has developed a new experimental research platform called the Centre for Sustainable Cropping (CSC), which is based at Balruddery Farm near Dundee. It is the first platform of its scale in the UK and has been designed to provide a test-bed for new sustainable management practices and crop varieties that are designed to:

- maintain yield quality and yield stability at lower levels of agrochemical inputs;
- reduce greenhouse gas emissions and nutrient leaching from the system; and

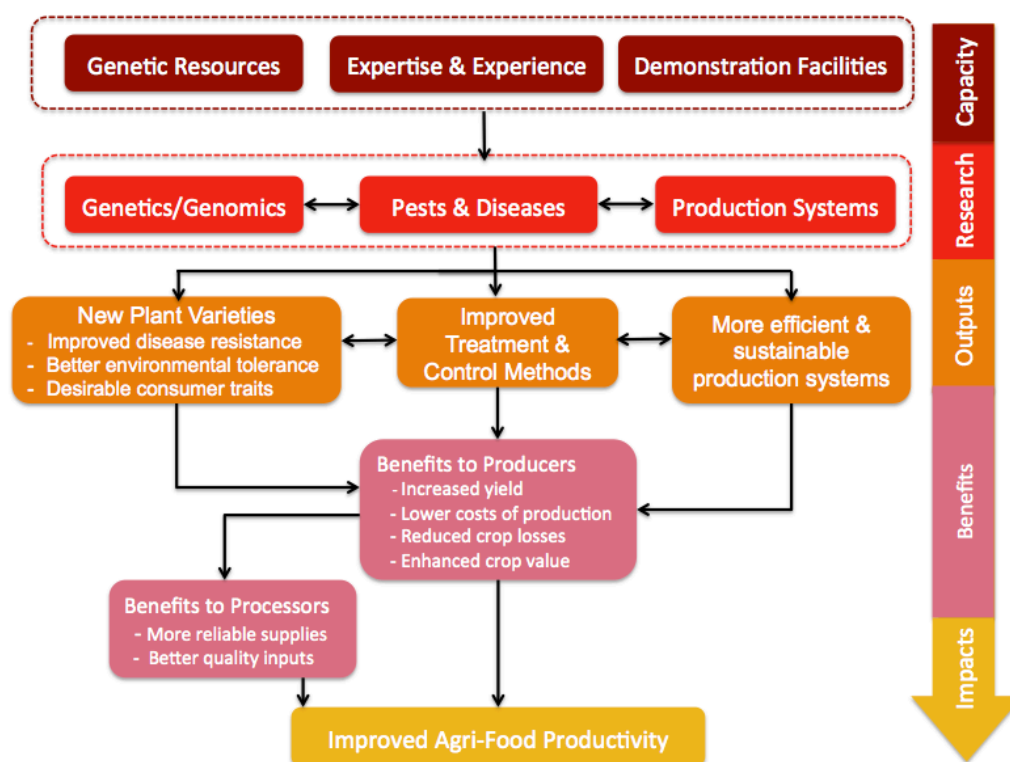
- enhance soil quality and arable biodiversity.

The centre enables researchers to undertake field-based experiments in which half of a field is cultivated using conventional farming techniques and the other half is cultivated using alternative methods. This enables researchers to analyse differences between the different cultivation methods in key performance variables including, amongst others, yield thereby generating evidence to support the recommendation of alternative methods. Perhaps even more importantly, the site also enables researchers to demonstrate these differences to interested parties from industry and thereby encourage superior methods to be adopted.

5.1.4 Contribution to Agri-food Productivity

The contribution that the James Hutton Institute makes to improving agri-food productivity is illustrated in Figure 5-1. The remainder of this chapter and the next chapter quantifies the economic value of this contribution.

Figure 5-1 – Contribution to Agri-Food Productivity



Source: BiGGAR Economics

5.2 Improved Treatment and Control

Pests and diseases can cause major reductions in crop yields if uncontrolled and efforts to control potentially damaging pests and diseases through pesticides and other interventions can be both costly and environmentally harmful. By seeking to better understand such pests and diseases, researchers at the James Hutton Institute aim to develop novel and sustainable strategies to manage or counter these threats. The implementation of these strategies can help to reduce the economic costs of pests and diseases and improve agricultural productivity.

In recent years much of the focus of this area of research has been on late blight, the infamous disease that caused the Irish potato famines of the 19th century. A

case study of this work, and the economic benefits that it has already helped to realise is provided in Figure 5-2.

Figure 5-2 – Late Blight Analytical Service

The Potato Council estimates that late blight currently costs the UK agricultural sector around £55 million/year in lost yield and reduced quality, making it the most serious disease affecting the UK potato crop.

Late blight is caused by a fungus like micro-organism called *Phytophthora infestans* and one of the major difficulties facing potato growers is that this organism can change over time. This means that what may have been an effective control strategy in the past or in a particular area may not necessarily be the best control strategy in future years or in other parts of the country.

To help address this the James Hutton Institute has been working closely with the Potato Council since 2006 on a national programme of blight survey work. This work was part of Potato Council's "Fight Against Blight" campaign that involved enlisting scouts to report outbreaks and post in infected samples. The infected samples were then analysed by researchers at the James Hutton Institute, who used them to identify the introduction and confirm the establishment and spread of two new strains of late blight in Great Britain.

The strains identified posed a significant threat to the blight control programmes used by the industry and growers had to respond quickly in order to prevent losses within their own businesses and amongst processors, packers and the seed potato sector. The changes required included:

- starting the blight control programme earlier than in previous years;
- reducing the intervals between spray applications;
- careful selection of fungicide; and
- awareness of varieties that offer greater resistance to blight.

These changes were made possible as a direct result of the understanding of the new blight strains provided by the research undertaken by the James Hutton Institute.

“the value of the James Hutton Institute is that they can approach problems using conventional approaches but also have a deep understanding of what’s triggering infection. The mix of skills within the Institute means that the whole is worth much more than the sum of the parts.”

Mike Storey, Head of R&D at the AHDB Potato Council

If these changes had not been implemented then the Potato Council estimate that production losses could have been between £2 and £5 million greater than they actually were.

The fungicides used to protect potatoes against late blight need to be applied at regular intervals. The length of interval between spray applications and the type of product used can have a big impact on the cost of control strategies. The Potato Council has estimated that during a high-pressure blight season the costs of control across Great Britain can be up to £72 million while during a low-pressure year the cost can be around £39 million. During a low pressure season the potential savings to the sector could therefore amount to £33 million.

The James Hutton Institute plays an important role in providing the evidence that growers need to decide on the most appropriate control strategy in any given year. Not only does this help to reduce losses during years when blight is a significant threat, it also enables the sector to realise savings from cheaper chemical control strategies during years where blight is not a major threat.

Source: BiGGAR Economics based on information provided by the Potato Council

Research on pests and diseases also plays an important role in informing the plant-breeding activity at the James Hutton Institute and has enabled the Institute to develop various new varieties of crops that are more resistant to important

pathogens. The economic contribution of James Hutton Institute's plant breeding activity, which includes the contribution of research into pests and diseases, is considered in chapter 5.

An important focus of the James Hutton Institute's research on pests and diseases is on developing varieties of potatoes that are more resistant to the two most important potato pathogens: potato cyst nematodes and late blight. In 2008 it was estimated that reductions in yield and quality caused by late blight cost producers in the UK around £55 million while potato cyst nematodes, which mainly affect the processing and fresh market sectors, cost nearly £26 million²². In 2016 prices this would equate to losses of over £100 million.

Researchers at the James Hutton Institute are actively engaged in research that aims to develop new varieties of potato that would be more resistant to these pathogens. If successful scientists at the Institute estimate that it could be possible to reduce losses from these diseases by around 5%. This could equate to a saving of £5 million. Although these benefits are yet to be realised, consultation with the Agricultural and Horticulture Development Board (AHDB) undertaken to support this study confirm that the aspiration of achieving a reduction of around 5% of total costs is reasonable.

Importantly, much of this work is being undertaken in collaboration with commercial partners in China. A rapidly growing and increasingly urban population coupled with increasing demand for a more meat intensive western diet and a shortage of farmland means that China has a significant and growing food problem/opportunity²³. The Chinese government has identified the potato as an important part of the solution to this problem and the James Hutton Institute is helping to ensure that this becomes an important opportunity for Scotland.

This is because although China is the largest potato producer in the world it has relatively low potato yields (in 2014 China's average potato yield was around 19 tonnes/hectare, compared to around 33 tonnes/hectare in the UK²⁴). The Chinese government believes that improving the yield of the potato crop will be easier than improving the yield of the country's other major food crops and for this reason in 2015 the Chinese Ministry of Agriculture announced its intention to transform the crop into the country's fourth major food crop²⁵.

The main reasons for low potato yields in China are the use of low-quality seed potatoes and incidence of disease²⁶. As one of the world's leading authorities on potato science and breeding the James Hutton Institute is well placed to help the Chinese authorities to address these issues. Although the benefits of this work have not yet been realised, the potential economic impact of helping to underpin food security in China is difficult to overestimate.

5.3 Efficient and Sustainable Production Systems

Another important contribution that the James Hutton Institute makes to agricultural productivity is by undertaking research into the factors that determine the productivity of agricultural systems in Scotland, the UK and elsewhere in the

²² Potato Council (May 2009), Pesticide availability for potatoes following revision of Directive 91/414/EEC: Impact assessments and identification of research priorities

²³ Forbes Asia (September 25th 2015), China's growing food problem/opportunity

²⁴ UN Food and Agriculture Organisation statistical database accessed in October 2016

²⁵ China Daily (7th January 2015), China to boost potato cultivation

²⁶ Global Agriculture Information Network (25th September 2015), China to boost potato production and transform potato into its fourth major grain

world. This work covers a wide range of research interests ranging from pest management and soil conditions to cropping practice and the interactions between roots and soils. The implications of this work for agricultural productivity are significant.

Underpinning much of this work is the James Hutton Institute's expertise on soil, the fundamental building block of all agricultural systems. This expertise dates back to the 1960's when what was then the Macaulay Institute developed a land use capability system that allowed soil maps and other landscape and climatic information to be collated into land classification maps. In the early 1980s the system was developed into the Macaulay Land Capability for Agriculture (LCA) classification.

The LCA system is now the official agricultural classification system used in Scotland by agriculturalists, planners, estate agents and others as a basis of land valuation. It provides the basis for farmers decisions about land management options and provides a measure of the value of agricultural land for sale and insurance purposes. It therefore plays a key role in underpinning the efficient financial operation of the agricultural sector.

Soil-related expertise has also enabled researchers at the James Hutton Institute to contribute to various projects designed to help improve the efficiency with which soil is cultivated, both in Scotland and elsewhere in the world.

One example of this was a recent project in which researchers at the Institute showed that cultivating potatoes at a shallower depth can help to avoid soil compaction, which in turn supports better growth. This finding has important implications for potato growers not only because it can improve crop quality but also because it can help to reduce the cost of mechanical depreciation (because less compacted soil is easier to plough). Consultation with the Potato Council undertaken to support this study confirms that the findings from this research are being taken up by industry and are already starting to generate benefits.

Another example of how the James Hutton Institute's soil related expertise has helped to improve agricultural productivity in Scotland is by helping to bring about a change in the technical advisory rules on the use of phosphate fertilisers. A case study of this work is provided in Figure 5-3.

Figure 5-3 – Reduction in Phosphate Fertiliser Use in Scottish Agriculture

Modern agriculture is reliant on phosphate fertilisers being added to soil in order to obtain high crop productivity. Phosphate fertilisers are added to soil to build phosphate and cultivate a reserve that is adequate to meet crop demand but over-fertilisation is wasteful and can damage water quality, while under-fertilisation can decrease crop yields.

Recent collaborative research from the James Hutton Institute and SRUC has been used to change the technical advisory rules for all Scottish farmers on how much phosphate fertiliser should be applied to agricultural land in Scotland. The economic benefits that arise from this are the savings on the unnecessary use of fertiliser and also the reduction in the clean-up costs associated with water contamination.

Using data published by the Scottish Government researchers at the James Hutton Institute have estimated that before the rules changed Scottish farmers were spending between £30 and £43 million each year on phosphate fertiliser. As a result of the new rules the researchers estimated that this cost could be reduced by around 10%, resulting in savings of £3 - £4 million per year.

In addition to this there would also be a reduction in the quantity of phosphate requiring removal from watercourses. It was estimated that this water pollution prevention could create an additional saving of £0.17 million per year. Thus, the total economic benefit was estimated at between £3.2 and £3.4 million per year with the potential for even greater savings. As the James Hutton Institute was one of two main partners involved in this research it is appropriate to attribute around half of this benefit to the Institute.

Source: BiGGAR Economics based on consultation with JHI staff

5.4 Summary Agricultural Productivity Benefit

This chapter has described how the research undertaken at the James Hutton Institute helps to support the productivity of the agri-food sector. It has also provided two particular case studies to illustrate this process. The quantifiable benefits associated with these case studies are summarised in Table 5.1.

Table 5.1 – Summary Illustrative Sustainable Production System Benefits – GVA (£m)

	Scotland	UK
Potato blight survey analysis	0.4	1.8
Phosphate reductions	1.6	1.6
Total	2.0	3.4

Source: BiGGAR Economics

It is however important to note that these benefits are purely illustrative and do not fully reflect the full contribution of these areas of work. The reality is that there are other projects that are likely to have delivered similar agricultural productivity benefits that could equally well have been included. That they have not been included is simply due to limitations in time and space. For this reason alone it is likely that the impact quantified above underestimates the full value of these areas of activity.

It is also important that the areas of work highlighted in this chapter are not considered in isolation but instead are recognised as fundamental components that help to underpin the wider impacts of the James Hutton Institute. The development of more sustainable and efficient production systems for example plays a key role in helping to maintain Scotland's high quality natural environment, the benefits of which were considered in the previous chapter. Similarly, work to understand important plant pests and diseases has played an important role in food production, the impact of which is considered in the next chapter.

6 CONTRIBUTIONS TO FOOD PRODUCTION

Plant breeding at the James Hutton Institute dates back to at least the 1950s and the Institute is internationally recognised for its work in this area. The main focus of this activity is on soft fruit, potatoes and barley. This chapter considers the contribution that this activity makes to the Scottish Economy.

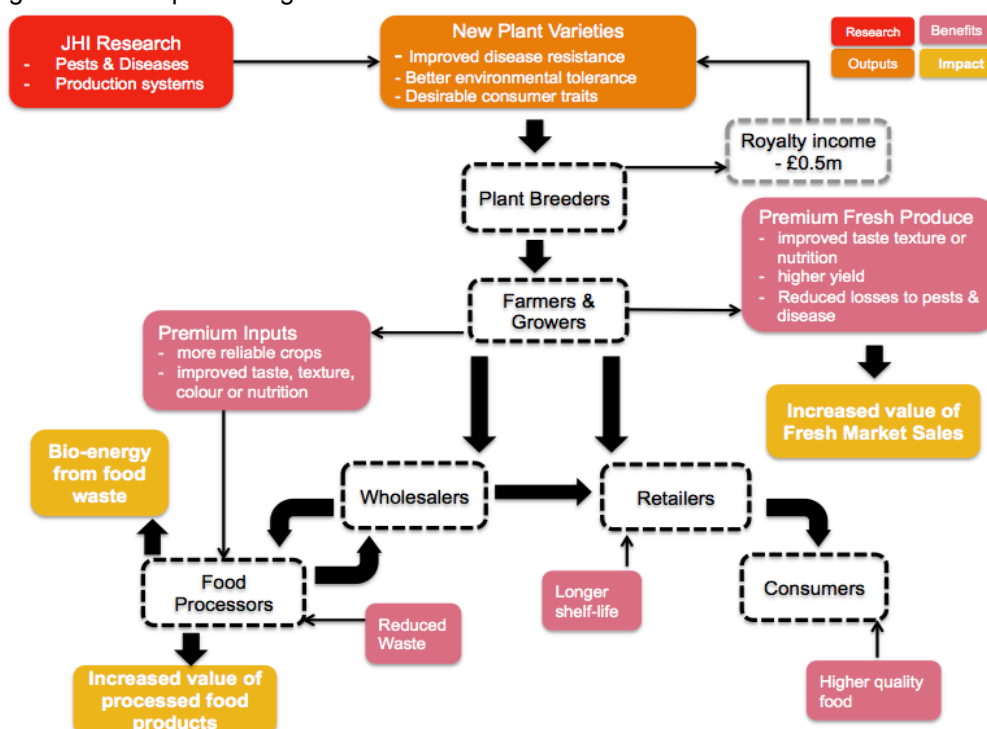
6.1 Crop Breeding Value Chain

More than 90% of the yield gains in major crops over the past 30 years have been due to plant breeding innovation²⁷. Organisations such as the James Hutton Institute are the origin of much of the knowledge and expertise that has made this type of innovation possible.

The plant breeding innovation process has several phases but starts with staff at the James Hutton Institute working with commercial seed developers to develop new varieties of crops that deliver better and/or more reliable yields and enhanced performance criteria. Seed developers then make new varieties available to commercial growers to produce more valuable crops. These crops are then sold directly to consumers (via retailers) or to the food-processing sector for use in a wide range of products. This process is illustrated in Figure 6-1.

The uplift in prices realised for fresh produce and processed products made using improved crops reflects the additional value associated with the new varieties added at each preceding stage of the value chain. In order to estimate the economic impact of plant breeding activity at the James Hutton Institute it is therefore necessary to consider the additional value of fresh market sales and the additional value realised by processors. This is considered below.

Figure 6-1 – Crop Breeding Value Chain



Source: BiGGAR Economics

²⁷ BSPB (2014), Plant breeding matters: the business and science of crop improvement

6.2 Fresh Market Sales

Internationally the intellectual property rights of plant breeders are protected through a system called Plant Variety Rights (PVR). To qualify for PVR, a new variety must undergo official tests to determine whether it is distinct, uniform and stable. Once these rights have been established, the plant breeders can collect royalties on the production and sale of seed/plants of their protected varieties. PVR income therefore directly reflects the volume of protected varieties grown around the world and can be used to assess the value that the James Hutton Institute generates through protected varieties. This impact is considered 6.3.

Not all of the plant breeding research undertaken at the James Hutton Institute aims to develop new varieties however. This is particularly true of the Institute’s work on barley, which has involved applying expertise in plant genetics to develop new genetic selection techniques that have significantly increased the efficiency of the plant breeding process and, via collaboration with industry, has led to the generation of improved varieties. This impact is considered in section 6.4

6.3 James Hutton Institute Varieties

By applying PVR data provided by the James Hutton Institute to the total market value of relevant crops it was possible to estimate that the total market value of James Hutton Institute varieties currently amounts to around £124.6 million. The assumptions used to estimate this are summarised in Table 6.1.

Table 6.1 – Value of James Hutton Institute Varieties

Crop	Total UK market value	UK market share	Approximate value of JHI varieties
Potatoes	711.3	4.2% ²⁸	29.8
Strawberries	508.0	1.0%	5.1
Blackberries	28.0	50%	14.0
Raspberries	184.0	25%	46.0
Blackcurrant	14.9	95%	14.2
Swede & turnip	26.0	53%	13.8
Kale	64.6*	20%	1.3
Forage rape		17%	0.5
Total	1,536.8	n/a	124.6

Source: BiGGAR Economics calculations based on data provided by the James Hutton Institute and DEFRA Horticultural Statistics. *Included in cabbage market value

Establishing the sales value of James Hutton Varieties is however only the starting point for estimating the value of this area of activity. To claim that this income is entirely attributable to the Institute would be unreasonable because it would ignore the contribution and investment of the grower and of all the other individuals who contribute at other stages of the supply chain. It would also be unreasonable because it would ignore the fact that there would be alternative varieties available to growers if James Hutton Institute varieties did not exist.

²⁸ Includes the market share of historic JHI varieties that are no longer protected under the PVR scheme

Growers who choose James Hutton varieties do so because they expect that that they will deliver some benefit over all the other varieties available (e.g. improved taste, better texture, higher or more reliable yield or greater disease resistance). If James Hutton Institute varieties were not available it would therefore be reasonable to expect that the economic performance of these growers would be lower than it otherwise could be.

As James Hutton Institute varieties are typically bred specifically for Scottish/UK growing conditions it is likely that if they were not available a proportion of the fresh market crop currently grown in the UK would be replaced by varieties grown overseas. Although this would not reduce the size of the UK market it would reduce the economic contribution that the market makes to the UK economy.

6.3.1 Quantifying the Impact of James Hutton Varieties

In order to estimate the economic contribution of James Hutton varieties it was necessary to come to a view on the “additionality” of James Hutton Institute varieties, i.e. the extent to which they enable growers to improve their performance relative to the next best variety available. The assumptions made to do this were made in consultation with staff and are summarised in the third column in Table 6.2. They took into account:

- the balance between the input of the James Hutton Institute and the individual seed developers involved in developing each variety;
- the overall size of the market and level of international competition within the market for each crop;
- particular characteristics of James Hutton Institute varieties that are known to have had a significant impact on particular crops (see Figure 6-2)

By applying these assumptions to the total value of UK sales of each of these varieties it was possible to estimate that the total sales value of crops attributable to the James Hutton Institute in 2014 amounted to £44.5 million. The number of jobs supported by these sales was then estimated by applying the average turnover/employee ratio for the agricultural sector in the UK.

Table 6.2 – Economic Impact of James Hutton Institute Varieties

Crop	Approximate value of JHI varieties	Additionality factor	Total benefit of JHI varieties
Potatoes	29.8	10%	2.3
Strawberries	5.1	10%	0.5
Blackberries	14.0	50%	7.0
Raspberries	46.0	50%	23.0
Blackcurrant	14.2	50%	7.1
Swede & turnip	13.8	25%	3.4
Kale	1.3	25%	0.3
Forage rape	0.5	25%	0.1
Total	124.6	n/a	44.5

Source: BiGGAR Economics

At present Scotland accounts for around 28% of the production value of soft fruit grown in the UK. According to the Scottish Government almost three quarters of soft fruit grown in Scotland is grown in Tayside and Grampian accounts for a further 6%. Scotland also accounts for around 22% of the total area used for growing potatoes in the UK and figures produced by the Scottish Government suggest that almost 50% of Scottish production comes from Tayside and around 13% comes from Grampian. The impact in each of the study areas was estimated by applying these proportions to the total UK impact.

In this way it was estimated that the James Hutton Institute contributed £12.9 million GVA to the Scottish economy in 2015 and supported almost 260 jobs as a result of the cumulative effect of its on-going and historic plant breeding activity. The value of this impact in each study area is presented in Table 6.3.

Table 6.3 – Impact of James Hutton Varieties

	Local areas	Scotland	UK
GVA (£m)	9.8	12.9	44.5
Jobs	196	257	887

Source: BiGGAR Economics

Figure 6-2 – Contribution to the Scottish Raspberry Industry

In the 1990s the raspberry industry in Scotland was in crisis due to cheap imports and the effects of disease on existing plantations. At that time the Scottish raspberry crop was used almost exclusively by the processing sector to make products such as jam.

From 1993 the James Hutton Institute was successful in securing funding for raspberry breeding, first from the EU and then from the Scottish Government. This funding was used to develop new varieties that were more resistant to disease and that could be grown under polytunnels. These new varieties enabled growers in Scotland to significantly improve productivity, by avoiding losses to disease and poor weather conditions. More importantly the new varieties also enabled growers to start producing higher quality fruit that was suitable for the much more lucrative fresh market.

If the new James Hutton raspberry 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. Figures produced by the Scottish Government suggest that in 2015 raspberries accounted for £15 million of the overall value of the Scottish soft fruit market. The James Hutton Institute has therefore played a key role in protecting this valuable market.

Source: BiGGAR Economics based on consultation with JHI staff

Although James Hutton Institute varieties are primarily bred for Scottish/UK growing conditions they are not exclusively grown in the UK. It is for example understood that James Hutton Institute varieties currently account for a significant proportion of global blackcurrant and raspberry production and a small share of the potato and strawberry markets. Data availability means that it is not possible to estimate the value of this production so the total UK impact described above is likely to under estimate the total contribution of this activity.

It is also important to highlight the impact considered in this section includes the contribution that the James Hutton Institute makes to the Scottish seed potato industry. This is worth highlighting because the Scottish seed potato sector is a distinctive strength of Scottish agriculture and a highly successful export sector, worth between £80 and £100 million to the Scottish economy each year.

Figures from the Scottish Government show that in 2014/15 Scotland exported around 90,000 tonnes of seed potatoes, which represents around 80% of the UK total. James Hutton Institute varieties accounted for 2% of these sales²⁹. The success of this industry is wholly dependant on Scotland's reputation for producing high health plants, which is in turn largely attributable to research undertaken at the Institute.

6.4 Barley Breeding

Scientists at the James Hutton Institute (and its predecessors) have been involved with barley breeding for several decades. Throughout this period scientists at the Institute have 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 2015³⁰.

Improvements in genetics and genomic research and the translation of outputs to plant breeding are rapidly assimilated by breeders around the world and advances developed by scientists at the James Hutton Institute are now regularly used elsewhere in Europe and increasingly around the world. The effect of this is apparent in European barley yields, which increased by around 20% between 2000 and 2015³¹.

As one of the world's leading authorities on the genetic selection of barley, much of this impact can be attributed to the James Hutton Institute.

6.4.1 Quantifying Improvements in Barley Yield

In 2015 1.1 million hectares of arable land in the UK were used to produce 7.3³² million tonnes of barley worth £824 million³³. Had the average yield of barley in 2015 been the same as it was in the mid-1980s then this land could have produced around 5.5 million tonnes of barley, which at 2015 prices would have been worth around £618 million - £206 million less than the actual value realised³⁴.

Using the same approach it was estimated that the yield improvements realised across Europe since 2000 have enabled an additional 12 million tonnes of barley worth around £1.4 billion to be produced. The British Society of Plant Breeders (BSPB) have estimated that as much as 90% of these improvements can be attributed to improvements in genetic selection³⁵.

The development of new varieties of barley is undertaken by commercial seed developers using research evidence and techniques developed by academic research institutes (such as the James Hutton Institute). To account for the contribution of these developers, it was therefore assumed that around half the gains due to genetic selection could be attributable to the research base.

²⁹ Science Advice for Scottish Agriculture (SASA), potato export statistics 2015/16

³⁰ Brassley P (2000), Output and technical change in twentieth-century British agriculture.

³¹ Eurostat

³² DEFRA (9th October 2015), Farming Statistics 2015

³³ DEFRA (28th April 2016), Total income from farming in the UK

³⁴ The alternative to this would have been for farmers to increase the acreage devoted to barley, but this would have reduced the amount of land available for other uses, including other crops, so there would still have been a cost to the UK economy

³⁵ BSPB (2014), Plant breeding matters: the business and science of crop improvement

The James Hutton Institute is currently recognised as one of the top three institutes involved in barley breeding the world. Consultation with staff at the James Hutton Institute suggests that most of the research evidence that has contributed to yield improvements in the European barley crop over the past few decades has emerged from one of these three institutes – although other institutes that will also have contributed to some extent. To account for this it was therefore assumed that 25% of the impact attributable to the research base could be attributed to the James Hutton Institute.

Together these assumptions imply that 12.5% of the genetic improvement in barley can be attributed to the James Hutton Institute (i.e. 50% X 25%).

By applying these assumptions it was estimated that around £23 million of the value of the UK barley crop in 2015 could be attributed to the James Hutton Institute. Across Europe the value of this impact was valued at £152.4 million. The value of this impact in Scotland and the local area was estimated based on the volume of barley produced in each of these study areas in 2015 and is summarised in Table 6.4. (As this impact relates to the productivity of the agricultural sector it was assumed that any employment effect would be minimal.)

Table 6.4 – Impact of James Hutton Institute Contribution to European Barley Yield

	Local areas	Scotland	UK	Europe
GVA (£m)	3.9	6.5	23.2	152.4

Source: BiGGAR Economics

It should be noted that the impact above relates only to improvements in UK barley yield that have been realised since the 1980s however, barley yield in the UK has been increasing since at least the 1960s. Had a longer time-scale been adopted then the value of this impact would have been higher. As noted above, scientists at the James Hutton Institute and its predecessors have been involved in barley breeding since at least the 1950s so there would be some justification for adopting a longer time-scale so the impact estimated above should be considered conservative.

6.5 Processor Benefits

To estimate the value that the James Hutton Institute delivers for food and drink processors it would be necessary to know how much additional value processors are able to realise as a result of using James Hutton Institute varieties but commercial confidentiality means that this information is not readily available. The benefits associated with two of the Institute’s most valuable food processing relationships (the development of blackcurrants for Ribena and the contribution of barley breeding to the whisky and brewing industries) have however been quantified in previous research³⁶. This section therefore draws on this research in order to provide an updated estimate of these contributions.

6.5.1 Ribena

One of the James Hutton Institute’s most enduring industrial partnerships to date is with Lucozade Ribena Suntory, the manufacturer responsible for the iconic British soft drink Ribena. A case study of this work is provided in Figure 6-3.

³⁶ DTZ (2009), SCRI living technology: economic impact assessment 2008/9

Consultations undertaken as part of the previous research undertaken by DTZ suggest that around three quarters of the turnover from sales of Ribena was related to the flavours created by blackcurrants developed by the James Hutton Institute. Consultation undertaken for this study suggests that the total sales value of Ribena in 2015 was around £150 million.

In order to estimate the net impact of these varieties it was necessary to consider what would happen to the economy if they were no longer available. The previous research did this by using data from the UK input-output tables to assess the degree to which consumers in the UK might be expected to switch to alternative brands. Using the same methodology it was estimated that if James Hutton Institute varieties were no longer available in 2015 around 27% of sales might be replaced by imported substitutes. This implies that in 2015 £29.8 million of Ribena sales in the UK were sustained by blackcurrant varieties developed by the James Hutton Institute.

According to the previous study Ribena is proportionately more likely to be substituted with imported brands because of the relatively low availability of blackcurrants in the UK. This was modelled by assuming that the rate of foreign substitution could be as high as 44%. Applying this assumption to the present analysis would imply that this impact could be as high as £49.5 million. As there is little evidence available to support this alternative assumption this analysis has adopted the more conservative assumption of 27%. It should however be noted that this could mean that this impact is underestimated.

The GVA and employment impacts associated with this additional turnover was then estimated by applying turnover/GVA and turnover/employee ratios for the soft drinks sector and multiplier effects were captured by applying appropriate multipliers to the direct effect. In this way it was estimated that the James Hutton Institute contributed £27.3 million GVA to the UK economy and supported around 220 jobs as a result of its work breeding blackcurrants for Ribena.

Figure 6-3 – Supporting an Iconic Brand

A successful commercial relationship has existed between fruit breeders at the James Hutton Institute and the makers of Ribena for 25 years. During this time the Institute has played an important role in supporting the continued success of the iconic soft drink.

Ribena was first introduced to the British public in 1938 and earned its place in British history when it was given to children during WWII as a vitamin C supplement. Today around £150 million worth of Ribena is sold each year, mostly in the UK, and the company directly employs around 800 people in London and Gloucestershire.

The original variety of blackcurrants used to make Ribena (which remains part of today's recipe) was developed back in the 19th century. Although this variety helps to produce the distinctive colour and taste associated with Ribena it is not a particularly economic variety to grow. For Ribena to thrive over the years it was therefore necessary to develop new varieties that had a similar taste and colour to the original variety but that were more economic to produce.

For the past 25 years the James Hutton Institute has played a key role in developing these new varieties such that the breeding programme is now acknowledged by the company as *"the best in the world"*. Of the ten different varieties of blackcurrants used in Ribena today, nine were bred by the James Hutton Institute.

Originally the main objective of the Ribena breeding programme was to improve the frost tolerance of blackcurrants to avoid crop losses during cold springs. At that time a cold spring could cost blackcurrant producers up to three quarters of their crop. This not only threatened the livelihood of producers but also had serious consequences for Ribena by disrupting the feedstock-to-product supply chain. The breeding programme has been, and continues to be, very successful, resulting in several new varieties that are much less vulnerable to frost.

In more recent years climate change has meant that warmer winters have displaced cold springs as the most important issue facing blackcurrant producers. 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. New varieties are now emerging from the breeding programme that can set fruit in warmer conditions and it is expected that this could save growers around £2 million/year.

The Ribena breeding programme has delivered real benefits to blackcurrant producers but has also played an important role in helping Ribena to maintain a strong position in a highly competitive market. In part this is because the new varieties developed at the James Hutton Institute have helped to make supplies of raw materials for Ribena much more reliable, which has helped the company to maintain high levels of efficiency. An important consequence of this has been to ensure that the company 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.

Source: Interviews with LRSuntory and James Hutton Institute staff

6.5.2 Barley

In 2010 the BSPB commissioned a study on the economic impact of plant breeding in the UK³⁷. One of the three main crops considered in the report was barley. The report quantified various benefits to food and drink processors that rely on barley that can be at least partially attributed to the James Hutton Institute.

Scientists at the James Hutton Institute for example helped to facilitate the development of varieties of non-glycosidic nitrile (GN) varieties of barley, which produces grain suitable for distilling. The availability of these varieties helped to safeguard Scotland's most important whisky export markets in north America from

³⁷ DTZ (July 2010), Economic impact of plant breeding in the UK

future regulatory change. According to the Scotch Whisky Association £826 million of Scotch whisky was exported to these markets in 2015³⁸.

For the reasons discussed above 12.5% of the genetic improvements in barley can be attributed to the James Hutton Institute, which implies that the Institute has helped to safeguard £103.3 million of whisky sales. Using ratios and multipliers from a report on the economic impact of Scotch whisky production³⁹ it was estimated that these sales contributed a total of £66.2 million GVA to the Scottish economy and supported around 225 jobs in 2015/16.

Advances in barley breeding have also reduced the beta glucan content in barley, which has improved the processability of the grain and significantly improved brewing productivity. It was estimated that this has enabled the UK brewing industry to realise productivity savings worth around £105 million/year. Similarly advances made by plant breeders to boost domestic malt production have also resulted in corresponding reductions in the volume of imported malt, which means that the UK can avoid associated freight costs. The savings associated with this were estimated at £7.8 million per annum

As above, it was assumed that 12.5% of these savings could be attributed to the James Hutton Institute. These savings are productivity improvements and as such directly increase GVA but would not have an associated employment effect.

The role that the James Hutton Institute has played in underpinning the Scotch whisky industry is considered further in the case study in Figure 6-4.

Figure 6-4 – Underpinning the Scotch Whisky Industry

Over the years researchers at the James Hutton Institute have been particularly active in developing understanding of the genomics of barley. Barley is one of the main raw ingredients used in the production of whisky so this work has helped to underpin the success of an industry that generates around £5 billion/year for the UK economy⁴⁰.

An important milestone in the James Hutton Institute's contribution to global barley production occurred in 2012 when an international consortium of scientists involving researchers from the Institute published a high resolution draft of the barley genome in the journal Nature. As part of this research researchers at the Institute developed various genome markers that can be used to identify particular traits in barley cultivars. These tools have since been taken up by breeders globally who use them to help develop new varieties that are better suited to particular uses and environmental conditions.

World wide the most important use for barley is as fodder for livestock so that the ability to increase yield due to genetic selection will have important implications for global food security. The second most important use for barley world-wide is in alcohol production, including beer - and whisky. This means that these developments have particularly important implications for the Scottish economy.

One of the factors that is extremely important to consumers of Scotch whisky is provenance, which means that the ability to produce whisky using grain grown in Scotland is an important priority for producers. To do this however producers require a reliable and consistently high quality supply of barley, which is challenging given the vagaries of the Scottish climate. By enabling barley breeders to select cultivars that produce a higher alcohol yield, generate less waste during the production process and are more resilient to climate change research undertaken at the Institute has therefore played an important role in underpinning the continued success of one of Scotland's most iconic industries.

Source: BiGGAR Economics based on interviews with the Scotch Whisky Research Institute

³⁸ Scotch Whisky Association (May 2016), Top 20 export markets 2015 – value and volume

³⁹ SWA (2015), The economic impact of Scotch whisky production in the UK

⁴⁰ 4 Consulting (January 2015), the economic impact of Scotch whisky production in the UK

6.6 Summary Contribution to Food Production

Adding together the benefits considered in this section suggests that in 2015 £175.4 of the GVA and around 1,330 of the jobs supported within the UK food and drink sector could be attributed to the crop related research undertaken at the James Hutton institute. A break down of this impact is provided in Table 6.4.

Table 6.5 – Summary Contribution to Food Production

	Local areas	Scotland	UK	Europe*
GVA (£m)				
Fresh market sales	9.8	12.9	44.5	44.5
Barley yield	3.9	6.5	23.2	152.4
Ribena sales	n/a	n/a	27.3	27.3
Whisky exports	n/a	66.2	66.2	66.2
Malt processability	n/a	1.2	13.3	13.3
Malt freight cost savings	n/a	0.2	1.0	1.0
Total	13.7	87.0	175.4	304.6
Jobs				
Fresh market sales	196	257	887	887
Barley yield	n/a	n/a	n/a	n/a
Ribena sales	n/a	n/a	220	220
Whisky exports	n/a	225	225	225
Malt processability	n/a	n/a	n/a	n/a
Malt freight cost savings	n/a	n/a	n/a	n/a
Total	196	482	1,331	1,331

Source: BiGGAR Economics *Where UK impact = global impact it was not possible to estimate non-UK impacts.

7 OTHER COMMERCIAL ACTIVITIES

This chapter assesses the economic impacts associated with other types of research and analytical services that the James Hutton Institute undertakes on behalf of commercial clients. It also describes the importance of some of the products that have been developed by researchers at the James Hutton Institute and highlights the role that the Institute is playing in supporting the development of technology-based companies in Scotland.

7.1 Analytical Services

The James Hutton Institute undertakes a variety of analytical services on behalf of industry. This commercial analytical work falls into two categories. The Institute undertakes routine analysis, such as soil sampling for Natural England, monitoring of water quality for windfarm installations and more broadly, product quality regulatory compliance work.

In addition to this, the Institute undertakes highly specialised work that leverages expertise in the Institute and research base to tackle analytical challenges. What sets the James Hutton Institute apart is its ability to combine the significant in-house technical expertise it has with a wide range of state-of-the-art instrumentation. This gives the Institute the ability to tackle 'problem samples', i.e. identifying unknowns and speculating on their formulation or provenance. This type of work is often high profit requiring a quick turnaround.

As a result of early work with the oil and gas sector, the James Hutton Institute has developed a reputation with industry and become an important source of analytical services for the industry. The Institute's X-ray diffraction laboratories in Aberdeen have over the last few years undertaken work providing high quality clay mineral analysis contributing to both the exploration and production of oil from sites all over the world.

Much of this work is for the oil giants Shell and BP. This research group at the Institute continually attains a top three ranking in the Reynolds Cup, a global round robin contest for clay mineral analysis, an achievement that demonstrates the very high quality of work undertaken at the Institute. Although not the only factor in the decision making process, having this information at their disposal aids oil and gas companies in deciding where to drill.

The Institute has also expanded its services into other areas, including lipid content profiling. In 2014, following an inspection by the US Food and Drug Administration (FDA), the Institute's facilities were approved for the analysis of lipid-based pharmaceutical and nutraceutical products to Good Manufacturing Practice (GMP) standards. Similar approval had already been obtained from the Medicines and Healthcare Regulatory Agency (MHRA) in the UK for the analysis of lipids to both GMP and Good Clinical Practice (GCP) standards.

This makes the James Hutton Institute one of the few specialist laboratories in the world able to offer lipid analysis services to companies undertaking clinical trials, and/or interested in obtaining product regulatory approval in both the EU and North America.

This service therefore allows companies to validate their product claims and if validated enables companies to charge a higher price for their products. With the rise of nutraceuticals, this type of analysis will become ever more important and is therefore an area which has significant scope for further growth and expansion.

For commercial sensitivity reasons it is difficult to estimate the impact of the analytical services the Institute provides. However, the economic impact of this work can be illustrated through an example; the Institute recently undertook analysis on behalf of a major oil company on a failing production unit, which had been out of commission for two months. The company requested the Institute’s analytical expertise to determine the nature of the blockage, which the Institute was able to provide and thereby enable the unit to be brought back online.

The production unit being out of action was causing the company a loss of 85,000 barrels of oil per day. Even at \$50 per barrel that works out to be a loss of £2.8 million per day. The Institute’s analysis was able to identify the blockage in the pipeline, which enabled the production unit to be brought back into service at least three days sooner than would otherwise have been possible, resulting in a productivity increase of around £8.4 million (i.e. 3 days at £2.8 million/day).

This increased the value of natural resources realised and therefore represents a direct increase in Scottish GVA. Based on the current balance of activity within the oil and gas sector it was assumed that 80% of this impact occurred within the local area. This impact is summarised in Table 7.1. It is however important to note that it relates to just one example of a particularly beneficial project and rather than the full value of all analytical services delivered for commercial clients. For this reason this impact should be considered conservative.

Table 7.1 – Illustrative Example of Impact generated by Analytical Services

	Local area	Scotland
GVA (£m)	6.7	8.4

Source: BiGGAR Economics

7.2 Commercial Research Contracts

In 2015 researchers at the James Hutton Institute secured around £1 million of commercial research contracts. These contracts covered a wide variety of activity ranging from research into specific agricultural pests and diseases to research to improve crop productivity.

It is reasonable to assume that the businesses and other organisations that invested in this type of activity only did so because they expected the projects to generate positive returns. Detailed information about the level of these returns is not available but an estimate can be made based on evaluation evidence about the impact of similar activity elsewhere.

In 2013 BiGGAR Economics undertook an evaluation of Interface, the agency responsible for brokering relationships between businesses (and other organisations) and universities in Scotland⁴¹. The connections that Interface made covers a range of different types of engagement including contract research projects. The evaluation found that on average every £1 invested by businesses generated £3.60 GVA in direct economic benefits for the commercial partner.

This finding is similar to other studies done in similar areas. For example in 2009 PriceWaterhouseCoopers LLP undertook a study for the Department of Business, Enterprise & Regulatory Reform⁴², which considered the impact of Regional

⁴¹ BiGGAR Economics (2013), Evaluation of Interface, the knowledge connection for industry

⁴² PriceWaterhouseCoopers, *Impact of RDA spending – National report – Volume 1 – Main Report*, March 2009, DBERR

Development Agency spending. This study found that interventions in science, R&D and innovation infrastructure had achieved cumulative GVA returns equivalent to 340% the cost of the projects and that this could increase to 870% if the long-term benefits were taken into account. This suggests that the 360% multiplier estimated by BiGGAR Economics could be conservative.

These evaluations covered a wide variety of activities and it is possible that the economic return generated by the type of research delivered by the James Hutton Institute could be higher or lower than that described above. To help determine how appropriate this assumption may be as a basis for assessing the impact of contract research undertaken by the James Hutton Institute it is therefore also instructive to consider the example of the potato blight survey work undertaken by the Institute that was described in the case study in Figure 5-2.

According to the Potato Council⁴³ the total cost of delivering this project amounted to around £270,000 and the direct savings realised as a result of the project amounted to between £2 and £5 million. The project therefore delivered a return on investment of between 7.5 and 19.5. Based on this evidence it is reasonable to conclude that the 360% assumption estimated by BiGGAR Economics is likely to be conservative.

To avoid overestimating the impact of this activity, the GVA impact of commercial research contracts delivered by the Institute was therefore estimated by applying the more conservative £3.60 multiplier to the total amount generated from providing these services in 2014/5. The employment impact was then estimated by dividing the direct GVA impact by GVA/employee in relevant sectors and indirect effects were captured by applying appropriate multipliers.

In this way it was estimated that commercial research contracts delivered by the James Hutton Institute in 2014/15 generated £5.9 million GVA for the UK economy and supported almost 120 jobs. Much of this type of research is undertaken for UK wide organisations so it was assumed that the impact on the Scottish economy would be proportionate to Scotland's share of UK total farm income (18%). This impact is summarised in Table 7.2.

Table 7.2 – Impact of Commercial Research Contracts

	Scotland	UK
GVA (£m)	1.0	5.9
Jobs	20	119

Source: BiGGAR Economics

7.3 Product Development

As well as offering services to businesses, the James Hutton Institute has also been directly involved in the development of a number of commercial products, some of which are sold directly through the Institute's commercial subsidiary James Hutton Limited. An example of one such product is MicroResp.

MicroResp is an electronic probe that measures respiration in soil, sediment and water samples and significantly reduces the time and space needed to undertake soil analysis. About 15% of sales of the device are in the UK, 43% are to Europe and 42% are outside Europe.

⁴³ AHDB (2012), Late blight populations and flight against blight: cost benefit analysis

The probe has applications in a number of different sectors including agriculture and civil engineering. It can for example be used to improve the efficiency of irrigation systems as well as forecasting potential droughts and floods, allowing a harvest to be collected at the most efficient time possible. Other examples of products include access to comprehensive databases compiled by the James Hutton Institute, which provide data on soils, climate, hydrology and land capability maps.

Researchers at the James Hutton Institute have also been responsible for, or involved in the development of, a number of products that are now sold by other commercial companies. For example, researchers at the Institute were responsible for developing a bespoke trap for Raspberry Beetles, an important pest affecting raspberries. The development of the product drew on a wide range of expertise within the James Hutton Institute including chemical ecology, pest physiology, agronomy and population dynamics. The trap is designed to detect the early signs of the pests and reduce their presence, allowing less spray to be used.

In 2015/16 the sale of these products generated around £65,000 for the James Hutton Institute. This contributes to the Institute's annual turnover and therefore the economic impact of this revenue has been incorporated within the core operational impact of the Institute. What is more difficult to quantify however are the wider benefits that the products generated for those who purchased them.

By enabling users to predict floods or droughts more effectively for example the MicroResp probe could potentially have enabled users to save a valuable crop. Similarly, by providing a more cost effective method of controlling Raspberry Beetles the Raspberry Beetle trap could have helped to reduce the cost of pest control measures for users.

7.4 Spin-Ins

In recent years staff expertise and research infrastructure has enabled the James Hutton Institute to attract two small businesses to co-locate with the Institute. One of these spin-in businesses, Isotopic, employs one full time staff member and is based on the Aberdeen campus of the Institute. Isotopic provide geochemical analysis used in oil field exploration, development and production studies.

The other business is called Intelligent Growth Solutions and is based at the Invergowrie site. Intelligent Growth Solutions aims to capitalise on recent advances in LED and energy technology to build a new type of farming facility that can grow crops such as strawberries, tomatoes and crops used by the pharmaceutical industry in highly controlled indoor environments. This is expected to result in reduced waste, water and energy usage and less need for pesticides. The company is building a new £2.5 million prototype facility on the James Hutton Institute's land at Invergowrie. The company currently employs three people and is understood to have considerable scope for growth.

Although the current economic impact of both of these businesses is small the fact that both have chosen to co-locate with the James Hutton Institute provides strong evidence of the regard with which the Institute is held by industry.

8 POLICY AND PRACTICE

Staff at the James Hutton Institute engage in a wide variety of activity designed to transfer the findings of their research into policy and practice, this activity includes:

- training future generations of researchers and thereby encouraging new ways of developing research that embeds science within user communities;
- engaging with industry, policy-makers and other stakeholders through events that help to disseminate research to users;
- contributing to committees and other bodies established to influence policy and practice in a variety of different areas;
- producing research outputs such as papers and presentations designed to disseminate findings from research to stakeholders; and
- engaging in on-going dialogue and interaction with stakeholders.

The objective of this activity is to improve the efficiency and effectiveness of policy and practice in Scotland. This chapter quantifies the benefits associated with this activity.

8.1 Approach to Knowledge Exchange

The James Hutton Institute's approach to research is based on the principle of 'co-construction' where researchers are encouraged to engage with the users of the research from the very outset as well as throughout the course of project delivery, thereby ensuring the relevance of the research undertaken. This two-way approach means that researchers at the Institute are particularly well placed to support the development and implementation of evidence-based policy and practice.

Policy and practice that is based on robust scientific evidence is likely to be more effective in achieving its objectives than policy that is not based on evidence. More effective policy and practice means that it should be possible either to achieve the same outcomes using fewer resources (thereby freeing up resources for other priorities) or to achieve better outcomes using the same inputs. Either way, more effective policy and practice can make a direct contribution to economic efficiency.

Researchers at the James Hutton Institute contribute to the development of policy and practice across a wide range of different areas and the combined value of resources devoted to these areas of influence is very substantial. This means that even very small improvements in effectiveness or efficiency can generate significant economic benefits.

In 2015/16 the Scottish Government expects to allocate a total of £660.7 million funding and payments under EU programmes such as the LEADER programme and the Common Agricultural Policy (CAP). Researchers from the James Hutton Institute are closely involved in providing the evidence base to ensure that these funds are allocated as efficiently as possible.

For example, researchers at the James Hutton Institute were responsible for identifying qualitative indicators that could be used to measure the performance of rural areas in Scotland against each of the Scottish Government's five priorities. These indicators were used to create an index that the Scottish Government is

now using to allocate LEADER funding around Scotland. By providing an objective set of criteria the index helps to ensure that funding is allocated equitably and efficiently, which improves the overall efficiency of the LEADER programme. The James Hutton Institute's role in providing the evidence base for CAP allocation is discussed further in Figure 8-1.

Figure 8-1 – Common Agricultural Policy

The Common Agricultural Policy (CAP) sets the framework for agricultural policy in EU member states and implements a system of agricultural support and funding that member states apply. A revised CAP was to be introduced from 2015. The way in which CAP is applied in each country was negotiated over a number of years prior to the revision. UK negotiations were led by the Department for Environment, Food and Rural Affairs (DEFRA) with input from each of the nations of the UK.

A feature of the new CAP is that payments will be made based on the area farmed and the type of farming leading to a redistribution of CAP payments across the farming sectors. The James Hutton Institute in conjunction with the SRUC and the Scottish Government's Rural and Environment Science and Analytical Services Division undertook research, in the form of advanced land-use modelling, to understand how changes to CAP payments would affect Scottish agriculture.

This research provided the Scottish Government with a robust means of assessing the impacts of different possible outcomes. Based on this research the Scottish Government was able to explain to farmers how they were likely to be affected, amend its negotiating position accordingly, make an evidence-based case for Scotland's negotiating position and ensure efficiency of public funding allocation.

Being able to ensure Scotland's needs are met, through an evidence-based narrative, is important to the Scottish economy. The redistributive effects of the original CAP proposals would have negated elements of Scottish agricultural policy, which aims to ensure that those sectors in which there is a need to concentrate resources are able to do so in order to improve productivity.

In 2015 21,460 Scottish businesses received a payment from the CAP and the total value of these payments amounted to £613 million⁴⁴. Even very small improvements in the efficiency with which this funding was allocated could therefore have significant implications for Scottish agricultural sector.

Source: BiGGAR Economics based on information provided by the James Hutton Institute

The James Hutton Institute's contribution to policy and practice is however not restricted to publicly funded programmes and initiatives but also extends into the private and charitable arena.

For example, for many years researchers at the Institute have been closely involved in providing advice and support to private estates and the Red Deer Commission (now part of SNH) on the management of red deer populations. Research⁴⁵ commissioned by the SNH estimates that red deer stalking contributes around £70.4 million to the Scottish economy each year and that deer management supports around 2,520 jobs. This implies that any improvements in the efficiency of deer management practices could have direct and significant economic benefits.

More recently researchers at the Institute have been particularly influential in efforts to conserve Scotland's wildcat populations by undertaking research that

⁴⁴ <http://www.gov.scot/Topics/farmingrural/Agriculture/grants/LatestPayments> accessed on 9th November 2016

⁴⁵ Putman, R. (2012), Scoping the economic benefits and costs of wild deer and their management in Scotland, Scottish Natural Heritage Commissioned Report No. 526

helped to identify the best locations for priority conservation areas. This research has played a major role in determining how and where almost £2.0 million of funding allocated to the Scottish Wildcat Action plan will be spent. While the James Hutton Institute has not played a direct role in securing this funding, the advice that it has provided has played an important role in ensuring that the resources are allocated as efficiently as possible.

The contribution that researchers at the James Hutton Institute make to policy and practice is not just restricted to Scotland, it also has an influence overseas. For example researchers at the CREW are currently evaluating a Scottish Government funded project to deliver boreholes in Malawi. By undertaking projects like this the Institute therefore also contributes the effectiveness and efficiency of Scotland's International Development Fund, which was worth £9 million in 2016/17.

8.2 Stakeholder and Public Engagement

Knowledge exchange activity at the James Hutton Institute is extensive and comprehensive covering industry, academia and the general public as well as communicating research to inform public policy.

Industry engagement has significant benefits as it provides users with up to date, practical and relevant information that can lead to cost savings or improvements in efficiency. Likewise, a strong evidence base can lead to better and more efficient public policy, which should mean that public authorities can deliver either the same outcomes for less money or improved outcomes for the same cost. This section outlines the wide-ranging activities undertaken by the Institute to disseminate its research and provide evidence for decision-making both in the UK and further afield.

8.2.1 Technical Guidance for Industry

As well as hosting industry events and conferences to disseminate the research of the Institute, scientists at the James Hutton Institute contribute public articles in trade journals and guidance notes and written advice for professional associations.

Between April 1st April 2011 and 30th September 2014, 95 written outputs for trade and industry were produced by the Institute's scientists. This included articles in UK-wide trade journals such as Farmers Weekly (e.g. 'Micronutrients for Arable Crops') and Scottish ones such as The Crofter (e.g. 'Vegetation Change on the Machair'). International examples include articles in the quarterly publication of the International Plant Nutrition Institute and the International Water Association River Basin Management Newsletter. The Institute has also been involved in the development of products for industry including freely-downloadable apps, such as for land managers to measure soil carbon co-produced with Quality Meat Scotland, and Soil Indicators for Scottish Soils. This engagement with industry supports the dissemination of cutting edge research to end users that can lead to efficiency savings.

8.2.2 Committees of Influence and Advisory Boards

The Institute's knowledge exchange strategy identifies committees of science, industry and policy at the national, European and international level, and taking leading roles in communication of science knowledge to policy and practice, as important strands of the Institute's work. This role of the Institute is necessary for the transfer of scientific knowledge into policy and practice but also so that the

Institute remains at the forefront of developing agendas and abreast of emerging issues.

The James Hutton Institute therefore actively identifies opportunities to contribute to organisations of peers, seeking membership of committees of influence in science, industry and policy at international, European and national levels. Table 8.1 illustrates the wide-ranging committees and boards that the Institute contributes to, at all geographic policy levels thereby ensuring the most extensive possible contribution to policy matters.

According to data provided by the Institute, over the period from 1st April 2011 to 30th September 2014 76 staff (20% of research scientists) were involved in Committees of Influence and Advisory Boards. This involvement of the Institute's researchers is crucial for communicating research outputs to policy makers in order for policy makers to make well-informed decisions.

Table 8.1 – Examples of Committees of Influence and Advisory Boards

Target Audience	Committee
International	Advisory Panel for Scientific Committee on Problems of the Environment
	United Nations Environment Programme project on Benefits of Soil Carbon
	International Organisation for Biological and Integrated Control of Noxious Animals and Plants
	UN Intergovernmental technical panel on soil
	Global GMO Working Group Co-Coordinator
European Union	EU EIP-AGRI Focus Group on IPM of Soil-Borne Diseases
	Nematode and Fungi
	Science and Technology Board of the EU Joint Programme Initiative on Water Challenges for a Changing World
	EU Joint Research Centre New Breeding Technologies Group
	European soil Partnership
	ALTER-Net Council - the European Biodiversity network)
UK	Board membership of the European Plant Science Organisation
	UK Plant Genetic Resources Group, Defra
	National Ecosystems Assessment Co-Chair
	UK Intergovernmental Platform on Biodiversity and Ecosystem Services
	UK Global Food Security Program Water and Agriculture Expert Group
Scotland	UK National Biodiversity Science Committee
	Scottish Tree Health Advisory Group
	Scottish Government Agri-Renewables Strategy Consultative Group
	Coordinated Agenda for Marine, Environment and Rural Affairs (CAMERA) environmental monitoring coordination group
	Scottish Government Hydro Nation Forum
	Scottish Government Input-Output Users Group
Industry	Industrial Biotechnology Innovation Centre, Scientific Advisory Board
	Water Supply and Sanitation Technology Platform Water Re-Use Task Force
	PepsiCo Technical Advisory Board
	Quakers Centre of Excellence Scientific Advisory Board

Source: James Hutton Institute Research Themes Review

8.2.3 Policy Engagement

In addition to contributing to Committees of Influence and Advisory Boards staff from the James Hutton Institute also engage with all stages of the cycles of

development and implementation of public policy. Opportunities to influence policy are taken at all stages of the policy making process including: generating initial ideas, contributing to key policy focus groups, developing policy options analysis and tools and evaluating implementation.

Much of the policy output include advice to European Union, UK and Scottish Government policy teams and working groups. By their nature, many such outputs are not in the public domain and are instead used to provide advice to government working groups or Ministers. This can take the form of written outputs, including presentations at workshops designed for stakeholders in government and public agencies responsible for policy development, meetings with Government Ministers, and requests for advice, including from overseas governments. Between 1st April 2011 and 30th September 2014, 603 such written outputs were produced for or with policy audiences.

Examples of some types of outputs and engagement with policy teams include contributing chapters on Conceptual Framework, Cultural Services and Regulating Services for the UK National Ecosystem Assessment. At an international level this has included, environmental risk assessment and risk management recommendations for the cultivation of the genetically modified insect resistant maize Bt11 and MON 810 as part of the European Food Standards Agency Scientific Opinions.

8.2.4 Public Engagement

In addition to its stakeholder engagement activity, the James Hutton Institute is also actively involved in the “open science agenda”, which aims to improve understanding and engagement between scientists and the general public. As part of this agenda scientists at the Institute regularly participate in dissemination and outreach activities aimed at the general public.

8.2.5 Quantifying the Impact of Stakeholder and Public Engagement

Staff at the James Hutton Institute make an important contribution to policy and practice in a wide variety of different areas but direct evidence about the impact of this contribution is not readily available, particularly as this activity is generally undertaken free of charge. In order to quantify the value of this activity it was therefore necessary to identify an indirect measure. One such measure is the amount of time that staff spend contributing to knowledge exchange activities.

Evidence gathered by the James Hutton Institute from staff time sheets suggests that during the period 2011 – 2014 staff at the James Hutton Institute participated in 180 committees and advisory boards. Consultations undertaken to support this study suggest that the time commitment associated with this type of activity typically amounted to around 20 days per year and that the average day rate for the members of staff concerned would be around £600. It was also assumed that the outputs for trade and policy audiences would each require at least a day to complete.

By multiplying the number of staff days devoted to knowledge exchange by the notional day rate of £600 it was possible to estimate that the cost of delivering this activity would have been around £2.3 million – or £0.7 million/year. This is therefore the minimum amount that stakeholders would have been charged if the expertise provided were to have been delivered on a commercial basis.

As with any other type of investment it is reasonable to expect that those making the investment (i.e. stakeholders involved in knowledge exchange events) would

only invest their time if they expect to realise a positive return from doing so. As discussed in section 7.2, evaluation evidence suggests that the value of these private returns is likely to be a minimum of 360%.

By applying this assumption to the total value of staff time it was therefore estimated that knowledge exchange activities undertaken by James Hutton Institute staff contributed a total of £8.2 million between 2011 and 2014, or around £2.3 million/year. Based on the wide reach of research undertaken at the Institute it was assumed that around 33% of this impact occurred in Scotland and the remainder occurred elsewhere in the UK. The impact in each study area is summarised in Table 8.2.

Table 8.2 – Imputed Value of Stakeholder Engagement

	Scotland	UK
GVA (£m)	1.4	3.1
Jobs	21	45

Source: BiGGAR Economics

8.3 Research Training

The James Hutton Institute acts as an important training ground for future researchers by providing them with the opportunity to work with cutting edge equipment, databases and scientists. As well as this PhD students at the James Hutton Institute also benefit from the support and mentoring of Institute staff and learn from the Institute’s co-construction approach to research.

These skills and experiences directly enhance the productivity of graduates once they enter the labour market, enabling them to contribute more to their future employer and generate a greater benefit for the economy than they might otherwise be able to. The GVA of this productivity gain includes the additional profits that graduate employers are able to generate by employing graduates and the additional employment costs that they are willing to pay in order to generate these additional profits.

The subject of the graduate earnings premium has been well researched so information about the earnings premium is readily available and can be used to provide a measure of the additional contribution graduates make to the economy each year. Unfortunately information about the additional profits of graduate employers is not readily available so the impact presented in this section is likely to be an underestimate of the Institute’s full economic impact.

Information for the graduate premium is provided in a research paper produced by the Department for Business, Innovation and Skills (BIS),⁴⁶ which considered data from the Labour Force Survey between 1996 and 2009. Although the analysis considered undergraduates as its primary focus, 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 BIS study found that completion of a PhD was associated with a graduate premium through a graduate’s life of £62,395. In 2015/16, 17 domestic PhD students and 4 non-domestic PhD students at the Institute graduated. However,

⁴⁶ Department for Business, Innovation and Skills (2011), The Returns to Higher Education Qualifications

on average 39%⁴⁷ of PhD graduates have previously completed a Masters, which means that the additional premium associated purely with the PhD training is £6,675.

It was then necessary to make assumptions about where each graduate would live and work after graduation. To do this it was assumed that eight home graduates remained in Scotland and 16 remained in the UK. It was also assumed that all non-UK graduates would leave the UK after graduating.

Based on these assumptions it was estimated that the PhD training delivered by the James Hutton Institute generated a productivity benefit of around £0.3 million for the Scottish economy in 2015. This impact is summarised below.

Table 8.3 – Graduate Premium Impact

	Local area	Scotland	UK	Global
GVA (£m)	-	0.3	0.7	0.9

Source: BiGGAR Economics

8.4 Knowledge exchange Partnerships

The James Hutton Institute also participates in the UK wide Knowledge Transfer Partnership (KTP) programme, which exists to facilitate the exchange of knowledge between academia and industry. The KTP programme recruits graduates to work on joint industry academic projects, in which companies utilise the expertise of research institutions in order to overcome specific challenges. These placements last for approximately three years and students are often retained by the industrial partner once the initial contract has been completed.

In 2015/16 the Institute was involved with two KTPs, including Intelligent Growth Solutions, which is mentioned in Section 7.4 and had completed a further three over the past six years. These projects are believed to be delivering significant benefits to the industrial partners involved. For example, the KTP with S&A Group in Herefordshire has led to the development of optimised fertigation systems for strawberries that have led to savings of £0.5 million/year for the company and the identification of the KTP associate as a Business Leader of Tomorrow prize at the prestigious Knowledge Transfer Partnerships (KTP) Awards.

These KTPs have an economic impact through the increased productivity the industrial partner achieves from overcoming the issue they were looking to address. A study by Regeneris Consulting⁴⁸ found that in the six years after their completion, each KTP contributed £667,000 GVA to the economy for companies based in Scotland. KTPs undertaken in the East Midlands (where the James Hutton Institute was involved with 2 KTPs) generated £713,000 GVA in the six years after the KTPs were completed. This was equivalent to an annual impact of £111,200 and £118,800 in Scotland and the East Midlands respectively.

It was assumed that the annual impacts for the duration of the project were 10% of the impacts after each KTP was completed, as the outputs of the knowledge exchange have not been fully realised. The same study found that on average each KTP project supported the creation of three jobs.

⁴⁷ HEFCE (2011), PhD Study: Trends and Profiles 1996-97 to 2009-10

⁴⁸ Regeneris Consulting (2010), Knowledge exchange Partnerships Strategic Review

By applying the findings of the Regeneris review to the number of KTPs in each study area, it can be shown that the Institute's involvement in the KTP programme generated £0.3 million GVA for the Scottish economy in 2015 and supported three jobs. This impact is summarised in Table 8.4.

Table 8.4 – Knowledge exchange Partnerships Impact

	Local areas	Scotland	UK
GVA (£m)	0.1	0.3	0.5
Jobs	<1	3	9

Source: BiGGAR Economics

8.5 Industry Focused Events

The James Hutton Institute also transfers knowledge into the wider economy through industry and stakeholder events. These events provide an opportunity for farmers, agronomists and other industry representatives to benefit and learn from the research undertaken at the James Hutton Institute and to interact with the scientists behind the research.

Each year, the Institute hosts or co-organises three major events focusing on potatoes, cereals and soft fruit. Potatoes in Practice, is an annual event hosted by the James Hutton Institute in collaboration with the Potato Council. With 67 exhibitors, the event is the largest field-based potato event in the UK, bringing together variety trials, research and trade exhibits in one place. The event attracts between 800 and 1,000 people each year. It includes viewing of new crop treatments, live machinery demonstrations, seminars on current issues effecting on the farming industry and networking between suppliers, industry experts and researchers.

The James Hutton Institute, SRUC and the Scottish Society for Crop Research also work together to hold the annual Cereals in Practice event. This is a showcase of variety trials alongside presentations of the latest research in the area. The event thus provides a unique opportunity for Institute researchers and practitioners in the cereals industry to discuss the latest recommendations and developments in the sector.

The third regular event is Fruit for the Future, which originally consisted of a seminar programme covering topics such as the Institute fruit breeding programmes, new and emerging pest and diseases of soft fruit and research on new crop opportunities. Continued engagement with the industry saw this event evolve into a dual event with practical fruit walks and progress updates in the summer and a more science focussed programme in the winter. The annual event is aimed at farmers, agronomists, representatives of the food and drink industry and scientists and seeks to communicate the latest commercial and research developments in the area.

In addition to these regular events the James Hutton Institute also regularly hosts one off conferences and events, aimed at academia, some of which attract an international audience. In August 2015 for example the Institute hosted the XXVI European Society for Rural Sociology Congress (ESRS) in Aberdeen, which over attracted 400 delegates from all over Europe.

Scientists at the James Hutton Institute also often work in partnership with other agencies to help attract major conferences and events to Scotland. For example, the Institute played an important role in helping Glasgow to secure the 2022

World Congress of Soil Science, competing against China, Italy and Switzerland. More than 3,000 delegates from across the globe are expected to travel to Glasgow for the conference. It be the first time that it has been held in Scotland and more than 80 years since it was last held in the UK. It is anticipated that the conference will inject more than £5.4 million into the local economy and secure some 16,000 room nights, providing a major boost to the local tourism sector.

Scientists from CREW are also in the process of bidding for a major week-long water conference that they hope will be hosted in Glasgow in 2018. The event would attract more than 150 scientists and numerous event partners to the city for a week. The economic contribution of these visitors would in part be attributable to the Institute.

The James Hutton Institute's approach to industry engagement can be demonstrated through its interactions and activities with the organisation, Linking Environment and Farming (LEAF). Figure 8-2 provides a case study of this.

Figure 8-2 – Public Engagement: LEAF

Linking Environment and Farming (LEAF) is an organisation that is committed to the delivery of sustainable and environmentally responsible farming. The James Hutton Institute's association with LEAF allows the Institute to disperse its research more widely among farmers.

LEAF has a network of innovation centres and demonstration farms, which work with commercial farms to demonstrate integrated farm management in practice. These farms offer the James Hutton Institute platforms which allow farming knowledge generation and exchange. Part of the LEAF organisation is the LEAF Marque, which is an independently verified assurance standard, recognising sustainably farmed products. This helps to promote better farm management practices and to raise public awareness of environmentally sustainable farming.

The James Hutton Institute takes part in various public engagement activities with LEAF and provides technical input to many LEAF publications. LEAF has approximately 2,200 members and 120 corporate members, with whom information and research is shared. An example of this is Open Farm Sunday, which helps to engage farmers and others with the science of sustainable farming. Another example of public engagement is the LEAF Technical Day, which allows farmers to share knowledge and best practice.

There are many benefits of public engagement and some of the Institute's social scientists undertake research on ways of improving knowledge exchange. Public engagement allows the latest innovations and ideas to reach farmers, and allows for quick dissemination of ideas. The James Hutton Institute recognises that farmers are the main audience for this dimension of their research, and public engagement helps the Institute to meet the needs of LEAF farmers. Scientists from the James Hutton Institute make considerable effort to engage farmers with their research, and are therefore able to communicate their research effectively. This is a two-fold benefit as not only does it assist the farmers but also it provides the James Hutton Institute an important test bed for research.

Source: BiGGAR Economics based on consultation with LEAF

8.5.1 Quantifying the Impact of Conferences and Events

Conferences and events hosted by the James Hutton Institute help to attract people to the Local area who might not otherwise have had a reason to visit. The expenditure of these visitors is therefore attributable to the James Hutton Institute and helps to generate wealth and support employment within the tourism sector.

In 2015/16 2,375 people attended multiple different events and visits organised by the Institute, the largest of which included:

- the European Society for Rural Sociology Congress in Aberdeen, which attracted more than 400 people;
- the TB Macaulay Lecture at the Royal Society of Edinburgh;
- a Soft Fruit information day held in Perth in collaboration with Bulrush Horticulture Ltd;
- a crop protection event in Dundee; and
- the annual 'Cereals in Practice' event in Aberdeenshire and annual 'Potatoes in Practice' and 'Fruit for the Future' events in Dundee, which together attracted more than 900 people.

Different types of visitors (day visitor, domestic overnight visitor, overseas visitor) have different levels of expenditure. Average delegate expenditure was obtained from the Great British Visitor Survey and the International Passenger Survey.

The economic impact of this expenditure was then estimated by applying GVA/employee and GVA/turnover ratios for the Scottish tourism sector. In this way it was estimated that in 2015/16 the additional tourism expenditure generated by conferences and events hosted by the James Hutton Institute generated £0.2 million GVA for the Scottish economy and supported around six jobs. The impact in each study area was estimated based on the location of each event and is summarised in Table 8.5.

Table 8.5 – Impact of Conferences and Events

	Local areas	Scotland	UK
GVA (£m)	0.2	0.2	0.2
Jobs	5	6	6

Source: BiGGAR Economics

8.6 Summary Policy and Practice Benefit

Taken together the impacts considered in this chapter suggest that in 2015/16 knowledge exchange activity delivered by staff at the James Hutton Institute generated a benefit of £2.2 million GVA for the Scottish economy. This chapter has also shown that this activity supported around 30 Scottish jobs. A breakdown of this impact within each of the study areas is provided in Table 8.6.

Table 8.6 – Summary Policy and Practice Impact

	Local areas	Scotland	UK	Global
GVA (£m)				
Stakeholder engagement	n/a	1.4	3.1	3.1
Graduate productivity	n/a	0.3	0.7	0.9
Knowledge exchange Partnerships	0.1	0.3	0.5	0.5
Conferences and events	0.2	0.2	0.2	0.2
Total	0.3	2.2	4.5	4.7
Jobs				
Stakeholder engagement	n/a	21	45	45
Knowledge exchange Partnerships	>1	3	9	9
Conferences and events	5	6	6	6
Total	5	30	60	60

Source: BiGGAR Economics

9 WIDER BENEFITS

As far as possible this report has attempted to quantify the economic benefits associated with the James Hutton Institute. Inevitably however there are benefits that just cannot be quantified. Some of these benefits are highlighted in this chapter.

9.1 Development of the Life Sciences Sector

The James Hutton Institute contributes directly to the development of the economies of both the Dundee and Aberdeen city regions by supporting the growth of the life sciences sector in the two city regions and across Scotland as a whole. There are over 600 life sciences organisations and more than 30,000 people employed in the life sciences sector in Scotland. The James Hutton Institute employs 334 people in the Dundee city region and 214 people in the Aberdeen city region. This demonstrates that the James Hutton Institute is an important component of the life sciences sector in Scotland.

By attracting and retaining talented employees the James Hutton Institute supports helps to create a critical mass of expertise and skills in the life sciences sector in both the Dundee and Aberdeen city regions. For this and other reasons the Institute is likely to be well placed to make an important contribution to the objectives of both the Aberdeen City Region Deal and the Tayside City Region Deal.

Proposals for the Tayside City Deal for example are focussed on promoting "fair economic growth" where business growth, social inclusion and skills development are at the heart of a cohesive region of knowledge and creativity. As a relatively high value employer the James Hutton Institute is well placed to contribute to this agenda.

In the Aberdeen city region, growth across a variety of different sectors other than the oil and gas sector is considered as being crucial for the long-term sustainable economic development of the region. A key commitment in the Aberdeen City Region Deal is to "*recognise the importance of the Aberdeen City Region's continued economic diversity and support innovation in the biopharmaceutical and food and drink sectors*". By providing high skilled jobs, the James Hutton Institute is playing an important role in the helping to diversify the economy of the Aberdeen city region.

The contribution that the James Hutton Institute makes to the life science sector in the two city regions in which it operates is enhanced by the collaborative relationship that exists between the Institute and the Universities of Aberdeen and Dundee. For the past 16 years for example the James Hutton Institute has hosted a group of plant scientists from the University of Dundee and the Institute also enjoys a variety of close collaborative relationships with the University of Aberdeen. These partnerships help to enhance the competitiveness of both institutions (for example by facilitating the publication of jointly authored research) and in so doing further support the development of the life sciences sector in Aberdeen and Dundee.

9.2 Local Regeneration and Development

The James Hutton Institute also contributes to the regeneration and development of communities throughout Scotland indirectly through its research and the support it provides for key policy areas. It would be impossible to list all the ways

in which these benefits are generated but by way of illustration it is helpful to consider the contribution that researchers at the James Hutton Institute have made to the regeneration of north Glasgow. A case study of this work is provided below.

Figure 9-1 – North Glasgow Regeneration

Glasgow City Council proposes to invest £400m over the next few years regenerating parts of the city. The investment is part of the Glasgow and Clyde Valley City Deal, which is expected to generate £2.2 billion GVA for the regional economy and unlock £3.3 billion of private sector investment.

An important component of the Council's plans are proposals to regenerate key sites in north Glasgow including Hamiltonhill, Port Dundas and Cowlairs. In order to realise the development potential of these areas however significant investment will be required to address existing deficiencies in the City's drainage system that were identified after the serious floods of 2002 and to provide the sewage and water infrastructure required to support significant population growth.

Researchers at the James Hutton Institute have been working closely with the Glasgow City Council and its partners to develop innovative proposals to address these requirements by adapting the City's existing canal network to alleviate flood risk. The Institute's role in the project involved developing the governance system required to bring together the key stakeholders and to provide the structure and operating systems required to manage the project. The contribution is therefore as much about innovative management approaches as fundamental science and highlights the applied nature of the Institute's approach and its ability to integrate scientific knowledge with practical solutions.

The alternative to this innovative solution would likely have involved a large-scale civil engineering project to develop new underground assets to alleviate flood risk. A similar project in the south of Glasgow (the Shieldhall Strategic Tunnel) is expected to cost around £100 million. In contrast, the innovative solution described above is likely to cost less than £1 million. The project has therefore helped to release £99 million of public funding that can now be invested directly in regenerating deprived communities rather than being used to develop expensive underground drainage infrastructure.

In addition to the economic benefits the project is also expected to deliver significant social benefits by using flood risk alleviation measures to enhance green spaces in the city and provide recreational opportunities for residents.

Source: BiGGAR Economics based on consultation with James Hutton Institute staff

Research undertaken at the James Hutton Institute has also contributed to the development of rural communities in Scotland. For example, research undertaken on behalf of Community Energy Scotland showed that when renewable energy assets such as wind farms are owned by local communities then they tend to generate greater benefits for the local areas in which they are located. The research was cited in the Scottish Government consultation document on increasing the involvement of a communities in the development of renewable projects. Other research directly commissioned by the Scottish Government includes work on overcoming the barriers to community land-based activities associated with the Land Reform agenda and ways of understanding and enhancing community resilience in the light of the Government's community empowerment agenda. The impact of this work is difficult to quantify but has significant economic as well as social benefits to rural residents.

9.3 International Reputation and Profile

For a small country like Scotland the ability to compete effectively in global markets is vitally important to continued economic success. As for any successful

corporation, developing and maintaining a strong international reputation is an important factor in maintaining global competitiveness.

The value of national brands is difficult to measure but evidence from leading branding consultancy, Brand Finance, suggests that it is substantial. In 2015 Brand Finance published an annual report on the world's 100 leading 'nation brands'. Using a method more usually applied to companies, Brand Finance assessed the impact that a country's reputation and image has on governments, investors, students and consumers. According to this research the UK brand was worth \$3.0 trillion in 2015⁴⁹.

Although Scotland is not included in the Brand Finance report, a press release accompanying the publication of the 2014 report noted that Scotland has a "robust nation brand" within the UK and highlighted that Scotland's decision to remain within the UK in the 2014 referendum had enabled the value of the UK's national brand to "surge" to \$2.8 trillion. That the value of the UK brand continued to increase in 2015 confirms that Scotland makes a significant contribution to the overall value of the UK brand.

In order to determine the contribution that institutes such as the James Hutton Institute makes to the value of the Scottish brand it is necessary to consider the factors that help to determine brand value. One widely used measure of brand value used by regional and national governments around the world is the Anholt-GfK Nation Brands Index. Conducted annually from 2008, the Anholt-GfK Roper Nation Brands Index examines the image of 50 nations using survey responses from approximately 20,000 adults in 20 countries.

In 2014 Scotland was ranked 17th out of the 50 nations included in the Index⁵⁰. This ranking was based on Scotland's perceived performance across 23 different attributes. The James Hutton Institute contributes directly to six of these attributes:

- science and technology exports (24th);
- employability (18th);
- quality of life (17th);
- environment (14th);
- educational qualifications (15th); and
- competently and honestly governed (15th).⁵¹

It can therefore be seen how the work of the James Hutton Institute improves the image of Scotland by preserving the environment, boosting quality of life, increasing the quality of scientific education and workforce, and advising the Government on the best scientific policy. Consultation with staff at the Institute also suggests that Institute's close association with one of the leading lights of the Scottish Enlightenment also has some resonance internationally.

⁴⁹ Brand Finance (October 2015), Nation Brands 2015: the annual report of the world's most valuable nation brands

⁵⁰ Scottish Government (2014), The Anholt-GfK Roper Nation Brands Index: 2014 Report for Scotland

⁵¹ VisitBritain (2015), How the world views Britain - 2015

This evidence suggests that the James Hutton Institute makes an important contribution to the Scottish brand value. The Scottish brand is in turn an important component of the UK nation brand, which is currently valued at \$3.0 trillion. Although it is impossible to measure the Institute's contribution to this, the scale of the numbers involved means that the impact of even a very small contribution could be very significant indeed.

9.4 Outdoor Nature Experiences and Wellbeing

Many leading international economists⁵² recognise that traditional measures of economic performance, such as GDP do not necessarily tell the whole story in relation to economic success. It is increasingly recognised that happiness and wellbeing have an important role to play in economic prosperity and development. Economists also believe that there is now a need to incorporate measures of wellbeing into economic analysis, meaning that consideration should be given to whether people's perceived happiness and individual life satisfaction is being enhanced.

However, the concept of wellbeing itself is not yet fully understood. The James Hutton Institute has been undertaking research in order to improve understanding of wellbeing. In particular, although it is widely held that outdoor nature experiences have a positive effect on wellbeing, how these benefits are derived is less well understood. The Institute's research in this area has focused on a number of different aspects, including the ways in which different groups of people (e.g. women and men, residents of deprived urban areas) experience the outdoors and how this may influence their engagement and the benefits derived.

The James Hutton Institute has also been involved in using innovative visual and mobile research methods to understand engagement with the outdoors and wellbeing. One example of this is the use of an eye tracker to investigate the effects of sound on responses to visual images. It is important to understand how visual attention (where people look) can affect wellbeing in order to better understand the effects of spending time in outdoor environments.

The Institute has also undertaken research considering the barriers to outdoor recreation for older people. This type of research is important for designing interventions to facilitate greater use of the outdoors amongst older people.

By undertaking this research the Institute is working to fill important gaps in understanding of how wellbeing benefits are derived from outdoor nature experiences, which is important from a policy development perspective. In addition to undertaking research in this area the Institute also contributes directly to the well being of people living in the immediate vicinity of its campuses by providing high quality recreational space for local residents.

⁵² See for example the Report by the Commission on the Measurement of Economic Performance and Social Progress led by Professor Joseph Stiglitz.

Figure 9-2 – Green Prescribing

Outdoor activity has been shown to be beneficial for physical and mental health and wellbeing, but older people are less likely to take part. A recent report commissioned by the Scottish Government and undertaken by the James Hutton Institute examined the barriers older people face with regards to outdoor recreation.

The Institute's research was able to identify a number of potential interventions that could be integrated with existing initiatives to offer opportunities for overcoming social and motivational barriers for older people in outdoor experiences. One of these initiatives is known as 'green prescribing' and Institute's research found that green prescribing by doctors and medical professionals could be a valuable way to promote outdoor recreation amongst older people. In addition, the research found that it may be useful to tailor interventions to suit people of different abilities and preferences and to target people at moments of key life change such as retirement, or friends or spouses passing away.

The Scottish Government will now look at these recommendations alongside its delivery partners, Forest Enterprise Scotland, Scottish Natural Heritage and local authorities.

Source: BiGGAR Economics

10 SUMMARY & CONCLUSIONS

Adding together all of the impacts considered in this report suggests that in 2015/16 the James Hutton Institute contributed a total of £447.9 million GVA to the global economy and supported around 3,280 jobs. This impact included:

- £54.7 million GVA and more than 900 jobs in the local areas in which the Institute operates;
- £211.8 million GVA and around 2,130 jobs in Scotland; and
- £318.5 million GVA and around 3,280 jobs across the UK.

Analysis of these figures shows that overall just 18% of the economic activity that the James Hutton Institute generated around the UK and just over a third of the jobs it supported were associated with the operational activities of the Institute. The vast majority of the impact generated by the Institute was associated with the research activity undertaken by the scientists who work there.

Overall 56% of the GVA generated by the Institute and 40% of the jobs it supports are associated with the research it undertakes to support agricultural productivity in the UK and beyond. This impact is generated by the work the Institute undertakes to develop sustainable production processes and improve the management and control of pests and diseases. It also includes the value that the Institute has added to the output of the UK agri-food sector as a result of its plant breeding activity.

The contribution that the James Hutton Institute makes to Scotland's natural capital represents a further 20% of the economic activity and 19% of the jobs quantified in this report. A high quality natural environment is fundamental to the success of many of Scotland's most important sectors, including the agri-food sector. This activity therefore underpins all of the other impacts considered in this report.

Table 10.1 and Table 10.2 provide a detailed breakdown of this impact for each study area.

Table 10.1 – James Hutton Institute GVA Impact 2015/16 (£m)

	Local areas	Scotland	UK	Global*
Direct	25.0	26.6	26.6	26.6
Supplier Spending	2.5	5.2	9.0	9.0
Staff and Student Spending	5.8	15.1	21.1	21.1
Capital Spending	0.3	0.5	0.5	0.5
Operational impacts	33.7	47.4	57.2	57.2
Contribution to Natural Capital	0.0	63.8	63.8	63.8
Potato blight cost savings	0.3	0.4	1.8	1.8
Fertiliser savings	<0.1	1.6	1.6	1.6
Contribution to Sustainable Land Use	0.3	2.0	3.4	3.4
JHI varieties	9.8	12.9	44.5	44.5
Barley breeding	3.9	6.5	23.2	152.4
Processor benefits	n/a	67.7	107.8	107.8
Contribution to Food Production	13.7	87.0	175.4	304.6
Analytical services	6.7	8.4	8.4	8.4
Commercial research contracts	n/a	1.0	5.9	5.9
Other Commercial Services	6.7	9.4	14.3	14.3
Stakeholder engagement	n/a	1.4	3.1	3.1
Graduate Impact	n/a	0.3	0.7	0.9
KTPs	0.1	0.3	0.5	0.5
Conferences and Events	0.2	0.2	0.2	0.2
Knowledge exchange impact	0.3	2.2	4.5	4.7
Total GVA Impact	54.7	211.8	318.5	447.9

Source: BiGGAR Economics. Note: Totals may not sum due to rounding. *Where UK impact = global impact it was not possible to estimate non-UK impacts.

Table 10.2 – James Hutton Institute Jobs Impact 2015/16

	Local areas	Scotland	UK
Direct	548	583	583
Supplier Spending	48	98	170
Staff and Student Spending	111	278	385
Capital Spending	3	4	4
Operational impacts	710	963	1,142
Contribution to Natural Capital	n/a	631	631
Potato blight cost savings	n/a	n/a	n/a
Fertiliser savings	n/a	n/a	n/a
Contribution to Sustainable Land Use	n/a	n/a	n/a
JHI varieties	196	257	887
Barley breeding	n/a	n/a	n/a
Processor benefits	n/a	225	444
Contribution to Food Production	196	482	1,331
Analytical services	n/a	n/a	n/a
Commercial research contracts	n/a	20	119
Other Commercial Services	n/a	20	119
Stakeholder engagement	n/a	21	45
Graduate Impact	n/a	n/a	n/a
KTPs	n/a	3	9
Conferences and Events	5	6	6
Knowledge exchange impact	5	30	60
Total Jobs Impact	911	2,126	3,283

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

10.1 Value for Money

The economic impact generated by the James Hutton Institute is substantial relative to its scale. This is illustrated by the ratios and multipliers presented in Table 10.3, which show that:

- for each £1 that the James Hutton Institute generates as a result of its direct operations, it supports £7.97 in total benefits within the Scottish economy and £11.98 across the UK as a whole;
- for each person directly employed the Institute supports a total of 3.6 jobs somewhere in Scotland, or 5.6 jobs in the UK; and
- for each £1 that the Institute receives in funding from the Scottish Government it generates £8.48 in economic impact for the Scottish economy and £12.75 across the UK as a whole.

Table 10.3 – Value for Money Ratios

	Scottish Multipliers	UK Multipliers
Direct GVA/total GVA	1:7.97	1:11.98
Direct Jobs/total Jobs	1:3.6	1:5.6
Scottish Government funding/impact	1:8.48	1:12.75

Source: BiGGAR Economics

10.2 Conclusions

In 2015/16 the James Hutton Institute contributed £318.5 million GVA to the UK economy and supported around 3,280 jobs - a substantial impact by any measure.

The magnitude of the impact is especially apparent when considered in relation to the scale of the Institute’s direct operations. This shows that every £1 GVA generated directly by the Institute supports £11.98 GVA somewhere in the UK and that every person directly employed supports 5.6 jobs across the UK. This report has also demonstrated that in 2015/16 the Institute delivered £12.75 GVA across the UK for every £1 funding it received from the Scottish Government - an impressive return on investment by any measure.

Despite the scale of these numbers this report does not pretend to have captured the economic value of the Institute in its entirety.

In part this is because there are simply too many different areas of activity to capture within a single report. By way of illustration, the analysis has not considered the contribution that scientists at the Institute have made to the efficiency of the Scottish criminal justice system by applying state of the art analytical capabilities to criminal forensics to save time in criminal investigations.

Other areas of activity have simply proved too difficult to quantify. One notable example of this is the Institute’s work on soil sciences. Soil is fundamental to agriculture so any improvements in the understanding of soil are likely to result in improvements to agricultural productivity. Although the Institute has particular strength in soil sciences, which has almost certainly helped to improve agricultural productivity, quantifiable evidence of this is not readily available. It is however apparent that work in this and other areas has played an important role in underpinning many of the other benefits that have been quantified in this report.

An important theme throughout this report has been the interrelated nature of many, if not most, of the impacts considered. A case in point is the plant breeding impacts considered in chapter 6. Although the largest numbers emerging from the analysis are presented in this chapter, it is important to emphasise they are not solely related to plant breeding expertise but are rather the product of decades of complimentary multi-disciplinary research. Without the input of these different areas of expertise these impacts would be significantly smaller.

Another important theme to have emerged from the analysis is the important contribution that the Institute makes to underpinning the success of many sectors of the Scottish economy. Of particular importance is the work that scientists at the Institute undertake to understand, protect and preserve the natural environment. While this work is important in its own right, it also plays a key role in supporting the continued success of many important sectors of the Scottish economy, including the agri-food sector.

These examples help to highlight that the James Hutton Institute is more than just the sum of its parts. The Institute is a repository for a diverse range of multi-disciplinary expertise and a vehicle that makes it possible to bring this expertise together in ways that generate multiple and substantial benefits both in Scotland and elsewhere in the world.

11 APPENDIX 1

BiGGAR Economics would like to thank the consultees listed in Table 11.1 for their time and help in compiling this report.

Table 11.1 – List of Consultees

Name	Role/Department	Organisation
Mike Storey	Head of Research and Development	British Potato Council
Tom Jenkins	Plant Sector Team Leader	InnovateUK
Fraser Black	Managing Director	James Hutton Ltd
Richard Allan	Head of the Centre for Water Expertise	James Hutton Institute
Kirsty Blackstock	Researcher in Social, Economic and Geographical Sciences	James Hutton Institute
Colin Campbell	Chief Executive	James Hutton Institute
Tim Daniell	Research Theme Leader: Delivering Sustainable Production Systems	James Hutton Institute
Bob Ferrier	Director of Research Impact	James Hutton Institute
Alison Hester	Research Theme Leader: Safeguarding Natural Capital	James Hutton Institute
Robin Matthews	Research Theme Leader: Nurturing Vibrant and Low Carbon Communities	James Hutton Institute
David Miller	Knowledge Exchange Coordinator	James Hutton Institute
Ray Perman	Chair of the Board of Directors	James Hutton Institute
Deborah Roberts	Group Leader: Social, Economic and Geographical Sciences	James Hutton Institute
Derek Stewart	Research Theme Leader: Enhancing Crop Productivity and Utilisation	James Hutton Institute
Ian Toth	Research Theme Leader: Controlling Weeds, Pests and Diseases	James Hutton Institute
Allan Lilly	Principal Soil Scientist	James Hutton Institute
Caroline Drummond	Chief Executive	Linking Environment and Farming (LEAF)
James Brosnan	Director of Research	Scotch Whisky Research Institute
Keith Connal	Deputy Director of Natural Resources	Scottish Government
Niel Ritchie	Team Leader	Scottish Government
Jon Rathjen	Team Leader of the Water Industry Team	Scottish Government
Mark Aitken	Principal Policy Officer of Land Use Unit	SEPA
James Wickham	Procurement Manager	Lucozade Ribena Suntory
Claire Halpin	Head of the Division of Plant Sciences	University of Dundee