

ROYAL BOTANIC GARDEN EDINBURGH

Economic Impact Assessment

OCTOBER 2016

CONTACTS



GRAHAM HILL
Partner

dd +44(0)131 347 3807
m +44(0)7876 396 308
e graham.hill@arcadis.com

Arcadis.
Apex 3,
95 Haymarket Terrace
Edinburgh EH12 5HD
United Kingdom



DONALD WEBB
Director

dd +44(0)161 440 8290
m +44(0)7813 892 090
e donald@brookdaleconsulting.co.uk

Brookdale Consulting Ltd
7 Brookdale Road
Bramhall
Cheshire SK7 2NW
United Kingdom



STEVE SHEPPARD
Managing Director

m +44(0) 7725 646 300
e steve.sheppard@adroit-economics.co.uk

Adroit Economics Ltd
Adroit House,
31 Finchley Road
Hale
Altrincham
Cheshire WA15 9RE
United Kingdom

CONTENTS

1	EXECUTIVE REPORT	1
1.1	Summary	1
1.2	The Results – Operational Expenditure Impacts	2
1.3	The results - Visitor/Tourism Impacts	2
1.4	The Results - Education and Training Impacts	2
1.5	The Results - RBGE Science activities and impact	3
1.6	Conclusions – Economic Impact and Return on Investment.....	4
2	INTRODUCTION	6
3	IMPACT ASSESSMENT METHODOLOGY	7
3.1	The principal sources of impact assessed	7
3.2	Sources of data and information	8
3.3	Impact calculation methodology and analytical tools	8
3.4	Approach towards assumptions and judgements	8
3.5	Distinguishing between Scottish economy impacts and wider global economy impacts	9
3.6	Method used to calculate the Economic Return on Investment (ERol)	10
3.7	Sensitivity and Scenario Analysis of the science impacts	10
4	INCOME, OPERATIONAL EXPENDITURE AND IMPACTS	11
4.1	Income	11
4.2	Operational Expenditure	13
4.3	Economic Impact of Operational Expenditure on the Scottish Economy	14
5	VISITOR/TOURISM IMPACTS	17
5.1	Valuing Visits to RBGE	18
6	EDUCATION AND TRAINING IMPACTS	22
6.1	Types of Course and Learner Numbers	23
6.2	Education and training revenue generated by RBGE.....	25
6.3	Valuing the benefits of schools' visits to RBGE	28
6.4	Productivity and GVA impacts of RBGE education and training programmes	30
6.5	Total educational impacts.....	37
7	SCIENCE IMPACTS OF RBGE	38
7.1	Economic impact of RBGE National Collections	40

7.2	Economic Impact of Scientific Research Projects	46
7.3	Science impacts – conclusions	59
8	CONCLUSIONS – ECONOMIC IMPACT OF RBGE ON THE SCOTTISH AND GLOBAL ECONOMIES.....	64
8.1	Overall Results.....	64
8.2	Breakdown of the Results.....	65

APPENDICES

APPENDIX A

Further Details of the Science Impact Calculations

APPENDIX B

The Evaluation Team

VERSION CONTROL

Version	Date	Author	Changes
1	05/10/2016	Arcadis	Not Applicable

This report dated 05 October 2016 has been prepared for The Royal Botanic Garden Edinburgh (the "Client") in accordance with the terms and conditions of appointment dated 07 April 2016 (the "Appointment") between the Client and **Arcadis LLP** ("Arcadis") for the purposes specified in the Appointment. For avoidance of doubt, no other person(s) may use or rely upon this report or its contents, and Arcadis accepts no responsibility for any such use or reliance thereon by any other third party.

1 Executive Report

1.1 Summary

Economic Impact of RBGE

It is estimated that RBGE activities generate globally £103m economic impact per year (net additional gross value added (GVA)) which equates to just under £5bn over a 25-year period (NPV @ 3.5%)*.

Of this, £52m per year (£1.6bn over a 25-year period) is net to the Scottish economy.

Excluding science research potential impacts, which are less certain, it is estimated that RBGE activities generate globally £40m economic impact per year (GVA) which equates to £808m over a 25-year period (NPV @ 3.5%).

Of this, £39m per year (£775m over a 25-year period) is net to the Scottish economy

The Economic Return on Investment (ERoI), on the £8.5m grant that RBGE receives from Scottish Government (2015/16) is estimated to be:

- Including all impacts:
 - Global – £34.18 per £1 of grant over a 25-year period (NPV@3.5%)
 - Scottish economy - £11.07 per £1 of grant over a 25-year period (NPV@3.5%)
- Excluding longer term, less certain science impacts:
 - Global - £5.58 per £1 of grant over a 25-year period (NPV@3.5%)
 - Scottish economy - £5.35 per £1 of grant over a 25-year period (NPV@3.5%)

* The global GVA over 25 years is proportionately higher than the Scottish impact due to the science impacts accruing to the international community in later years

Sources of Economic Impact

RBGE generates economic impact in the following ways, all of which have been considered in this assessment:

- **Operating Impacts** – payment of staff salaries and procurement of goods and services from suppliers to run RBGE and its activities
- **Visitor/Tourism Impacts** – measured in terms of visitor revenue and, for those who gain access to the gardens free, in terms of shadow pricing
- **Educational and Training Impacts** – comprising fee income from students outside of Scotland and improved proficiency and productivity of learners who, on completion of courses remain and work in Scotland. The improved labour supply benefits employers, enabling them to achieve increased productivity and GVA
- **Science Impacts** – derived from external researchers accessing the national collection and from the impact of the 100 or so science international research projects on which RBGE is currently working

1.2 The Results – Operational Expenditure Impacts

- **Expenditure** - RBGE spends £11.23m per year on staff salaries, procurement of goods and services from suppliers and other items. 99.4% of this is spent in Scotland and so directly benefits the Scottish economy
- **Expenditure by outcome:** RBGE operates an outcome cost accounting system. Breakdown of annual expenditure by the four main outcomes is as follows: Tourism and recreation (45%), Education and Skills (10%), National Collection (21%), Science and Conservation (24%)
- **Income** – RBGE derives income to support this expenditure from a variety of sources. 72% (£8.5m) derives from grant-in-aid of from the Scottish Government. RBGE generates a further £3.27m from a number of sources, for example: education fees 23% (£770k); Botanic Trading Company 16% (£508k) and admissions 15% (£500k)
- **Net additional GVA to the Scottish economy generated by RBGE operational expenditure** - RBGE operational expenditure is estimated to generate £94m net additional GVA in the Scottish economy by year 10, £130m by year 15 and £186m by year 25 (NPV@3.5%)

1.3 The results - Visitor/Tourism Impacts

- **Numbers of visitors** – RBGE attracted a total of 993,703 visitors to the four gardens (2015), 89.5% of which were to the main garden in Edinburgh
- **Visitor value** – visitors to the garden in Edinburgh gain access free, but pay to visit the indoor collection and to attend various events; visitors to the other gardens pay; additional revenue is generated from catering, plant, gift and book sales. To calculate total visitor value, a 'shadow price' of £6.50 has been applied to visitors who access the Edinburgh garden free, reflecting the utility value gained. On this basis, total visitor value (revenue and shadow) equalled £7.5m in 2015/16
- **Growth in visitor numbers** – visitor numbers have increased by 63% between 2008 and 2015. To err on the side of caution, no further growth in the figures above has been assumed
- **Net additional GVA to the Scottish economy generated by visitors to RBGE** – it is assumed that all visitor value represents a net benefit to the Scottish economy as follows (i) visitors from outside of Scotland generate revenue for RBGE (actual and shadow); visitors from within Scotland, gain utility value. On this basis, visitor value net to the Scottish economy is estimated to equal £82m by year 10, £114m by year 15 and £163m by year 25 (NPV@3.5%)

1.4 The Results - Education and Training Impacts

- **Range of education and training provided** - RBGE plays a major education and training role in the fields of botany and horticulture starting with school age children and running through to hobbyists and scientific and industry professionals. RBGE runs 25 different schools' programmes for Key Stages 1-3 from nursery through to secondary school as well as teacher CPD and the ability for schools to bring self-guided groups; RBGE offers an apprenticeship course; a 2-year diploma course (direct and online); RHS Certificate and short courses plus hobby courses and workshops for interest groups; RBGE runs higher education courses – HND, BSc, MSc and PhDs with the BSc and HND validated by the University of Glasgow and SRUC respectively. The MSc is run jointly with the University of Edinburgh.
- **Numbers of learners per year** – as at 2015/16, the total number of learners per year visiting/ attending courses at RBGE was 11,028, broken down as follows: 9,425 (schools), 1,382 (apprentices/diplomas/certificate/short courses) and 221 (higher education, HND to PHD)
- **Education and training revenue** - RBGE generates significant revenue from provision of education and training courses. Fees (plus course material payments) amounted to £785,749 in 2015/16

- **Types of economic benefit to the Scottish economy** – RBGE education and training activities generate two types of benefit to the Scottish economy (i) fees paid by learners from outside of Scotland generate represent additional revenue in the Scottish Economy; (ii) learners who remain in Scotland on completion of their course and enter the labour market, contribute to a more proficient workforce enabling employers to increase productivity and hence GVA
- **Net additional GVA to the Scottish economy generated by RBGE education and training activities** - equals £21m by year 10, £29m by year 15 and £41m by year 25 (NPV@3.5%)

1.5 The Results - RBGE Science activities and impact

- **Expenditure** – RBGE spends approximately £2.7m per year on science activities, of which £2.0m is grant funded by Scottish Government
- **Two types of science economic impact** - RBGE's science activities and associated economic impacts can be divided into two groups:
 - Those that derive from external researchers accessing the collections – external researchers can access the herbarium and live collections in various ways, gaining valuable knowledge via personal visit (131 researcher visit days per year), via post, via download of images and records (560,000 images pa, 98,000 records per year). This generates three types of economic impact (i) visiting researcher spend in the Scottish economy (ii) the direct value of accessing the collection (calculated as a shadow value based on time spent multiplied by hourly GVA per researcher), and (iii) downstream benefits of knowledge accessed from the collections e.g. enabling external research projects to achieve greater success and/or sooner. The majority of the impacts from (i) and (ii) are net to the Scottish economy
 - Those that derive from the 100 or so science research projects in which RBGE staff are currently engaged. A number of these projects will have direct and major economic impact on certain countries in the world. Only a proportion (33-50%) of total benefits has been attributed to RBGE depending on the partners involved. Three such projects have been reviewed in detail (i) improved cocoa plant varieties that will result in increased yield (£37m-£75m by year 25 attributable to RBGE inputs); (ii) improving the locations in which new rubber crops are planted that will result in improved output (£140m-£671m by year 25 attributable to RBGE inputs) and (iii) reduction of illegal logging in Tanzania that will save the Tanzanian Government (£76m-£152m by year 25 attributable to RBGE inputs) in lost tax revenue.
 - Using these projects as an illustrative sample, the results have been scaled up to estimate the potential impact of all 100 or so current research projects (applying low, medium and high scenario multiples of 5, 6 and 7). The majority of these impacts benefit the global economy but a proportion of the impact will benefit the Scottish economy. Low, medium and high scenarios have been modelled assuming that 15%, 20% and 25% of the benefits directly affect, or feed back to the Scottish economy
- **Economic impacts** – RBGE science activities in total generate a potential economic benefit to the global economy of £783m GVA (£294m net to the Scottish economy) by year 10, £1.5bn GVA (£0.5bn to Scotland) by year 15 and £4.5bn GVA (£1.2bn to Scotland) by year 25 (NPV@3.5%).
- **Economic Return on Investment (ERoI)** – these impacts potentially generate the following ERoI on the science element of the grant:
 - Global impact: £26.47 per £1 of grant by year 10, £42.44 by year 15 and £109.68 by year 25
 - Impact net to the Scottish economy: £6.29 per £1 of grant by year 10, £9.64 by year 15 and £22.94 by year 25
- **Excluding science impact figures which are less certain** – namely those that derive from the outcome of longer term RBGE science research projects and only include the benefits that derive from accessing the collection, the majority of these benefits are net to the Scottish economy:
 - The economic benefits to Scottish economy that derive from this are £171m by year 10, £248m by year 15 and £385m by year 25 (NPV@3.5%).

1.6 Conclusions – Economic Impact and Return on Investment

Two sets of impact results are presented in this assessment:

- Impacts based on operational spend, visitor, education and science services impacts
- Impacts based on the above plus potential longer term science research impacts, which are potentially large but of which there is less certainty

Economic impact of RBGE – including all science impacts

Table 1.1: Economic impact of the RBGE (£ GVA) – including all science impacts

Economic impact of the RBGE (£ GVA) – including all science impacts					
		1 yr snap shot	10-yr NPV	15-yr NPV	25-yr NPV
Global benefits		102,701,894	996,643,785	1,788,867,016	4,952,470,204
To the Scottish Economy		51,876,997	490,155,944	769,143,853	1,603,690,045

Economic impact of RBGE – excluding science research project impacts

Table 1.2: Economic impact of the RBGE (£ GVA) - total benefits excluding science research projects

Economic impact of the RBGE (£ GVA) – excluding science research project impacts					
		1 yr. snap shot	10-yr NPV	15-yr NPV	25-yr NPV
Global benefits		39,608,377	384,636,672	543,437,526	808,315,467
To the Scottish Economy		39,258,294	367,754,521	520,057,955	774,859,098

Operating costs and grant

Table 1.3: Investment – total operating costs and grant

Investment – total operating costs and grant element					
		1 yr. snap shot	10-yr NPV	15-yr NPV	25-yr NPV
Grant		8,495,000	73,122,297	101,264,820	144,910,833
Total operating costs		11,231,511	96,677,327	133,885,457	191,591,246

Economic Return on Investment (ERoI)

Table 1.4: Economic Return on Investment (ERoI) including all science impacts

Economic Return on Investment (ERoI) including all science impacts					
		1 yr. snap shot	10-yr NPV	15-yr NPV	25-yr NPV
Grant	Global benefits divided by grant	12.09	13.63	17.67	34.18
	Scottish economy benefits divided by grant	6.11	6.70	7.60	11.07
Total operating costs	Global benefits divided by total operating cost	9.14	10.31	13.36	25.85
	Scottish economy benefits divided by total operating costs	4.62	5.07	5.74	8.37

Table 1.5: Economic Return on Investment (ERoI) excluding science research project impacts

Economic Return on Investment (ERoI) excluding science research project impacts					
		1 yr. snap shot	10-yr NPV	15-yr NPV	25-yr NPV
Grant	Global benefits divided by grant	4.66	5.26	5.37	5.58
	Scottish economy benefits divided by grant	4.62	5.03	5.14	5.35
Total operating costs	Global benefits divided by total operating cost	3.53	3.98	4.06	4.22

2 Introduction

Arcadis and Adroit Economics were commissioned by Royal Botanic Garden Edinburgh (RBGE) to undertake a socio-economic impact assessment of RBGE's contribution to the Scottish economy and society.

The last assessment of RBGE's contribution was in 2009¹ when DTZ estimated Gross Value Added to the Scottish economy of £13.2m plus further visitor, volunteer and education impacts of £5.2-£7.2m per year. The DTZ assessment excluded any assessment of science impacts.

Since that time, RBGE has changed substantially in terms of its approach to enhancing the Scottish economy and society with active strategies for social and community engagement, enhancement and economic benefit. Its science strategy aims to deliver benefits to Scotland and around the world, enhancing Scotland's reputation on the international stage and informing international efforts around conservation, biodiversity and sustainable exploitation of natural resources. In particular, some of RBGE's current science could have substantial long term impact as Section 7 shows.

This report assesses the contribution of these activities in 2015/16 as well as looking forward into the future.

The report has the following sections:

- Executive Report
- Impact Assessment Methodology
- Operating Impacts
- Visitor/Tourism Impacts
- Educational Impacts
- Science Impacts
- Conclusions

The Report is numerically data rich and aimed at an audience familiar with economic studies and findings.

¹ DTZ (2009) Impact of Royal Botanic Garden Edinburgh Final Report

3 Impact Assessment Methodology

This section sets out:

- The principal sources of impact assessed
- Sources of data and information
- Impact calculation methodology and analytical tools
- Approach towards assumptions and judgments
- Distinguishing between Scottish economy impacts and wider global economy impacts
- Method used to calculate Economic Return on Investment (ERoI)
- Sensitivity and scenario analysis of the science impacts

3.1 The principal sources of impact assessed

Table 3.1 sets out the principal ways in which RBGE generates economic benefit to the Scottish and wider global economy. The aim has been to capture as full as possible an assessment of RBGE's impacts using a bespoke economic model.

Table 3.1: Principal ways in which RBGE generates economic benefit to the Scottish economy and principal assumptions used to calculate the impact

Theme	How RBGE generates economic benefit to the Scottish economy and key assumptions
Operating expenditure	Salaries to staff who then spend in the Scottish Economy; procurement of goods and services from Scottish suppliers (GVA element at 30%) - all including a multiplier of 1.25 in line with national accounts to capture the ripple effects across the Scottish economy.
Visitors	Visitors - utility value of visit based on an assumed ticket price for RBGE (£6.50 average across Edinburgh visitors) and on actual ticket prices for Glass House visits and for other gardens. Visitor spend on books, plants, catering and event tickets; spend of visitors from outside Scotland outside of the gardens (assumed at 3% of average total visitor spend to Edinburgh).
Education	Primary, secondary, special and nursery - utility value of visit based on parent's willingness to pay for school trip; apprenticeship, diplomas, foundation and degree, masters and PhD students who remain and work in Scotland based on increased skill levels and consequent proficiency/ productivity increase to employers (GVA per FTE uplift); fees to Scotland from students from outside of Scotland (less 40% spent on salaries that are already taken into account in the operational impact calculations)
Science	<p>Impacts that derive from RBGE science activities can be split into two types</p> <ul style="list-style-type: none"> • Those that derive from delivery of science services – essentially this comprises enabling access to the national collections and library for scientific purposes. Types of benefit to the Scottish economy associated with this include (i) spend in Edinburgh of visiting scientists/researchers on travel, subsistence etc.; and (ii) value to 3rd party researchers of accessing specimens (via visit, post and online). The value of this service has been calculated in terms of time taken to undertake activity applied to average GVA per FTE for R&D. All of these impacts are assumed to benefit the Scottish economy. • Wider, longer term benefits that derive from successful science research projects, the results of which have a global economic impact (a) that RBGE research staff are directly involved in – in many cases, RBGE research staff are part of a wider international team, and (b) successful science research projects that in part owe an element of their success to knowledge and understanding gained by 3rd party researchers accessing the national collection/ library. Most of these projects are international, but for the purposes of this evaluation, it is assumed that 20% of the benefit flows back to the Scottish economy through various mechanisms (see Section 7 for more detail)

3.2 Sources of data and information

The sources used for the work have been as follows:

- RBGE's internal documents such as corporate plan, business plan, monitoring reports etc.
- Site visit and tour of the Edinburgh site.
- In-depth consultations with key staff and stakeholders.
- Desk research of a wide variety of sources to provide background information or assumptions for modelling.

3.3 Impact calculation methodology and analytical tools

The economic impact of RBGE on the Scottish and wider global economies has been assessed in terms of net additional GVA² over four time periods agreed with RBGE:

- 1 year (2015/16) snap shot
- 10 year period, discounting values to present values using the standard NPV³ function at 3.5%
- 15 year period with discounting as above
- 25 year period with discounting as above.

The longer time periods are important because they capture impacts of current science projects that take time to occur.

Details of the impact calculation for each impact theme are provided in the section for each theme, below.

3.4 Approach towards assumptions and judgements

Calculating the economic impact of projects is not a precise science. The calculation inevitably depends on a number of assumptions and judgements. For areas where data are readily available such as operating impact, the calculations can be fairly precise. For areas such as science impacts, there are limited data available so the aim is to understand the scientific objectives and to identify, scope and capture the actual and potential impacts. The general approach adopted towards making assumptions and judgements is to ensure that each is (i) reasonable and (ii) proportionate. This is in accordance with best practice evaluation techniques adopted by the Scottish and UK Governments.

Where there are no market prices available to estimate value of impacts, so shadow pricing has been used to estimate potential values. For example, the willingness to pay of parents for their children to go on a school trip. Or valuing the time spent by a scientist in examining a sample from the RBGE collections.

All assumptions and judgements are documented. Key assumptions and judgments are described in this report.

² GVA=Gross Value Added: the Government's preferred measure of economic wealth creation, comprising wages and profits, and excluding purchases. GVA is a similar measure to GDP excluding taxes (less subsidies).

³ Net Present Value.

3.5 Distinguishing between Scottish economy impacts and wider global economy impacts

Table 3.2: Basis on which the proportion of impacts that benefit the Scottish economy has been determined

Basis for determining which global impacts benefit the Scottish Economy		
Source of impact	Details	Rationale for estimating proportion that benefits the Scottish economy
Operating expenditure	Salaries to staff who then spend in the Scottish Economy; procurement of goods and services from Scottish suppliers (including multiplier of 1.25)	The detailed operational expenditure accounts provided by RBGE have been reviewed and identified supplier spend that is clearly spent overseas; for all remaining supplier spend it is assumed 100% is spent in Scotland. It is assumed that 30% of this represents GVA (based on typical sales to GVA ratios for the UK). All salary spend from the accounts has been identified and it is assumed that 100% of staff are based in Scotland, although some travel overseas as part of their work (particularly research scientists). 100% of salary spend has been taken as a benefit to the Scottish economy. It is assumed that 100% of salary spend translates into GVA.
Visitors	Visitors (all) - utility value of visit based on assumed ticket price for RBGE (£6.50 average) and on actual ticket prices for Glass House visits and the other gardens	It is assumed that all visitor benefits are net to the Scottish economy, on the following basis: (i) for visitors from Scotland, they receive a benefit (utility value) from visiting the gardens (whether expressed in the form of purchasing a ticket or calculated through shadow pricing). Hence this is deemed as a benefit to Scottish residents and therefore to the Scottish economy (ii) for visitors from outside of Scotland, they also receive a benefit from visiting the gardens, expressed either as income to RBGE and Scotland (for those that purchase tickets) or a shadow price for those that enter free.
Sales to visitors	Plants, books etc., catering (operating profit to RBGE only)	Similar rationale as for visitors - Scottish residents gain the benefit of their purchases and the spend of visitors to Scotland represents income to Scotland.
Events - visitors	Ticket sales	Similar rationale as above.
Wider visitor impacts	RBGE visitors from outside of Scotland, additional spend, outside of gardens that is attributable to RBGE (based on assumed 3% of total spend per day per visitor)	Spend of visitors from outside of Scotland, outside of the gardens, which is attributable to visiting the gardens, represents income to Scotland.
Schools visits assumed all from inside Scotland)	Primary, secondary, special and nursery - utility value of visit based on parent's willingness to pay for school trip	It is assumed that all school visits are from within Scotland and hence that the benefit of the visit (utility value) goes to Scottish learners based on willingness to pay of parents – see Section 5 for details.
Students that stay and work in Scotland	Increased skill level/ proficiency of students that stay and work in Scotland based on estimated GVA uplift to Scottish business	All students, irrespective of where they are from, that stay and work in Scotland on completion of their course, will add value to the Scottish labour market and employers.

Students from outside of Scotland	Fees paid (less amount spent on salaries as already taken into account in operational impact)	In addition, the fees paid by students from outside Scotland represent income to the Scottish economy.
Science	Collections - research visitors spend in Scotland	Spend of researchers visiting the collections from outside Scotland represents income to Scotland.
	Collections - value of accessing specimens calculated with reference to researcher time-cost spent on activity	Similar to the visitor rationale - visiting researchers from Scotland gain a utility value, so visiting researchers from outside of Scotland pay a shadow value which represents shadow income to Scotland.
	Collections down-stream benefits - 5% of downloads contribute to projects that will have an economic impact	It is assumed that RBGE is attributed with a proportion (33-50%) of the benefits of its international science projects reflecting inputs of other partners. This is based on discussion with RBGE senior scientists. It is assumed that 20% of global research projects directly/indirectly benefit the Scottish economy.
	3 case studies of international science projects	
	Scale up factor to reflect benefits of all other science projects (multiple of 6 used)	

3.6 Method used to calculate the Economic Return on Investment (ERoI)

The Economic Return on Investment is calculated by dividing the total impacts (NPV) by total operational spend and by the grant element, showing the £GVA generated as a result of £1 spend and £1 grant.

3.7 Sensitivity and Scenario Analysis of the science impacts

Assessing the economic impact of the RBGE, like that of any other project, is not an exact science but instead depends on a number of assumptions and judgements as explained above. There is reasonable certainty about the impacts that derive from operational expenditure, visitors and education, and from accessing specimens in the collection, but less certainty about the impacts that derive from the down-stream benefits of the collection to research projects and of RBGE's science research activities. The aim has been to present conservative and justifiable impacts, however, there are some major assumptions used to calculate the potential science-related impacts. To acknowledge this, sensitivity analysis has been undertaken of the science impact calculations by identifying the most critical assumptions and then varying these to assess the change in impact. These calculations are presented in the Appendix 1.

4 Income, Operational Expenditure and Impacts

Summary:

- **Expenditure** - RBGE spends £11.23m per year – on staff salaries, procurement of goods and services from suppliers and other items. 99.4% of this is spent in Scotland and so directly benefits the Scottish economy
- **Expenditure by outcome:** RBGE operates an outcome cost accounting system. Breakdown of annual expenditure by the four main outcomes is as follows: Tourism and recreation (45%), Education and Skills (10%), National Collection (21%), Science and Conservation (24%)
- **Income** – RBGE derives income to support this expenditure from a variety of sources. 72% (£8.5m) derives from grant-in-aid of from the Scottish Government. RBGE generates the remainder from a number of sources: education fees 23% (£770k); Botanic Trading Company 16% (£508k) and admissions 15% (£500k)
- **Net additional GVA to the Scottish economy generated by RBGE operational expenditure -** RBGE operational expenditure is estimated to generate £94m net additional GVA in the Scottish economy by year 10, £130m by year 15 and £186m by year 25 (NPV@3.5%)

This section sets out RBGE's current and projected operational expenditure, broken down by outcome; sources of income to support this expenditure and the estimated net additional GVA impacts of this expenditure on the Scottish Economy.

4.1 Income

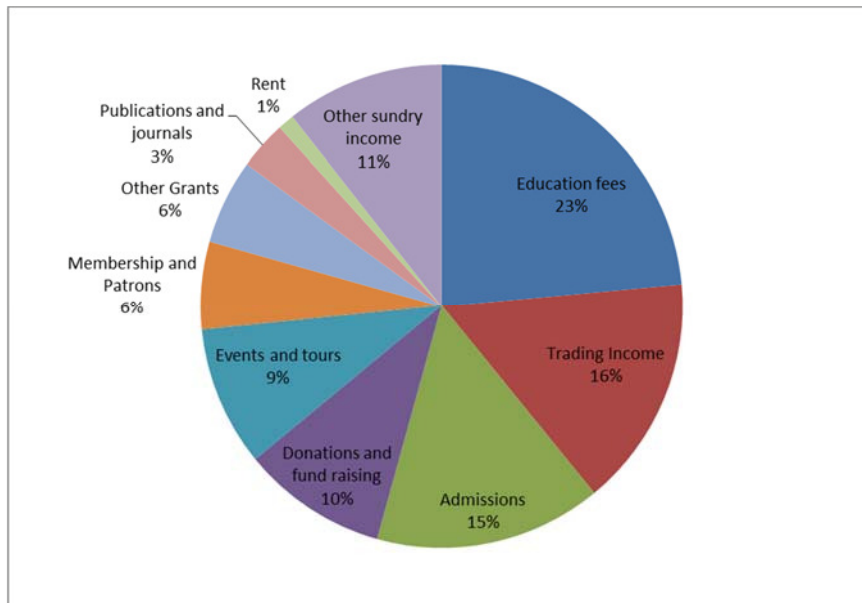
RBGE is organised into four divisions as follows: Science, Horticulture, Corporate Services and Enterprise. It has its own Board of Trustees appointed by Scottish Ministers.

RBGE's total operating expenditure for financial year 2015/16 is £11,231,511. RBGE derives income from various sources to support this expenditure.

RBGE is a Non Departmental Public Body (NDPB) and receives Grant-in-Aid from the Scottish Government's Environment and Forestry Directorate (ENFOR) alongside capital grants from Scottish Government and research grants from other sources. RBGE also generates trading income from shops/cafes at its four gardens and income from visitor admissions, memberships, donations and a variety of other sources. For the financial year 2015/16, RBGE's income breakdown is as follows:

- Grant-in-aid of £8.5m from the Scottish Government formed 72% of total income.
- RBGE generated a further £3.27m from a wide range of sources as shown in Figure 4.1. Education fees were the largest source at 23% (£770k) while income from the Botanic Trading Company formed 16% (£508k) and admissions 15% (£500k). Some of these income sources have been growing strongly in the past few years as RBGE implements its Corporate Plan to increase and diversify its self-generated income.

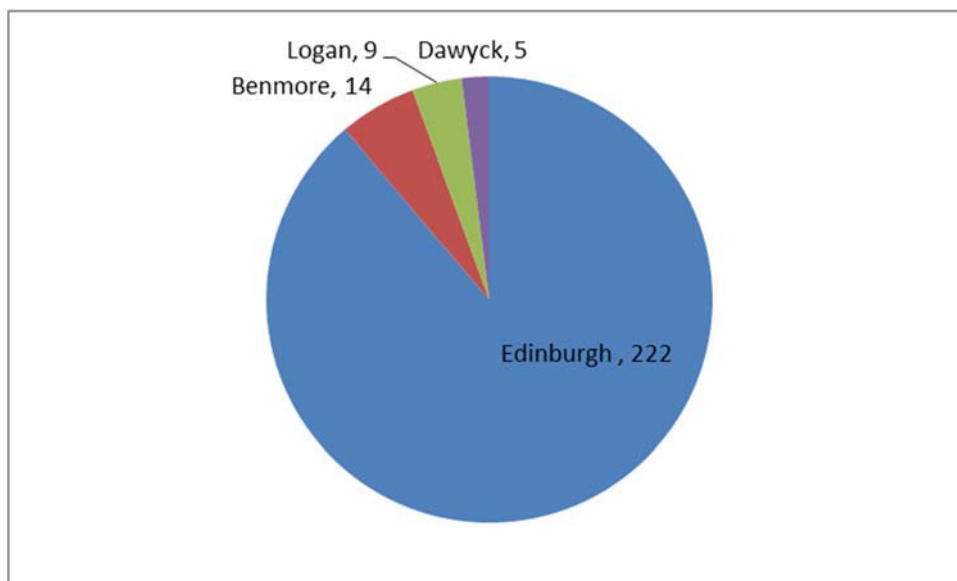
Figure 4.1: Sources of RBGE Self-Generated Income (£s)



Source: RBGE Management Accounts

One of RBGE's largest costs is payment of staff. RBGE directly employs 250 staff across its four sites⁴, the majority (89%) in Edinburgh. The number of staff by site is shown in Figure 4.2.

Figure 4.2: Staffing at RBGE by site (2015/16)



Source: RBGE HR database

In addition, at the end of March 2016 there were 326 volunteers, the majority in horticulture, with an estimated 20,000 volunteer hours across the 2015/16 year. This highlights RBGE's importance as an outlet for community volunteering.

⁴ 229 permanent and 21 contract.

4.2 Operational Expenditure

RBGE's total annual operating expenditure for financial year 2015/16 is £11,231,511.

Operational expenditure can usefully be broken down in several ways:

- By type – e.g. staff salaries, procurement of goods and services from suppliers
- By outcome – e.g. Tourism and recreation; education and skills; national collection; science and conservation.

Table 4.1 shows the breakdown by type of expenditure. Note that it is estimated that RBGE spends 99.4% of total operating expenditure in the Scottish economy.

Table 4.1: Gross expenditure in Scotland and outside

Gross expenditure in Scotland and outside	Spent in Scotland	Spend outside of Scotland	Total
Supplier spend	3,548,745	71,076	3,619,821
Staff salary spend	7,631,791	-	7,631,791
Total expenditure	11,180,535	71,076	11,251,612
	99.4%	0.6%	100.0%

Table 4.2 shows breakdown of operational expenditure by outcome. RBGE operates an outcome cost accounting system, recording income and expenditure by four main outcome headings:

- Tourism and recreation
- Education and Skills
- National Collections
- Science and Conservation

Table 4.2: Proportion of RBGE operating spend – by outcome

	Salaries	Supplier	Total
Tourism and recreation	27%	18%	45%
Education and skills	7%	3%	10%
National collection	16%	5%	21%
Science and conservation	15%	9%	24%
Total	65%	35%	100%

4.2.1 Projecting operational expenditure over a 10, 15 and 25-year period

This evaluation calculates net additional economic impact and Economic Return on Investment (ERoI) of RBGE expenditure and activities over a 10, 15 and 25-year period using standard cost benefit analysis methodology. Operational expenditure, therefore, needs to be projected over these periods.

Tables 4.3(a) and (b) show RBGE operational expenditure projects, in total and broken down by outcome. Note that it is assumed in this assessment that operational expenditure rises in line with inflation but otherwise remains flat.

Table 4.3(a): Projection of total RBGE operational expenditure

	Current year	NPV - 10 yrs	NPV - 15 yrs	NPV - 25 yrs
Total operating expenditure	11,231,511	96,677,327	133,885,457	191,591,246

Table 4.3(b): Projection of RBGE operational expenditure by outcome

Operating costs by outcome	Base	yr1-25	yr2	yr3...	...yr25	NPV - 10 yrs	NPV - 15 yrs	NPV - 25 yrs
Tourism and recreation	5,031,751	5,031,751	5,031,751	5,031,751	5,031,751	43,311,732	59,981,086	85,833,453
Education and skills	1,132,156	1,132,156	1,132,156	1,132,156	1,132,156	9,745,240	13,495,883	19,312,725
National collection	2,395,712	2,395,712	2,395,712	2,395,712	2,395,712	20,621,537	28,558,133	40,866,935
Science and conservation	2,691,994	2,691,994	2,691,994	2,691,994	2,691,994	23,171,837	32,089,964	45,921,016

4.3 Economic Impact of Operational Expenditure on the Scottish Economy

4.3.1 Approach to calculating the economic impacts of operational expenditure on the Scottish economy

In this assessment, the primary measure of economic impact is GVA, hence the focus is on estimating the quantum of net additional GVA generated in the Scottish economy by RBGE, through operational expenditure. This involves two steps:

- Step 1: Calculating annual net additional GVA generated in the Scottish economy as a result of RBGE operational expenditure
 - Breaking down operational expenditure into appropriate categories
 - Calculating what proportion is spent in Scotland
 - Calculating what proportion of each category represents GVA
 - Taking account of ripple effects (2nd and 3rd round effects) by applying an appropriate multiplier
- Step 2: Projecting both expenditure and net GVA impacts over the study period and calculating the net present value.
 - Calculating impacts over three time periods in this assessment – a 10 year, 15 and 25 year period
 - Only taking account of real expenditure increases – i.e. it is assumed expenditure increases only in line with inflation in this assessment
 - Calculating the net present value of projected GVA impacts over each time period, using the standard Net Present Value function at a 3.5% discount rate

Operational expenditure impacts can be usefully divided into the following three broad types:

- **Supplier spend impacts** – procurement of goods and services by RBGE from suppliers. Given that GVA is the principal measure of economic impact, only the proportion of spend with suppliers which represents GVA has been taken. It is assumed that 30% of spend with suppliers represents GVA.
- **Staff spend impacts** – payment of staff salaries who live and work in Scotland. In this assessment, 100% of staff are deemed to live and work in Scotland. 100% of staff salaries have therefore been counted. Moreover, the full 100% of staff salaries has been counted as a contribution towards net additional economic impact in the Scottish economy on the basis that this assessment focuses on calculating net additional GVA as the principal metric to measure economic impact, and, salaries, by definition are one of the two principal components of GVA. Some assessments however deploy alternative approaches, such as only taking account of the proportion of staff salaries likely to be immediately spent (rather than saved), using family expenditure survey data to estimate the proportion
- **Indirect impacts** (also termed ripple or multiplier impacts) – impact that results from spend of suppliers with other suppliers (often termed 2nd and 3rd round supplier spend impacts) and spend of retailers and other firms that staff spend their salaries with, with their suppliers. Induced impacts are often described as ripple impacts. Different methods are available for estimating induced impacts, from the simple approach of applying an overall multiplier to direct and indirect impacts, through to more complex input-output analysis. A simple approach has been adopted in this assessment using a multiplier of 1.25 to estimate induced impacts, in line with national accounts.

4.3.1 Annual net additional GVA to the Scottish economy that derives from RBGE operational expenditure, over a 10, 15 and 25-year period

Total 4.4 shows how RBGE's total expenditure in the Scottish economy of £11,180,535 per year has been translated into net additional GVA of £10,870,518 in line with the methodology above:

- It is assumed that 30% of spend with suppliers represents GVA
- It is assumed that 100% of staff salaries represent GVA
- A multiplier of 25% has been applied to the total of these, to take account of ripple effects (2nd and 3rd round consumption and supplier effects).

Table 4.4: Conversion of gross expenditure to GVA and inclusion of indirect impacts (2nd and 3rd round multiplier effects)

Gross expenditure		In Scotland	Outside of Scotland	Total
Spend £				
Supplier spend		3,548,745	71,076	3,619,821
Staff salaries		7,631,791	-	7,631,791
Total expenditure		11,180,535	71,076	11,251,612
		99.4%	0.6%	100.0%
Conversion to GVA impacts				
Supplier spend (GVA)	30%	1,064,623	21,323	1,085,946
Staff salaries (GVA)	100%	7,631,791	-	7,631,791
Multiplier - impact that results from spend of suppliers with other suppliers and from spend by retailers and other suppliers whom staff spend their salaries with	25%	2,174,104	5,331	2,179,434
Total		10,870,518	26,654	10,897,171

4.3.2 Net additional GVA to the Scottish economy that derives from RBGE operational expenditure, over a 10, 15 and 25-year period

Tables 4.5(a) and (b) show the net additional GVA benefits to the Scottish economy that derive from RBGE operational expenditure, over a 10, 15 and 25-year period, in total and broken down by outcome:

- RBGE operational expenditure is estimated to generate £94m net additional GVA in the Scottish economy by year 10, £130m by year 15 and £186m by year 25

Table 4.5(a): Net additional GVA to the Scottish economy that derives from RBGE operational spend over a 10, 15 and 25-year period

Operating spend impacts (£ GVA)	Base	yr1- 25	NPV - 10 yrs	NPV - 15 yrs	NPV - 25 yrs
Total	10,897,171	10,897,171	93,799,435	129,899,952	185,887,955
Scotland	10,870,518	10,870,518	93,570,009	129,582,228	185,433,288

Table 4.5(b): RBGE operating impacts

Operating spend impacts		Base	yr1-25	NPV - 10 yrs	NPV - 15 yrs	NPV - 25 yrs
	Total	10,897,171	10,897,171	93,799,435	129,899,952	185,887,955
	Scotland	10,870,518	10,870,518	93,570,009	129,582,228	185,433,288
Scotland	Tourism and recreation	4,647,061	4,647,061	40,000,448	55,395,389	79,271,281
	Education and skills	1,141,423	1,141,423	9,825,014	13,606,359	19,470,817
	National collection	2,538,355	2,538,355	21,849,361	30,258,508	43,300,187
	Science and conservation	2,543,679	2,543,679	21,895,187	30,321,971	43,391,003
Outside of Scotland	Tourism and recreation	13,708	13,708	117,990	163,401	233,829
	Education and skills	2,285	2,285	19,665	27,234	38,971
	National collection	3,808	3,808	32,775	45,389	64,952
	Science and conservation	6,854	6,854	58,995	81,701	116,914
Global	Tourism and recreation	4,660,769	4,660,769	40,118,438	55,558,791	79,505,110
	Education and skills	1,143,708	1,143,708	9,844,679	13,633,593	19,509,789
	National collection	2,542,162	2,542,162	21,882,136	30,303,897	43,365,139
	Science and conservation	2,550,532	2,550,532	21,954,182	30,403,672	43,507,917
Total		10,897,171	10,897,171	93,799,435	129,899,952	185,887,955

5 Visitor/Tourism Impacts

Summary:

- **Numbers of visitors** – RBGE attracted a total of 993,703 visitors to the four gardens (2015), 89.5% of which were to the main garden in Edinburgh
- **Visitor value** – visitors to the garden in Edinburgh gain access free, but pay to visit the indoor collection and to attend various events; visitors to the other gardens pay; additional revenue is generated from catering, plant, gift and book sales. To calculate total visitor value, a ‘shadow price’ of £6.50 has been applied to visitors who access the Edinburgh garden free, reflecting the utility value gained. On this basis, total visitor value (revenue and shadow) equalled £7.4m in 2015/16
- **Growth in visitor numbers** – visitor numbers have increased by 63% between 2008 and 2015. To err on the side of caution, no further growth in the figures above is assumed
- **Net additional GVA to the Scottish economy generated by visitors to RBGE** – it is assumed that all visitor value represents a net benefit to the Scottish economy as follows (i) visitors from outside of Scotland generate revenue for RBGE (actual and shadow); visitors from within Scotland, gain utility value. On this basis, visitor value net to the Scottish economy is estimated to equal £82m by year 10, £114m by year 15 and £163m by year 25 (NPV@3.5%)

RBGE’s Enterprise Division is responsible for visitor services. It aims to maximise the tourist potential of RBGE’s four Gardens, ‘enabling visitors to appreciate, enjoy and be inspired by plants, through the provision of access to high quality green spaces’.

A new Head of Marketing & Communications was appointed in 2012. The Division aims to raise the profile of the RBGE and to contribute to its financial sustainability through fundraising, membership and commercial income generation. The Division’s turnover is £3 million per year, delivering an annual profit of more than £400K. These results have been achieved without increasing the core staffing resource or operational budgets. Some highlights of the Division’s work include:

- A new winter light event, Botanic Lights, attracting 23,000 visitors in its first year generating over £300,000 of income and almost £60,000 profit.
- VisitScotland ratings are ‘excellent to outstanding’.
- Logan and Dawyck Gardens have achieved five-star quality tourism awards and several industry awards for excellence have also been achieved.

Visitor numbers have risen sharply since the last impact report which recorded total visitors across all four sites of 489,000 in 2008, down from 700,000 in 2004. The latest figures record over 993,000 visitors as shown in Table 5.1

Table 5.1: RBGE Visitor numbers 2015/16

	Visitor numbers
Edinburgh (free entry)	889,420
Edinburgh Glasshouses (paid entry)	98,110
Benmore (paid entry)	48,078
Dawyck (paid entry)	33,773
Logan (paid entry)	22,432
Total	993,703

Results of visitor surveys undertaken by RBGE suggest the following:

- Edinburgh residents form just less than half to two thirds of total visitors to the Edinburgh garden.
- Overseas visitors form around half of visitors during the tourist season with half of these being from the USA.
- Key reasons for visiting were to enjoy the landscape and plants, to exercise and to relax.
- In the most recent survey, 84% of visitors were 'very satisfied'

5.1 Valuing Visits to RBGE

Visitors to the Edinburgh gardens get free admission although a proportion pay to access the glass houses once they are in the gardens. Visitors to the other gardens outside Edinburgh are charged an access fee. Calculating visitor impacts requires the value gained by visitors who have not paid to be taken into account. Visitors to the Edinburgh gardens clearly gain a 'utility' benefit from their visit. The question therefore is how to value this. This involved determining what economists refer to as a 'shadow price', namely a price that visitors could reasonably be expected to pay, if access was charged. There are a number of methods for deriving a shadow price in the economic literature. The most common is to look at what other similar attractions charge; while more complex methods, such as that used in the Kew Gardens study⁵ determined the shadow price with reference to 'distance travelled and consequent travel costs to visitors' comprising a transport cost and a time cost element.

A simple approach has been used in this assessment with a shadow price (average ticket price of £6.50) based on the following considerations:

- Entry to the other gardens is £4.50 – it seems reasonable to add a premium to the value of a visit to the main garden in Edinburgh
- RBGE is one of Edinburgh's top free attractions. Top paid attractions in Edinburgh charge £15-£16.50⁶ for an adult. However, this level of charging is at the top end of the market in Edinburgh.
- Consultations with RBGE staff experienced in other gardens and with a good understanding of access pricing suggested that £6.50 was a reasonable comparator.

This shadow price of £6.50 has been adopted as an average for all visitors, taking account of children and concessions. This average value also includes membership income.

In conclusion, RBGE generated value from visitors in several different ways in 2015/16:

- From visitors to the four gardens – derived from revenue from actual ticket sales and imputed revenue from those who visited free (the Edinburgh gardens only) based on shadow pricing - £6,836,904
 - Of which from visitors to the Glass House and Inverleith House in the Edinburgh gardens - £586,400
- Revenue from catering, via RBGE's trading company - £541,859
- Revenue from visitors attending special events – the Botanic Lights and the Lune Cinema - £45,164
- Revenue for visitors attending special garden sales - £16,033
- **In total representing an annual value generated from visits of £7.44m**

The following tables show the calculations.

⁵ Oxford Economics (2016) Economic valuation of the Royal Botanic Gardens, Kew

⁶ Royal Yacht Britannia and Edinburgh Castle

5.1.1 Garden Visit Value

In 2015, all four gardens received a total of 993,703 visitors. Table 5.2 provides a breakdown by garden.

Table 5.2: Visitor Numbers

	2008	2009	2010	2011	2012	2013	2014	2015
RBGE	505,321	581,358	707,244	790,545	721,827	679,756	806,810	889,420
<i>glass houses</i>	43,741	56,317	48,255	58,958	52,140	59,700	65,393	98,110
<i>Inverleith house</i>							20504	21300
Benmore	52,728	52,063	49,129	45,455	41,696	46,992	47,137	48,078
Dawyck	29,415	34,726	30,158	28,697	27,253	28,917	34,465	33,773
Logan	22,269	24,576	22,131	20,677	18,555	19,365	21,165	22,432
Total visitor numbers to all four gardens	609,733	692,723	808,662	885,374	809,331	775,030	909,577	993,703

According to RBGE's visitor report⁷, 54% of visitors were from Scotland, 19% from the rest of the UK and 27% from overseas

Based on actual ticket sales and shadow ticket prices for those who gained free entry, it is estimated that the total value of visiting the gardens was £6.8m in 2015. Table 5.3 shows the calculations for this.

Table 5.3: Calculating the value of visitors

			Visitors from overseas	Visitors from the rest of the UK	Visitors from outside Scotland	Visitors from Scotland
	Actual and assumed ticket price (ave)	Annual visitor value based on assumed ave ticket price and 2015 visitor numbers	27%	19%	46%	54%
RBGE	6.50	5,781,230				
glass houses	5.00	490,550				
Inverleith house	4.50	95,850				
Benmore	4.50	216,351				
Dawyck	4.50	151,979				
Logan	4.50	100,944				
Total		6,836,904	1,845,964	1,299,012	3,144,976	3,691,928

5.1.2 Revenue from Catering

⁷ Scotinform (2015) RBGE 2015 Visitor Survey Report

Net income to RBGE's trading company, Botanics Trading Co Ltd, was £541,859 for 2015/16

Table 5.4: Net contribution to RBGE from catering

Botanics Trading Co Ltd financial year summary 15-16	Actual £
Retail Profit	126,380
Edinburgh day catering	150,860
Edinburgh private venue hire and catering	230,853
Benmore catering	18,630
Dawyck catering	10,136
Logan catering	5,000
Total income from catering commissions	541,859

5.1.3 Revenue from events

Adding sales of tickets for events - the Lune Cinema and Botanic Lights to the catering revenue Table 5.4 shows that RBGE generated a total of £587,023 net additional income from visitors, over and above garden visits, in the year 2015/16.

Table 5.4: Total income from catering and events

Total income from events	
Lune Cinema	5,164
Botanic lights (forecast)	40,000
Net income to Botanics Trading Co Ltd (carried forward from table 5.3)	541,859
Total income from visitors over and above garden visits	587,023

RBGE also generated revenue from special garden sales events.

Table 5.5: Revenue from garden sales events

	2016
Plant sales	13,007
Admissions - gate	1,260
Cake stall	1,616
Concessions	150
Total	16,033

5.1.4 Total visitor value

Based on the above value and revenue streams, it is estimated that RBGE generated a total visitor value of £7,439,960 in 2015/16. Table 5.6 shows the net present value of this annual value over a 10, 15 and 25-year period.

This calculation assumes no growth in visitor numbers. In reality, RBGE is likely to experience some growth. For example, the latest visitor statistics show an increase of 63% over the period 2008 to 2015. To err on the side of caution, however, no further growth is modelled.

Table 5.6: Visitor value – 25-yr NPV at 3.5%

All	yr0 ⁸	yr1-25	NPV - 10 yrs.	NPV - 15 yrs.	NPV - 25 yrs.
Visitors (based on assumed visit value for RBGE and actual ticket price for other gardens)	6,836,904	6,836,904	58,849,922	81,499,447	116,626,413
<i>Garden sales event per year (income)</i>	16,033	16,033	138,007	191,122	273,497
<i>Other events and catering (income)</i>	587,023	587,023	5,052,910	6,997,620	10,013,654
Total - all events and catering	603,056	603,056	5,190,917	7,188,741	10,287,151
Total on-site value associated with visitors	7,439,960	7,439,960	10,243,827	14,186,361	20,300,805
Visitor wider spend in Scotland	2,107,247	2,107,247	18,138,518	25,119,476	35,946,187
Totals visitor value – onsite and offsite			82,179,357	113,807,664	162,859,751

⁸ The data for the latest available year has been used, either 2015, 2016 or FY 15/16 in each case.

6 Education and Training impacts

Summary:

- **Range of education and training provided** - RBGE plays a major education and training role in the fields of botany and horticulture starting with school age children and running right through to hobbyists and scientific and industry professionals. RBGE runs 25 different schools' programmes for Key Stages 1-3 from nursery through to secondary school as well as teacher CPD and the ability for schools to bring self-guided groups; RBGE offers an apprenticeship course; a 2-year diploma course (direct and online); RHS Certificate and short courses plus hobby courses and workshops for interest groups; RBGE runs higher education courses – HND, BSc, MSc and PhDs with the BSc and HND validated by the University of Glasgow and SRUC respectively. The MSc is run jointly with the University of Edinburgh.
- **Numbers of learners per year** – as at 2015/16, the total number of learners per year visiting/attending courses at RBGE was 11,028, broken down as follows: 9,425 (schools), 1,382 (apprentices/diplomas/certificate/short courses) and 221 (higher education, HND to PHD)
- **Education and training revenue** - RBGE generates significant revenue from provision of education and training courses. Fees (plus course material payments) amounted to £785,749 in 2015/16
- **Types of economic benefit to the Scottish economy** – RBGE education and training activities generate two types of benefit to the Scottish economy (i) fees paid by learners from outside of Scotland generate represent additional revenue in the Scottish Economy; (ii) learners who remain in Scotland on completion of their course and enter the labour market, contribute to a more proficient workforce enabling employers to increase productivity and hence GVA
- **Net additional GVA to the Scottish economy generated by RBGE education and training activities** - equals £21m by year 10, £29m by year 15 and £41m by year 25 (NPV@3.5%)

RBGE plays a major education and training role in the fields of botany and horticulture starting with school age children and running right through to hobbyists and scientific and industry professionals. It aims to encourage lifelong learning through public engagement and extensive access to the living collection.

At a professional level, RBGE aims to equip '*professional horticulturists and biodiversity scientists with the skills to address biodiversity loss nationally and internationally, and to safeguard plant heritage and culture*'. For the general population, RBGE aims to increase '*knowledge and appreciation of people of all ages and backgrounds about plants and the natural environment, and their place and responsibilities in the world*'.

6.1 Types of Course and Learner Numbers

RBGE's extensive range of education and training courses is summarised as follows:

- Schools – 25 different programmes for Key Stages 1-3 from nursery through to secondary school as well as teacher CPD and the ability for schools to bring self-guided groups.
- Apprenticeship – apprenticeship course plus RBGE usually has 3 of its own apprentices and is looking to create a new apprenticeship with a house builder to improve ground work planting.
- RBGE Diploma – 2-year course (direct and online) with four courses offered including subjects such as Garden Design and Herbology.
- Certificate and short courses – 6 short course certificates of 10-day duration, including RHS certification at levels 2 and 3 plus hobby courses and workshops for interest groups
- Higher education courses – HND, BSc, MSc and PhDs with the BSc and HND validated by the University of Glasgow and SRUC respectively. The MSc is run jointly with the University of Edinburgh. The scale of this activity is substantial with more than 50 PhDs since 2009 and nearly 90 students from 34 countries on the MSc.

In addition, RBGE runs a series of courses and workshops, designed to offer health, wellbeing and learning benefits to community groups including the disadvantaged and disabled. Examples include, a monthly drop-in course for those suffering with dementia. The Edible Gardening Project throughout the year to encourage people to grow their own vegetables. The Reading Together book group sharing stories by reading aloud.

The total number of learners, from schools to PhDs, per year, at the current time is 11,028.

Table 6.1 shows the number of learners per course, per year and source of learners (within Scotland, wider UK and overseas)

Table 6.1: Numbers of learners per course

	Course types	Details and source of info	Total learners on course over full length of course	Learners on course per year	% learners that come from Scotland	% learners that come from the rest of the UK	% learners that come from overseas
Schools	School visits 1	Number of Primary School participants (2015/16)	7,008	7,008	100%	0%	0%
	School visits 2	Number of Secondary School participants (2015/16)	473	473	100%	0%	0%
	School visits 3	Number of Special School participants (2015/16)	119	119	100%	0%	0%
	School visits 4	Number of Nursery School participants (2015/16)	205	205	100%	0%	0%
	School visits 5	Number of Self-Guided participants (2015/16)	1,198	1,198	80%	15%	5%
	School visits 6	Number of Teacher CPD participants (2015/16)	298	298	100%	0%	0%

	Course types	Details and source of info	Total learners on course over full length of course	Learners on course per year	% learners that come from Scotland	% learners that come from the rest of the UK	% learners that come from overseas
	School visits 7	Garden studio. Teaching schools in deprived areas how to grow veg	124	124	100%	0%	0%
Apprenticeships	Apprenticeship 1	2 at Edinburgh, 1 at Benmore - plan to expand - in discussion with developer	3	3	100%	0%	0%
RBGE Diplomas	Diploma course 1	Attended Courses: Four RBGE in-house diploma courses - 1 to 2 years - Botanical Illustration, Garden Design, Garden History, Herbology	30	20	63%	17%	20%
	Diploma course 2	Online (Distance & Blended) Courses: Two RBGE in-house diploma courses - 1 to 3 years - Botanical Illustration, Garden History delivered online via Propagate Learning. Herbology due to start in October 2016.	56	18	26%	45%	29%
RBGE Certificates	Certificates - 1	RBGE in-house certificate courses 8-10 days - Botanical Illustration, Field Botany, Herbology and Practical Horticulture	84	84	65%	20%	15%
	Certificates - 2	RHS Certificates - Attended	39	39	65%	20%	15%
	Certificates - 3	RHS Certificates - Online (Distance & Blended)	330	194	37%	50%	13%
Short Courses	Hobby/personal interest course 1	Short courses - 100 different courses - horticulture, herbology, photography - non accredited (lifelong learning)	1,024	1,024	80%	10%	10%
HND/BSc, MSc, PhD	Undergraduate 1	HN Level - SCQF Levels 7 & 8 Year 1 – 22 students (HND Year 1); Year 2 – 24 students (HND Year 2) Horticulture with Plantsmanship. RBGE provides 50% of the course, as well as pastoral care and administrative support	65	46	40%	41%	19%
	Undergraduate 2	Degree level - SCQF levels 9 & 10, continuation of HND. Year 3 - 9 students (BSc) Year 4 – 11 students (BSc hon)	27	18	56%	33%	11%

	Course types	Details and source of info	Total learners on course over full length of course	Learners on course per year	% learners that come from Scotland	% learners that come from the rest of the UK	% learners that come from overseas
	Masters 1	There were 19 MSc students starting in September 2015. MSc biodiversity and taxonomy of plants.	38	19	3%	3%	94%
	PhD 1	The number of PhD students at RBGE in 2015/16 is 24 with a further 5 due to begin early in 2016/17	24	8	3%	3%	94%
	Outside HE teaching	Three modules for Edinburgh College of Art; teaching sessions for Leeds University masters course, St Andrews University undergraduate, Dundee medical school	130	130	20%	30%	50%
Totals			11,275	11,028			

6.2 Education and training revenue generated by RBGE

RBGE generates significant revenue from provision of education and training courses. Fees (plus course material payments) amounted to £785,749 in 2015/16. Table 6.2 provides a breakdown.

Table 6.2: Education and training income to RBGE – breakdown 2015/16

	Course types	Fees	Course materials	Other fees	Total
Schools	School visits 1	23,050	-	-	23,050
	School visits 2	1,556	-	-	1,556
	School visits 3	391	-	-	391
	School visits 4	674	-	-	674
	School visits 5	3,940	-	-	3,940
	School visits 6	980	-	-	980
	School visits 7	408	-	-	408
Apprenticeships		-	-	-	-
RBGE Diplomas	Diploma course 1	85,100	-	-	85,100
	Diploma course 2	59,600	-	-	59,600

	Course types	Fees	Course materials	Other fees	Total
RBGE Certificates	Certificates - 1	41,815	-	-	41,815
	Certificates - 2	22,760	-	-	22,760
	Certificates - 3	85,600	-	-	85,600
Short Courses	Hobby/personal interest 1	86,530	-	-	86,530
HND/BSc, MSc. PhD	Undergraduate 1	92,683	1,505	-	94,188
	Undergraduate 2	56,416	916	8,503	65,835
	Masters 1	137,096	2,421	3,580	143,097
	PhD 1	57,724	-	-	57,724
	Outside HE teaching	12,500	-	-	12,500
Total		768,824	-	-	785,749

Table 6.3 shows the breakdown of education and training income by location of learner. This is important when considering the net contribution of RBGE to the Scottish economy. Fees from Scottish students cannot be counted because they are paid by people who live in Scotland and/or by the Scottish Government; however, fees paid by those located outside of Scotland can be counted as net additional income to Scotland.

- 22% (£176,245) of total education and training revenue derives from learners originally located outside of Scotland in the wider UK and
- 36% (£284,364) from overseas students

Table 6.3: Education and training income to RBGE – breakdown by original location of learner 2015/16

	Course types	Total fees + course materials + other payments	Net fees attributable to Scottish students only	Net fees attributable to wider UK students only	Net fees attributable to overseas students only
Schools	School visits 1	23,050	23,050	-	-
	School visits 2	1,556	1,556	-	-
	School visits 3	391	391	-	-
	School visits 4	674	674	-	-
	School visits 5	3,940	3,152	591	197
	School visits 6	980	980	-	-
	School visits 7	408	408	-	-
Apprenticeships		-	-	-	-
RBGE Diplomas	Diploma course 1	85,100	53,613	14,467	17,020
	Diploma course 2	59,600	15,496	26,820	17,284
RBGE Certificates	Certificates - 1	41,815	27,180	8,363	6,272
	Certificates - 2	22,760	14,794	4,552	3,414
	Certificates - 3	85,600	31,672	42,800	11,128
Short Courses	Hobby/personal interest course 1	86,530	69,224	8,653	8,653
HND/BSc, MSc. PhD	Undergraduate 1	94,188	37,675	38,617	17,896
	Undergraduate 2	65,835	36,867	21,725	7,242
	Masters 1	143,097	4,209	4,209	134,680
	PhD 1	57,724	1,698	1,698	54,329
	Outside HE teaching	12,500	2,500	3,750	6,250
Total		785,749	325,140	176,245	284,364
<i>% share by location of learner</i>		<i>100%</i>	<i>41%</i>	<i>22%</i>	<i>36%</i>

Table 6.4 shows the cumulative present value of education and training revenue generated by RBGE over a 10, 15 and 25-year period (NPV@3.5%). The net benefits of this activity to the Scottish economy (based on fees paid by learners/students from outside of Scotland only) are estimated to be between £3.9 and £7.8m over the period.

Table 6.4: present value of education and training revenue over a 10, 15 and 25yr period (NPV at 3.5%)

Education and training revenue analysis	NPV - 10 yrs.	NPV - 15 yrs.	NPV - 25 yrs.
Net fees attributable to Scottish students only	2,777,186	3,846,040	5,503,716
Net fees attributable to wider UK students only	1,484,786	2,056,235	2,942,490
Net fees attributable to overseas students only	2,447,719	3,389,770	4,850,791
Total (gross)	6,709,691	9,292,045	13,296,997
Net fees attributable to Scottish students only	41%	41%	41%
Net fees attributable to wider UK students only	22%	22%	22%
Net fees attributable to overseas students only	36%	36%	36%
Total (gross)	100%	100%	100%
Fees net to the Scottish Economy	3,932,505	5,446,005	7,793,281
	59%	59%	59%

6.3 Valuing the benefits of schools' visits to RBGE

Visiting the RBGE will contribute to the overall educational experience of school children and may enhance their learning outcomes. Within the scope of this work it is not possible to assess the individual learning outcomes achieved. However, it is possible to make estimates based on established methodologies.

6.3.1 Methods for valuing the school visits to learners and the economy

The following methods for valuing the benefit of school visits to learner and economy have been considered:

- Increases in educational attainment are associated with increased employability and earnings. One measure, therefore, of the value of visiting RBGE is to assess the contribution to increased educational attainment and to estimate the contribution of this increased employability and pay (calculated in terms of enhanced life-time earnings). The Kew study adopted this method⁹.
- An alternative method is to value the visit in cost terms, taking account of the willingness to pay of schools and parents which provides a lower estimate of the benefit realised. This latter method has been adopted for RBGE as it is more conservative and justifiable than enhanced life-time earnings.

⁹ Oxford Economics (2016) Economic valuation of the Royal Botanic Gardens, Kew

6.3.2 Calculating the value of school visits with reference to shadow pricing (willingness to pay)

Table 6.5 shows estimates from an academic source of the amount parents are willing to pay for a typical school trip. These independent estimates have been used to produce a shadow price of the value of schools visits to RBGE.

Table 6.5 Willingness to pay for school trips in the UK

Willingness to Pay: Average cost to parent of school day trip[1]	
1.	Primary school £8.32
2.	Secondary school £19.38
[1] http://dera.ioe.ac.uk/5220/1/RR588.pdf	

Table 6.6 shows the resulting shadow price when the estimates above are applied to the numbers of learners at RBGE in 2015/16.

Table 6.6: Valuing schools' visits with reference to shadow pricing (willingness to pay)

Schools visits	Type	No learners pa	Value attributed to visit £	Basis/source of value	Total value pa £
School visits 1	Number of Primary School participants (2015/16)	7,008	8.32	research showing price parents willing to pay for school trip	58,307
School visits 2	Number of Secondary School participants (2015/16)	473	19.38		9,167
School visits 3	Number of Special School participants (2015/16)	119	19.38		2,306
School visits 4	Number of Nursery School participants (2015/16)	205	8.32		1,706
School visits 5	Number of Self-Guided participants (2015/16)	1,198	8.32		9,967
School visits 6	CPD - teachers	Excluded here but included in training impact assessment			
School visits 7	Garden studio. Targeting schools in deprived areas	124	99.84	assumed 12 a year (12x£8.32)	12,380
Total					93,833

Table 6.7 shows the NPV of the shadow price over a 10, 15 and 25-year period assuming the level of activity remains constant at the 2015/16 level.

Table 6.7: Valuing schools' visits over a 10, 15 and 25-year period

Value (shadow pricing) of schools' visits	NPV - 10 yrs.	NPV - 15 yrs.	NPV - 25 yrs.
School visits 1	501,885	695,045	994,615
School visits 2	78,904	109,272	156,370
School visits 3	19,851	27,491	39,340
School visits 4	14,681	20,332	29,095
School visits 5	85,796	118,816	170,027
School visits 6	-	-	-
School visits 7	106,565	147,578	211,185
Total	807,682	1,118,534	1,600,632

It is assumed that 100% of the value of schools' visits benefit the Scottish economy, on the basis that all schools' visits are from schools and learners based in Scotland. RBGE does not keep detailed records of the location of visiting schools but agrees that most are from Scotland. On this basis the NPV over 10 years is £808k and over 25 years is £1.6m.

6.4 Productivity and GVA impacts of RBGE education and training programmes

In addition to generating net income to the Scottish economy from fees, RBGE's education and training activities will ultimately generate economic benefits to employers. Learners/students, on satisfactory completion of RBGE courses, will achieve qualifications and learning outcomes that reflect their increased knowledge and skills.

Education and training programme evaluation methodology has shown that these qualifications and learning outcomes translate into increased proficiency and productivity in the labour market for the individuals and their employers.

The standard method for quantifying this economic benefit is in terms of increased life-time earning potential for the individual. However, experience in evaluating a range of science and technology education and training programmes for several of the UK's former sector skills councils, suggests that earnings increases reflect only part of the economic benefit. To capture the full benefit, the analysis needs to include uplifts to GVA at the level of the employer, enabled by recruiting more proficient staff.

A model to assess GVA uplift benefits derived from skills training programmes has been developed. The analysis has been applied to RBGE and the calculations and results are set out below.

6.4.1 Calculating GVA impacts of RBGE education and training programmes

Calculating GVA impacts of RBGE education and training programmes involves three steps:

- Step 1 – calculate the learner outcomes attributable to RBGE courses per year
- Step 2 – calculate the GVA uplift per learner outcome
- Step 3 – identify the proportion of GVA uplift that is a net benefit to the Scottish economy

Step 1 – Calculating the learner outcomes attributable to RBGE courses per year

To calculate learner outcomes attributable to RBGE courses per year, requires taking account of the number of learners/students per course, number of years to complete the course, contribution of successfully completing the course to a learner level uplift, and, contribution of RBGE to the course (in cases where courses are jointly taught with other institutions).

Table 6.8 shows the calculations involved.

Table 6.8: Learner/student outcomes per year, attributable to RBGE

RBGE courses	Gross to net student outcomes per year								
	No students per year	Number of years to complete course (if more than 1 year)	No students per year divided by number of years to complete course	Contribution of course to achieving whole level uplift		Contribution of RBGE to course (e.g. Glasgow University provides 50% of teaching etc.)		% of students who will go into labour market	Net student outcomes per year
School visits- 6 CPD participants	298	1	298	2%	5.96	100%	5.96	100%	5.96
Apprenticeship 1	3	1	3	100%	3	100%	3	100%	3.00
Diploma course 1	20	1	20	100%	20	100%	20	100%	20.00
Diploma course 2	18	1	18	100%	18	100%	18	100%	18.00
Certificates - 1	84	1	84	10%	8.4	100%	8.4	50%	4.20
Certificates - 2	39	1	39	30%	11.7	100%	11.7	50%	5.85
Certificates - 3	194	1	194	30%	58.2	100%	58.2	50%	29.10
Hobby/personal interest course 1	1024	1	1024	10%	102.4	100%	102.4	10%	10.24
Undergraduate 1	46	2	23	100%	23	50%	11.5	100%	11.50
Undergraduate 2	18	2	9	100%	9	50%	4.5	100%	4.50
Masters 1	19	1	19	100%	19	100%	19	100%	19.00
PhD 1	8	3	2.67	100%	2.67	100%	2.67	100%	2.67
Outside HE teaching	130	1	130	10%	13	100%	13	100%	13.00

Step 2 – Calculating the GVA uplift per learner outcome

Convert the net student outcomes to GVA uplift. This calculation involves two steps:

- Step 2a: calculate the £ GVA uplift per educational attainment (level) increase
- Step 2b: apply these GVA uplift metrics to the number of learners achieving educational attainment (level) uplifts per year as a result of RBGE courses.

Step 2a: Calculating the £ GVA uplift per educational attainment (level) increase: one of the principal ways in which qualifications are classified is in terms of levels (levels 1 to 9). Much of the education and training data is classified in this way. The £GVA uplift associated therefore needs to increase in levels. There is no data publicly available on this, but there is on pay per level. Hence the uplift in pay, between levels, has been used as a proxy for GVA uplift. Table 6.9 shows the calculations.

Table 6.9: Calculating the GVA uplift per educational attainment (level) increase

Calculating £ GVA uplift per educational attainment (level) increase			GVA per FTE		
			Crop and animal production, hunting and related service activities	Construction of buildings	Scientific research and development
			39,509.29	59,610.79	48,252.71
Level increase	Course	Pay uplift against average for all employees	GVA per FTE uplift		
7 to 8	PhD	33.1%			15,947.93
6 to 7	Masters	29.7%			14,312.25
4/5 to 6	Degree	11.0%			5,315.98
3 to 4/5	Foundation/HNC	11.0%			5,315.98
2 to 3	A Levels	11.2%	4,419.68		
1 to 2	GCSE grades A*-C	5.2%	2,042.43		
0 to 1	Entry apprenticeship	9.7%	3,817.00		

Step 2b; Applying these GVA uplift metrics to the number of learners achieving educational attainment (level) uplifts per year as a result of RBGE courses:

Table 6.10 shows how the GVA uplifts calculated above can be applied to the number of learners at RBGE to estimate the total GVA uplift associated with RBGE learning activity.

Table 6.10: GVA uplift attributable student outcomes per year

RBGE courses	GVA uplift pa					
	Net student outcomes per year	Level uplift	GVAperFTE uplift	Adjustment GVA uplift figure covers 2 level uplifts	GVA uplift per course	Total GVA uplift
School visits 6	5.96	6 to 7	14,312.25	100%	14,312.25	85,301
Apprenticeship 1	3.00	0 to 1	3,817.00	100%	3,817.00	11,451
Diploma course 1	20.00	3 to 4/5	5,315.98	100%	5,315.98	106,320
Diploma course 2	18.00	3 to 4/5	5,315.98	100%	5,315.98	95,688
Certificates - 1	4.20	3 to 4/5	5,315.98	100%	5,315.98	22,327
Certificates - 2	5.85	3 to 4/5	5,315.98	100%	5,315.98	31,098
Certificates - 3	29.10	3 to 4/5	5,315.98	100%	5,315.98	154,695
Hobby/personal interest course 1	10.24	3 to 4/5	5,315.98	100%	5,315.98	54,436
Undergraduate 1	11.50	4/5 to 6	5,315.98	50%	2,657.99	30,567
Undergraduate 2	4.50	4/5 to 6	5,315.98	50%	2,657.99	11,961
Masters 1	19.00	6 to 7	14,312.25	100%	15,947.93	42,528
PhD 1	2.67	7 to 8	15,947.93	100%	15,947.93	42,528
Outside HE teaching	13.00	4/5 to 6	5,315.98	100%	5,315.98	69,108

Step 3 – identifying the proportion of GVA uplift that is a net benefit to the Scottish economy

Only learners that remain working in the Scottish economy will benefit Scottish employers and the Scottish economy on successful completion of courses. Those that leave and work outside of Scotland, will not directly benefit the Scottish economy. There may be some intangible reputational/image and relationship benefits that derive from those that work outside of Scotland, particularly foreign students. For example, there are examples of foreign students who, once in work, may influence favourable trade and inward investment decisions to the benefit of their country of study. This type of impact is not valued in this assessment.

Table 6.11 shows the calculations used to estimate the number of learners that remain and work in Scotland.

Table 6.11: GVA uplift impacts – Scotland, wider UK and overseas

RBGE courses		Impacts at the level of the Scottish economy (based on where learners will work on completion. Presumption is that they will work where they came from)					
RBGE courses	Total GVA uplift	% learners that come from Scotland	% learners that come from the rest of the UK	% learners that come from overseas	Impact in Scottish labour market	Impact in UK labour market (inc. Scotland)	Impact in Global labour market
School visits 6	85,301	100%	0%	0%	85,301	-	-
Apprenticeship 1	11,451	100%	0%	0%	11,451	-	-
Diploma course 1	106,320	63%	17%	20%	66,981	18,074	21,264
Diploma course 2	95,688	26%	45%	29%	24,879	43,059	27,749
Certificates - 1	22,327	65%	20%	15%	14,513	4,465	3,349
Certificates - 2	31,098	65%	20%	15%	20,214	6,220	4,665
Certificates - 3	154,695	37%	50%	13%	57,237	77,347	20,110
Hobby/personal interest course 1	54,436	80%	10%	10%	43,548	5,444	5,444
Undergraduate 1	30,567	40%	41%	19%	12,227	12,532	5,808
Undergraduate 2	11,961	56%	33%	11%	6,698	3,947	1,316
Masters 1	-	3%	3%	94%	1,251	1,251	40,026
PhD 1	42,528	3%	3%	94%	1,251	1,251	40,026
Outside HE teaching	69,108	20%	30%	50%	13,822	20,732	34,554
Total	715,479				366,120	201,071	420,221
					37%	20%	43%

Valuing GVA uplifts over a 10, 15 and 25-year period

There are two approaches to valuing GVA uplifts over time. Both involve calculating the present value of GVA uplifts attributable to each new batch of students that complete courses and qualify each year, but:

- The first method only takes into account the GVA uplift per new batch of learners, once, in the year of qualification
- The second method takes account of the uplift, year-on-year, for 6 to 7 years of each new batch of learners. The rationale behind this is that there are on-going benefits from the learning outcomes that will persist for some time.

Table 6.12 shows the results of the one-off uplift approach for all learners irrespective of location, while Table 6.13 shows the one-off uplift approach for Scotland alone. Table 6.14 shows the results of the year-on-year cumulative uplift approach highlighting benefits of £24-£48m over 10 to 25 years. The latter approach has been used in this evaluation because it is a more accurate estimate of the full education and training benefits to the economy.

Table 6.12: Valuing GVA uplifts over a 10, 15 and 25-year period – one-off uplift: all learners

GVA uplifts attributable to all learners	yr0	yr1-25	NPV - 10 yrs.	NPV - 15 yrs.	NPV - 25 yrs.
School visits 6	85,301	85,301	734,244	1,016,832	1,455,096
Apprenticeship 1	11,451	11,451	98,567	136,502	195,335
Diploma course 1	106,320	106,320	915,165	1,267,384	1,813,638
Diploma course 2	95,688	95,688	823,649	1,140,646	1,632,274
Certificates - 1	22,327	22,327	192,185	266,151	380,864
Certificates - 2	31,098	31,098	267,686	370,710	530,489
Certificates - 3	154,695	154,695	1,331,565	1,844,044	2,638,843
Hobby/personal interest course 1	54,436	54,436	468,565	648,901	928,583
Undergraduate 1	30,567	30,567	263,110	364,373	521,421
Undergraduate 2	11,961	11,961	102,956	142,581	204,034
Masters 1	271,933	271,933	2,340,711	3,241,579	4,638,727
PhD 1	42,528	42,528	366,066	506,954	725,455
Outside HE teaching	69,108	69,108	594,857	823,800	1,178,865
Total	987,411	987,411	8,499,326	11,770,455	16,843,623

Table 6.13: Valuing GVA uplifts over a 10, 15 and 25-year period – one-off-uplift: learners that stay in Scotland and benefit Scottish employers and the Scottish economy

GVA uplifts attributable to learners that stay in Scotland	yr0	yr1-25	NPV - 10 yrs.	NPV - 15 yrs.	NPV - 25 yrs.
School visits 6	85,301	85,301	734,244	1,016,832	1,455,096
Apprenticeship 1	11,451	11,451	98,567	136,502	195,335
Diploma course 1	66,981	66,981	576,554	798,452	1,142,592
Diploma course 2	24,879	24,879	214,149	296,568	424,391
Certificates - 1	14,513	14,513	124,920	172,998	247,562
Certificates - 2	20,214	20,214	173,996	240,961	344,818
Certificates - 3	57,237	57,237	492,679	682,296	976,372
Hobby/personal interest course 1	43,548	43,548	374,852	519,121	742,866
Undergraduate 1	12,227	12,227	105,244	145,749	208,568
Undergraduate 2	6,698	6,698	57,655	79,845	114,259
Masters 1	7,998	7,998	68,844	95,341	136,433
PhD 1	1,251	1,251	10,767	14,910	21,337
Outside HE teaching	13,822	13,822	118,971	164,760	235,773
Total	366,120	366,120	3,151,442	4,364,335	6,245,402

Table 6.14: Valuing GVA uplifts over a 10, 15 and 25-year period – year-on-year (cumulative) over 7 years: learners that stay in Scotland and benefit Scottish employers and the Scottish economy

Benefits NPV - cumulative	Yr0	yr1	yr2	yr3	yr4	yr5	yr6	yr7	Total
Tail off function		100%	98%	95%	80%	60%	40%	20%	
10 yr. NPV	3,151,442	3,151,442	3,088,413	2,993,870	2,521,154	1,890,865	1,260,577	630,288	8,688,052
15 yr. NPV	4,364,335	4,364,335	4,277,049	4,146,119	3,491,468	2,618,601	1,745,734	872,867	5,880,509
25 yr. NPV	6,245,402	6,245,402	6,120,494	5,933,132	4,996,321	3,747,241	2,498,161	1,249,080	37,035,232

6.5 Total educational impacts

The following tables show the total of all of the above strands of educational impact.

Table 6.15: Total global educational impacts

		Global £			
		1 yr. snap shot	10-yr NPV	15-yr NPV	25-yr NPV
Schools visits (assumed all from inside Scotland)	Primary, secondary, special and nursery - utility value of visit based on parent's willingness to pay for school trip	93,833	807,682	1,118,534	1,600,632
Students that stay and work in Scotland	Increased skill level/ proficiency of students that stay and work in Scotland based on estimated GVA uplift to Scottish business	366,120	18,688,052	25,880,509	37,035,232
Students from outside of Scotland	Increased skill level/ proficiency of students that work outside of Scotland based on estimated GVA uplift to Scottish business	420,221.5	17,832,477	24,695,648	35,339,686
Total		880,175	37,328,211	51,694,691	73,975,550

Table 6.16: Total Scottish educational impacts

		Net to Scottish Economy £			
Net to Scottish Economy		1 yr. snap shot	10-yr NPV	15-yr NPV	25-yr NPV
Schools visits (assumed all from inside Scotland)	Primary, secondary, special and nursery - utility value of visit based on parent's willingness to pay for school trip	93,833	807,682	1,118,534	1,600,632
Students that stay and work in Scotland	Increased skill level/ proficiency of students that stay and work in Scotland based on estimated GVA uplift to Scottish business	366,120	18,688,052	25,880,509	37,035,232
Students from outside of Scotland	Fees paid (less amount spent on salaries as already taken into account in operational impact)	96,792	1,179,752	1,633,802	2,337,984
Total		556,745	20,675,486	28,632,845	40,973,848

7 Science impacts of RBGE

Summary:

- **Expenditure** – RBGE spends approximately £2.7m per year on science activities, of which £2.0m is grant funded from Scottish Government.
- **Two types of science economic impact** - RBGE's science activities and associated economic impacts can be divided into two groups:
 - Those that derive from external researchers accessing the collections – external researchers can access the herbarium and live collections in various ways, gaining valuable knowledge (via personal visit (131 researcher visit days per year), via post, via download of images and records (560,000 images pa, 98,000 records per year). This generates three types of economic impact (i) visiting researcher spend in the Scottish economy (ii) the direct value of accessing the collection (calculated as a shadow value based on time spent multiplied by hourly GVA per researcher), and (iii) downstream benefits of knowledge accessed from the collections e.g. enabling external research projects to achieve greater success and/or sooner. The majority of the impacts from (i) and (ii) are net to the Scottish economy
 - Those that derive from the science research projects in which RBGE staff are currently engaged. A number of these projects will have direct and major economic impact on certain countries in the world. Only a proportion (33-50%) of total benefits have been attributed to RBGE depending on the partners involved. Three such projects have been examined in detail (i) improved cocoa plant variety that will result in increased yield (£37m-£75m per year by year 25 attributable to RBGE inputs); (ii) improving the locations in which new rubber crops are planted that will result in improved output (£140m-£671m per year by year 25 attributable to RBGE inputs) and (iii) reduction of illegal logging in Tanzania that will save the Tanzanian Government (£76m-£152m per year by year 25 attributable to RBGE inputs) in lost tax revenue.
 - Using these projects as an illustrative sample, results have been scaled up to estimate the potential impact of all 100 or so current research projects (applying low, medium and high scenario multiples of 5, 6 and 7). The majority of these impacts benefit the global economy but a proportion of the impact will benefit the Scottish economy. Low, medium and high scenarios have been modelled assuming that 15%, 20% and 25% of the benefits directly affect, or feed back to the Scottish economy
- **Economic impacts** – RBGE science activities in total generate a potential economic benefit to the global economy of £783m GVA (£294m net to the Scottish economy) by year 10, £1.5bn GVA (£0.5bn to Scotland) by year 15 and £4.5bn GVA (£1.2bn to Scotland) by year 25 (NPV@3.5%).
- **Economic Return on Investment (ERol)** – these impacts potentially generate the following ERol on the science element of the grant:
 - Global impact: £26.47 per £1 of grant by year 10, £42.44 by year 15 and £109.68 by year 25
 - Impact net to the Scottish economy: £6.29 per £1 of grant by year 10, £9.64 by year 15 and £22.94 by year 25
- **Excluding less certain science impact figures** – namely those that derive from the outcome of longer term RBGE science research projects and only include the benefits that derive from accessing the collection, the majority of these benefits are net to the Scottish economy:
 - The economic benefits to Scottish economy that derive from this are £171m by year 10, £248m by year 15 and £385m by year 25 (NPV@3.5%).

RBGE's scientific mission¹⁰ is to explore, conserve and explain plant life around the globe. RBGE has a leading role in biodiversity research and conservation and is one of the most active botanic gardens in the world. It is conducting research in over 40 countries worldwide. Its plant collections are globally significant with 13,000 plants in the living collection, including some that are now extinct in the wild. The RBGE herbarium has over 3 million specimens collected over hundreds of years and continues to be an active source of information for plant research and exploration. RBGE's archive and library are also internationally recognised and support Scotland's position as a leading nation in scientific discovery.

RBGE's research activities generate several different forms of economic impact, internationally and at the level of the Scottish economy. These can be divided into two broad categories of economic impact:

- Firstly, economic impacts that derive from external researchers accessing the national collections and the use of the results in research projects. The approach used to estimate these impacts is (i) to estimate the spend on travel and subsistence of visiting researchers (ii) the value of the visit to visiting researchers measured in terms of time spent multiplied by GVA per researcher and (iii) the possible contribution of the knowledge gained from the visit to external research projects
- Secondly economic impacts that derive from research projects that RBGE staff are directly involved in, in Scotland and internationally. Given the breadth of RBGE's research, it has not been possible to review all projects in detail. The approach has been to select a number of case studies from RBGE's current science research projects and calculate their potential impacts. The case studies have been selected to provide an overview of RBGE science in terms of scale, geography and socio-economic significance. Then, treating these case studies as a sample, 'scale up' factors have been applied to estimate the possible economic impact of the full portfolio of current projects. The impacts of legacy projects have not been taken into account; neither have the impact of future potential research projects been considered due to the limitations of the exercise.

The economic impact of both categories of activity has been calculated globally and at the level of the Scottish economy.

Aspects of both assessments required the development of assumptions. For this reason, some of the results are less certain. Hence, the results at the end of this section are presented in two ways:

- Firstly, the science activity impact results that are most certain, excluding the less certain elements.
- Secondly the results for all science impacts, though elements of these are subject to major assumptions that should be treated with caution.

The case studies presented in the section are as follows:

- RBGE National Collections
- Cocoa in Colombia
- Illegal logging in Tanzania
- Rubber planting
- Flora of Nepal
- Solanum research

¹⁰ www.rbge.org.uk/about-us

7.1 Economic impact of RBGE National Collections

RBGE's national collections are an important resource for Scotland. The living collection maintains 13,000 plants while the herbarium holds around three million specimens with approximately 20,000 being added per year.

This assessment considers the economic impact that derives from the collections, mainly in relation to scientific research. It does not include any assessment of visitor enjoyment (see Section 5) nor does it include RBGE's archive and library.

The collections can be accessed in a number of ways as follows:

- Visits to the herbarium and living collection
- Postal samples sent out to researchers around the world
- Download – of either a high quality digital image and/or a database record
- Destructive sampling e.g. for DNA extraction.

RBGE is working to make its collections more accessible through digital imaging of herbarium specimens. This is a painstaking process given the number of samples and the fact that to be useful for scientific purposes, such images have to be extremely high resolution. Approximately 10% of the specimens in the herbarium now have a digital image available and a third have a record entry in the data base. There were approximately 98,000 image downloads and 560,000 record downloads in the financial year 2015/16. In addition, there were 130 research visitors from 22 countries spending 551 research days at RBGE to study specimens. The average length of stay was 4.2 days. Countries of origin included UK, China 17, Germany 6, USA 5, Japan 4, Russia 3, Singapore 3.

For the living collection, from Jan 2015 to September 2016 RBGE sent out 700 plant items in 118 batches to 92 different recipients in 28 countries from Australia to Vietnam.

7.1.1 Benefits to the Scottish Economy of accessing specimens held in the collections

The following types of economic benefit are identified from accessing the specimens in the collections:

- Spending on travel and subsistence in Scotland by researchers from outside of Scotland
- The utility value of accessing the specimens – via visit, postal or online – to researchers, measured in terms of time spent in accessing and researching the collections
- Contribution of the knowledge derived from accessing specimens to research projects that result in local or global economic benefit

7.1.2 Spending on travel and subsistence in Scotland by researchers from outside of Scotland

Table 7.1 shows that there were 131 researcher visits to the Collections recorded for the last year. It is assumed that 95% of these were by researchers from outside of Scotland. On the basis that researchers spend £80 per day in Scotland during the visit on travel, accommodation, food and drink (Visit Scotland), this generates an annual research visitor spend in Scotland of £41,876.

Table 7.1: Estimate of visiting scientist spend in Scotland on travel, accommodation and subsistence

Estimate of visiting scientist spend in Scotland on travel, accommodation and subsistence		
	Researchers from Scotland	Researchers from outside Scotland
No science visits pa	131	
% assumed from inside and outside Scotland	5%	95%
Number assumed from inside and outside Scotland	6.6	124.5
Ave spend per day on travel, accommodation and subsistence in Scotland ¹¹	£80	£80
Total spend per stay (4.2 days) per year	£2,204	£41,876

Table 7.2 shows the present value of visiting researcher visitor spend over a 10, 15 and 25-year period.

Table 7.2: Valuing spend in Scotland on travel, accommodation and subsistence, of visiting researchers from outside Scotland over a 10, 15 and 25-year period

Valuing Spending in Scotland, on travel and subsistence, of Researchers from outside Scotland visiting the Collections, over a 10, 15 and 25-yr period					
	Base	yr1-25	NPV - 10 yrs.	NPV - 15 yrs.	NPV - 25 yrs.
Estimate of visiting scientist spend in Scotland on travel, accommodation and subsistence (£)	41,876	41,876	360,455	499,184	714,336

¹¹ Based on Visit Scotland publication 'Scotland The key facts on tourism in 2015'

7.1.3 The utility value of accessing the specimens – via visit, postal or online – to researchers, measured in terms of time spent in accessing specimens

The utility value to researchers (a form of shadow pricing) is calculated of accessing specimens with reference to the amount of time they spend on accessing the specimens, applied to average GVA per FTE for research activities (£26.22 per hour from ONS).

Low, medium and high scenarios are estimated by varying the assumed number of hours spent on accessing each specimen via visiting, downloading and postal from 0.5-2 hours. It is assumed that 5% of researchers are from Scotland. Table 7.3 shows the calculations for each scenario.

Table 7.3: Estimate of visiting scientist spend in Scotland on travel, accommodation and subsistence

Calculating value of accessing specimens in terms of researcher's time for Scotland only		
Low – Medium- High Scenarios	Hrs	GVA
Physical visit (assume 8 hour day and 4.2 days on average)	33.6	881.14
Review digitised and postal specimens	0.5-2.0	13.11-52.45
Review records and downloading	0.5-2.0	13.11-52.45
Low		
Value of visit/download in terms of research time devoted to action	Scotland	Global
Physical visits	5,780	115,597
Download digitised image and postal	64,250	1,284,991
Download record	367,140	7,342,804
Total	437,170	8,743,392
Medium		
Value of visit/download in terms of research time devoted to action	Scotland	Global
Physical visits	5,780	115,597
Download digitised image and postal	128,499	2,569,981
Download record	734,280	14,685,608
Total	868,559	17,371,187
High		
Value of visit/download in terms of research time devoted to action	Scotland	Global
Physical visits	5,780	115,597
Download digitised image and postal	256,998	5,139,963
Download record	1,468,561	29,371,217
Total	1,731,339	34,626,776

Table 7.4 shows the present value of the researcher time spent accessing specimens over a 10, 15 and 25-year period in Scotland.

Table 7.4: Present value of the researcher time spent accessing specimens over a 10, 15 and 25

Value of accessing specimen in terms of research time involved in activity								
		yr1	yr2	yr3...	...y.r25	NPV - 10 yrs.	NPV - 15 yrs.	NPV - 25 yrs.
annual % increase		2%	2%	2%	2%			
Value of accessing specimen in terms of research time involved in activity	L	9,180,561	9,364,172	9,551,456	14,766,357	86,043,916	124,578,409	193,700,600
	M	18,239,746	18,604,541	18,976,632	29,337,487	170,950,242	247,509,762	384,840,277
	H	36,358,115	37,085,277	37,826,983	58,479,747	340,762,894	493,372,469	767,119,632

7.1.4 Contribution of the knowledge derived from accessing specimens to research projects that result in local or global economic benefit

The final element of economic impact attributed to the national collections is the potential down-stream impact from the knowledge derived from access to the collections by external researchers, thus helping these projects achieve greater/ earlier success. In the absence of any hard evidence of this contribution, a very simple assumption has been made as a proxy to calculate the impact, namely that 5% of downloads/postal specimens contribute to projects that will have an economic impact and that the attributable contribution is equal to 5% of the value of the time spent in accessing the collection.

Table 7.5: Present value of the researcher time spent accessing specimens over a 10, 15 and 25

Collections down-stream benefits - 5% of downloads/postal specimens contribute to projects that will have an economic impact		1-yr snapshot	10-yr NPV	15-yr NPV	25-yr NPV
Global impact	Low	4,435,253	43,021,958	62,289,205	96,850,300
	Medium	17,623,736	170,950,242	247,509,762	384,840,277
	High	52,695,293	511,144,340	740,058,703	1,150,679,448
Impact at the level of the Scottish Economy	Low	665,288	6,453,294	9,343,381	14,527,545
	Medium	3,524,747	34,190,048	49,501,952	76,968,055
	High	13,173,823	127,786,085	185,014,676	287,669,862

7.1.5 Total impacts of the collections

A summary of the total impacts of the collections is set out in Tables 7.6 (Global impacts) and 7.7 (Scottish impacts).

Table 7.6: Summary of the total impacts of the collections over a 1, 10, 15 and 25-year period

Global collections' impacts - range		1-yr snapshot	10-yr NPV	15-yr NPV	25-yr NPV
Collections – all research visitors spend in Scotland	Low	44,080	379,427	525,457	751,933
	Medium	44,080	379,427	525,457	751,933
	High	44,080	379,427	525,457	751,933
Collections - accessing specimens	Low	9,180,561	86,043,916	124,578,409	193,700,600
	Medium	18,239,746	170,950,242	247,509,762	384,840,277
	High	36,358,115	340,762,894	493,372,469	767,119,632
Collections down-stream benefits - 5% of downloads/postal contribute to projects that will have an economic impact	Low	4,435,253	43,021,958	62,289,205	96,850,300
	Medium	17,623,736	170,950,242	247,509,762	384,840,277
	High	52,695,293	511,144,340	740,058,703	1,150,679,448
Total impact of the collections	Low	13,659,895	129,445,301	187,393,070	291,302,833
	Medium	35,907,562	342,279,910	495,544,981	770,432,488
	High	89,097,488	852,286,661	1,233,956,629	1,918,551,012

Table 7.7: Summary of the Scottish impacts of the collections over a 1, 10, 15 and 25-year period

Collections' impacts in the Scottish economy		1-yr snapshot	10-yr NPV	15-yr NPV	25-yr NPV
Collections – non-Scottish research visitors spend in Scotland	Low	41,876	360,455	499,184	714,336
	Medium	44,080	379,427	525,457	751,933
	High	44,080	379,427	525,457	751,933
Collections - accessing specimens	Low	9,180,561	86,043,916	124,578,409	193,700,600
	Medium	18,239,746	170,950,242	247,509,762	384,840,277
	High	36,358,115	340,762,894	493,372,469	767,119,632
Collections - down-stream - 5% of downloads/postal contribute to projects with economic impact	Low	665,288	6,453,294	9,343,381	14,527,545
	Medium	3,524,747	34,190,048	49,501,952	76,968,055
	High	13,173,823	127,786,085	185,014,676	287,669,862
Total impact of the collections	Low	9,887,725	92,857,665	134,420,974	208,942,481
	Medium	21,808,573	205,519,717	297,537,171	462,560,266
	High	49,576,018	468,928,405	678,912,601	1,055,541,426

7.2 Economic Impact of Scientific Research Projects

7.2.1 Case Study 1: Cocoa in Colombia

RBGE has a long-term association with the country of Colombia in South America, which, as the second most biodiverse country on the planet, is a priority area for biodiversity research and conservation.

Collaborations have included the University of the Andes hosting an RBGE visiting professor plus on-going collaborative research projects involving RBGE, the University of Rosario and other parties such as the USDA and University of Miami.

One of these research projects studies the evolutionary history and genetic diversity of cocoa, which is an important crop to Colombia, producing around 47,000 tonnes worth some \$100m at the farm gate (latest data from FAO). The research¹² found cocoa plants to be representatives of a very old species with great potential to tap into undiscovered genetic diversity that could help improve disease resistance in the modern crop.

There are two fungal diseases which are economically significant in South America – Witches Broom and Frosty Pod Rot. The impact of these diseases can be measured from past outbreaks. For example, a Witches Broom outbreak in Brazil saw cocoa production drop by 76% from 380,000 tonnes to 90,000 tonnes per year in the late 1990s¹³. It devastated rural cocoa production in the country with the loss of many livelihoods in the cocoa supply chain and hardship for farmers and their families. An outbreak such as this could cost Colombian farmers \$80m per year.

A new research project involving RBGE and the University of Rosario is seeking to establish the economic value of native populations of cocoa plants. The project has the following stages:

- Compare the genetic variation of Colombian cocoa plants with that of other countries
- Search for resistance to Witches Broom and Frosty Pod Rot in cocoa cultivars and native populations
- Calculate the potential economic value of alternative varieties from native populations
- Consider ways to introduce resistant varieties to the Colombian industry

Colombia is currently a net importer of chocolate and its government aims to improve productivity. Cocoa plantations have also provided an important alternative to cocaine farming and have become known as the 'peace crop' in Colombia.

7.2.1.1 Modelling the potential global economic benefit of the cocoa project

The potential global economic benefits of the project have been modelled as follows:

- First, identifying the total value of the cocoa crop in the target countries, based on current farm gate prices in USD, converted to £GB
- Secondly making conservative estimates of the increased yield that could result from adoption of new cultivars resistant to fungal diseases
- Thirdly estimating the losses avoided from infrequent but catastrophic outbreaks of fungal disease by adoption of resistant cultivars

These calculations have been applied first to Colombia, the host of the project and then to other cocoa producing countries in South America.

¹² Richardson, Whitlock, Meerow, & Madriñán (2015) 'The age of chocolate: a diversification history of Theobroma and Malvaceae' in *Frontiers in Ecology and Evolution*.

¹³ Common Fund for Commodities 2005

7.2.1.2 Modelling Colombia Cocoa crop yield increases

The last data from FAOstat show the value of the Colombia cocoa crop, at farm gate prices (2013), as circa \$100m (£77m at a 1.3 exchange rate).

Cocoa plants with improved resistance will generate a higher yield increasing the annual tonnage produced, and, all else being equal, the value of the crop. Table 7.5 shows how this has been modelled:

- Using a low, medium and high yield increase scenario (1%, 1.5% and 2% respectively) per year on the original crop value.
- Assuming that this increase does not commence until year 12 and that there is a build up over years 12, 13 and 14. This is because of the time taken to develop a new variety. Also cocoa plants have a 7-10-year life and take 2-3 years to be productive.
- Calculating the present value of the yield increase on a one-off basis and on a year-on-year basis, applied to the original value of the crop.
- Not including for any replanting costs as it is assumed that farmers will plant with the best available varieties as and when required and that new resistant varieties will substitute other varieties at that time.

Table 7.5: Value of the Colombian cocoa crop

Modelling increase in cocoa output due to project (£)											
		Assumed increase in output per year as a result of the project	yr1	yr2	yr11	yr12	yr13	yr25	NPV - 10 yrs.	NPV - 15 yrs.	NPV - 25 yrs.
Impact of project on increased output pa	L	1%	0%	0%	33%	66%	100%	100%			
	M	1.50%	0%	0%	33%	66%	100%	100%			
	H	2%	0%	0%	33%	66%	100%	100%			
One off uplift	L		-	-	253,846	507,692	769,231	769,231	-	2,003,828	5,956,018
	M		-	-	380,769	761,538	1,153,846	1,153,846	-	3,005,742	8,934,028
	H		-	-	507,692	1,015,385	1,538,462	1,538,462	-	4,007,656	11,912,037
Annual uplift applied to original year-on-year	L		-	-	253,846	761,538	1,530,769	10,761,538	-	5,081,351	41,468,186
	M		-	-	380,769	1,142,308	2,296,154	16,142,308	-	7,622,026	62,202,280
	H		-	-	507,692	1,523,077	3,061,538	21,523,077	-	10,162,702	82,936,373

7.2.1.3 Modelling avoidance of Colombian Cocoa crop losses due to avoidance of periodic devastating outbreaks of disease

Table 7.6 shows how avoidance of potential cocoa crop losses in Colombia has been modelled due to improved fungal disease resistance.

- Modelling three scenarios, a low, medium and high, assuming that devastating outbreaks of disease that affect 40%, 60% and 80% of total crop value in line with the Brazilian outbreak described earlier.
- assuming that 100% of loss is avoided due to the new plant variety
- assuming that devastating outbreaks occur in years 14 and 21

Table 7.6: modelling the avoidance of infrequent but devastating outbreaks of disease

Cocoa Colombia - avoidance of infrequent but devastating outbreaks of disease										
			yr0	yr1...	...yr14...	...yr21...	...yr25	NPV - 10 yrs.	NPV - 15 yrs.	NPV - 25 yrs.
Total annual value of crop £		76,923,077								
Rate of Loss	L	40%	0%	0%	100%	100%	0%			
	M	60%	0%	0%	100%	100%	0%			
	H	80%	0%	0%	100%	100%	0%			
Value of Loss	L		-	-	30,769,231	30,769,231	-	-	20,362,563	36,367,353
	M		-	-	46,153,846	46,153,846	-	-	30,543,845	54,551,030
	H		-	-	61,538,462	61,538,462	-	-	40,725,126	72,734,707

7.2.1.4 Modelling the benefits to the wider cocoa industry

It is assumed that the project is developed and first rolled out in Colombia after which, if successful, it is likely to be adopted by other cocoa producing nations.

The last data showing the value of the wider cocoa crop, at farm gate prices (FAOstat 2013), suggests a crop value of \$724m across the whole of South America. Assuming not all countries adopt, the model allows for 70% of countries adopting which gives a value of \$500m (£385m at a 1.3 exchange rate) as shown in Table 7.7.

Table 7.7: Value of the wider cocoa crop

Cocoa - adoption across South America	100%	70%	1.3
	\$	\$	£
Farm gate output 2013	724,000,000	500,000,000	384,615,385

Tables 7.8 and 7.9 show how the benefits for the wider cocoa crop have been modelled.

Regarding the increase in yield, Table 7.8 shows that:

- a further time lag is assumed before other nations adopt the improved variety
- benefits first accrue in year 15.

Table 7.8: Yield increase in the wider cocoa crop

Cocoa – across 70% of S America - increase in output													
			yr0	yr1	yr2	yr14	yr15	yr16	yr17	yr25	NPV - 10 yrs.	NPV - 15 yrs.	NPV - 25 yrs.
Total annual value of crop		384,615,385											
Impact of project on increased output pa	L	1%	0%	0%	0%	0%	33%	66%	100%	100%			
	M	1.50%	0%	0%	0%	0%	33%	66%	100%	100%			
	H	2%	0%	0%	0%	0%	33%	66%	100%	100%			
One off uplift	L		-	-	-	-	253,846	507,692	769,231	769,231	-	156,822	3,952,902
	M		-	-	-	-	380,769	761,538	1,153,846	1,153,846	-	235,232	5,929,353
	H		-	-	-	-	507,692	1,015,385	1,538,462	1,538,462	-	313,643	7,905,804
Annual uplift applied to original year-on-year	L		-	-	-	-	253,846	761,538	1,530,769	7,684,615	-	156,822	20,734,896
	M		-	-	-	-	380,769	1,142,308	2,296,154	11,526,923	-	235,232	31,102,344
	H		-	-	-	-	507,692	1,523,077	3,061,538	15,369,231	-	313,643	41,469,792

Regarding avoiding diseases outbreaks across South America, Table 7.9 shows the modelling of:

- three scenarios, a low, medium and high, assuming that devastating outbreaks of disease that affect 40%, 60% and 80% of total crop value
- assuming that 100% of losses are avoided due to the new plant variety
- assuming that one devastating outbreak occurs in year 21

Table 7.9: Modelling the avoidance of infrequent but devastating outbreaks of disease in the wider cocoa crop

Cocoa all of S America - avoidance of infrequent but devastating outbreaks of disease											
			yr0	yr1	yr2	yr20	yr21	yr22	NPV - 10 yrs.	NPV - 15 yrs.	NPV - 25 yrs.
Total annual value of crop £		384,615,385									
Rate of Loss	L	40%	0%	0%	0%	0%	100%	0%			
	M	60%	0%	0%	0%	0%	100%	0%			
	H	80%	0%	0%	0%	0%	100%	0%			
Value of Loss	L		-	-	-	-	30,769,231	-	-	-	15,463,566
	M		-	-	-	-	46,153,846	-	-	-	23,195,349
	H		-	-	-	-	61,538,462	-	-	-	30,927,131

7.2.1.5 The combined benefits of increased yield and avoidance of disease loss to Colombia and wider cocoa crops

Table 7.10 aggregates the results of the modelling above and shows the combined benefits of increased yield and avoidance of disease losses to Colombia and the wider cocoa crops of South America:

- The present value of the combined potential benefits over a 25-year period, are estimated to be between £114m and £228m.

Table 7.10: The combined benefits of increased yield and avoidance of disease loss to the Colombia and wider cocoa crops

Cocoa - increase in output and prevention of infrequent but catastrophic outbreaks of disease - Colombia initially then across 70% of S America										
		NPV - 10 yrs.			NPV - 15 yrs.			NPV - 25 yrs.		
		Increase output	Disease prevention	Total	Increase output	Disease prevention	Total	Increase output	Disease prevention	Total
Colombia		-	-	-	5,081,351	20,362,563	25,443,914	41,468,186	36,367,353	77,835,540
	L	-	-	-	5,081,351	20,362,563	25,443,914	41,468,186	36,367,353	77,835,540
	M	-	-	-	7,622,026	30,543,845	38,165,871	62,202,280	54,551,030	116,753,310
	H	-	-	-	10,162,702	40,725,126	50,887,828	82,936,373	72,734,707	155,671,080
Rest of S America		-	-	-	156,822	-	156,822	20,734,896	15,463,566	36,198,462
	L	-	-	-	156,822	-	156,822	20,734,896	15,463,566	36,198,462
	M	-	-	-	235,232	-	235,232	31,102,344	23,195,349	54,297,693
	H	-	-	-	313,643	-	313,643	41,469,792	30,927,131	72,396,924
Colombia + rest of S America		-	-	-	5,238,172	20,362,563	25,600,735	62,203,083	51,830,919	114,034,002
	L	-	-	-	5,238,172	20,362,563	25,600,735	62,203,083	51,830,919	114,034,002
	M	-	-	-	7,857,258	30,543,845	38,401,103	93,304,624	77,746,379	171,051,003
	H	-	-	-	10,476,345	40,725,126	51,201,471	124,406,165	103,661,838	228,068,003

33% of these benefits are taken as being attributable to RBGE.

7.2.2 Case Study 2: Improving Sustainability of Natural Rubber

Strong global demand for rubber has seen prices rise, and this has encouraged producers to plant new rubber plantations in core rubber producing countries such as Thailand, China, Vietnam, Laos and Cambodia. Prices peaked in 2011 at \$2,700 per tonne but have since fallen back to less than \$2,000, while total production of natural rubber has continued to increase, reaching 12m tonnes in 2013 (FAOstat latest data).

Finding sustainable sources of rubber is a key challenge for industry. Synthetic rubbers are reliant on fossil fuels while natural rubbers can be grown sustainably if planted and harvested in the right way.

Rubber is a long term crop requiring seven years before the first harvest is achieved; while a plantation can be expected to have a total life of twenty-five years. High rubber prices have led to the establishment of plantations in unsuitable areas, sometimes involving deforestation. As rubber prices have fallen, many plantations are no longer viable.

Creation of these plantations has displaced alternative crops such as tea, bananas and sugar cane. The resultant monoculture requires chemicals to control pests, while the lack of undergrowth allows moisture to escape from the soil. When combined with the high water demand of rubber, this can lead to water shortages in the dry season and soil erosion.

RBGE has been monitoring these developments and, concerned at the threat to the rich biodiversity of these countries, has developed a mapping capability to support development of sustainable rubber plantations. This mapping takes account of factors such as steepness of slopes, altitude, frequency of frost and wind conditions and susceptibility to drought. For example, rubber plants are very susceptible to wind and frost.

Alongside industry efforts to find new sources of rubber, RBGE's work has been at the forefront of highlighting the need for sustainable natural rubber plantations.

RBGE's work identifies the best locations for natural rubber and, in particular, locations where rubber should not be grown. RBGE's mapping assessment has found that 98% of new plantations in the last five years are located in unsuitable growing areas, resulting in poor yields, or total crop failure.

Industry is responding to the need to develop sustainable supply chains. Michelin is the first major tyre maker to pledge to eliminate rubber from deforested areas in its supply chain. RBGE is working with the World Agro-forestry Centre to help communicate the need for sustainable planting to rubber farmers. RBGE is also providing information to a UK tyre research company on sustainability. By helping to improve the growing of rubber, farmers will get better yields with lower losses and biodiversity losses will be avoided. The potential benefits that could result from RBGE's work in this area have been modelled.

The global natural rubber crop was worth \$21.6bn at the farm gate in 2013 (FAOstat latest data). The five countries where RBGE has been working account for 48% of total production worth \$10.4bn. This is £8bn at a 1.3 exchange rate. To calculate the benefits of planting in more appropriate locations:

- The yield improvements that may be achieved through better planting for 1% of the total crop value of the 5 countries (1% of £8bn = £800m) have been modelled as follows:
 - Three scenarios have been modelled – low, medium and high – of the proportion of £800m that is better-planted, the timing and the yield improvements. Regarding timing, it is assumed that despite best intentions, there will be a time lag before better locations are found, land rights acquired and new planting takes place.
 - Allowing for the 7-year period following planting that it takes before the first year of yield, it is assumed in all cases that the first year of yield is year 8.
 - It is assumed for all three scenarios that 5% of the £800m benefits from improved yield in year 8, and that the percentage that benefits increases year-on-year at a rate of 2%, 3%, and 4%, for the three scenarios (low, medium and high)
 - It is assumed that better planting provides two benefits, namely avoidance of total crop failure for a proportion of the crop, and for the remainder, improved yield. Scenarios have been modelled for each of these as follows. It is assumed that total crop failure of 2.5%, 5% and 7.5% is avoided as a result of better planting and that of the remainder, yield improvements of 20%, 40% and 60% are assumed.

There has been no calculation of the benefits that then flow through reducing the impact of poor planting of rubber crops. Improved planting of rubber crops will result in reduced displacement of alternative crops like tea, bananas and sugar cane; reduced creation of resultant monoculture and consequent need to treat with chemicals to control pests; and reduced loss of moisture leading to water shortages in the dry season and soil erosion. Reductions of these adverse impacts of poor rubber crop planting could be quite substantial.

The methodology above, gives an indication of the potential scale of long term benefits to the rubber industry of optimal planting. Calculations for the low scenario are shown in tables 7.11 and 7.12.

Table 7.11: Modelling the present value (£) of the yield improvement of planting a new crop, equivalent to 1% of the global crop value, in an optimal location over a 10, 15 and 25-year period

Modelling loss for % total output											
	£	yr1...	...yr8	yr9...	...yr22	yr23	yr24	yr25	NPV - 10 yrs.	NPV - 15 yrs.	NPV - 25 yrs.
Crop value per year - optimal crop	2% increments from year 8 onwards	0.0%	5.0%	7.0%	33.0%	35.0%	37.0%	39.0%			
1%	80,000,000	-	4,000,000	5,600,000	2,076,923	1,846,154	1,384,615	923,077	12,679,532	52,069,032	173,048,912
% total failure	2.5%	-	100,000	140,000	26,400,000	28,000,000	29,600,000	31,200,000	316,988	1,301,726	4,326,223
remainder	98%	-	3,900,000	5,460,000	660,000	700,000	740,000	780,000			
% poor yield	20%	-	780,000	1,092,000	25,740,000	27,300,000	28,860,000	30,420,000	2,472,509	10,153,461	33,744,538
Total loss		-	880,000	1,232,000	5,148,000	5,460,000	5,772,000	6,084,000	2,789,497	11,455,187	38,070,761

Table 7.12: Modelling the year-on-year increased yield value

Modelling year-on-year increased yield									
	yr8	yr9	yr10	yr11	yr24	yr25	NPV - 10 yrs.	NPV - 15 yrs.	NPV - 25 yrs.
Year 1	880,000	1,232,000	1,584,000	1,936,000	6,512,000	6,864,000	2,789,497	11,455,187	38,070,761
Year 2	-	880,000	1,232,000	1,584,000	6,160,000	6,512,000	1,572,239	9,071,811	33,878,863
Year 3	-	-	880,000	1,232,000	5,808,000	6,160,000	645,683	6,979,138	29,977,667
Year 4	-	-	-	880,000	5,456,000	5,808,000	-	5,348,194	27,279,852
Year 5	-	-	-	-	5,104,000	5,456,000	-	3,885,238	24,647,169
Year 6	-	-	-	-	4,752,000	5,104,000	-	2,604,025	22,087,483
Year 7	-	-	-	-	4,400,000	4,752,000	-	1,519,071	19,609,129
Year 8	-	-	-	-	4,048,000	4,400,000	-	645,683	17,220,936
Year 9	-	-	-	-	3,696,000	4,048,000	-	-	14,932,251
Year 10	-	-	-	-	3,344,000	3,696,000	-	-	12,752,965
Year 11	-	-	-	-	2,992,000	3,344,000	-	-	10,693,540

Modelling year-on-year increased yield									
Year 12				-	2,640,000	2,992,000	-	-	8,765,035
Year 13					2,288,000	2,640,000	-	-	6,979,138
Year 14					1,936,000	2,288,000	-	-	5,348,194
Year 15					1,584,000	1,936,000	-	-	3,885,238
Year 16					1,232,000	1,584,000	-	-	2,604,025
Year 17					880,000	1,232,000	-	-	1,519,071
Year 18					-	880,000	-	-	645,683
						Total	5,007,419	41,508,348	280,896,998

50% of these benefits are taken as being attributable to RBGE.

7.2.3 Case Study 3: Illegal Logging in Tanzania

Tanzania is a heavily forested country with around half of its land area consisting of forests naturally regenerated from native woodlands. Plantations account for only 1% of land area. RBGE has been working in the country to highlight the scale of illegal logging and how it can be controlled. Control of corruption is a priority in Tanzania. A report by TRAFFIC estimated that the government lost over \$58 million in tax revenue from illegal logging in one year (2004-05).¹⁴ This is £45m at a 1.3 exchange rate. At this time, it was estimated that 97% of logging was illegal.

In 2010, RBGE developed a model to predict where the most likely sites for illegal logging would be. This model focused on the coastal forest area of some 2,700 sq km. The aim is to help the Central Government and District Forest Offices to target their resources more effectively. The work has raised awareness of the issues and supported the Government in its efforts to stamp out corruption and capture lost revenues.

The deforestation rate has dropped from 1% in the 1990s to 0.8% for the period 2010-15 (FAO, 2015). Associated annual carbon emissions have dropped from 0.63 Mt CO₂ to 0.2 Mt CO₂.

It is difficult to get accurate data on the impact of RBGE's work. However, there is increased awareness of the urgency of the need to act to save the forests meaning that forest management and conservation costs have increased but with the money being better spent. Revenue collection has also increased

RBGE's recent surveys have found a substantial reduction in illegal logging since the original report in 2004/05 though it is not possible to quantify this yet as data are still being inputted.

To estimate the potential impacts of this work, the present value of reduced tax losses through better monitoring of logging and reduced illegal logging has been modelled from \$58m per year (£45m at a 1.3 exchange rate) – based on net loss reductions of 20%, 30% and 40%, over a 10, 15 and 25-year period. Table 7.13 shows the calculations.

¹⁴ Milledge et al. (2007) Forestry, Governance and National Development: Lessons Learned from a Logging Boom in Southern Tanzania. Report by TRAFFIC

Table 7.13: Modelling increased export taxation derived from better monitoring of logging and reduction of illegal logging

Tax loss reduction through reducing illegal logging								
	% reduction in lost tax revenue	yr1	yr2....yr24	yr25	NPV - 10 yrs.	NPV - 15 yrs.	NPV - 25 yrs.
L	20.0%	8,923,077	8,923,077	8,923,077	8,923,077	76,807,049	106,367,719	152,213,126
M	30.0%	13,384,615	13,384,615	13,384,615	13,384,615	115,210,573	159,551,579	228,319,689
H	40.0%	17,846,154	17,846,154	17,846,154	17,846,154	153,614,098	212,735,439	304,426,253

50% of these benefits are assumed to be attributable to RBGE.

7.2.4 Conclusions - economic impact of the 3 case studies – cocoa, rubber and logging

Tables 7.14 and 7.15 show the total impacts of the three science projects and the impacts attributable to the inputs of RBGE. Attribution reflects the fact that RBGE is working with partners on these projects and only impacts directly due to RBGE are included.

Table 7.14: Total impacts of the three science projects

Total impacts of the three science projects				
		NPV - 10 yrs.	NPV - 15 yrs.	NPV - 25 yrs.
Cocoa - S America	L	-	25,600,735	114,034,002
	M	-	38,401,103	171,051,003
	H	-	51,201,471	228,068,003
Rubber	L	5,007,419	41,508,348	280,896,998
	M	10,805,676	100,223,615	732,876,495
	H	17,323,716	174,813,684	1,343,111,706
Logging	L	76,807,049	106,367,719	152,213,126
	M	115,210,573	159,551,579	228,319,689
	H	153,614,098	212,735,439	304,426,253
Total of these three flagship projects	L	81,814,468	173,476,803	547,144,127
	M	126,016,249	298,176,297	1,132,247,187
	H	170,937,814	438,750,593	1,875,605,962

Table 7.15: Impacts of the three science projects attributable to RBGE

Impacts of the three science projects attributable to inputs of RBGE					
		RBGE attribution	NPV - 10 yrs.	NPV - 15 yrs.	NPV - 25 yrs.
Cocoa - S America	L	33%	-	8,448,243	37,631,221
	M	33%	-	12,672,364	56,446,831
	H	33%	-	16,896,485	75,262,441
Rubber	L	50%	2,503,709	20,754,174	140,448,499
	M	50%	5,402,838	50,111,807	366,438,247
	H	50%	8,661,858	87,406,842	671,555,853
Logging	L	50%	38,403,524	53,183,860	76,106,563
	M	50%	57,605,287	79,775,790	114,159,845
	H	50%	76,807,049	106,367,719	152,213,126
Total of these three flagship projects	L		40,907,234	82,386,277	254,186,283
	M		63,008,125	142,559,961	537,044,923
	H		85,468,907	210,671,046	899,031,421

7.2.5 Scaling up the impact of the 3 case studies to estimate the impact of all other RBGE research projects

The time and budget was not available for a more exhaustive audit of RBGE current and legacy research project activity, hence the results of the three case studies – cocoa, rubber and logging, have been used to prepare a very approximate estimate of the possible impact of all RBGE current research project activities, by applying a scale up factor.

Three scale up scenarios have been modelled, applying a factor of 5, 6 and 7. These factors were agreed in discussion with RBGE senior staff through consideration of the overall scientific research effort of RBGE and the proportion that these three projects represent.

Although a crude method, it does provide a working estimate of the total global economic benefit of RBGE's current portfolio of research activities. The figures should be treated with appropriate caution however and suitably caveated, given the crude ready-reckoning nature of the scale up assessment.

This said, within the limitations of this exercise, neither the impacts of legacy projects, many of which will be nearer to maturity than current projects, nor the impacts of future rounds of project funding and research activity have been modelled. In this sense, only looking at the benefits of the current portfolio of projects could be regarded as a very conservative assessment.

Table 7.16: Scale up factors to reflect additional benefits of all other science projects

Scale up factor to reflect additional benefits of all other science projects	Scale up scenarios
Low	5
Medium	6
High	7

Table 7.17: Applying the scale up factors

Scale up results						
	Estimated total impact of research projects in which RBGE is currently involved			Proportion of benefit attributable to RBGE input to projects		
	NPV - 10 yrs.	NPV - 15 yrs.	NPV - 25 yrs.	NPV - 10 yrs.	NPV - 15 yrs.	NPV - 25 yrs.
L	409,072,339	867,384,016	2,735,720,633	204,536,169	411,931,383	1,270,931,415
M	756,097,495	1,789,057,782	6,793,483,120	378,048,747	855,359,766	3,222,269,537
H	1,196,564,697	3,071,254,151	13,129,241,737	598,282,349	1,474,697,325	6,293,219,944

7.2.6 Case Study 4: Solanum Research

RBGE is researching Solanum species which include potatoes, tomatoes, sweet peppers, egg plants and chilli peppers. The aim of the research is to categorise and characterise the diversity of wild species in different countries and to establish gaps in knowledge and collection of these species in global databases.

Working with partners around the world, RBGE is ensuring the widest possible knowledge and conservation of these wild species so they can be available to plant breeders for the varieties of the future. Wild species may often contain genes which are resistant to stress or pests and diseases given the varied, harsh conditions that they grow in. With climate change bringing the threat of new pests and diseases or harsher growing conditions, these wild species will be invaluable to plant breeders in developing the varieties of the future with tolerance to different types of stress. According to Scottish Government statistics, the value of the Scottish potato crop was £167m in 2015. Scottish potatoes are exported to over 40 countries worldwide. Of the total 25,800 hectares of potatoes planted in 2015, almost half was for the high value market of seed potatoes with export volumes alone reaching a long term peak of 90,000 tonnes in 2015. RBGE's work with its global partners could have an important role in underpinning the long term future of the industry.

7.2.7 Case Study 5: Flora of Nepal

Nepal is one of the ten poorest countries in the world but is also a country rich in biodiversity providing a wealth of material for biodiversity and climate change research. RBGE has been working long term in Nepal. Its 'Flora of Nepal' project has documented 7,000 species in the country and provides a foundation for biodiversity research. Alongside this long term research, RBGE has also assisted in a number of projects to improve livelihoods of locals. For example:

- Greater Himalayan Trail Guide Books for trekking guides – these bilingual guide books allow Sherpas to enrich the experience of tourist groups with understanding of the plants around them. Traditionally, Sherpas have little knowledge of plants and biodiversity.
- Illustrative Guides – RBGE has produced booklets for local villagers to help them identify plants useful for medicine, cooking spices and fuel. This has included identifying invasive species that can damage biodiversity but can provide a useful source of fuel as bio-briquettes for cooking, heating and charcoal production for sale or soil improvement. This work improves the sustainability of these poor communities.
- Biodiversity Education Garden – RBGE has been working with the Nepalese government to develop a new accessible Biodiversity Education Garden for 12-20 year olds inaugurated by the Nepalese President in 2016. It is expected that around 100,000 children will visit the garden annually.

RBGE's work helps to enhance Scotland's international reputation and involves high level government meetings and soft diplomacy. RBGE also works with the Nepalese community of several thousand in Scotland helping them to integrate, connect and contribute. This is an important contribution to one of Scotland's ethnic minorities.

7.3 Science impacts – conclusions

7.3.1 Summary

Table 7.18 shows the total economic benefits of RBGE science activities over one year, then the present value of science activities over a 10, 15 and 25-year period.

Total 'global impacts' have been calculated then estimates of those that benefit the Scottish economy.

Two impact figures have been estimated for each as follows:

- Those that derive from delivery of science services – essentially this comprises enabling access to the national collections and library. Types of benefit to the Scottish economy associated with this include (i) spend in Edinburgh of visiting scientists/researchers on travel, subsistence etc.; (ii) value to 3rd party researchers of accessing specimens (via visit and online). The value of this service has been calculated in terms of time taken to undertake activity applied to average GVA per FTE for R&D. All of these benefits are assumed to benefit the Scottish economy.
- Wider, longer term benefits that derive from successful science research projects, the results of which have a global economic impact (a) that RBGE research staff are directly involved in – in many cases, RBGE research staff are part of a wider international team, and (b) successful science research projects that in part owe an element of their success to knowledge and understanding gained by 3rd party researchers accessing the national collections/ library. Most of these projects are international, but for the purposes of this evaluation, it has been assumed that 20% of the benefit flows back to the Scottish economy through various mechanisms

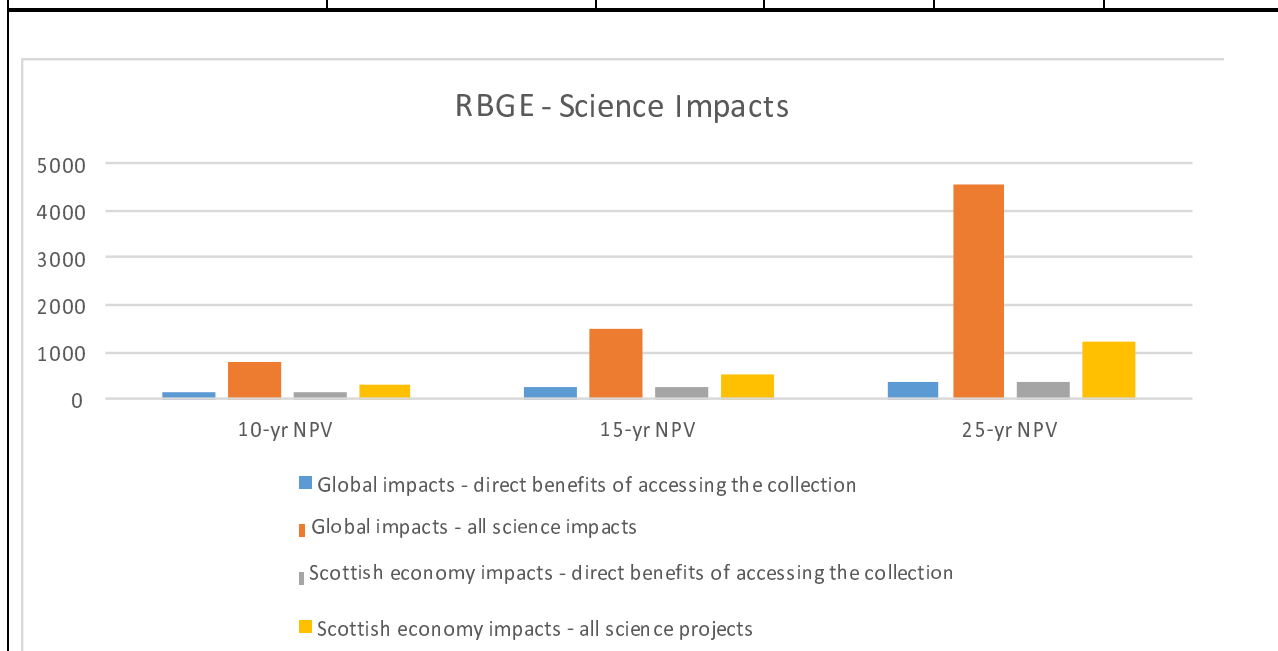
The reason for distinguishing between the two is that there is more certainty about the direct benefits/value of accessing the collections, but considerably less certainty about the benefits that derive from science research projects and the potential downstream benefits of accessing the collections. Hence, whilst these benefits should not be discounted, it is helpful to see the difference between the two science impact figure totals.

The results are as follows:

- Direct benefits of accessing the collections (excluding downstream benefits to third party research projects)
 - 100% of the direct impacts of accessing the collection benefit the Scottish economy. This represents a benefit to the Scottish economy of circa £18m per year, accumulating to a present value of £171m over a 10-year period, £248m over a 15-year period and £385m over a 25-year period
- All science impacts – namely, (i) impact of accessing the collections (including downstream benefits to third party research projects) and (ii) impacts of the current research projects in which RBGE staff are currently engaged
 - Total 'global' economic impact is estimated to be circa £81m per year, accumulating to a present value of £783m over a 10-year period, £1.5bn over a 15-year period and £4.5bn over a 25-year period
 - This represents a benefit to the Scottish economy of circa £30m per year, accumulating to a present value of £293m over a 10-year period, £0.5bn over a 15-year period and £1.2bn over a 25-year period

Table 7.18: Science impacts - summary

Science impacts					
		1 yr. snap shot	10-yr NPV	15-yr NPV	25-yr NPV
Global impacts	Science services - direct benefits of accessing the collection	18,283,826	171,329,669	248,035,219	385,592,210
	All science activities – science services plus longer term benefits of successful research projects	81,377,343	783,336,782	1,493,464,708	4,529,746,948
Benefits to the Scottish economy	Science services - direct benefits of accessing the collection	18,283,826	171,329,669	248,035,219	385,592,210
	All science activities – science services plus longer term benefits of successful research projects	30,902,529	293,731,091	497,121,117	1,214,423,158



Tables 7.19 to 7.22 provide a breakdown of the science impact results.

Table 7.19: Direct benefits of accessing the collection – global benefits

	Excludes off-site science activities	Global benefits £			
Global benefits	Science	1 yr. snap shot	10-yr NPV	15-yr NPV	25-yr NPV
Collections	Collections - research visitors spend in Scotland	44,080	379,427	525,457	751,933
	Collections - value of accessing specimens calculated with reference to researcher time-cost spent on activity - Scottish researchers	18,239,746	170,950,242	247,509,762	384,840,277
	Collections down-stream benefits - 5% of downloads contribute to projects that will have an economic impact	excluded			
	Collections Total	18,283,826	171,329,669	248,035,219	385,592,210
RBGE engaged in science research projects	3 case studies of international science projects	excluded			
	Scale up factor to reflect additional benefits of all other science projects (multiple of 6 used)	excluded			
	Research projects - total	-	-	-	-
Total		18,283,826	171,329,669	248,035,219	385,592,210

Table 7.20: Direct benefits of accessing the collection – benefits to the Scottish economy

	Excludes off-site science activities	Net to Scottish Economy £				
Net to Scottish Economy	Science	1 yr. snap shot	10-yr NPV	15-yr NPV	25-yr NPV	Attributable to the Scottish Economy
Collections	Collections - research visitors spend in Scotland	44,080	379,427	525,457	751,933	
	Collections - value of accessing specimens calculated with reference to researcher time-cost spent on activity - Scottish researchers	18,239,746	170,950,242	247,509,762	384,840,277	
	Collections down-stream benefits - 5% of downloads contribute to projects that will have an economic impact	excluded				
	Collections Total	18,283,826	171,329,669	248,035,219	385,592,210	20%
RBGE engaged in	3 case studies of international science projects	excluded				

	Excludes off-site science activities	Net to Scottish Economy £				
science research projects	Scale up factor to reflect additional benefits of all other science projects (multiple of 6 used)	excluded				
	Research projects - total	-	-	-	-	
Total		18,283,826	171,329,669	248,035,219	385,592,210	20%

Table 7.21: Benefits of all science activities – global

		Global benefits £			
Global benefits	Science	1 yr. snap shot	10-yr NPV	15-yr NPV	25-yr NPV
Collections	Collections - research visitors spend in Scotland	44,080	379,427	525,457	751,933
	Collections - value of accessing specimens calculated with reference to researcher time-cost spent on activity	18,239,746	170,950,242	247,509,762	384,840,277
	Collections down-stream benefits - 5% of downloads contribute to projects that will have an economic impact	17,623,736	170,950,242	247,509,762	384,840,277
	Collections Total	35,907,562	342,279,910	495,544,981	770,432,488
RBGE engaged in science research projects	3 case studies of international science projects	6,495,683	63,008,125	142,559,961	537,044,923
	Scale up factor to reflect additional benefits of all other science projects (multiple of 6 used)	38,974,098	378,048,747	855,359,766	3,222,269,537
	Research projects - total	45,469,781	441,056,872	997,919,727	3,759,314,460
Total		81,377,343	783,336,782	1,493,464,708	4,529,746,948

Table 7.22: Benefits of all science activities – to the Scottish economy

		Net to Scottish Economy £				Attributable to the Scottish Economy
Net to Scottish Economy	Science	1 yr. snap shot	10-yr NPV	15-yr NPV	25-yr NPV	
Collections	Collections - research visitors spend in Scotland	44,080	379,427	525,457	751,933	
	Collections - value of accessing specimens calculated with	18,239,746	170,950,242	247,509,762	384,840,277	

		Net to Scottish Economy £				Attributable to the Scottish Economy
	reference to researcher time-cost spent on activity					
	Collections down-stream benefits - 5% of downloads contribute to projects that will have an economic impact	3,524,747	34,190,048	49,501,952	76,968,055	20%
	Collections Total	21,808,573	205,519,717	297,537,171	462,560,266	
RBGE engaged in science research projects	3 case studies of international science projects	1,299,137	12,601,625	28,511,992	107,408,985	
	Scale up factor to reflect additional benefits of all other science projects (multiple of 6 used)	7,794,820	75,609,749	171,071,953	644,453,907	
	Research projects - total	9,093,956	88,211,374	199,583,945	751,862,892	20%
Total		30,902,529	293,731,091	497,121,117	1,214,423,158	

8 Conclusions – Economic Impact of RBGE on the Scottish and Global Economies

Two sets of impact results are presented in this assessment:

- Impacts based on operational spend, visitor, education and science services impacts
- Impacts based on the above plus potential longer term science research impacts, which are potentially large but of which there is less certainty

8.1 Overall Results

Economic impact of RBGE – including all science impacts

Table 8.1: Economic impact of the RBGE (£ GVA) – including all science impacts

Economic impact of the RBGE (£ GVA) – including all science impacts					
		1 yr. snap shot	10-yr NPV	15-yr NPV	25-yr NPV
Global benefits		102,701,894	996,643,785	1,788,867,016	4,952,470,204
To the Scottish Economy		51,876,997	490,155,944	769,143,853	1,603,690,045

Economic impact of RBGE – excluding science research project impacts

Table 8.2: Economic impact of the RBGE (£ GVA) - total benefits excluding science research projects

Economic impact of the RBGE (£ GVA) – excluding science research project impacts					
		1 yr. snap shot	10-yr NPV	15-yr NPV	25-yr NPV
Global benefits		39,608,377	384,636,672	543,437,526	808,315,467
To the Scottish Economy		39,258,294	367,754,521	520,057,955	774,859,098

Operating costs and grant

Table 8.3: Investment – total operating costs and grant

Investment – total operating costs and grant element					
		1 yr. snap shot	10-yr NPV	15-yr NPV	25-yr NPV
Grant		8,495,000	73,122,297	101,264,820	144,910,833
Total operating costs		11,231,511	96,677,327	133,885,457	191,591,246

Economic Return on Investment (ERoI)

Table 8.4: Economic Return on Investment (ERoI) including all science impacts

Economic Return on Investment (ERoI) including all science impacts					
		1 yr. snap shot	10-yr NPV	15-yr NPV	25-yr NPV
Grant	Global benefits divided by grant	12.09	13.63	17.67	34.18
	Scottish economy benefits divided by grant	6.11	6.70	7.60	11.07
Total operating costs	Global benefits divided by total operating cost	9.14	10.31	13.36	25.85
	Scottish economy benefits divided by total operating costs	4.62	5.07	5.74	8.37

Table 8.5: Economic Return on Investment (ERoI) excluding science research project impacts

Economic Return on Investment (ERoI) excluding science research project impacts					
		1 yr. snap shot	10-yr NPV	15-yr NPV	25-yr NPV
Grant	Global benefits divided by grant	4.66	5.26	5.37	5.58
	Scottish economy benefits divided by grant	4.62	5.03	5.14	5.35
Total operating costs	Global benefits divided by total operating cost	3.53	3.98	4.06	4.22
	Scottish economy benefits divided by total operating costs	3.50	3.80	3.88	4.04

8.2 Breakdown of the Results

The following sets of tables provide a breakdown of estimates made of the economic impact of the RBGE (£ GVA), in total (global impacts) and net to the Scottish economy:

- Tables 8.6 to 8.9 provide a breakdown by source of impact (i) operational expenditure (ii) visitor revenue and benefits (iii) education and training revenue and benefits (iv) science services and direct¹⁵ and indirect¹⁶ science research projects
 - Tables 8.6 and 8.7 show the benefits excluding longer term science research project benefits
 - Tables 8.8 and 8.9 show the benefits including longer term science research projects
- Tables 8.10 to 8.14 provide a breakdown by activity by outcome (i) tourism and recreation (ii) education and skills (iii) national collection (iv) science and conservation
 - Tables 8.10 and 8.11 show the impacts
 - Table 8.12 shows costs against each heading – operational costs and the grant component
 - Tables 8.13 and 8.14 show the Economic Return on Investment (ERoI) – benefits divided by operating costs and then by grant

¹⁵ Science research projects in which RBGE personnel are involved

¹⁶ Science research projects that have no involvement of RBGE personnel but which are assisted through the knowledge gained via external researchers accessing specimens in the collection

8.2.1 Breakdown of the impacts by source of impact

8.2.1.1 All impacts, except longer term science research projects

Table 8.6: Economic impact of the RBGE (£ GVA) - total global benefits excluding longer term science research project benefits

Global benefits	All impacts excluding longer term science research project benefits	Global £ GVA				% Scottish benefits of total yr 25
		1 yr. snap shot	10-yr NPV	15-yr NPV	25-yr NPV	
Operational expenditure	Salaries to staff who then spend in Scottish Economy; procurement of goods and services from Scottish suppliers GVA element at 30% (all including multiplier of 1.25)	10,897,171	93,799,435	129,899,952	185,887,955	100%
Visitors	Visitors (all)- utility value of visit based on assumed ticket price for RBGE (£6.50 ave across all visitors) and on actual ticket prices for Glass House visits and for other gardens. Visitor spend on books, plants, catering and event tickets; spend of visitors from outside of Scotland outside of gardens (assumed at 3% of ave total visitor spend to Edinburgh)	9,547,206	82,179,357	113,807,664	162,859,751	100%
Education	Primary, secondary, special and nursery - utility value of visit based on parent's willingness to pay for school trip; apprenticeship, diplomas, foundation and degree, masters and PhD students based on increased skill level and consequent proficiency/ productivity increase to employers (GVAperFTE uplift)	880,174	37,328,211	51,694,691	73,975,550	55%
Science	Benefits that derive from accessing the collection (i) Spend in Edinburgh of visiting scientists/researchers on travel, subsistence etc.; (ii) utility value of accessing specimens (via visit and online) in terms of time taken to undertake activity applied to aver GVAperFTE for R&D; Excluding longer term benefits that derive from science research projects – (i) projects in which RBGE personnel are involved (ii) projects, with no involvement of RBGE personnel but which benefit from the knowledge gained via external researchers accessing the collection	18,283,826	171,329,669	248,035,219	385,592,210	100%
Total		39,608,377	384,636,672	543,437,526	808,315,467	

Table 8.7: Economic impact of the RBGE (£ GVA) – benefits to the Scottish economy, excluding longer term science research project benefits

Net to Scottish Economy	All impacts excluding longer term science research project benefits	Net to Scottish Economy £ GVA			
		1 yr. snapshot	10-yr NPV	15-yr NPV	25-yr NPV
Operational expenditure	Salaries to staff who then spend in Scottish Economy; procurement of goods and services from Scottish suppliers GVA element at 30% (all including multiplier of 1.25)	10,870,518	93,570,009	129,582,228	185,433,288
Visitors	Visitors (all)- utility value of visit based on assumed ticket price for RBGE (£6.50 ave across all visitors) and on actual ticket prices for Glass House visits and for other gardens. Visitor spend on books, plants, catering and event tickets; spend of visitors from outside of Scotland outside of gardens (assumed at 3% of ave total visitor spend to Edinburgh)	9,547,206	82,179,357	113,807,664	162,859,751
Education	Primary, secondary, special and nursery - utility value of visit based on parent's willingness to pay for school trip; apprenticeship, diplomas, foundation and degree, masters and PhD students who remain and work in Scotland based on increased skill level and consequent proficiency/ productivity increase to employers (GVAperFTE uplift); fees to Scotland from students from outside of Scotland (less 40% spent on salaries that are already taken into account in the operational impact)	556,744	20,675,486	28,632,845	40,973,848
Science	Benefits that derive from accessing the collection (i) Spend in Edinburgh of visiting scientists/researchers on travel, subsistence etc.; (ii) utility value of accessing specimens (via visit and online) in terms of time taken to undertake activity applied to aver GVAperFTE for R&D; Excluding longer term benefits that derive from science research projects – (i) projects in which RBGE personnel are involved (ii) projects, with no involvement of RBGE personnel but which benefit from the knowledge gained via external researchers accessing the collection	18,283,826	171,329,669	248,035,219	385,592,210
Total		39,258,294	367,754,521	520,057,955	774,859,098

8.2.1.2 All impacts, including longer term science research projects

Table 8.8: Economic impact of the RBGE (£ GVA) - total global benefits including longer term science research project benefits

Global benefits	(including longer term science research project benefits)	Global £ GVA				% Scottish benefits of total yr 25
		1 yr. snap shot	10-yr NPV	15-yr NPV	25-yr NPV	
Operational expenditure	Salaries to staff who then spend in Scottish Economy; procurement of goods and services from Scottish suppliers GVA element at 30%) (all including multiplier of 1.25)	10,897,171	93,799,435	129,899,952	185,887,955	100%
Visitors	Visitors (all)- utility value of visit based on assumed ticket price for RBGE (£6.50 ave across all visitors) and on actual ticket prices for Glass House visits and for other gardens. Visitor spend on books, plants, catering and event tickets; spend of visitors from outside of Scotland outside of gardens (assumed at 3% of ave total visitor spend to Edinburgh)	9,547,206	82,179,357	113,807,664	162,859,751	100%
Education	Primary, secondary, special and nursery - utility value of visit based on parent's willingness to pay for school trip; apprenticeship, diplomas, foundation and degree, masters and PhD students based on increased skill level and consequent proficiency/ productivity increase to employers (GVAperFTE uplift)	880,174	37,328,211	51,694,691	73,975,550	55%
Science	Benefits that derive from accessing the collection (i) Spend in Edinburgh of visiting scientists/researchers on travel, subsistence etc.; (ii) utility value of accessing specimens (via visit and online) in terms of time taken to undertake activity applied to aver GVAperFTE for R&D; Longer term benefits that derive from science research projects – (i) projects in which RBGE personnel are involved (ii) projects, with no involvement of RBGE personnel but which benefit from the knowledge gained via external researchers accessing the collection	81,377,343	783,336,782	1,493,464,708	4,529,746,948	27%
Total		102,701,894	996,643,785	1,788,867,016	4,952,470,204	

Table 8.9: Economic impact of the RBGE (£ GVA) – benefits to the Scottish economy, including longer term science research project benefits

Net to Scottish Economy	(including longer term science research project benefits)	Net to Scottish Economy £ GVA			
		1 yr. snapshot	10-yr NPV	15-yr NPV	25-yr NPV
Operational expenditure	Salaries to staff who then spend in Scottish Economy; procurement of goods and services from Scottish suppliers GVA element at 30% (all including multiplier of 1.25)	10,870,518	93,570,009	129,582,228	185,433,288
Visitors	Visitors (all)- utility value of visit based on assumed ticket price for RBGE (£6.50 ave across all visitors) and on actual ticket prices for Glass House visits and for other gardens. Visitor spend on books, plants, catering and event tickets; spend of visitors from outside of Scotland outside of gardens (assumed at 3% of ave total visitor spend to Edinburgh)	9,547,206	82,179,357	113,807,664	162,859,751
Education	Primary, secondary, special and nursery - utility value of visit based on parent's willingness to pay for school trip; apprenticeship, diplomas, foundation and degree, masters and PhD students who remain and work in Scotland based on increased skill level and consequent proficiency/ productivity increase to employers (GVAperFTE uplift); fees to Scotland from students from outside of Scotland (less 40% spent on salaries that are already taken into account in the operational impact)	556,744	20,675,486	28,632,845	40,973,848
Science	Benefits that derive from accessing the collection (i) Spend in Edinburgh of visiting scientists/researchers on travel, subsistence etc.; (ii) utility value of accessing specimens (via visit and online) in terms of time taken to undertake activity applied to aver GVAperFTE for R&D; Longer term benefits that derive from science research projects – (i) projects in which RBGE personnel are involved (ii) projects, with no involvement of RBGE personnel but which benefit from the knowledge gained via external researchers accessing the collection	30,902,529	293,731,091	497,121,117	1,214,423,158
Total		51,876,997	490,155,944	769,143,853	1,603,690,045

8.2.2 Breakdown of the impacts by outcome

The following tables breakdown the economic impacts by the four outcomes that RBGE uses for monitoring and reporting performance. The benefits attributable to the operational spend, which are set out as a separate impact category in the above tables, are now incorporated with the benefits of each output activity.

8.2.2.1 All impacts, except longer term science research projects

Table 8.10: Economic impact of the RBGE (£ GVA) – benefits by outcome, excluding longer term science research project benefits

Four outcomes	Net to Scottish Economy £ GVA				Global £ GVA			
	1 yr. snap shot	10-yr NPV	15-yr NPV	25-yr NPV	1 yr. snap shot	10-yr NPV	15-yr NPV	25-yr NPV
Tourism and recreation	14,194,267	122,179,805	169,203,053	242,131,032	14,207,975	122,297,795	169,366,454	242,364,861
Education and skills	1,698,168	30,500,499	42,239,204	60,444,666	2,023,882	47,172,890	65,328,284	93,485,339
National collection	20,822,181	193,179,030	278,293,727	428,892,397	20,825,988	193,211,805	278,339,116	428,957,349
Science and conservation	2,543,679	21,895,187	30,321,971	43,391,003	2,550,532	21,954,182	30,403,672	43,507,917
Total	39,258,294	367,754,521	520,057,955	774,859,098	39,608,377	384,636,672	543,437,526	808,315,467

Table 8.11: Economic impact of the RBGE (£ GVA) – benefits by outcome, including longer term science research project benefits

Four outcomes	Net to Scottish Economy £ GVA				Global £ GVA			
	1 yr. snap shot	10-yr NPV	15-yr NPV	25-yr NPV	1 yr. snap shot	10-yr NPV	15-yr NPV	25-yr NPV
Tourism and recreation	14,194,267	122,179,805	169,203,053	242,131,032	14,207,975	122,297,795	169,366,454	242,364,861
Education and skills	1,698,168	30,500,499	42,239,204	60,444,666	2,023,882	47,172,890	65,328,284	93,485,339
National collection	24,346,928	227,369,078	327,795,680	505,860,453	38,449,724	364,162,047	525,848,879	813,797,627
Science and conservation	11,637,635	110,106,562	229,905,917	795,253,895	48,020,313	463,011,054	1,028,323,399	3,802,822,378
Total	51,876,997	490,155,944	769,143,853	1,603,690,045	102,701,894	996,643,785	1,788,867,016	4,952,470,204

Table 8.12: Operational expenditure (and contribution of grant) breakdown by outcome

Four outcomes	Operational expenditure £			Grant £		
	10-yr NPV	15-yr NPV	25-yr NPV	10-yr NPV	15-yr NPV	25-yr NPV
Tourism and recreation	43,311,732	59,981,086	85,833,453	32,700,486	45,285,897	64,804,510
Education and skills	9,745,240	13,495,883	19,312,725	7,357,685	10,189,431	14,581,164
National collection	20,621,537	28,558,133	40,866,935	15,569,321	21,561,474	30,854,656
Science and conservation	23,171,837	32,089,964	45,921,016	17,494,805	24,228,017	34,670,503
Total	96,850,346	134,125,066	191,934,129	73,122,297	101,264,820	144,910,833

8.13: Economic Return on Investment: benefits excluding longer term science research impacts, divided by (operating costs and grant)

Four outcomes	ERol _ Net to Scottish Economy GVA benefits						ERol - Global GVA benefits					
	ERol - operational expenditure			ERol - grant			ERol - operational expenditure			ERol - grant		
	10-yr NPV	15-yr NPV	25-yr NPV	10-yr NPV	15-yr NPV	25-yr NPV	10-yr NPV	15-yr NPV	25-yr NPV	10-yr NPV	15-yr NPV	25-yr NPV
Tourism and recreation	2.82	2.82	2.82	2.82	3.74	3.74	2.82	2.82	2.82	2.82	3.74	3.74
Education and skills	1.50	3.13	3.13	3.13	1.99	4.15	1.79	4.84	4.84	4.84	2.37	6.41
National collection	8.69	9.37	9.74	10.49	11.51	12.41	8.69	9.37	9.75	10.50	11.51	12.41
Science and conservation	0.94	0.94	0.94	0.94	1.25	1.25	0.95	0.95	0.95	0.95	1.25	1.25
Total	3.49	3.80	3.88	4.04	4.62	5.03	3.52	3.97	4.05	4.21	4.66	5.26

Table 8.14: Economic Return on Investment: benefits *including* longer term science research impacts, divided by (operating costs and grant)

	ERol - Net to Scottish Economy GVA benefits						ERol - Global GVA benefits					
	ERol - operational expenditure			ERol - grant			ERol - operational expenditure			ERol - grant		
Four outcomes	10-yr NPV	15-yr NPV	25-yr NPV	10-yr NPV	15-yr NPV	25-yr NPV	10-yr NPV	15-yr NPV	25-yr NPV	10-yr NPV	15-yr NPV	25-yr NPV
Tourism and recreation	2.82	2.82	2.82	2.82	3.74	3.74	3.74	3.74	2.82	2.82	2.82	2.82
Education and skills	1.50	3.13	3.13	3.13	1.99	4.15	4.15	4.15	1.79	4.84	4.84	4.84
National collection	10.16	11.03	11.48	12.38	13.46	14.60	15.20	16.39	16.05	17.66	18.41	19.91
Science and conservation	4.32	4.75	7.16	17.32	5.73	6.29	9.49	22.94	17.84	19.98	32.05	82.81
Total	4.61	5.06	5.73	8.36	6.11	6.70	7.60	11.07	9.13	10.29	13.34	25.80

APPENDIX A

Further Details of the Science Impact Calculations

This section has further details of the science research project economic impact calculations regarding the:

- Basis on which impacts of the 3 selected case study projects have been scaled up to estimate the potential economic impact of the full suite of science research projects in which RBGE staff are currently involved
- Basis on which the benefits of science research project activity have been estimated, most of which are international, to the Scottish Economy
- Sensitivity analysis and high, medium and low scenario modelling undertaken

1. Scale up Rationale

The following is the basis on which the impact of the 3 selected case study projects have been scaled up:

- there are 101 current projects
- the economic impacts of 3 have been monetised
- the literal scale up factor of the 3 would be $(101/3) = 33.67$
- instead the following range of scale up factors - 5/6/7 – have been selected in order to discount this heavily, representing only circa one fifth (20%) of the literal scale up factor. The reasons for this are to reflect the fact that the three projects were chosen because they have particularly large economic impacts and are not therefore representative of the average
- this doesn't fully justify the choice of 5/6/7 as scale up factors, but it starts to suggest it is within the bounds of reasonableness, in the sense that it has been assumed that average project impact is one fifth of the impact of these three.

2. Basis on Which Science Research Benefits Attributable to the Scottish Economy Have Been Estimated

Many of the science research projects in which RBGE staff are currently engaged are international and will not necessarily directly benefit the Scottish economy, some will however and moreover, some of the current suite of projects are Scottish specific.

In order to estimate what proportion of total global science research project economic impact might be reasonably attributable to the Scottish economy, the following attribution metrics have been assumed:

- Low - 15%
- Medium - 20%
- High - 25%

These figures are based on two separate justifications

Method 1: Scoring of the current portfolio of projects

- RBGE has scored each of the current portfolio of projects (i) by whether the results/implementation of the results of each has a physical benefit in Scotland (as opposed to only in other countries) and (ii) weighted each project by how near to market each project is (1=front end blue sky...3=near to market)
- Focusing on near to market projects, the weighted result is 43% for Scotland, 57% international
- Using attribution factors of 15/20/25% however represent a 50% discount/ down weighting on this to reflect the possibility that those projects whose results benefit Scotland, have a smaller total economic impact than the average

Method 2: Based on RBGE cost data

- RBGE costs of research projects undertaken in the UK (RBGE confirms that this can be read as undertaken in Scotland) (= 18% of total global research costs)
- These are the costs for the last available accounting year and will vary slightly year by year - hence, assuming costs correlate with impacts, this supports an attribution figure of 20%

Neither of these methods is 100% full proof but, in the absence of any other available evidence, they provide the most robust basis available for arriving at attribution assumptions, ensuring that the approach adopted is moving towards if not within the bounds of 'reasonableness' and 'proportionate'.

3. Sensitivity Analysis and High, Medium and Low Scenario Modelling Undertaken

Assessing the economic impact of the RBGE, like that of any other project, is not an exact science but instead depends on a number of assumptions and judgements. The impacts that derive from operational expenditure, visitors and education, are reasonably certain but the impacts that derive from RBGE's science activities, are considerably less certain as some quite major assumptions have been made when calculating the potential science-related impacts. To reflect this, sensitivity analysis of the science impact calculations has been undertaken to identify the most critical assumptions and testing the impact on the results of varying these assumptions, as indicated in Tables 9.1 and 9.2 below

Table 9.1: Global science impacts - range

Global science impacts - range		1-yr snapshot	10-yr NPV	15-yr NPV	25-yr NPV	
Collections - research visitors spend in Scotland	Low	44,080	379,427	525,457	751,933	
	Medium	44,080	379,427	525,457	751,933	
	High	44,080	379,427	525,457	751,933	
Collection - accessing specimens	Low	9,180,561	86,043,916	124,578,409	193,700,600	2%
	Medium	18,239,746	170,950,242	247,509,762	384,840,277	
	High	36,358,115	340,762,894	493,372,469	767,119,632	
Collection down-stream benefits - 5% of downloads contribute to projects that will have an economic impact	Low	4,435,253	43,021,958	62,289,205	96,850,300	10
	Medium	17,623,736	170,950,242	247,509,762	384,840,277	20
	High	52,695,293	511,144,340	740,058,703	1,150,679,448	30
3 case study science projects - cocoa, rubber, logging	Low	4,217,241	40,907,234	82,386,277	254,186,283	
	Medium	6,495,683	63,008,125	142,559,961	537,044,923	
	High	8,811,228	85,468,907	210,671,046	899,031,421	
Scaling up 3 projects to reflect benefits of all other science projects (current and legacy)	Low	21,086,203	204,536,169	411,931,383	1,270,931,415	5
	Medium	38,974,098	378,048,747	855,359,766	3,222,269,537	6
	High	61,678,593	598,282,349	1,474,697,325	6,293,219,944	7
Total	Low	38,963,338	374,888,704	681,710,730	1,816,420,531	
	Medium	81,377,343	783,336,782	1,493,464,708	4,529,746,948	
	High	159,587,308	1,536,037,916	2,919,325,001	9,110,802,377	
Variance against current science impact figures (total R99/current figure R16)	Low		0.26	0.28	0.28	
	Medium		0.48	0.57	0.71	
	High		0.76	0.99	1.39	

Table 9.2: Scottish economy science impacts - range

Science impacts in the Scottish economy - range		1-yr snapshot	10-yr NPV	15-yr NPV	25-yr NPV	
Collections - research visitors spend in Scotland	Low	41,876	360,455	499,184	714,336	
	Medium	44,080	379,427	525,457	751,933	
	High	44,080	379,427	525,457	751,933	
Collection - accessing specimens	Low	9,180,561	86,043,916	124,578,409	193,700,600	
	Medium	18,239,746	170,950,242	247,509,762	384,840,277	
	High	36,358,115	340,762,894	493,372,469	767,119,632	
Collection down-stream benefits - 5% of downloads contribute to projects that will have an economic impact	Low	665,288	6,453,294	9,343,381	14,527,545	15%
	Medium	3,524,747	34,190,048	49,501,952	76,968,055	20%
	High	13,173,823	127,786,085	185,014,676	287,669,862	25%
3 case study science projects - cocoa, rubber, logging	Low	632,586	6,136,085	12,357,941	38,127,942	15%
	Medium	1,299,137	12,601,625	28,511,992	107,408,985	20%
	High	2,202,807	21,367,227	52,667,762	224,757,855	25%
Scaling up 3 projects to reflect benefits of all other science projects (current and legacy)	Low	3,162,930	30,680,425	61,789,707	190,639,712	15%
	Medium	7,794,820	75,609,749	171,071,953	644,453,907	20%
	High	15,419,648	149,570,587	368,674,331	1,573,304,986	25%
Total	Low	13,683,242	129,674,175	208,568,623	437,710,136	
	Medium	30,902,529	293,731,091	497,121,117	1,214,423,158	
	High	67,198,473	639,866,219	1,100,254,694	2,853,604,268	
% of global impacts	Low		35%	31%	24%	
	Medium		37%	33%	27%	
	High		42%	38%	31%	
Variance against current science impact figures (total R99/current figure R16)	Low		0.44	0.42	0.36	
	Medium		1.00	1.00	1.00	
	High		2.18	2.21	2.35	

APPENDIX B

The Evaluation Team

Graham Hill

Graham is the Arcadis Account Leader for the Royal Botanic Garden Edinburgh. He is a Partner of Arcadis and City Executive; focussing on the needs and opportunities for Scotland's leading Cities to be more resilient and sustainable to achieve competitive advantage and improve quality of life.

He is a highly experienced Project Manager and Chartered Quantity Surveyor with over 30 years of experience in the industry.

Following graduation, Graham worked for Central Government in the PSA Major Projects Division, where he gained invaluable experience on a range of defence and civic projects within the public sector. Following professional qualification, Graham joined Tozer Capita where he specialised in office developments such as Headquarters Offices in Edinburgh for RBS, Standard Life and Deutsche Bank.

Since joining Arcadis, Graham has led a number of major residential and mixed use projects for Arcadis, focusing on the commercial viability of the masterplan design and deliverability of major projects for clients such as Quartermile, Applecross, Taylor Wimpey and Murray Land. He has more recently worked with public sector organisations in improving built asset and project performance.

Graham is a Board Member of Architecture and Design Scotland, an Edinburgh Advisory Group Member of Common Purpose and on Heriot Watt University's Industrial Advisory Forum for Buildings.

Dr Steve Sheppard: Founder and Managing Director of Adroit Economics, specialises in technology, innovation, enterprise and infrastructure projects.

Steve has over 20 years experience in economics, regeneration, development and planning – working in consultancy, real estate and academia. During his career, he has undertaken assignments for a range of high-profile clients including BIS, most of the English RDAs, universities, research organisations, local partnerships and the European Commission.

Steve brings a unique blend of experience – policy and strategy; economics; development and planning; project feasibility; financial and economic appraisal; science and technology; inward investment and marketing; programme evaluation; and organisational structure and change. Steve has experience of preparing business cases and options for complex multi-use campus style developments in the UK and internationally.

Donald Webb has over 20 years consultancy experience and specialises in economic impact, policy evaluation and real estate.

He has particular expertise in the plants sector and in economic impact of scientific research facilities. He has worked with many of Scotland's research providers including James Hutton, SRUC, University of Edinburgh and RBGE.

He has also worked with UK national science funders to assess impact, for example Research Councils such as BBSRC, EPSRC, NERC and STFC. Other projects include: Economic Impact of Edinburgh Napier University expansion; Economic case for Edinburgh's bioquarter; Economic Impact of James Hutton Institute; Economic contribution of Scottish Government sponsored research institutes; Cost benefit of the UK plants and seeds regime for Defra; Economic Impact of Plant Breeding; Cost Benefit of Honey Bees in the UK for Defra; Economic Impact of the Natural Environment Research Council; Economic Impact of East Malling Research; Economic Impact of John Innes Centre, Institute of Food Research and Pirbright Institute; Economic appraisal of the University of Edinburgh's Easter Bush Research Centre.

He has extensive experience of assessing the link between property investment and economic growth, extensive experience in the bio-science sector and other knowledge intensive industries across the UK.

Arcadis LLP

Apex 3,
95 Haymarket Terrace
Edinburgh EH12 5HD
United Kingdom
T: +44 (0)131 347 3800

[arcadis.com](https://www.arcadis.com)

