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THE ECONOMIC VALUE OF ROYAL BOTANIC GARDENS, KEW

A TOTAL ECONOMIC VALUE APPROACH

OCTOBER 2019

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EXECUTIVE SUMMARY

2.4m

Total number of visits to Kew Gardens and Wakehurst in 2018/19, including almost 100,000 from school children.



Royal Botanic Gardens, Kew (Kew) has two botanic gardens: the world-famous Kew Gardens in south-west London and Wakehurst, Kew's wild botanic garden in Sussex. In the financial year 2018/19, Kew Gardens and Wakehurst together received a total of 2.4 million visits, including almost 100,000 from school children.

But Kew is far more than simply a visitor attraction—it is a unique global resource for plant and fungal knowledge. The extensive collections, databases, scientific expertise, and global partnerships make Kew an unparalleled resource for students and researchers.

This study provides an update to our 2016 report on the total economic value of Kew,¹ using a cost-benefit analysis within a welfare economics framework. This report details the economic benefits that accrue not only to visitors to Kew's two botanic gardens, but to "indirect users" such as beneficiaries of its scientific output, and even "non-users" who may value Kew's existence even though they do not actually visit. We use a range of economic techniques to estimate these values, reflecting the diversity of activities that Kew undertakes.

TOTAL VALUE TO UK VISITORS

In 2018/19, 1.2 million visits were made to Kew Gardens by UK residents (excluding students and teachers), and there were approximately 251,000 visits to Wakehurst. Of these, just under 736,000 of the visits to Kew Gardens were made by members, who typically paid £71 per year for membership, while non-members paid an entry fee of £18 to visit Kew Gardens.²

However, entry fees represent only part of the true value that people place on their visit to Kew Gardens or Wakehurst. By including an estimate of what each visitor would have been prepared to pay *over and above the ticket price* (known as their "consumer surplus"), we calculate that the total UK visitor value of Kew Gardens in 2018/19 was £50.3 million, while Wakehurst generated a total UK visitor value of almost £5.4 million over the same period.

In addition, Kew hosts special events at both Kew Gardens and Wakehurst throughout the year. We conservatively estimate that the total visitor value of these events was £10.4 million in 2018/19.

Combining these visitor values, we find that the total value of Kew to UK visitors in 2018/19 was £66.1 million.

£66m

Total value to UK-based visitors in 2018/19.



¹ Oxford Economics, "Economic Valuation of the Royal Botanic Gardens, Kew," *A total economic value approach*, April 2016 <<https://www.oxfordeconomics.com/my-oxford/projects/330449>> [accessed May 2019]

² This ticket price relates to the cost for an adult to purchase a ticket at the gate without donation. Source: www.kew.org, "Tickets and prices," <<https://www.kew.org/kew-gardens/visit-kew-gardens/tickets>> [accessed May 2019]

EDUCATIONAL VALUE TO UK STUDENTS

Kew also generates significant educational benefits for the UK, from hands-on learning about plants and conservation for schoolchildren to training opportunities for university students and trainee teachers. Using insights from a range of academic studies, **we calculate that the total value of these educational benefits in 2018/19 was £27.5 million.**

£76m

Estimated boost to the UK's long-term economic output.



VALUE TO UK SCIENCE

Kew makes a substantial contribution to the scientific base in the UK—which, in turn, drives innovation, productivity, and economic growth. Kew is a global resource for plant and fungal knowledge, and has one of the largest and most diverse collections of plant and fungal specimens (both living and preserved) in the world.

The extensive collections, databases, expertise, and global partnerships of its science departments give Kew a leading role in the science of plants and fungi. Its resources are used by researchers and other stakeholders worldwide. Research undertaken by Kew scientists focuses on documenting and understanding global plant and fungal diversity, generating outputs of both intrinsic and instrumental value, including some with a direct commercial application.

Attributing a value to the diverse scientific research that Kew undertakes and enables is challenging. Nonetheless, the scope of science undertaken at Kew and the audience it serves, both within the UK and internationally, is clearly important. Consistent with our 2016 study, we have followed an approach to valuing research that explores how public science funding can drive productivity improvements in the private sector. **On this basis, we estimate that Kew's scientific activities in 2018/19 could deliver a £76.3 million boost to the UK's economic output in the long term.**

'NON-USE' AND 'OPTION' VALUE

A further valuation category is represented by UK residents who do not visit the gardens, but who still value them and want them to be supported. This so-called “non-use” value is commonly estimated for environmental or cultural amenities, which are seen as intrinsically valuable by citizens. Furthermore, some people may also value the option of visiting Kew at some point in future.

To quantify these intrinsic values, we undertook a survey of UK residents to explore how much public funding people felt Kew *ought* to receive, in comparison to its current annual level of around £1.20 per UK taxpayer. Just under 60% of respondents stated they would choose to retain the current level of funding, while 34% said they would be prepared to increase funding to the gardens. **Based on these results, we estimate that Kew's non-use and option value was £61.1 million in 2018/19.**

£61m

Total estimated 'non-use' and 'option' value of Kew in 2018/19.



VALUE OF OTHER SERVICES

Kew provides a number of other revenue-generating services, including its retail activity, catering, venue hire, licensing, and publishing.

In total, the income received by Kew from these services amounted to £14.4 million in 2018/19.

INTERNATIONAL VALUE

Kew Gardens and Wakehurst attract visitors from all over the world, led by the US, Australia, and Canada. In 2018/19, we estimate that overseas visitors received £13.6 million of value from visits to Kew's two botanic gardens, while Kew's total educational value to international students was £1.5 million.

This gives a total international value for 2018/19 of £15.1 million.

OVERALL COST-BENEFIT ANALYSIS

Combining all these value components, we estimate that the total gross value to the UK of Kew in 2018/19 was £245.4 million. When the international benefits that we have been able to quantify are added, this total reaches £260.5 million.

This estimated annual benefit was derived from costs (the operational expenditure needed to run Kew) of £73.7 million. A *benefit-cost ratio* can therefore be calculated to reflect Kew's value to society in relation to the costs of operation.

For the UK, dividing the £245 million in benefits by £73.7 million of operating costs gives a benefit-cost ratio of 3.3. **This means that for each £1.00 spent operating Kew in 2018/19, £3.30 of benefits were generated for the UK.** Adding the quantifiable international value gives a benefit-cost ratio of 3.5. Fig. 1, overleaf, provides a breakdown of all the annual benefits and costs we have estimated in our analysis.

Note: These results should be considered conservative, because Kew generates other significant benefits that were not possible to quantify—most notably the international value of its scientific research and collections. The latter represent a unique resource which facilitate research by Kew scientists and academics around the world, as they seek to address global challenges such as climate change, biodiversity loss, and habitat destruction.

It has also not been possible to quantify the value of the “insurance” provided by seeds stored in the Millennium Seed Bank, and of the increased UK planting and horticultural activity that Kew encourages through its outreach programmes—the most prominent of which is “Grow Wild”. As well as increasing the number of wildflowers grown across the country, Grow Wild seeks to bring communities together in a joint endeavour, to help young people connect with the natural world, and to promote mental and physical wellbeing (as visits to Kew Gardens and Wakehurst do).

£245m

Total gross value to the UK
in 2018/19.



£261m

Total gross value in 2018/19
when the value to
international visitors and
students is included.



Fig. 1. Summary of costs and benefits of Royal Botanic Gardens, Kew, 2018/19

	£ million
Costs	73.7
Of which:	
Research and conservation	48.0
Visitor activities	12.9
Other	12.8
Quantified UK benefits	245.4
Quantified total benefits	260.5
Of which:	
Value to UK Kew Gardens visitors	50.3
Value to international Kew Gardens visitors	13.1
Value to UK Wakehurst visitors	5.4
Value to international Wakehurst visitors	0.5
Value to attendees of special events	10.4
Non-use and option value for UK residents	61.1
Scientific value	76.3
Educational value for UK students	27.5
Education value for international students	1.5
Other income	14.4
Ratio of quantified UK benefits to costs	3.3
Ratio of quantified benefits to costs (including international benefits)	3.5

Source: Oxford Economics

COMPARISON WITH OUR PREVIOUS STUDY

Our results for 2018/19 suggest the gross value of the benefits that Kew brings to the UK has increased by £57 million, or 30%, since 2015/16.³ Costs increased by £16 million, or 27%, over the same period, meaning that the UK benefit-cost ratio has remained unchanged at 3.3.

The growth rate of international benefits was slightly greater than for UK benefits, and the international benefit-cost ratio has therefore increased slightly from 3.4 in 2015/16 to 3.5 in 2018/19.

³ To enable a like-for-like comparison, we have re-calculated the 2015/16 results to incorporate methodological changes made as part of the current study. Details of the changes and the impact of these on the earlier results are presented in Appendix 3.

1. INTRODUCTION

Royal Botanic Gardens, Kew (Kew) has two botanic gardens, Kew Gardens and Wakehurst. Founded in 1759 and declared a UNESCO World Heritage site in 2003, Kew Gardens is a world-famous visitor attraction and special events venue. Wakehurst is Kew's wild botanic garden in West Sussex and home to the Millennium Seed Bank. Kew's two botanic gardens received 2.4 million visits in 2018/19, including nearly 100,000 visits from schoolchildren, and there were almost 120,000 Kew and Wakehurst members.

This study provides a timely update to Oxford Economics' 2016 report on the value of Kew.⁴ We have again employed a cost-benefit analysis (CBA) within a welfare economics framework to assess the total value to visitors from the UK and abroad, as well as Kew's educational and science value, and its "non-use" value to UK residents.

As its name suggests, CBA involves comparing the benefits of a given project or initiative with its costs. On the cost side, operating and maintaining Kew incurs what economists call an "opportunity cost". Funds used to sustain the operations of Kew are resources that society—whether private visitors or public funding bodies—could put to alternative uses. In 2018/19, Kew incurred operating expenses of £73.7 million,⁵ of which around 65% related to the costs associated with research and conservation activities.⁶

In return, Kew provides a wide range of benefits to society. In addition to visitors appreciating the beauty and diversity of its gardens, Kew's extensive collections and scientific contribution bolster the UK's science base and hence contributes to productivity growth; attendees at special events come from far and wide to see exceptional entertainment in a unique setting; and Kew plays a substantial educational role, ranging from school visits to horticulture diplomas, professional development for teachers, and higher education courses.

Kew also benefits society in less tangible ways, for example through its research into climate change mitigation and the reduction of biodiversity loss. Kew works with over 400 partner organisations across more than 100 countries, engaging with governments to champion biodiversity. Kew is also banking seeds of the world's wild plant species to act as an insurance policy against the extinction of plants in the wild, providing a resource to grow plants

⁴ Oxford Economics, "Economic Valuation of the Royal Botanic Gardens, Kew," *A total economic value approach*, April 2016 <<https://www.oxfordeconomics.com/my-oxford/projects/330449>> [accessed May 2019]

⁵ The total costs of Kew relate to the total operational expenditure associated with Kew in 2018/19. However, we have excluded £6 million of capital costs as the asset value created from these expenditures has not been included in our benefits analysis. Moreover, Kew recognises within its accounts a share of the income and expenditure of the Bentham-Moxon Trust and the Kew Foundation based on the percentage of voting rights of these charities' Boards of Trustees held by Kew trustees or Kew staff. In 2018/19 this amounted to a net expenditure £0.4 million. These costs were removed from our calculation of Kew's total costs as they do not relate to Kew's operational expenditure.

⁶ Other costs include the costs of visitors activities and the costs of raising funds via trading and fundraising.

and study them safely. With over 2.25 billion seeds from 189 countries, it is the largest conservation project of its kind.⁷ In total, the gardens are home to more than 870 threatened species, subspecies or varieties, and there are some 48,000 samples of plant DNA in Kew's DNA and Tissue Bank.⁸

Citizens place intrinsic value on the role Kew plays in conserving biodiversity for future generations and, more broadly, on the existence of Kew Gardens and Wakehurst as places of heritage and beauty—this is known as the non-use value. Some people may also value the option of being able to visit one of Kew's gardens in future. All of these benefits represent the full value society ascribes to Kew and its work.

For the purposes of this report, all costs and benefits are quantified with respect to 2018/19—the most recent full year for which data are available. We begin by estimating the value of Kew Gardens to its UK resident visitors; this exercise is then repeated for Wakehurst and for special events at both gardens. Subsequent chapters assess Kew's educational contribution for domestic students; its scientific impact in terms of the boost it gives to the UK's productivity in the long term; its non-use value; and its international value. Finally, Chapter 10 brings these strands of value together and sets them against the costs of operating and maintaining Kew, to derive a "benefit-cost ratio". This ratio gives us a sense of the overall value for money of Kew.

THE VALUE OF ORNAMENTAL HORTICULTURE AND LANDSCAPING IN THE UK

Among its many benefits, Kew contributes greatly to the skills and knowledge of the UK horticulture industry—not least by inspiring participation among both professional and amateur horticulturists. A report published by Oxford Economics in October 2018 estimated that this industry was worth more than £24 billion to the UK economy in 2017.⁹

The study, commissioned by the Ornamental Horticulture Roundtable Group (OHRG), considered the full benefits of everything from domestic gardening to horticulture-related tourism in the UK, and therefore encompassed ornamental horticulture's supply chain and wage consumption "multiplier effects". The report found that well over half a million UK jobs were supported by the industry in 2017, and more than £5 billion in tax revenues were linked to ornamental horticulture.

The UK is regarded as the "gardening capital of the world", and about one-third of all international tourist visits to the country involve at least one trip to a park or garden. In all, garden tourism was found to have contributed almost £3 billion to UK GDP in 2017.

⁷ Royal Botanic Gardens, Kew, "What is biodiversity?," 2019 <<https://www.kew.org/read-and-watch/what-is-biodiversity>> [accessed October 2019]

⁸ As of May 2019, there were 872 taxa in the Living Collections categorised as threatened on the International Union for the Conservation of Nature (IUCN) Red List of Threatened Species. Source: Royal Botanic Gardens, Kew, "Living Collections Strategy," 2019 <<https://www.kew.org/sites/default/files/2019-07/Living%20Collections%20Strategy%202019%20FINAL.pdf>>

⁹ Oxford Economics, "The Economic Impact of Ornamental Horticulture and Landscaping in the UK", October 2018. <<https://www.oxfordeconomics.com/recent-releases/3b5ce883-cc72-4cf9-910e-be267fe93f46>>

However, the full value of the horticulture industry extends far beyond these contributions to GDP and employment. Engagement with plants, gardening, and green spaces has been shown to be remarkably beneficial to individual health and wellbeing, while also offering a raft of wider environmental benefits. The 2018 report highlighted the value of green spaces in stimulating physical activity, easing stress and anxiety disorders, promoting social cohesion, and reducing crime levels. Reviews of evidence in this area suggest the economic value of these health and social benefits amounts to many billions of pounds.

Furthermore, there is a broad slate of crucial “ecosystem services” that natural spaces and green infrastructure provide—ranging from absorbing air and noise pollution and alleviating flood risks, to mitigating extremes of temperature and sustaining wildlife and biodiversity.

Another indicator of the value we place on access to green space can be found in the ONS’s estimate of its impact on UK house prices. In 2018, it calculated that the presence and proximity of natural features added an estimated £131 billion to the value of the UK’s housing stock.¹⁰

¹⁰ Office for National Statistics, “UK natural capital: ecosystem accounts for urban areas,” *Statistical bulletin*, 2018

2. HOW WE CALCULATE THE TOTAL VALUE OF ROYAL BOTANIC GARDENS, KEW

This chapter offers a brief overview of the methodology we have employed to estimate the full benefits of Royal Botanic Gardens, Kew (Kew). This extends beyond the “standard” welfare economics approach by applying a Total Economic Value methodology to our cost-benefit analysis.

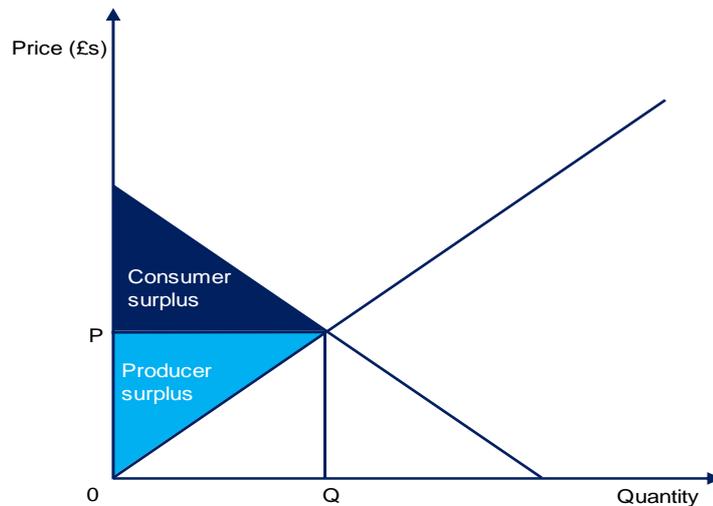
2.1 OUR THEORETICAL FRAMEWORK

Welfare economics seeks to assess the *true value* of the subject of study, rather than simply taking market prices as a guide to value. In this case, visitors to Kew’s two botanic gardens will typically feel they get value from the experience that exceeds the cost of their visit—making their trip “worth it”. In welfare economics, the value accrued to the consumer in excess of what they pay is known as their “consumer surplus”. A visitor may pay the £18 entry fee to visit Kew Gardens, but enjoy it so much that they would have been prepared to visit even if the ticket price were £30—making their consumer surplus £12. If a second visitor is willing to pay £20 to visit, their consumer surplus would be £2.

A similar dynamic can be seen on the producer’s side. In this case, the “producer surplus” is the difference between the revenue received by Kew and the minimum it is able to produce these services for. Roughly speaking, producer surplus therefore equates to the producer’s profits: breaking even means there is a zero producer surplus.

Fig. 2 illustrates these concepts graphically. When the price of the thing being valued—in this case, the entry fee for visitors to Kew Gardens—is P , the consumer surplus is identified by the area shaded in dark blue, which represents the sum of all its individual visitors’ consumer surpluses. This is the area between what those visitors pay and the point at which they would become indifferent to visiting (the latter defines a demand curve that traces the number of visitors expected at each different price of entry).

Fig. 2. Illustration of consumer and producer surpluses



Similarly, the producer surplus (the light blue area on Fig. 2) represents the difference between the revenue received by Kew and the operational and maintenance costs associated with the gardens. Note that this figure could be negative if the revenues generated from visitors directly are insufficient to cover the gardens' full costs.

In theory, adding up the producer and consumer surpluses that flow from a product, programme, or initiative in this way gives the true benefit that those parties derive from it. In the case of Kew, however, quantifying these areas is challenging—not least because how much visitors would have been willing to pay, and hence how much they really value the gardens, is not immediately apparent, and inferring this is complex.

2.2 TOTAL ECONOMIC VALUE

The above approach is often employed when estimating the value of something traded in a market. However, Kew's value is much broader than the benefits derived from it as a visitor attraction. When assessing the value of cultural or environmental assets, the standard welfare framework should be broadened.

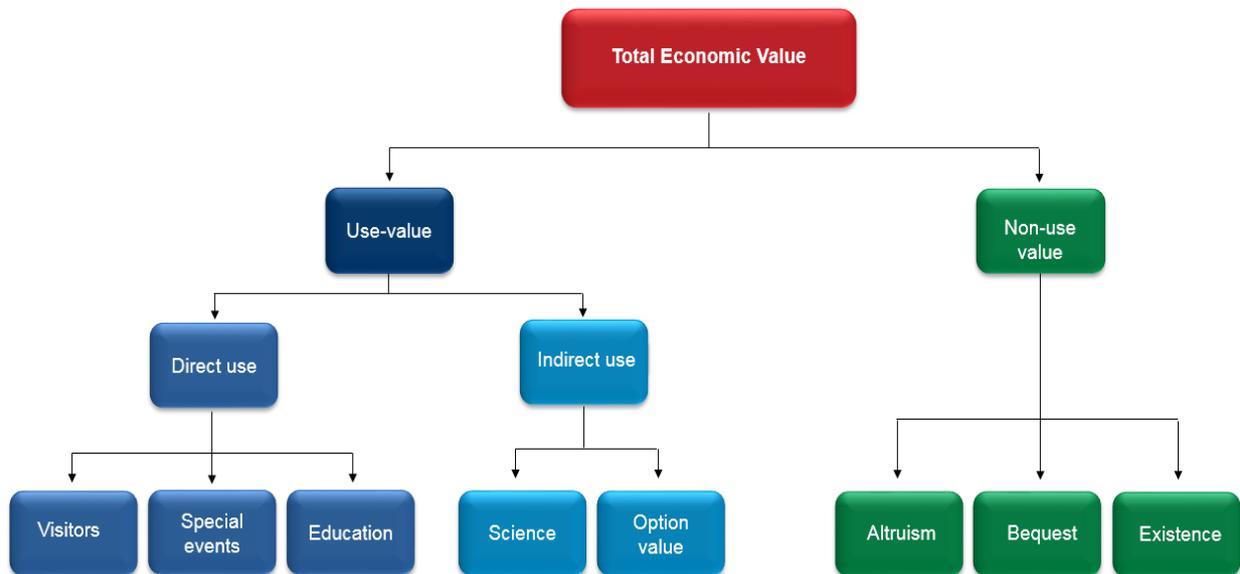
For example, the labour market benefits that derive from the educational opportunities provided by Kew often lie in the future and are hard to disentangle from other contributions to a person's subsequent labour market success.

In addition to Kew's combined consumer and producer surpluses, the social welfare associated with the gardens includes any non-market effects that are not captured by those who either produce or directly consume them. These "externalities" can be substantial, particularly in the case of activities such as Kew's science, which stimulates innovation and boosts economic productivity. Such non-market benefits are diffuse and hard to capture—let alone price—but putting a value on them is an essential part of understanding the benefits that Kew generates.

In order to capture each of these diverse elements, we therefore applied a Total Economic Value (TEV) approach to our cost-benefit analysis, as outlined

in publications by the OECD¹¹ and the Department for Environment, Food and Rural Affairs (DEFRA).¹² TEV is used to measure the sum of the producer surplus and consumer surplus associated with an “environmental asset”, including values that arise for direct users, indirect users (such as beneficiaries of its scientific output), and non-users (such as those who value its existence and role in sustaining biodiversity). Fig. 3, overleaf, sets out the TEV framework used in this study.

Fig. 3. Total Economic Value framework for Royal Botanic Gardens, Kew



- **Direct use values** include the surpluses associated with visits by members of the public, special events attendees, and the benefits accruing to learners of all types.
- A major source of benefits accrues **indirectly** to wider society through the scientific value added by Kew. A second source of indirect value derives from the fact that members of the public who do not visit nevertheless have the option to do so in future.
- Finally, there are **non-use values**: people who do not use Kew directly may nonetheless value it for the enjoyment it gives to others (altruism); the fact that it will be maintained for future generations; and simply the fact that it exists at all.

¹¹ OECD, “Cost-Benefit Analysis and the Environment: Recent Developments” (2006).

¹² Department for Environment, Food and Rural Affairs, “Assessing environmental impact: guidance” (2013).

Note: the TEV approach used to assess the value of each element of Kew's contribution is consistent with a standard welfare economics approach, as well as with HM Treasury guidelines as set out in the HM Treasury Green Book.¹³

2.3 THE SCOPE OF THIS STUDY

One important consideration when undertaking a cost-benefit analysis of this type is the geographical scope of the costs and benefits to be considered. A cost-benefit analysis (CBA) may relate to the costs and benefits of an initiative as it affects the world as a whole, or costs and benefits may be assessed with respect to a particular jurisdiction—such as the UK. In the latter case, only benefits to the people (consumer surplus) and entities (producer surplus) within that jurisdiction should be considered in the assessment.

The people and entities that fall within the study form what is known as “the population of standing”. For this report, the central focus is on the costs and benefits that Kew provides to UK society as a whole. Accordingly, we report our CBA from a UK standpoint.

However, there is also an important global role for Kew. Accordingly, we include a separate chapter on Kew's international value—with a focus on value to international visitors, students and science.

All quantified costs and benefits relate to 2018/19 and represent an *annual flow* of value. There are two main reasons for taking this approach. Firstly, the value generated by Kew for visitors, educational participants, non-users, and through science occurs fairly continuously, and is therefore best suited to measurement (and most easily understood) as a flow over a defined time period. Secondly, we are interested in comparing costs and benefits, partly with a view to informing debate around the level of public funding that Kew receives each year. Considering the value of benefits accrued over a financial year facilitates comparison with the costs accrued over the same period.

¹³ HM Treasury, "The Green Book: Central Government Guidance on Appraisal and Evaluation," 2018 <https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/685903/The_Green_Book.pdf> [accessed May 2019]

3. VALUE TO KEW GARDENS VISITORS FROM THE UK

In 2018/19, a total of 1.2 million visits were made to Kew Gardens by UK residents (excluding students and teachers).¹⁴ Many of these visits were made by the Kew Gardens' 102,000 members, who typically paid £71 for annual membership.^{15 16 17} Visitors who were not members paid an entry fee of £18.¹⁸ But as outlined above, the entry fees paid by visitors represent only a small part of the true value these people place on their visit to the Gardens. This chapter outlines the analytical method used to estimate this valuation and the results for UK visitors to Kew Gardens.

We estimate the value UK visitors place on visits to Wakehurst in the next chapter, while results for international visitors to both Kew Gardens and Wakehurst are discussed in Chapter 9.

3.1 OUR APPROACH

Researchers use a variety of approaches to calculate the value visitors receive from amenities such as the gardens at Kew. The goal of these methodologies is to reveal their *willingness to pay* (WTP). One approach is simply to ask people how much they would have been prepared to pay to visit Kew Gardens. However these "stated preference" techniques suffer from various problems. For example, people may be concerned that they are being asked in order to test the water for future increases in the entry fee. Equally they may simply not find it easy to put a monetary value on the experience.

A well-established alternative approach to eliciting WTP is to use "revealed preference" techniques. These, as the name suggests, use people's observed actions to infer their WTP.

The approach adopted for this study is the *Travel Cost Method* (TCM). The TCM is based on the insight that travelling to visit an attraction such as Kew Gardens inevitably involves costs other than the formal entry fee. A visitor driving to the Kew Gardens would face costs in terms of fuel consumption, vehicle depreciation and the opportunity cost of their own time spent travelling. The net value from a visit to Kew Gardens which remains after travel costs have been taken into account is therefore likely to be substantially greater for

¹⁴ This figure also excludes complimentary admissions, corporate clients, reciprocal entries, carers, community groups and coach drivers.

¹⁵ Total number of members at the end of March 2019

¹⁶ This relates to the membership cost of a single adult plus one family guest. Source: www.kew.org, "Become a member of Kew Gardens," <<https://www.kew.org/join-and-support/become-a-member-kew>> [accessed May 2019]

¹⁷ Visits made by members includes visits by their guests or children.

¹⁸ Cost for an adult to purchase a ticket at the gate without donation. Source: www.kew.org, "Tickets and prices," <<https://www.kew.org/kew-gardens/visit-kew-gardens/tickets>> [accessed May 2019]

someone who lives five miles away than for a similar person living 100 miles away. This is because the visitor who lives far away faces a substantially higher effective entry fee (the sum of all the costs of getting to and accessing the Gardens). These variations in travel costs can be taken as a proxy for different entry fees to Kew Gardens.

The degree to which visitors living further from Kew Gardens become more scarce allows us to infer how sensitive the typical visitor is to changes in the cost of going to Kew Gardens. That enables us to determine how quickly the total number of visitors in 2018/19 would fall away if the entry fee were to be raised, and hence identify the location of Kew Gardens' demand curve. From that demand curve we can estimate the *consumer surplus* accruing to visitors: i.e. the difference between what visitors actually pay, and the maximum amount they would have been willing to pay to visit the gardens.

For this study, we have estimated the value of consumer surplus using an *Individual Travel Cost Method* (ITCM).¹⁹ The ITCM focuses on the frequency of visits made by members of the public, seeking to determine what impact greater distance has on the frequency of visits for a given individual. People who live close to Kew Gardens face low travel costs—both in terms of the immediate costs of transport and the opportunity cost of time spent travelling—and hence are more likely to visit regularly than an equivalent person living further away.²⁰

3.2 QUANTIFYING THE GARDENS VISITORS' CONSUMER SURPLUS

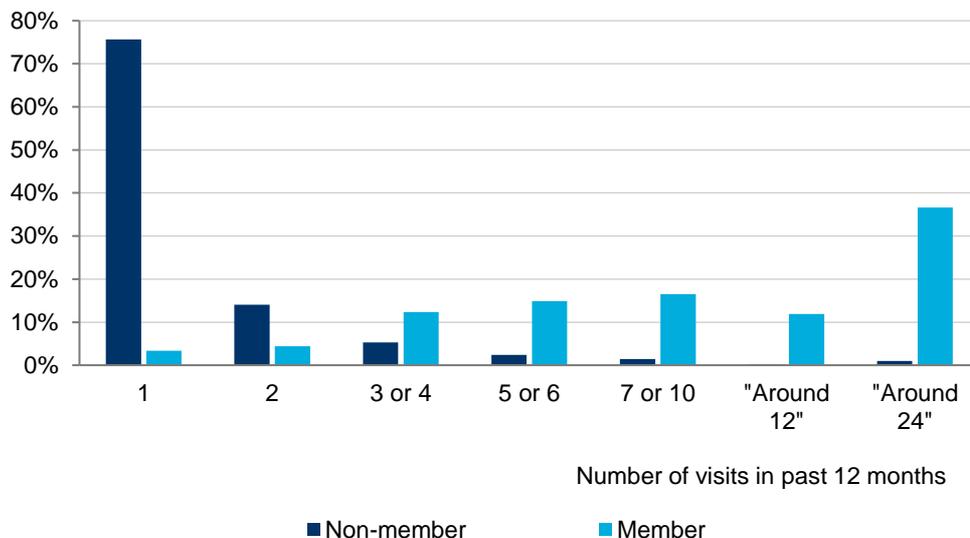
The main dataset used in our analysis was the 2017/18 Kew Gardens visitor survey. Undertaken on a continual basis from October 2017 to September 2018,²¹ this survey asked 1,098 respondents how many times they had visited Kew Gardens over the past 12 months, as well as their place of residence by the first part of their postcode, and a wide range of other questions about everything from their socioeconomic background and age to the length of their stay at the Gardens and the size of the group they visited with. Fig. 4 illustrates the number of visits made by each respondent during the previous 12 months, split into members and non-members.

¹⁹ Literature suggests that the ITCM is superior to the other main type of TCM—the Zonal Travel Cost Method (ZTCM). See for example: Eva Vicente & Pablo De Frutos, "Application of the travel cost method to estimate the economic value of cultural goods: Blockbuster art exhibitions," *Hacienda Pública Española / Revista de Economía Pública*, 37-63 (2010) and Pam Faulks, Natalie Stoeckl and Michele Cegielski Trevor Mules, "The Economic Value of Tourism in the Australian Alps," *Sustainable Tourism*, 2005. Since we had access to a detailed set of visitor survey results for Kew Gardens we were able to develop an ITCM for this part of the study. For latter parts of the study less rich data sets were available and so we were forced to use the less data-intensive ZTCM approach.

²⁰ A visitor driving to the Kew Gardens would face costs in terms of fuel consumption, vehicle depreciation and the opportunity cost of their own time spent travelling.

²¹ At the time when the analysis was undertaken survey results were not available for the full 2018/19 year. We have therefore taken the most recent 12-month period for which data were available, and re-scaled the data to align with actual 2018/19 visitor numbers.

Fig. 4. Number of visits to the Gardens during the past 12 months



Source: BVA BDRC

Regression analysis allowed us to identify the impact of a marginal change in the total cost of travel on the number of visits respondents made over the past 12 months. Other data from the survey allowed the model to control for differences in visitor characteristics that may influence the number of visits they make, such as their age and income group. Determining the relationship between travel costs and the propensity of a person to visit multiple times enables us to estimate the average consumer surplus for each visit.²²

The visit patterns of members and non-members differ markedly, with the majority (65%) of surveyed members having visited at least seven times in the past year and the majority of non-members visiting once. For this reason, separate models were run for member and non-member respondents, and the results combined to give a weighted average consumer surplus per visit for all visitors. More detail on the methodology is set out in Appendix 1.

Our modelling suggests that members have an average consumer surplus per visit of around £23, while non-members value the visit at about £39 above the cost of getting to and entering Kew Gardens. Taking a weighted average of member and non-member visits suggests that the average visitor in 2018/19 had an estimated consumer surplus of £30 per visit.

Given that there were around 1.2 million visits by UK residents (excluding students and teachers), this suggests a **total consumer surplus for Kew Gardens visitors from the UK in 2018/19 of £37 million.**

²² A central principle of the travel cost method of valuation is that people incur the full cost of their trip solely in order to visit the subject of evaluation, in this case Kew Gardens. In practice, of course, many people will combine their trip with other visits, and perhaps a weekend break in London. To avoid over-valuing Kew Gardens, it is important to identify only travel costs incurred in respect of Kew Gardens. To do so, we excluded respondents who were staying away from home from our regression analysis.

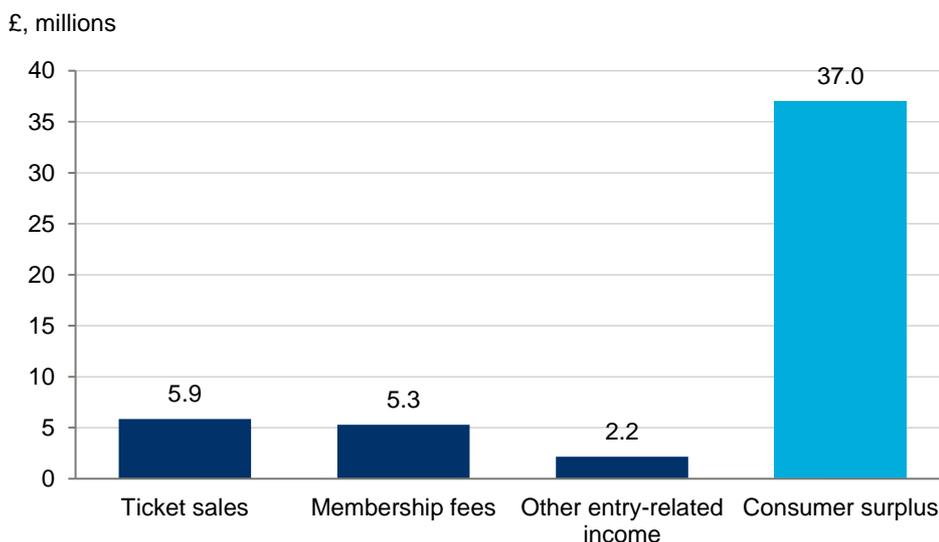
£50.3m

Total gross value of Kew Gardens to UK visitors in 2018/19.

3.3 TOTAL VISITOR VALUE AT KEW GARDENS

The above analysis has uncovered the consumer surplus captured by visitors to Kew Gardens. But in estimating the full cost-benefit ratio, it is important not to ignore the element of visitor value that is claimed by Kew Gardens in the form of ticket sales, membership revenue, and other entry-related revenues. The total income received by Kew Gardens from these sources in 2018/19 was £16.4 million, of which we estimate 81% (£13.3 million) was attributable to UK visitors.²³ **The total gross value of Kew Gardens to UK visitors was therefore £50.3 million in 2018/19.**

Fig. 5. Gross value of Kew Gardens to UK visitors by category, 2018/19 ²⁴



Source: Royal Botanic Gardens, Kew and Oxford Economics

VOLUNTEERS AT ROYAL BOTANIC GARDENS, KEW ²⁵

Kew has been working with volunteers since 1992. Its volunteer programme, which had a retention rate of almost 85% in 2018/19, offers a range of roles including horticultural support, visitor engagement, and support across Kew’s schools, family, and science programmes.

These volunteers contribute significantly to the organisation’s overall offer. In 2018/19, a total of 780 volunteers collectively contributed some 118,000 hours to Kew programmes, including leading 1,900 guided tours of Kew Gardens. Kew estimates that paying staff to work for an equivalent number of hours would have cost £1.9 million.

As part of Kew’s internal monitoring, a volunteer investment and value audit is conducted each year. In 2018/19, the audit found that for every £1 the organisation invested in its volunteer programme, it received an equivalent volunteer labour value of £11.80 in return.

²³ Using estimated splits of UK and international visitors calculated from exit polls.

²⁴ Other entry-related income includes Gift Aid, parking, lockers and tours.

²⁵ All figures in this box were supplied by Kew.

4. VALUE TO WAKEHURST'S UK VISITORS

In addition to the 1.2 million visits made to Kew Gardens by UK residents in 2018/19, a further 251,000 visits were made to Wakehurst, Kew's wild botanic garden in the Sussex High Weald (excluding school pupils and teachers). Wakehurst is home to various tree and other living collections and the Millennium Seed Bank.

As with Kew Gardens, visitors to Wakehurst can be members paying an annual subscription of £29.50, or non-members for whom tickets are priced at £13.95.²⁶ Those holding a National Trust membership may also access Wakehurst, and this group accounted for more than 60% of visits made to Wakehurst by UK residents in 2018/19 (excluding school pupils and teachers).

This chapter reports our estimates of further modelling work to establish the value derived by UK visitors to Wakehurst in 2018/19.

4.1 QUANTIFYING WAKEHURST VISITORS' CONSUMER SURPLUS

It was not possible to obtain such detailed data for Wakehurst visitors as for Kew Gardens visitors, and so we needed to develop a slightly different type of travel cost model to estimate the consumer surplus of Wakehurst's UK visitors.

This alternative approach is known as the *Zonal Travel Cost Method* (ZTCM). A zonal model divides the country into concentric zones around Wakehurst and, by observing the place of residence of visitors, determines the visit rate per 100,000 of population in each zone. For example, if 200,000 visitors to Wakehurst live between 30 and 50 miles from the gardens, and the total population in that area stands at five million, the visit rate for this zone would be 40 per 1,000 of population. The zone between 50 and 70 miles might be home to 50,000 Wakehurst visitors and have a population of three million, yielding a visit rate of 16.7 per 1,000 of population. In this example, the zone that is further away exhibits a lower visit rate due to the higher costs associated with reaching the site, in line with what we would expect to see.

To undertake the modelling, we used visitor survey data collected annually by the Association of Leading Visitor Attractions (ALVA). Collected from Spring 2017 to Autumn 2018, the sample included 921 responses.²⁷ Drawing on this survey, we were able to construct zonal visit rates using the first half of visitors' postcodes (TW9, SO21, etc.) to place each visitor in one of the 2,981 "outward" postcode areas across the UK. Drawing on population estimates

²⁶This figure relates to adult prices. Source: www.kew.org, "Tickets and prices," <<https://www.kew.org/wakehurst/buy-tickets>> [accessed May 2019]

²⁷ This was the most recent sample available for Wakehurst. As with Kew Gardens, we re-scaled the data to align with actual visitor numbers for 2018/19.

from the ONS, we were also able to identify the population living in each outward postcode area.²⁸

Next, using a Google mapping algorithm, we established the travel time (and distance) from each outward code to Wakehurst. We were thus able to group each outward code area, its Wakehurst UK visitors (grossed up to the full number of UK visitors for the year), and its population into one of nine zones up to 3.5 hours' travel time from Wakehurst—representing 99% of day-trip visitors (Fig. 6).

Fig. 6. Visit rates to Wakehurst by travel time

Travel time to Wakehurst (minutes)	Visits per 1,000 population	Proportion of all Wakehurst UK day-trip visitors, 2018/19
0 - 80	10.9	74%
81 - 90	10.0	9%
91 - 110	5.7	10%
111 - 120	3.2	3%
121 - 170	0.4	2%
171 - 180	0.5	0%
181 - 210	0.2	0%

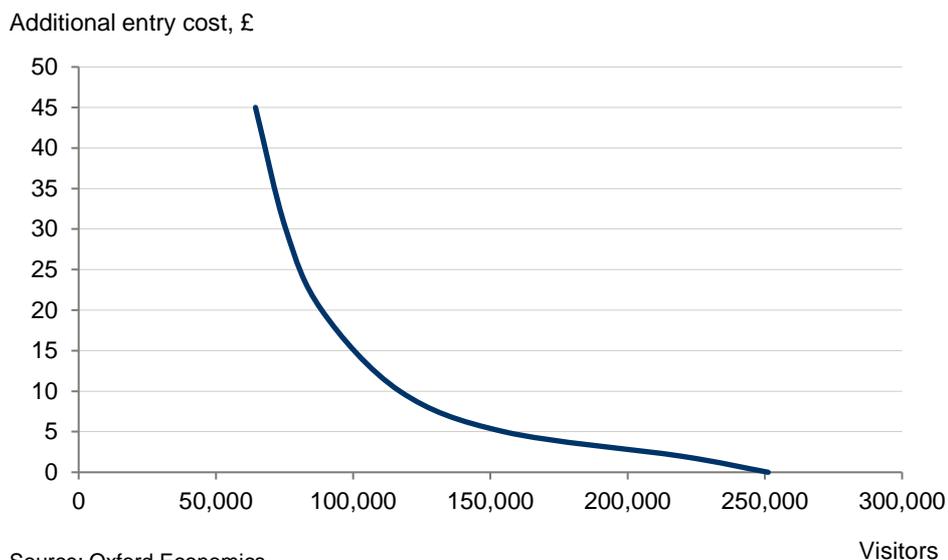
Having established the travel zones we estimated a total per-person travel cost from each zone to Wakehurst. This incorporated direct travel costs and value of time, in the same way as set out for the ITCM model in Chapter 3.

Having established the travel zones, visit rates and associated costs it was possible to determine the underlying demand curve for Wakehurst's UK visitors in 2018/19. This allowed us to estimate the consumer surplus of these visitors, by looking at the impact on visitor numbers from different simulated increases in the entry fee. (More detail on the ZTCM model is given in Appendix 1.)

Fig. 7 illustrates Wakehurst's UK visitor demand curve based on a range of simulated rises in the ticket price. It shows that the number of visitors is initially very sensitive to small price increases: i.e. a small change in price would result in a large change in the number of visitors at the left-hand end of the curve. But as we move to the right of the curve, visitors become less sensitive to price changes.

²⁸ The only population estimates available from the ONS for postcode areas are from the 2011 Census. We adjusted these to reflect population growth since then using 2017 ONS mid-year population estimates for lower level super output areas. Source: [www.ons.gov.uk, "Lower layer Super Output Area population estimates ,"](https://www.ons.gov.uk/peoplepopulationandcommunity/populationandmigration/populationestimates/datasets/lowersuperoutputareamidyearpopulationestimates) <<https://www.ons.gov.uk/peoplepopulationandcommunity/populationandmigration/populationestimates/datasets/lowersuperoutputareamidyearpopulationestimates>> [accessed May 2019]

Fig. 7. Estimated UK visitor demand curve for Wakehurst ²⁹



In essence, the total area underneath the demand curve is equal to the difference between the actual cost and the maximum that visitors would have been willing to pay to visit Wakehurst. Put another way, the area under the demand curve represents the consumer surplus of Wakehurst’s UK visitors.

4.2 TOTAL VISITOR VALUE AT WAKEHURST

Using the ZTCM model, we find that the average consumer surplus per Wakehurst visit for all types of UK visitor was £18, indicating an **aggregate consumer surplus for its 251,000 UK visitors in 2018/19 of £4.6 million.**

As explained in Chapter 3, it is also important to recognise the revenues raised by admissions, membership, and parking charges at Wakehurst as part of its visitor value. These revenues are collected by Wakehurst in order to cover the operating of the site, but they nevertheless represent a portion of the value that visitors place on Wakehurst. Adding just under £761,000 of annual visitor revenues to the consumer surplus above puts the **total UK visitor value of Wakehurst at £5.4 million for 2018/19.**³⁰

£5.4m
Total gross value of
Wakehurst to UK
visitors in 2018/19.

²⁹ In determining the consumer surplus we truncated the demand curve—in this case at total additional cost of £45.00, since less than 3% of the visitor sample faced costs higher than this.

³⁰ Data on Wakehurst revenue streams were provided by Kew. Note: membership fee data provided by Kew included fee payments from both Kew Gardens and Wakehurst. We used membership visit numbers for the two sites to apportion the fees between sites.

5. VALUE TO SPECIAL EVENTS VISITORS

In addition to its role as a visitor attraction in its own right, Royal Botanic Gardens, Kew (Kew) also hosts a diverse range of events. In 2018/19, these included:³¹

- **Christmas at Kew**—a Christmas festival and light show along a 2.6 km path through the gardens.
- **Glow Wild**—a winter lantern trail at Wakehurst.
- **Handmade at Kew**—an international contemporary craft fair.
- **Kew the Music**—a week of live outdoor music concerts from world-famous acts.
- **Orchids After Hours**—in addition to the free daytime display, Kew Gardens ran an “after dark” event for six evenings. 6,200 orchids were displayed, accompanied by craft activities and talks from horticulturists.
- **Richmond RunFest**—a range of races starting in Kew Gardens.
- **State of the World’s Fungi Symposium**—a two-day symposium which brought together fungal and plant scientists, ecologists, conservationists and industry and policy experts from around the world.
- **Temperate Tipples and preview nights**—the Temperate House is the world’s largest Victorian glasshouse. These events showcased some of the world’s rarest and most threatened plant species.
- **The Wonder Project**—an interactive art experience exploring Wakehurst through soundscapes, sculptures, and art installations.
- **Alice in Wonderland**—an outdoor theatre production at Kew Gardens.

These events attract different kinds of visitors to those making a general visit to the gardens. But they are amenable to the same travel cost analysis outlined in preceding chapters, to estimate the consumer surplus these events provide to attendees. We used zonal travel costs models to value the following events:

- Christmas at Kew, which in 2018 attracted over 259,000 visitors to Kew Gardens.
- Glow Wild, which in 2018 attracted over 53,000 visitors to Wakehurst.
- Orchids After Hours, which in 2018 attracted over 4,000 visitors to its evening events at Kew Gardens.

³¹ Events with less than 30 attendees have not been shown here.

- The Wonder Project, which in 2018 attracted almost 3,000 visitors to Wakehurst.

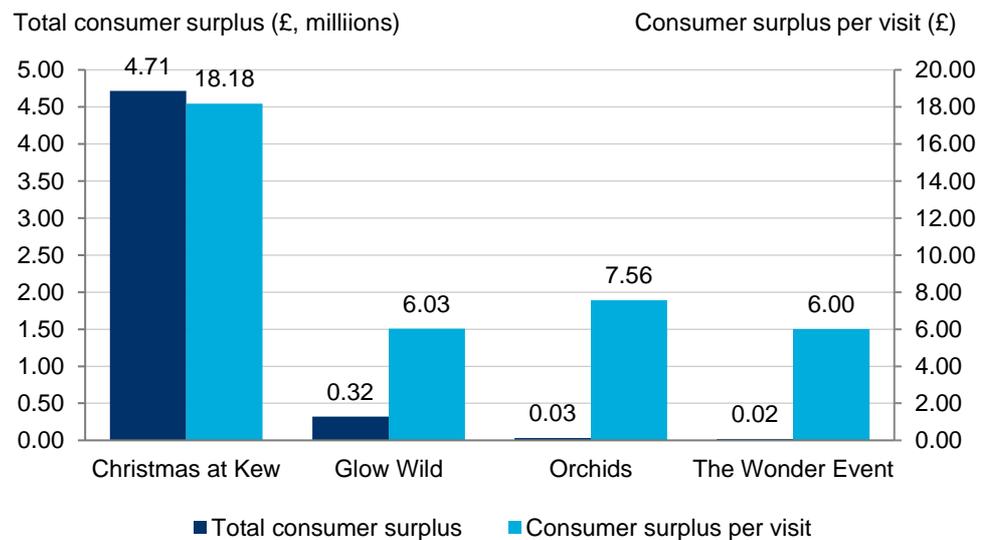
Note: these four events collectively accounted for 87% of visitors to Kew’s special events in 2018/19. Our methodology could not be applied to the other Kew events due to data limitations—survey data were not available for all events, while in other cases data were available but sample sizes were too small to conduct a robust analysis.

5.1 QUANTIFYING THE CONSUMER SURPLUS OF SPECIAL EVENTS

Using sales data, we were able to assign a postcode to each ticket sale made for one of the four highlighted events. Visitor travel zones were then defined for each of these events, from which the relationship between costs and visit rates was established.

Constructing the implied demand curve for each event allowed us to estimate the consumer surplus associated with them. The results for each event are shown in Fig. 8. Adding together the value received from each of these events gives a total consumer surplus of £5.1 million. (Note that these surplus values are assumed to accrue to the UK, as the underlying data do not allow us to distinguish between UK and international event attendees.)

Fig. 8. Consumer surplus of Royal Botanic Gardens, Kew special events, 2018/19



Source: Oxford Economics

£10.4m

Total gross value of Kew’s special events in 2018/19.

5.2 TOTAL SPECIAL EVENT VALUE AT ROYAL BOTANIC GARDENS, KEW

Revenue in respect of the 10 events listed at the start of this chapter totalled £5.3 million. This represents the part of the value attendees place on their visit that is claimed by Kew to put on the events. Adding this to the consumer surplus generated by the four events identified above yields a **total estimated benefit from these special events of around £10.4 million.**

However, since the consumer surpluses generated by other special events run by Kew were not calculated within this analysis, we can say that £10.4 million represents a conservative assessment of the special events value generated by Kew in 2018/19.

6. VALUE TO UK STUDENTS

Royal Botanic Gardens, Kew (Kew) generates significant educational benefits for the UK. For the purposes of this report, we have divided its educational offerings into seven distinct areas:

- **School visits**—Kew works with schools across the UK to bring school children to the gardens for a day of hands-on learning about plants and conservation.
- **Diploma courses**—Kew’s School of Horticulture offers a three-year diploma with broad-based training in botanical horticulture.
- **Apprenticeships**—Kew’s School of Horticulture also hosts apprentices who spend four days each week training at Kew.
- **Specialist training**—specialist courses aimed at researchers and PhD students.
- **MSc Course and university course visits**—this category includes short visits for university students, a partnership with Queen Mary University of London to deliver an MSc, and internships.
- **Supervision of PhD students**—coordinated primarily through individual supervisors across Kew Science.
- **Teacher training courses**—a series of courses for trainee teachers.

The educational activity supported through Kew contributes to the personal development of those individuals who engage with it. Depending on the nature of their engagement, individuals will gain some level of knowledge and/or practical skills. In turn, these would be expected to enhance individuals’ employability and productivity when they enter the world of work.

There is an existing body of academic research which investigates the impact of various levels of education on an individual’s lifetime earnings.³² In this chapter, we show how we have used the findings from that research to estimate the lifetime earnings uplift that individuals might receive from the time they spend on the various educational activities overseen by Kew.

Note: this chapter presents the value of Kew’s educational contribution to UK students only. The value to international students will be discussed in Chapter 9.

6.1 SCHOOL VISITS

In the 2018/19 financial year, 88,500 school students visited Kew Gardens and 10,900 visited Wakehurst to participate in educational visits. Approximately 45% of visits are self-led, and 55% are assisted, where sessions are led with

³² Estimating returns to education is far from straightforward. All of the studies cited in this chapter attempt to identify a causal relationship between education and subsequent labour market outcomes, rather than simply the correlation between them.

Kew teachers. On average, each student spent four to five hours at Kew Gardens or Wakehurst during their visit. For simplicity, we have assumed each visit was equivalent to a whole day's instruction.

On the day of the school visit, Kew Gardens or Wakehurst may be considered a substitute for students' normal place of learning. We have therefore assumed a day spent at the gardens has a similar value to a day of classroom learning.

For our 2016 study, we reviewed literature on returns to schooling, and we identified that an additional year of education adds approximately 10% to an individual's lifetime earnings.³³

For this study, we have assumed that the average age of a student on a school visit to Kew Gardens or Wakehurst was nine years old, that these students will join the UK workforce in 2031 when they are 21, and retire when they are 68.³⁴ The lifetime earnings for someone starting work in 2031 was estimated to be £1.4 million (at 2018 prices)—to be conservative, this calculation was based on average UK incomes for someone qualified at GCSE-level.³⁵

When considering benefits that will arise in the future, we need to adjust for the fact that people prefer to consume goods and services now rather than in future (this is known as "social time preference"). In line with standard government appraisal practice, we made this adjustment by applying a discount rate to convert future benefits into their *present value*. In line with the government's Green Book, we used a discount rate of 3.5% (3% after 30 years).³⁶ This process gave a lifetime earnings figure of £446,000 in present value terms.

A 10% uplift of these earnings—the uplift that can be expected from an additional year's schooling—is therefore worth £44,600 in present value terms. Assuming that a day at Kew Gardens or Wakehurst is one out of 190 days of an academic year implies that the educational value of a visit is £235 per pupil. Multiplying this across 99,000 school visits suggests **the total value of school trips in 2018/19 was £23.3 million.**

³³ Oxford Economics, "Economic Valuation of the Royal Botanic Gardens, Kew," *A total economic value approach*, April 2016 <<https://www.oxfordeconomics.com/my-oxford/projects/330449>> [accessed May 2019]. See Chapter 5.

³⁴ Kew indicated that the majority of school visits were made by pupils aged seven to 11. We have therefore made a simplifying assumption that the average age of a pupil on a school visit was nine years old in 2018/19.

³⁵ This estimate was developed using data on pay by age and qualification from the ONS publication: Office for National Statistics, "Graduates in the UK Labour Market: 2017," *Employment and labour market*, 2017 <<https://www.ons.gov.uk/employmentandlabourmarket/peopleinwork/employmentandemployeetypes/datasets/gr-graduatesintheuklabourmarket2017>> [accessed May 2019], in conjunction with Oxford Economics' forecasts of real wage growth.

³⁶ HM Treasury, "The Green Book: Central Government Guidance on Appraisal and Evaluation," 2018 <https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/685903/The_Green_Book.pdf> [accessed May 2019]

KEW'S ONLINE EDUCATION RESOURCE ³⁷

To engage with pupils nationally, in November 2018 Kew launched Endeavour—an online learning platform which can be accessed free of charge. It is designed to inspire primary and secondary school teachers and pupils throughout the UK to learn more about why plants matter and to encourage critical thinking about topics related to plants, science, and the environment. Endeavour includes everything required for teachers to deliver a dynamic, pupil-led session. In doing so it showcases applications of science in real life, and the content has been designed to help to build pupils' knowledge of science.

6.2 THE DIPLOMA COURSE

Kew's School of Horticulture offers a three-year, full-time diploma course. In 2018/19, there were 29 students registered on the course, of which 22 were from the UK.

The Kew diploma course in horticulture is viewed as a higher education qualification, equivalent to a bachelor's degree (FHEQ level 6³⁸). We therefore estimated returns to the course using evidence from academic literature on the value of a university degree. Chevalier *et al.* assessed the marginal return to a degree (as opposed to leaving education after A-levels), and estimated the uplift in lifetime earnings is 22% for men and 30% for women.³⁹ A separate study for the UK government calculated a similar rate of return of 27%.⁴⁰ We have used 26%, which is the simple average of the Chevalier *et al.* estimate for men and women.

Assuming that students enrolled on the diploma course are qualified at A-level or equivalent, and that the average age of a student in 2018/19 was 19 years, we estimated that if these students did not complete their diploma, their average lifetime earnings would be in the region of £495,000 (in present values).⁴¹ Then applying a 26% uplift to this figure suggests the value of a Kew diploma is £129,000 per student over three years, or £43,000 per year. Applying this to the 22 UK students enrolled in 2018/19 suggests the **total value generated by Kew's diploma course in 2018/19 was £944,000.**

³⁷ The content of this box was supplied by Kew.

³⁸ Framework for Higher Education Qualifications of Degree-Awarding Bodies in England, Wales and Northern Ireland.

³⁹ Arnaud Chevalier *et al.*, "Does Education Raise Productivity, or Just Reflect It?," *The Economic Journal*, F499-517 (2004).

⁴⁰ London Economics, "The Returns to Higher Education Qualifications," *Department for Business Innovation and Skills*, Research Paper 45 (2011).

⁴¹ We have assumed a diploma student's counterfactual average lifetime earnings would be equivalent to someone qualified at A-level. We have also assumed that the average student in 2018/19 will start work in 2021 and their career would last from the ages of 21 to 65. To calculate present values we have applied a discount rate of 3.5% (3% after 30 years).

6.3 APPRENTICESHIPS

Kew's School of Horticulture also hosts apprentices who spend four days each week undertaking workplace training at Kew, and attend a local college to study for their trailblazer apprenticeship in horticulture on the other day.⁴² Apprenticeships last for two years; in 2018/19, there were 17 apprentices.

To estimate the value of these apprentices, we used research for the Department for Business Innovation and Skills (BIS) which indicated that the lifetime earnings return to a Level-2 apprenticeship is 12%.⁴³ Following a similar approach to that for diploma students, we then calculated a return per apprentice of £25,000 per year (in present value terms).⁴⁴ Multiplying this figure across 17 apprentices suggests a **total value of £426,000**.

6.4 SPECIALIST TRAINING

In 2018/19 Kew supported a range of short courses, including:

- One-year, full time courses for horticulturists. In 2018/19 Kew offered courses on a range of topics including arboriculture, display and nursery glasshouses, kitchen garden production, ornamental horticulture and propagation. Students who completed these courses were awarded with a "Kew Specialist Certificate" in their area of study.
- A two-week course which gave participants an overview of 70 of the most commonly encountered tropical plant families, as well as an introduction to plant morphology and identification tools.
- A one-week wood identification course designed for individuals working with wood such as botanists, archaeologists, conservators, furniture and picture restorers, and workers in forensic science and allied professions.
- A two-week course in applied plant taxonomy, identification and field survey skills. This is designed for doctoral students and early-career researchers undertaking all aspects of environmental science, but particularly ecology, botany and conservation.

Taken together, these courses supported 22 domestic students in 2018/19 (or 65 students including those from overseas). We have assumed these courses are equivalent to PhD level. To estimate the value of these specialist courses, we again used research for BIS which indicated that returns to those with a

⁴² For more information of trailblazer apprenticeships see: www.gov.uk, "Search for apprenticeship standards," <<https://www.gov.uk/guidance/search-for-apprenticeship-standards>> [accessed May 2019].

⁴³ London Economics, "The Returns to Higher Education Qualifications," *Department for Business Innovation and Skills*, Research Paper 45 (2011)

⁴⁴ We have assumed apprentice's counterfactual average lifetime earnings would be equivalent to someone qualified at GCSE-level. We have also assumed that the average age of an apprentice in 2018/19 was 17 years old. The uplift factor was scaled to reflect that apprenticeship students are only at Kew Gardens for four-fifths of the week and also to reflect the length of the apprenticeship

PhD are 15% higher compared to those with undergraduate degrees.⁴⁵ Applying this to lifetime earnings for someone qualified at degree level (£956,000), then scaling for the time spent at Kew, suggests a **total value of £307,000 across all participants in 2018/19**.⁴⁶

6.5 MSC COURSE AND UNIVERSITY COURSE VISITS

Kew delivers short programmes of teaching on plant and fungal science related topics to university students. In 2018/19, 12 different university groups visited Kew for talks and tours, with some 300 students attending. Students were from undergraduate and postgraduate courses, from both the UK and further afield.

Kew is also partnered with Queen Mary University of London in the delivery of a jointly developed MSc in Plant and Fungal Taxonomy, Diversity and Conservation, which is now in its fifth year. As part of this masters, Kew delivers four of the six taught modules, and provides the six-month research project training for the majority of students. In 2018/19, Kew supported 24 such students.

In addition to specific taught courses, Kew offers two types of internships: a 12-month sandwich internship, and a two-to-three month summer internship. Kew accepted a total of 15 interns in 2018/19. These internships are specifically designed for students who undertake an industrial placement as part of their course.

Adding together each component of the university provision shows that Kew supported a total of 331 students in 2018/19. The precise numbers of UK and international participants per course were not available, so we used UK student place of origin data from the Higher Education Statistics Agency (HESA) to split participants of Kew's university courses into UK and international students. This suggested that 237 masters and undergraduate students on course visits were from the UK.

We thus estimated that in 2018/19, Kew provided 2,900 days of education to UK undergraduate and masters students.⁴⁷ Combining estimates from the BIS report on returns to undergraduate and masters students with estimates on the counterfactual lifetime earnings of each of these groups, we estimated the additional value these students would receive from their education.⁴⁸ Scaling this

⁴⁵ London Economics, "The Returns to Higher Education Qualifications," *Department for Business Innovation and Skills*, Research Paper 45 (2011)

⁴⁶ This is based on the assumptions that the average student in 2018/19 will start work in 2019 and their career would last from the ages of 21 to 65. To calculate present values we have applied a discount rate of 3.5% (3% after 30 years).

⁴⁷ Including internships.

⁴⁸ Returns on investment for the different types of students have been detailed in the sections above. We have assumed counterfactual average lifetime earnings for undergraduate students would be equivalent to someone qualified at A-level. For Masters and PhD students, average lifetime earnings was assumed to be equivalent to someone qualified at graduate level. We assumed that students were in their first year of study when they visited Kew. Therefore, we assumed that undergraduate students will start work in 2021, masters students will start work in 2019 and PhD students will start work in 2022.

to the time spent at Kew, we estimate that the **value of university course support for domestic students by Kew in 2018/19 was £1.4 million.**

6.6 PHD SUPPORT

Kew offers support to PhD students, co-supervising 56 in 2018/19—coordinated primarily through individual supervisors across Kew Science. The precise numbers of UK and international PhD students were not available, so we again used place-of-origin data from HESA to split participants into UK and international students. This suggested that 32 PhD students were from the UK.

PhD students come from a wide variety of universities and programmes, and their relationship with Kew can vary greatly. Some PhD students are based on site full-time, while others are at Kew part-time, occasionally visit for a week or a month, or work entirely remotely. Others still can spend a placement of 6-12 months at Kew. Based on consultation with Kew, we have assumed that 25% of the value accruing to PhD students may be attributed to their interactions with Kew.

We estimate that in 2018/19, Kew provided 1,900 days of education to UK PhD students.⁴⁹ Combining estimates from the BIS report on the returns to PhD students with estimates on the counterfactual lifetime earnings of someone qualified at graduate level, we estimated the additional value that these students would receive from their education.⁵⁰ Scaling this to the time spent at Kew, we estimate the **value of the PhD support offered by Kew to be £313,000 for domestic students in 2018/19.**

6.7 TEACHER TRAINING

Along similar lines to the previous categories, Kew hosts field trips by trainee teachers studying for Post Graduate Certificate of Education (PGCE) qualifications. Kew provided an estimated five days of education to 299 UK trainee teachers in 2018/19. Assuming PGCE courses generate similar value to an MSc course (and using the lifetime wage for someone qualified at degree level), this is **estimated to generate £857,000 of benefits to the UK.**

⁴⁹ Including internships.

⁵⁰ Returns on investment for the different types of students have been detailed in the sections above. We have assumed counterfactual average lifetime earnings for undergraduate students would be equivalent to someone qualified at A-level. For Masters and PhD students, average lifetime earnings was assumed to be equivalent to someone qualified at graduate level. We assumed that students were in their first year of study when they visited Kew. Therefore, we assumed that undergraduate students will start work in 2021, Masters students will start work in 2019 and PhD students will start work in 2022.

£27.5m

Estimated total educational value for UK students in 2018/19.

6.8 TOTAL VALUE OF EDUCATIONAL BENEFITS

Adding all the education benefits outlined in this chapter suggests that the **total value of educational benefits for UK students generated by Kew in 2018/19 was £27.5 million**. Fig. 9 summarises the value we have attributed to each of Kew's educational areas.

Fig. 9. Value of educational courses for UK students, 2018/19

Value of Kew's educational programmes	£
School visits	23,300,000
Diploma course	944,000
Apprenticeships	426,000
Specialist training	307,000
MSc Course and university course visits	1,400,000
PhD support	313,000
Teacher training	857,000
Total	27,500,000

Source: Oxford Economics

7. VALUE TO UK SCIENCE

Royal Botanic Gardens, Kew (Kew) is a global resource for plant and fungal knowledge, possessing one of the world’s largest and most diverse collections of plant and fungal specimens (both living and preserved). The combination of extensive collections, databases, scientific expertise and global partnerships give Kew a leading role in the study of plants and fungi. In 2018, there were over 7,000 visitors to Kew’s science collections.⁵¹ Details of these collections are presented in the table below.

Kew’s resources and materials are used by researchers and other stakeholders worldwide. Research undertaken by Kew scientists focuses on documenting and understanding global plant and fungal diversity. The majority of the research is fundamental, with the objective of increasing understanding of plants and fungi, although the outputs can often be of economic importance and some have a direct commercial application.

KEW SCIENCE COLLECTIONS MANAGED BY THE COLLECTIONS DEPARTMENT

Collection	Approximate number of specimens	Description
Herbarium	7,000,000	Preserved and dried vascular plant specimens. While the overall number of species represented is unknown, the current herbarium catalogue (12% of the full collection) represents 187,500 species.
Spirit collection	76,000	Specimens of plants, plant parts, and fungi preserved in spirit, representing almost 30,000 species.
Fungarium	1,250,000	Preserved and dried fungi, lichens, and fungal analogues such as oomycetes and myxomycetes. An additional 1,100 fungal cultures are stored in liquid nitrogen. While the total number of species represented is unknown, the current Fungarium catalogue (40% of the full collection) contains 52,000 species.
Economic botany collection	100,000	A broad range of samples documenting use of plants by people, including 42,000 wood collections. In all, approximately 20,000 species are represented.
Seed collection	92,500	Living seed collections are held in the Millennium Seed Bank, with more than 2.3 billion individual seeds representing around 40,200 species. An additional 20,000 preserved seed samples from herbarium sheets are held for taxonomic reference.
DNA and tissue bank	58,000	48,000 samples of plant genomic DNA stored at -80°C, and 10,000 silica-dried tissue samples at room temperature—together representing around 35,000 species.
Microscope slide collection	150,000	Microscope slides documenting plant and fungal anatomy, including around 40,000 slides of pollen, 36,000 slides of wood, and 10,500 slides of fungi. In all, an estimated 76,000 species are represented in this collection.

Source: Royal Botanic Gardens, Kew, "Science Collections Strategy 2018-2028,"

<<https://www.kew.org/sites/default/files/2019-02/Kew%20Science%20Collections%20Strategy%202018-2028%20Download.pdf>>

The table above highlights the extensive and diverse nature of the science collections at Kew. It is these factors that make the collections an important part of UK research infrastructure, with the potential to help scientists address global challenges such as climate change, biodiversity

⁵¹ This includes around 6,000 visitors to Kew’s Library, Art and Archives Collections

loss, and habitat destruction. In addition to their research value, the seeds stored in the Millennium Seed Bank serve as an “insurance policy” against the risk of those species going extinct in the wild (although placing a value on such insurance would be extremely challenging).

Note: in our previous study, we reviewed potential approaches to attributing value to Kew’s collections. These included estimating the potential economic value of a species or information stored, or the cost of building or replacing a collection. Such approaches are subject to a very high degree of uncertainty, and we were unable to identify methodologies and data sources that would enable us to derive robust valuations for the Kew collections.

It is important to note that, even if they could be robustly estimated, such measures would provide an indication of the accumulated *stock* of value associated with the collections. As such, they would not be suitable for inclusion within our total economic value framework, which considers annual *flows* of costs and benefits.

To estimate the value of Kew’s scientific research we follow the same approach adopted in our 2016 study. This was based on the observation that the benefits to society that research can generate often exceed those received by the individuals carrying out the research. Economists call these wider benefits to society “externalities”.

Various researchers have attempted to place a value on the wider benefits of research and development (R&D) activity. Most notably in the UK, Haskel *et al.* investigate how public science funding can drive productivity improvements in the private sector.⁵² The authors constructed a model of the effect of private and public sector R&D on the long-run productivity of the UK economy, finding that public sector R&D has a 20% rate of return to the UK economy.

We have once again applied this finding to Kew’s science budget to estimate the value it generates. While this is essentially an input-based approach, incorporating the multiplier allows us to adjust for the fact that the value generated by scientific research is, on average, substantially greater than the cost of undertaking that research.

Kew’s total expenditure on science in 2018/19 was £20.3 million. This comprises the £18.3 million cost of managing the Science directorate and carrying out research, plus a proportion of the cost of managing the Living Collections.⁵³ Applying the rate of return identified by Haskel *et al.* suggests an increase of £4.1 million per year in UK economic output for the lifetime of the research.⁵⁴

⁵² Alan Hughes and Elif Bascavusoglu-Moreau Jonathan Haskel, “The economic significance of the UK science,” *UK-Innovation Research Centre*, 2014

⁵³ Kew’s Living Collections provide important support to its scientific research. However, they also support other aspects of Kew’s activity, such as by helping to sustain an attractive environment for visitors and contributing to educational initiatives. Kew estimates that 41% (£2.0 million) of the expenditure associated with the Living Collections in 2018/19 supported scientific research.

⁵⁴ Assumptions include a six year lag between the investment and associated benefits.

£76.3m

Estimated present discounted value of Kew's scientific activities in 2018/19.

The length of this lifetime depends on the assumed depreciation rate and the characteristics of the research in question. Studies suggest that private R&D investments depreciate at a rate of 20% per year, but that public R&D investments do not depreciate or depreciate at slower rates.⁵⁵ Haskel *et al.* assume a discount rate of 5% per year and that the increase in knowledge is infinitely-lived. In order to maintain consistency with HM Treasury discount rates and government modelling assumptions on depreciation, however, we applied a 3.5% discount rate and a 2% yearly depreciation rate.

Following that approach, the £4.1 million per year increase generated by Kew's scientific activities in 2018/19 has a present discounted value of £76.3 million.

⁵⁵ Frontier Economics, "Rates of return to investment in science and innovation," *A report prepared for the Department of Business, Innovation and Skills (BIS)*, Research Report (2014)

PROTECTING BRITISH ASH TREES

Ash (*Fraxinus excelsior*) is one of the most common broadleaved trees in the UK. It is currently threatened by ash dieback, a disease caused by the fungus *Hymenoscyphus fraxineus*. Scientists from the Plant Health team at Kew are at the forefront of research on ash dieback, assessing the current impact and future severity of the disease. A major focus of the team is on the analysis of ash tree genomes, to better understand the genetic basis of resistance to the disease.

Ash dieback has only recently invaded Europe from its native range in Asia. Spores from the fungus germinate on ash leaves; the tree's wood starts to die when the fungus enters its twigs. If the fungus reaches the trunk, it can kill the whole tree.

Kew's Plant Health team has provided evidence to the Department for Environment, Food and Rural Affairs (Defra) as it manages and responds to ash dieback in the UK. The team's research has helped Defra and other stakeholders understand:

- the proportion of ash trees that can be expected to die in the UK because of ash dieback, and the rate at which they are likely to die;
- the genetic basis of resistance to ash dieback;
- the viability of a breeding programme to increase ash dieback resistance, and potential effectiveness of natural selection in evolving increased resistance; and
- the susceptibility of ash trees to emerald ash borer (*Agrilus planipennis*), a small bark-boring beetle which causes ash trees to die within three years of infestation.

Scientists at Kew and their collaborators have sequenced and assembled a reference genome of a British ash tree. In collaboration with Forest Research, they have examined the genetic makeup of 700 ash trees with low susceptibility to ash dieback and 700 with high susceptibility, and are using these data to identify genes associated with resistance to the disease.

Another threat is the emerald ash borer beetle. While not yet present in the UK, it has killed hundreds of millions of ash trees in the United States. Kew scientists have collaborated with the US Department of Agriculture to assess the susceptibility of European ash to this pest. They are also comparing the genomes of Asian, American, and European ash species to identify genes associated with resistance to the beetle. This work has used the living collection in Kew's arboretum, which includes 227 specimens of around 40 ash species.

CONTRIBUTING TO THE DELIVERY OF THE UN SUSTAINABLE DEVELOPMENT GOALS

Work undertaken by Kew scientists is contributing to the UK's delivery of the UN Sustainable Development Goals—specifically Goal 2 (“zero hunger”) and Goal 15 (“life on land”). This work is highlighted in two programmes, outlined below.

The Millennium Seed Bank partnership

Kew's global seed banking network, the Millennium Seed Bank (MSB) partnership, is the largest *ex-situ* plant conservation programme in the world. Its focus is (i) plant life faced with the threat of extinction, and (ii) plants which will be of most use in the future.

Kew's *State of the World's Plants* report (2016) highlighted that 21% of global plant species are threatened with extinction.⁵⁶ Seeds are conserved in the MSB as an insurance against the risk of extinction in their native habitat. For example, the project aims to collect and conserve seeds from more than 350 species of “crop wild relative”, facilitating their use in breeding new crops that are better adapted to climate change.

UK National Tree Seed project

Kew's UK National Tree Seed project collects and stores seed from native trees and shrubs throughout the UK—in order to conserve the genetic diversity of UK trees and woodlands, and to develop genetically representative collections in the MSB. Already, more than 10 million seeds have been successfully stored from more than 7,500 trees.

High-quality seed collections stored in the MSB can be kept alive for many decades. This means that seeds collected as part of this project will be a resource for future generations, with the collections and associated data being made available for research and conservation. A study of the project's collection of ash trees suggests that more than 90% of the UK genetic diversity of this species has been conserved to date.

Note: the case studies extracted above originally appeared in the UK Voluntary National Review of the Sustainable Development Goals.⁵⁷

⁵⁶ Royal Botanic Gardens, Kew, "State of the World's Plants," 2016
<https://stateoftheworldsplants.org/2016/report/sotwp_2016.pdf>

⁵⁷ HM Government, "Voluntary National Review of progress towards the Sustainable Development Goals," *Sustainable Development Goals*, 2019
<https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/818212/UKVNR-web-accessible1.pdf>

8. NON-USE AND OPTION VALUE

In addition to the day visitors and the special events visitors, another category of valuation is represented by UK residents who do not visit Kew Gardens or Wakehurst but may yet still value the gardens and want them to be supported. This so-called “non-use” value is commonly estimated for environmental or cultural amenities, which are often seen as intrinsically valuable by citizens.⁵⁸ For example, people may value the fact that the ballet exists and support its continued funding, even though they may never want to attend the ballet.

Non-use values can consist of three different components:

- **Existence value**—the value people attach to the existence of Royal Botanic Gardens, Kew (Kew) despite the fact that they have no intention of visiting it.
- **Bequest value**—the value that people place on preserving Kew for the benefit of future generations.
- **Altruism value**—the value people attach to Kew simply because they know that other people enjoy it.

People may also value the possibility of having the option of visiting Kew at some point in future. The framework presented in Chapter 2 shows that this **option value** represents an “indirect use” benefit of Kew, rather than a non-use value. However, in practice it is often difficult for people to distinguish between these concepts, so we have quantified the option value alongside the non-use values. As such, hereafter we will refer to non-use values and the option value collectively as the **non-use value**.

8.1 METHODOLOGY

An online survey of the UK general population was conducted to measure non-use and option values of Kew by Lightspeed GMI.⁵⁹ Survey quotas were imposed on age and region of residence to ensure a representative sample of the UK population.⁶⁰ A total of 1,200 UK residents were surveyed.

⁵⁸ The importance of assessing non-use values within a TEV is noted in Treasury and Department for Work and Pensions supplement to the Green Book: Department for Work and Pensions, “Valuation Techniques for Social Cost-Benefit Analysis: Stated Preference, Revealed Preference and Subjective Well-Being Approaches,” *A Discussion of the Current Issues*, 2011
<https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/209107/greenbook_valuationtechniques.pdf> [accessed May 2019] .

⁵⁹ The survey included UK residents aged 16 and older and was undertaken between 25 April 2019 and 3 May 2019.

⁶⁰ Survey quotas set for 16-24 year olds were slightly relaxed in order to complete the study—162 records out of 168 targeted were met for this age group. Quotas were also relaxed for 65+ year olds (this group was missing one record) and for people from East Anglia (103 records out of 108 targeted were met for this group.)

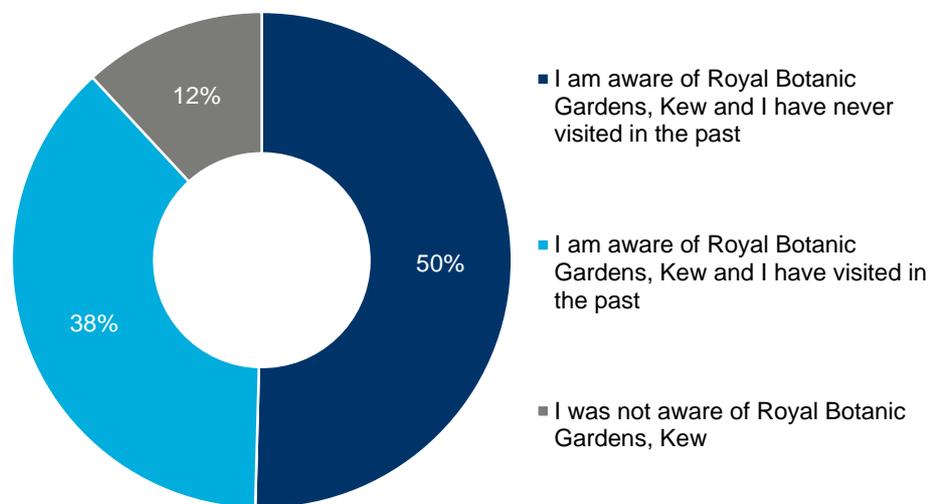
This is an established technique for determining an intangible, but nonetheless real, type of value. The HM Treasury Green Book, for example, acknowledges that it may be useful to ask people about their “willingness to pay” for a benefit through a specially constructed survey when it is not possible to estimate values from market data or consumers’ behaviour.⁶¹

8.2 SURVEY ANALYSIS

8.2.1 Awareness of Royal Botanic Gardens, Kew

The first step in our analysis was to identify whether respondents have visited Kew in the past, as only respondents who have never visited Kew are included in our main estimate of the non-use value. Our survey identified that 88% of respondents were aware of Kew, and 38% of respondents were both aware of Kew and had visited in the past (Fig. 10).

Fig. 10. Awareness of Royal Botanic Gardens, Kew: survey responses, 2019⁶²



Source: Oxford Economics analysis of survey conducted by Lightspeed GMI

N = 1,200

Although only respondents who have never visited Kew are included in the main estimate of the non-use value, it is informative to compare the responses given by users and non-users, to understand how respondents’ valuations vary with different levels of exposure.

⁶¹ See: HM Treasury, "The Green Book: Central Government Guidance on Appraisal and Evaluation," 2018 <https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/685903/The_Green_Book.pdf> [accessed May 2019] and Richard T. Carson, "Contingent Valuation: A Practical Alternative when Prices Aren't Available," *Journal of Economic Perspectives*, 26 (2012) <https://econweb.ucsd.edu/~rcarson/papers/Carson_JEP12.pdf> [accessed May 2019]

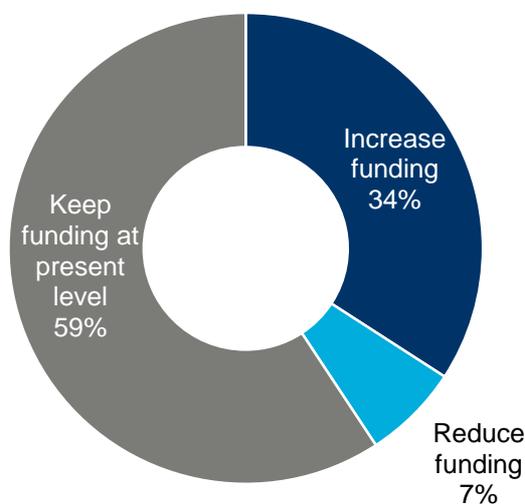
8.2.2 Valuation of Royal Botanic Gardens, Kew

The estimation of the non-use value is based on survey questions relating to respondents' *willingness to pay* to support the operation of Kew. When asking these kinds of questions it is important to set them within a realistic context so that respondents give proper consideration to their response and take into account their *ability to pay*.

For the Kew survey, respondents were told that the average UK taxpayer contributes £1.20 to Kew in the form of tax-funded public grants. Then, as a line of initial inquiry, respondents were asked whether they would ideally want to increase, decrease or keep that contribution the same.

The majority of respondents (59%) stated they would choose to retain the current level of funding and 34% said they would be prepared to increase funding to the gardens. A small but notable number of respondents (7%) said they would decrease funding.⁶³

Fig. 11. Awareness of Royal Botanic Gardens, Kew and desired level of funding



Source: Oxford Economics analysis of survey conducted by Lightspeed GMI

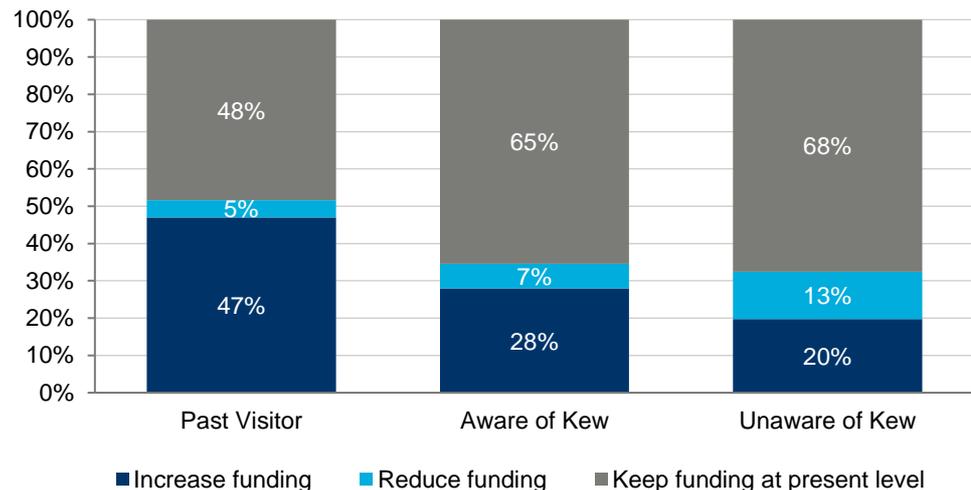
N = 1,200

When we disaggregated these results by type of visitor (Fig. 12), we found that past visitors to Kew were most likely to suggest increasing the current level of funding - 47% of respondents selected this option. A similar amount in this group also opted to keep funding at the current level.

⁶³ A small number of respondents (56) initially said they would decrease funding to Kew and then when asked for the maximum amount they were willing to pay, indicated that they would be willing to increase funding to Kew or maintain its current level. The number of people choosing to increase funding or maintain its current levels was increased accordingly. A similar adjustment was made for people (24 respondents) whose willingness to pay response suggested they wanted to decrease funding or keep it the same, even if their earlier response suggested they thought funding should increase.

Around two-thirds of respondents who were aware of the gardens but had never visited or were unaware of the gardens stated they would retain the present funding level. Far fewer respondents in these groups indicated they would increase funding. Perhaps unsurprisingly, those who were unaware of Kew were most likely to suggest a reduction of funding (13%, compared to just 5% of past visitors).

Fig. 12. Awareness of Royal Botanic Gardens, Kew and desired level of funding, by visitor type



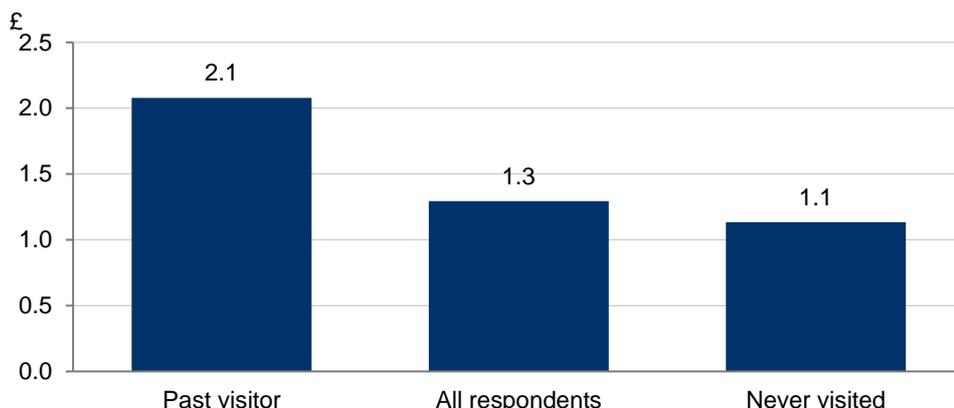
Source: Oxford Economics analysis of survey conducted by Lightspeed GMI

N = 1,200

If respondents, in answering the initial question, chose to increase or decrease their contributions, they were asked a follow-up question on the maximum they would be willing to pay for Kew. The responses to this question and the one before, enabled us to calculate respondents' average willingness to pay, or average non-use value, for Kew.

The resulting non-use values are shown in Fig. 13 below for different types of respondent. The average value among previous visitors to the gardens was £1.30 per respondent, while non-users reported an average valuation of £1.10 per respondent.

Fig. 13. Average valuation of Royal Botanic Gardens, Kew per respondent



Note: Standard deviations for previous visitors (2.0), all respondents (0.5), and non-users (0.3).
Source: Oxford Economics analysis of survey conducted by Lightspeed GMI

The raw survey results contained some very large outliers regarding maximum willingness to pay; including these would have distorted our findings, which are based on the mean value. To adjust the sample, we followed the Tukey Method, which defines the upper boundary as 1.5 times the inter-quartile range. Valuations above the upper boundary of 10.70 (for past visitors), 3.78 (all respondents), and 1.95 (non-users) were therefore discarded. For this type of valuation, there is a natural lower bound of zero, and the Tukey Method was not applied here to preserve the choices of people voting to decrease funding. In implementing these adjustments, we lost about 25% of the highest valuations in the sample.

£61.1m

Total estimated non-use and option values of Kew in 2018/19.

Our central estimate of non-use and option value is based on results from those who have never visited Kew.⁶⁴ Multiplying £1.10 by the total number of UK residents aged 16 and older yields a total non-use value of £61.1 million.⁶⁵

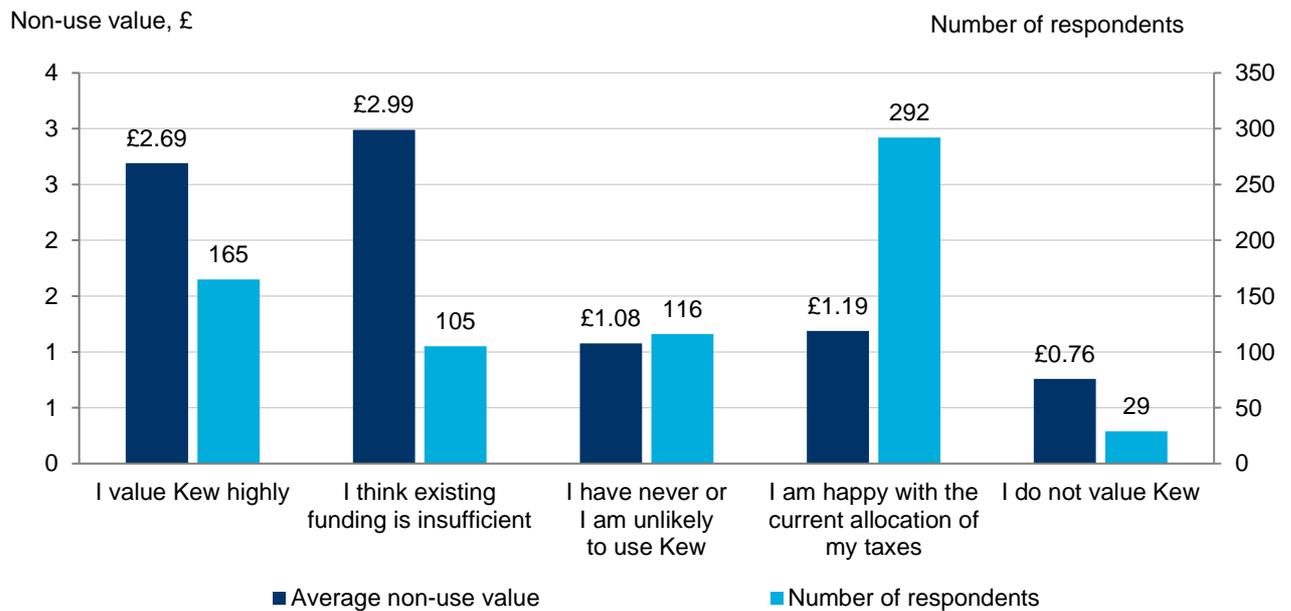
After reporting their valuation of the gardens, respondents were asked to justify their responses. Fig. 14 shows the average non-use value of respondents according to the reasons given for their valuation.⁶⁶ Large numbers (over 50%) of non-users stated they valued Kew highly and/or were happy with the current allocation of their taxes, and had average valuations at or above the current funding level. Some non-users (105) felt existing funding was insufficient and gave a significantly higher average value than the current funding level (almost £3). Very few non-users (29) said they did not value Kew.

⁶⁴ Pure non-use values from those who have never used a resource are a better guide to non-use valuations because those who have previously used the facility could conflate use and non-use values. See, for example: John Rolfe and Jill Windle, "Do values for protecting iconic assets vary across populations? A Great Barrier Reef case study," *Australian National University, Environmental Economics Research Hub.*, Research Reports (2010)

⁶⁵ While the estimation of average value per person excludes results for previous visitors, the total value is grossed up to the total population because those who have visited previously may still perceive a non-use and option value. Grossing to the total population is an approach followed in other studies of this type. See, for example: www.ecosystemvaluation.org, "Contingent Valuation Method," *Ecosystem Valuation*, <http://www.ecosystemvaluation.org/contingent_valuation.htm> and <http://www.fao.org>, "Non-use values," <<http://www.fao.org/3/ae212e/ae212e08.htm>> [accessed May 2019]

⁶⁶ Respondents were able to choose more than one reason.

Fig. 14. Average non-use and option value by reason given for valuation among non-users, with respondent numbers



Source: Oxford Economics analysis of survey conducted by Lightspeed GMI

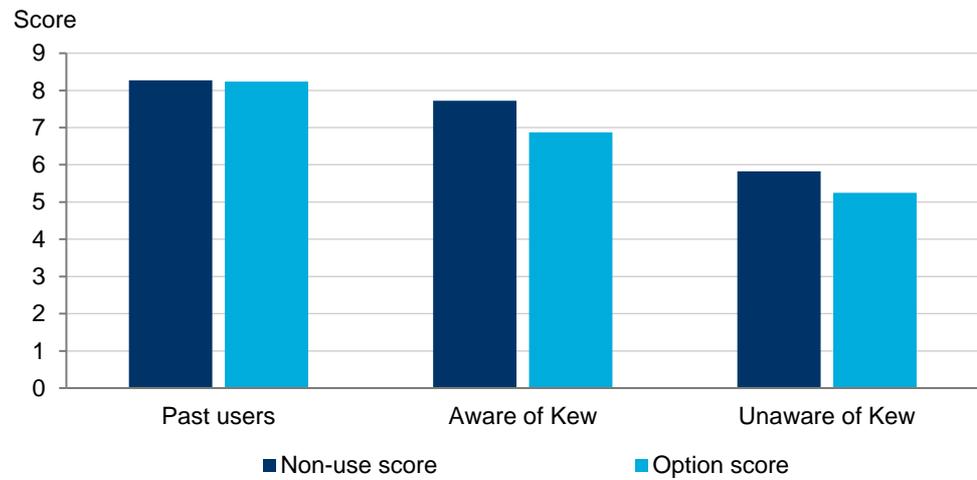
8.2.3 Components of non-use value

Non-use values have three components: the value of an amenity’s existence (“existence value”), the value of it as a gift to future generations (“bequest value”), and the “altruism value” of the attraction simply because it gives pleasure to others. In addition, respondents may perceive the “option value” of having the opportunity to visit Kew in future.

It is difficult for respondents to make a meaningful separation of the various sources of value when answering questions of this type. Nonetheless, to get a sense of the relative importance of the different factors, respondents were asked to rate their agreement or disagreement on a scale of 1 to 10 with statements on non-use and option value. Summary results are displayed in Fig. 15.

Respondents who were past users of Kew tended to award highest scores out of the three groups. For this group, there was little difference in the scores attributed to non-use and option values. Respondents who were aware of Kew but had never visited attributed slightly more value to non-use than to the option of visiting in future. Respondents who were unaware of Kew gave the lowest scores.

Fig. 15. Non-use and option value for survey respondents ⁶⁷



Source: Oxford Economics analysis of survey conducted by Lightspeed GMI

8.3 SUMMARY OF SURVEY RESULTS

The survey conducted with 1,200 individuals spread throughout the UK showed that, of all the respondents, 50% were non-users with a per-respondent valuation of £1.10 for Kew funding. This valuation, when scaled up for the UK population aged 16 and over, gives us a **total non-use value of £61.1 million.**

⁶⁷ Non-use score is the average of the scores for existence value and bequest value. Respondents are assumed to have incorporated altruism value within their responses for existence value.

THE GROW WILD PROGRAMME ^{68 69}

Some 6% of past Kew visitors who participated in our non-use survey, and 4% of non-visitors, reported that they had taken part in a Kew outreach programme. The most prominent of these is “Grow Wild”, which brings people together to value and enjoy wildflowers and fungi. Since its inception in 2014, Grow Wild has engaged over four million people, winning national awards and delivering environmental and wellbeing benefits. Activities run across the UK, and include:

- **Community projects:** Grow Wild awards grants of up to £4,000 to community groups bringing people together to transform communal spaces by growing UK native plants. Since 2014, it has awarded £830,000 to 294 community groups and engaged over 110,000 people through 2,200 events.
- **Seed kits:** Grow Wild encourages the transformation of urban and unloved spaces with wildflowers through the distribution of free seed kits to youth and community groups. Since 2014, some 296,000 kits have been distributed among 57,000 groups and an estimated 1.4 million people. Three-quarters of the groups surveyed stated they would not have grown wildflowers without Grow Wild.
- **Fungi kits:** fungi are very important to UK biodiversity, but are often misunderstood and underappreciated. Grow Wild offers people the opportunity to learn more by growing their own mushrooms in small teams. Since 2017, it has distributed some 10,300 kits, engaging 7,600 groups and 52,000 people. Almost all (97%) of the groups surveyed said they would not have tried growing fungi without Grow Wild.
- **Youth projects:** Grow Wild funds young people aged 12–25 to produce a creative project inspired by wildflowers or fungi. Since 2014, more than 150 young people have led projects, engaging thousands of people, and growing their knowledge and transferable skills.
- **Digital campaigns:** to date, Grow Wild has received some 3.2 million digital interactions and attracted 60,000 social media followers through its digital campaigns, which share information about plants and fungi and encourage engagement with the natural world.

As well as increasing the number of wildflowers grown across the country, Grow Wild benefits society by bringing communities together in joint endeavours, helping young people to connect with the natural world, and promoting mental and physical wellbeing through healthy outdoor activity and the creation of spaces for interaction with other people.

⁶⁸ The information in this box was sourced from Royal Botanic Gardens, Kew and The National Lottery Fund, “What it means to Grow Wild,” <<https://www.growwilduk.com/what-it-means-grow-wild>> [accessed Aug 2018]

⁶⁹ Further details of Grow Wild are available at: <https://www.growwilduk.com/>

OTHER OUTREACH INITIATIVES

In addition to Grow Wild, Kew runs a variety of outreach and community engagement activities designed to engage groups who are considered “hard(er) to reach”. For example, Kew operates a group annual membership for organisations that provide services directly to people who face physical, sensory, psychological, or social barriers to visiting Kew independently. In the 2018/19 financial year, this Community Membership Scheme comprised 303 groups; during that year, more than 8,400 of its members visited Kew, benefitting from heavily discounted membership rates.

As part of the Heritage Lottery-Funded Temperate House Activity Plan, Kew also operates a range of other activities free of charge, including:

- **Monthly knitting nature sessions**—using plant materials, participants discuss and learn about Kew’s science and rare plants while knitting.
- **Plant poets**—a range of creative poetry activities focusing on Kew science, horticulture and heritage.
- **Community group leader training**—training is provided to group leaders to give them the confidence to explore Kew with their groups. Community resources are developed with groups for them to use during their visits (e.g. cards with images and explanations, magnifying glasses, etc).
- **Community horticulture learning**—this includes practical “make and do” sessions for community members, horticulture workshops, and introduction to horticulture sessions. In 2018/19, more than 400 participants engaged in these activities.
- **Early Years programme**—this includes various classes for different age ranges, such as music and movement for 0-2 year-olds, little explorers for 2-5 year-olds, and Family Learning Cards which include questions and ideas to help families learn about Kew.
- **Youth Explainers**—a bespoke training programme that equips young people with the knowledge, skills, and confidence to engage visitors to Kew in plant science and conservation. Through the Youth explainer programme, young people are able to achieve a Silver CREST Award (the Skills and Volunteering certificates for a Silver DofE Award), and more than six months volunteering experience. In 2018/19, 25 young people graduated as Youth Explainers.

9. INTERNATIONAL VALUE

The preceding chapters present quantitative estimates of the value of Royal Botanic Gardens, Kew (Kew) to the UK. However, the benefits that Kew generates extend far beyond the UK's borders and in this chapter we consider the international value of Kew in terms of visitors, students, and international science.

9.1 VALUE TO INTERNATIONAL KEW VISITORS

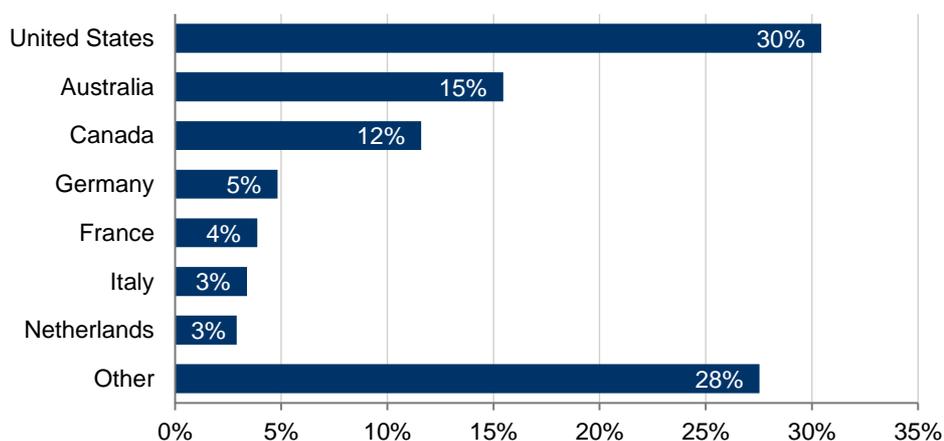
Chapter 3 considered the value to UK visitors of Kew Gardens. By similar logic, Kew Gardens also generate value for their international visitors. Kew is well-known and highly-regarded across the world. But the people of some countries, such as Australia, have an even stronger cultural affinity with it. This is partly derived from the cultural connections between the two countries, established by Sir Joseph Banks, who was instrumental in making Kew the leading botanic garden in the world. Such cultural connections mean that there tend to be systematic differences in visit rates from different countries that are unrelated to travel costs. This makes using the travel cost method to establish international visitors' willingness to pay problematic. We therefore make the relatively conservative assumption that, on average, international visitors have the same consumer surplus as visitors from the UK.

In 2018/19, approximately 261,000 international visitors came to Kew Gardens. They made up about 18% of total Kew Gardens visitors. The top three countries in terms of international visitor origin in that year were the USA, Australia, and Canada.

£13.6m

Estimated total value of Kew to its international visitors in 2018/19.

Fig. 16. Countries of origin of international visitors, 2018/19⁷⁰



Source: BVA BDRC

N=207

⁷⁰ The analysis present in this chart was developed from the 2017/18 Kew Gardens visitor survey.

The analysis in Chapter 3 identified an average surplus of £30 per UK-resident visitor. Re-weighting this finding to reflect the split between members and non-members amongst international visitors suggests an average consumer surplus of £38 for international visitors. Applying this figure to international visitors to Kew Gardens suggests a total consumer surplus of £10 million in 2018/19. Adding revenues from entry-related fees of £3.1 million brings the total gross value of Kew Gardens to international visitors to £13.1 million.

Following a similar approach, we estimate that Wakehurst international visitors received a total gross value of £0.5 million in 2018/19.

The estimates above are likely to be conservative since they do not take into account the full costs an overseas visitor would incur in devoting a day of their trip to visit Kew, which suggests that they may place great value on their visit. It would be reasonable to assume, for example, that if a visitor on a seven-day trip to the UK spends one of their days at Kew, one seventh of the associated costs of their whole trip to the UK could be attributable to Kew. However, in practice, travel cost modelling is of little use in determining the willingness to pay of overseas visitors, since widely varying country-specific propensities to visit mean that cultural ties are much stronger predictors of visit rates across countries than differences in the cost of the visit. Nor does our analysis take account of the contribution of Kew in attracting overseas visitors to the UK.

9.2 VALUE TO INTERNATIONAL STUDENTS

Chapter 6 estimated the educational benefits to UK students. Many of those programmes also educate international students, and some programmes are exclusively for international students. Information was not available on the country of origin of international students, and so it was not possible to estimate specific values of the returns to education for each nationality of student. We therefore used the UK return to education as a proxy in the absence of better information. The estimated values of different types of course are set out below. Overall, the value of educational benefits to international students is estimated to have been £1.5 million in 2018/19.

- **The diploma course**—seven international students were enrolled on the Kew Diploma in Horticulture in the last financial year, representing a return of £300,000 that year.
- **Specialist training**—43 international students enrolled in one of the short courses offered by Kew in 2018/19. This generated an economic return of £177,000 for international students.
- **University course visits**—University course visits that international students participated in generated a return of £828,000.
- **PhD support**—Kew's PhD support generated a return of £236,000 for international PhD students.

£1.5m

Estimated value of Kew to international students in 2018/19.

9.3 VALUE OF SCIENCE TO THE WORLD

The previous chapter estimated the value to the UK of Kew's science contributions, using an expenditure multiplier for publicly funded R&D in the UK. However, Kew's scientific research and collections are also likely to generate substantial value outside of the UK.

This is firstly because Kew supports and provides important aspects of the infrastructure used in large swathes of plant and fungal biology research around the world. In particular, Kew has one of the largest and most diverse collections of plant and fungal specimens globally. These collections are complemented by databases, scientific expertise and global partnerships which give Kew a leading role in facilitating access to fundamental plant and fungal information.

Furthermore, much of Kew's applied research directly generates benefits outside of the UK, for example by increasing crop yields in developing countries, or through conservation initiatives. Kew undertakes scientific activity and collaborations across 110 countries, working with key organisations, individuals and communities in more than 400 partnerships.

An indication of the global reach of Kew's scientific work is provided by the strategic outputs set out in its Science Strategy:⁷¹

- **Plants of the World Online (POWO)**—Kew launched POWO in 2017 with the aim of enabling users to access information on all the world's known seed-bearing plants by 2020.
- **Training the Next Generation**—as described in Chapter 6, Kew delivers the MSc in Plant and Fungal Taxonomy, Diversity and Conservation.
- **State of the World's Plants and Fungi**—this regular report is a global horizon scan of the status of the plant and fungal kingdoms. Alongside publication of the report, Kew hosts a symposium of up to 250 delegates to which top international speakers are invited to address critical questions related to the report and current scientific and environmental challenges.
- **Tropical Important Plant Areas (TIPAs)**—Kew is working to identify and map TIPAs in seven priority countries. Through identifying TIPAs and promoting their protection to national policy makers, Kew aims to enhance the conservation of plant diversity in the tropics and allow future generations to benefit from these important natural resources.
- **The Plant and Fungal Trees of Life**—Kew is working to complete the "trees of life" for plants and fungi, producing genome-scale DNA data for a representative of each genus of plant and fungus using the latest DNA sequencing technologies and sharing data worldwide.

⁷¹ Royal Botanic Gardens, Kew, "A Global Resource for Plant and Fungal Knowledge," *Science Strategy*, 2015-2020 <<https://www.kew.org/sites/default/files/2019-01/Kew%20Science%20Strategy%202015-2020%20Single%20pages.pdf>> [accessed May 2019]

Placing a monetary value on Kew's international scientific value is even more challenging than estimating a value of science to the UK. The benefits of its scientific research accrue in many different countries in many different ways, with varying degrees of visibility. Furthermore, Kew's international scientific research contributes to the UK's cultural power and prestige (its "soft power").

10. CONCLUSION

In order to establish the full economic value of Royal Botanic Gardens, Kew (Kew) to the UK in 2018/19, this report has presented estimates of:

- the value generated by Kew for its visitors;
- the impact of Kew’s educational activities on future earnings;
- the value generated through its scientific research; and
- the perceived value attributed to Kew by non-users and those who may wish to visit in future.

In developing a cost benefit analysis, our objective is to compare the benefits of Kew to total operating costs. As well as the benefits identified in this study and listed above, those operating costs enable Kew to provide a number of other revenue-generating services. These include retail activity, catering, venue hire, licensing and publishing.⁷² In total, the income received by Kew from these services amounted to £14.4 million in 2018/19.

Adding this income to the values estimated in the preceding sections suggests that the total quantifiable economic value of Kew to the UK in 2018/19 was £245 million. This figure increases to £261 million when the quantifiable aspects of Kew’s international benefits are incorporated.

These estimates should be regarded as conservative since they do not incorporate important aspects of the value generated by Kew which cannot easily be valued. These include the “insurance” value provided by seeds stored in the Millennium Seed Bank, and the value of increased planting and horticultural activity that is encouraged among the wider UK population by Kew’s activities—most notably through its Grow Wild programme.

Perhaps more significantly, the estimated international value of Kew does not incorporate the international value of its scientific research and collections. This could be very substantial, both because of the large contribution Kew makes to the infrastructure upon which large swathes of plant and fungal biology research around the world rely, and because much of Kew’s conservation and other applied work primarily benefits other countries. Each of these things, in turn, contributes to the UK’s cultural—or so-called “soft” —power and prestige. They are, however, very difficult to value robustly.

Nonetheless, it is important to place the quantitative estimates of the value generated by Kew in context by setting it against the costs of operation, which totalled £73.7 million in 2018/19.^{73 74} Dividing the value of quantified UK

£3.30

Value of benefits generated for the UK by every £1 spent operating Kew in 2018/19.

⁷² This also includes third party income.

⁷³ The costs associated with each of the benefits that have been monetised in our analysis have been included in the total costs calculation.

⁷⁴ The total costs of Kew relate to the total operational expenditure associated with Kew in 2018/19, as identified in the introduction.

benefits by these costs gives a benefit-cost ratio of 3.3. **This means that for each £1.00 spent operating Kew in 2018/19, £3.30 of benefits were generated for the UK** (Fig. 17). If we include the elements of international value we have been able to quantify, the benefit cost ratio rises to 3.5.⁷⁵

Fig. 17. Summary of costs and benefits for Royal Botanic Gardens, Kew 2018/19

	£ million
Costs	73.7
Of which:	
Research and conservation	48.0
Visitor activities	12.9
Other	12.8
Quantified UK benefits	245.4
Quantified total benefits	260.5
Of which:	
Value to UK Kew Gardens visitors	50.3
Value to international Kew Gardens visitors	13.1
Value to UK Wakehurst visitors	5.4
Value to international Wakehurst visitors	0.5
Value to attendees of special events	10.4
Non-use and option value for UK residents	61.1
Scientific value	76.3
Educational value for UK students	27.5
Education value for international students	1.5
Other income	14.4
Ratio of quantified UK benefits to costs	3.3
Ratio of quantified benefits to costs (including international benefits)	3.5

Source: Oxford Economics

Our results for 2018/19 suggest the gross value of the benefits Kew brings to the UK has increased by £57 million, or 30%, since 2015/16.⁷⁶ Costs increased by £16 million, or 27%, over the same period, meaning that the UK benefit-cost ratio has remained unchanged at 3.3. The growth rate of international benefits was slightly greater than for UK benefits, and the international benefit-cost ratio increased slightly from 3.4 in 2015/16 to 3.5 in 2018/19.

It is important to recognise that Kew’s activities, and therefore the value they generate, continue to evolve. For example: Kew is currently proposing the development of a new scientific quarter at the Gardens site to maximise the impact of Kew’s scientific activities. Kew is also planning to invest in its scientific computing infrastructure to support increased research of genomic data, and to digitise its herbarium and fungarium collections. Finally, Kew is

£3.50

Value of benefits generated by every £1 spent operating Kew in 2018/19, when international benefits are included.

⁷⁵ Please see Appendix 3 for a comparison of these results with those from our 2016 study.

⁷⁶ To enable a like-for-like comparison, we have re-calculated the 2015/16 results to incorporate methodological changes made as part of the current study. Details of the changes and the impact of these on the earlier results are presented in Appendix 3.

planning to develop a centre of natural capital innovation at Wakehurst, which will expand its programme of scientific research at that site.

APPENDIX 1: VISITOR VALUES

INDIVIDUAL TRAVEL COST METHOD (ITCM)

Under the ITCM, the number of visits made by a person over a given time period is thought of as a function of the costs they face in accessing the site and a range of other personal characteristics, such as their age and income group. Details of these characteristics are captured in the visitor survey undertaken BDRC Continental.

The analysis developed a variable for the costs associated with each visit, before modelling the relationship between cost and the number of visits made. This, in turn, allowed us to establish the average consumer surplus per visit. Here we describe the steps in the analysis in greater detail.

Developing the visit cost variable

Constructing an accurate travel cost variable is a key challenge for the analysis. To capture the full cost of a visit it is necessary to calculate the true direct travel costs—taking account of fuel consumption, but also vehicle depreciation, insurance and taxation—as well as the opportunity cost of the time spent travelling. This was done for each respondent in the sample.

We used a Google mapping algorithm to identify travel times and distances from the centre of each of 2,981 outward codes (the first part of a postcode) to Kew Gardens. The appropriate travel time and distance was then allocated to each survey observation. To estimate the direct travel costs we used the HMRC mileage rate of 45 pence per mile, which takes account of all vehicle costs from fuel and servicing to insurance and depreciation. Where the survey respondent was part of a group of people visiting Kew Gardens, these transport costs were divided by the number of people in the group to obtain a cost per person.

Estimation of the opportunity cost of travel time is somewhat more contentious. According to economic theory, individuals' values of time should be related to their wage rate. People are assumed to trade off leisure and income until the value to them of an extra hour of leisure is equal to the income they would receive from working that hour. In practice, labour market choices are rarely so flexible and empirical studies tend to demonstrate that people value an hour of leisure time less than their hourly income. Consequently we draw upon the Department for Transport's estimate of the average value of leisure (non-work) time as £5.70 per hour in 2018.⁷⁷

An important issue to think about when using the travel costs method is the degree to which it is reasonable to assume that travel costs are being incurred solely to visit Kew Gardens. For day-trip visitors it seems reasonable to assume that a visit to Kew Gardens was the dominant if not the sole reason for their trip. But for people who stayed away from home—perhaps British residents visiting Kew Gardens despite their place of residence being a long distance away, and certainly international tourists—it does not seem reasonable to attribute their entire trip costs to their desire to visit the gardens.

Identifying what portion of those costs should be attributed to Kew Gardens is problematic without extensive and detailed survey data. However, at a minimum it is reasonable to assume that these visitors' on-the-day travel costs – perhaps from a hotel in central London – reflect the value they place

⁷⁷⁷⁷ This figure was calculated using DfT's TAG databook. Source: Department for Transport, "TAG Databook," v1.12 (June 2018) <https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/719393/TAG-data-book-may-2018.xls> [accessed May 2019]

on the visit. We therefore implicitly assume that the 28% of visitors who are not on a daytrip have the same average consumer surplus as those who are. This is likely to be a conservative estimate.

Finally, it is worth noting that the mapping algorithm works on driving time. In practice, a large number of visitors to the Gardens either walk or take public transport. Informal analysis of travel times from various parts of London shows that drive times tend to be similar or slightly shorter than public transport travel times for trips to Kew Gardens. This suggests that the use of drive times will make little difference to the estimation. To the extent that it underestimates travel times for public transport users hailing from west London, the effect will be to bias downwards the estimate of consumer surplus. The use of drive times can therefore be seen as a conservative approach to the estimation of consumer surplus.

Modelling and results

Having developed the travel cost variable, the purpose of the regression analysis is to use these data to determine how sensitive the annual number of visits a person makes is to the full costs associated with each visit (including costs of travel, time and entry).

Features of the data determine the appropriate modelling approach to be adopted. First, the number of visits made by any one person is “count data”: a person visits once, twice or three times, but never 2.5 times. A standard ordinary least squares (OLS) regression would not be appropriate for this type of data both because of its count nature and because the data is not conditionally normally distributed around the mean. Consequently a form of Poisson regression was adopted, the detail of which is explored further below.

Second, since the survey was undertaken on visitors to Kew Gardens, there are obviously no respondents in the sample who have zero visits. In other words the sample is “truncated” at zero and every observation is associated with one or more visits.

A count data model with a semi-log functional form was therefore used in the estimation, taking the form of the equation below for both members and non-members, where V_i represents the number of visits made by individual i , TC_i is the total travel cost faced by the individual, and X_i is a vector of personal characteristics such as age and income group.

$$\ln V_i = \alpha + \beta_1 TC_i + \beta_2 TC_i^2 + X_i + \varepsilon_i$$

The model was split between members and non-members, since each group exhibits very different visit rates, and the marginal cost of a visit is not the same between the two, given the charging structure.

Fig. 18 and 19, overleaf, show results for the various types of Poisson model that were tested. The estimated parameters are similar across models showing that the results are robust to specification.

Fig. 18. Members

	Poisson	Truncated Poisson	Negative Binomial	Truncated Negative Binomial
Intercept	2.3417588***	2.3416025***	2.3536977***	2.333237243
Travel Cost	-0.0531406***	-0.0532276***	-0.0518565***	-0.054038123
Travel Cost Square	0.0005177***	0.0005181***	0.0005531***	0.000576000
Age	0.0077448***	0.0077523***	0.0079577***	0.008257669
Income	0.304958	0.305269	0.200171	0.019910114
Statistics				
AIC	2479.0000	2516.0000	476.0000	3090.1917
BIC	4343.0000	4343.0000	3104.0000	3114.8605
R-Square	0.8461	0.8479	0.8657	NA
Log Likelihood	-2166.6710	-2166.5120	-1546.3756	-1539.0959
Theta (lnAlpha)			-1.1777	

Legend: *p<.1; **p<.05; ***p<.01

Fig. 19. Non-members

	Poisson	Truncated Poisson	Negative Binomial	Truncated Negative Binomial
Intercept	1.2533740***	1.4954377**	1.1681859***	10.21670926
Costs	-0.0365314***	-0.0784056***	-0.0313781***	7.18066570
Costs2	0.0001487***	0.0003031***	0.0001347***	-0.02903838
Age	0.0127892***	0.0187735**	0.0127407***	-2.24769654
Income	0.1512275***	0.2363161*	0.1489660*	26.69646052
Statistics				
AIC	606	840	242	3381.570029
BIC	1381	1190	1190	3404.198675
R-Square	0.831974144	0.791001176	0.799839063	NA
Log Likelihood	-685.8528168	-685.8528168	-590.2797039	-589.1869043
Theta (lnAlpha)			-1.7327	

Legend: *p<.1; **p<.05; ***p<.01

Choice of model type

Data on the number of visits to Kew Gardens is integer based (e.g. 0, 1, 2, 3, ...). We therefore estimated the data across four different model types belonging to the family of count data models.

The first model we considered was a conventional “Poisson” model, which assumes the data are equally dispersed. Or put another way, the model assumes the mean of the data is equal to its variance. However, if this assumption is violated the Poisson model can produce misleading results. Therefore, we considered an alternative specification which permits overdispersion in the data: a “Negative Binomial” model. The test statistic for this model (“lnalpha”), which assesses whether there is overdispersion, was statistically significant for both members and non-members data, suggesting the negative binomial model was more appropriate. One final data consideration was that by

definition, including the current visit to Kew Gardens, the minimum number of visits incurred is at least one. Therefore, the final model we tested was a variant of the negative binomial model which accounts for data that are truncated at zero

Our choice of “best” model was guided through the use of different model selection criteria. These are given in the tables above (see Fig. 18 and Fig. 19), with colour coding used to identify the “best in class”. Green reflects the best result across the four models provided, and red reflects the worst. For members, the standard negative binomial model is the preferred model. Not only does our test suggest the data are over-dispersed, but the negative binomial model also outperforms all other models using Akaike Information Criterion (AIC), Bayesian Information Criterion (BIC) and Log-Likelihood statistics. indicating that the model fits the data best given the set of explanatory variables. This model also exhibits a good R-squared statistic for a cross-sectional model. Similarly, the negative binomial model is our preferred model for non-members. This model performs favourably better than others using AIC, BIC and Log-Likelihood statistics.

Deriving the consumer surplus

Given the results of the modelling exercise, the final step is to translate these into estimates of the consumer surplus. One property of a linear model of the above type is that it can easily be used to determine the *average* consumer surplus *per visit* as $CS = \frac{-1}{\beta_1}$.⁷⁸ When a squared term is added to the model, as in the members’ model above, the consumer surplus can be estimated using the ratio $CS = \frac{-1}{\beta_1 + 2\beta_2}$. This figure is then multiplied up by the total number of annual visits to Kew Gardens to give the aggregate consumer surplus.

ZONAL TRAVEL COST METHOD

Visit rates by geographic zone were established by building on the approach described above to generate travel costs per respondent. The outward code areas were grouped into travel cost bands.

The next step in the Zonal Travel Cost Method is to identify the demand curve implied by the rate at which the visits drop away with increasing visit-related costs. The relationship between the total cost of a visit and the visit rate per thousand of population is non-linear, with rates dropping very rapidly at short distances from Wakehurst and then falling more slowly at greater distances as seen in Fig. 6 above. Taking the log of visit rate and travel costs produces a linear relationship. Consequently the log of the visit rate can be regressed upon the log of visit costs using OLS, as per the equation below.

$$\ln(Vr_i) = \alpha + \beta_1 \ln(TC_i) + \varepsilon_i$$

The results of this regression determine the relationship between costs and visit rates in the abstract, allowing us to simulate the likely number of visitors were the entry fee to Wakehurst to be raised by any given amount. A linear relationship was estimated for the data, exhibiting an R-squared of 0.42. This value is lower than we would ideally like, reflecting the challenges presented by this dataset. In particular, the propensity of people from London to visit Wakehurst is greater than for that in people in certain more local areas, perhaps reflecting the linkage with Kew or other cultural factors. In addition,

⁷⁸ John B Loomis and Michael D Creel, "Theoretical and Empirical Advantages of Truncated Count Data Estimators for Analysis of Deer Hunting in California," *American Journal of Agricultural Economics*, 72 (1990)

there are relatively few visitors from further afield than London. This lack of geographical dispersion in the data limits the number of possible zones, and therefore the number of data points with which to establish a relationship. For these reasons, the consumer surplus modelling results for Wakehurst are subject to a higher degree of uncertainty than those for Kew Gardens.

For the Christmas at Kew ZTCM the R-squared on the regression was 0.93, while those for Glow Wild, Orchids, and The Wonder Project were 0.51, 0.96 and 0.61 respectively.

Using these coefficients, we were able to simulate visitor numbers at a variety of new entry fees to trace the full demand curve as seen in Fig. 7, giving the consumer surplus as the area under the demand curve.

APPENDIX 2: NON-USE SURVEY

NON-USE SURVEY QUESTIONNAIRE

Royal Botanic Gardens, Kew is undertaking work with Oxford Economics to assess the importance of the Gardens to UK society and the economy. To do this it is important for us to understand how members of the public view the Royal Botanic Gardens, Kew.

We appreciate you taking the time to complete this survey. It will only take a few minutes and all responses will be treated as confidential.

SECTION 1: ABOUT YOU

We are collecting the information in this section to see how respondents to this survey compare to the general profile of the population.

- 1) What is your postcode?
Please enter the first half of your postcode

- 2) What is your gender?

Male	<input type="checkbox"/>
Female	<input type="checkbox"/>

- 3) Which of the following best describes your employment status?
Only one option may be selected

Full time employment	<input type="checkbox"/>
Part time employment	<input type="checkbox"/>
Self-employed	<input type="checkbox"/>
Looking after family	<input type="checkbox"/>
Student	<input type="checkbox"/>
Unemployed	<input type="checkbox"/>
Retired	<input type="checkbox"/>
Long-term illness	<input type="checkbox"/>
Other (please specify)	<input type="checkbox"/>

Other _____

- 4) What is the highest educational level you have reached?
Only one option may be selected

GCSE/O level/CSE	<input type="checkbox"/>
Vocational qualification	<input type="checkbox"/>

A-level or equivalent	
Bachelor degree or equivalent	
Masters/PhD or equivalent	
Other professional qualifications	
No formal qualifications	
Still studying	

5) What is your age?

16-24	
25-34	
35-44	
45-54	
55-64	
65+	

6) What region do you live in?

Inner and Greater London	
South East/East Anglia	
South West	
Wales	
East and West Midlands	
North West	
Yorkshire and Humberside	
North	
Scotland	

7) Which of the following brackets does your annual household income (before tax) fall into?
Note: this relates to the income for your household as a whole and not just yourself, only one option may be selected.

Less than £15,200	
£15,200 - £21,300	
£21,301 - £26,000	

£26,001 - £31,700	
£31,701 - £37,200	
£37,201 - £43,100	
£43,101 - £51,700	
£51,701 - £64,900	
£64,901 - £98,700	
Over £98,700	
I'd prefer not to answer	

SECTION 2: ROYAL BOTANIC GARDENS, KEW

- 1) What comes to mind when you think about Royal Botanic Gardens, Kew?

- 2) Which of the following best applies to you prior to taking this survey?

I am aware of Royal Botanic Gardens, Kew and I have visited in the past	
I am aware of Royal Botanic Gardens, Kew and I have never visited in the past	
I was not aware of Royal Botanic Gardens, Kew	

IF Q2 is 1: Which one of these apply?

I have visited within the last 12 months	
I have used Royal Botanic Gardens, Kew's website before	
I have participated in Royal Botanic Gardens, Kew's outreach activities, such as the Grow Wild programme	
None of these	

IF Q2 is 2: Which one applies to you?

Select all that apply

Have you ever used Royal Botanic Gardens, Kew's website	
Have you ever participated in Royal Botanic Gardens, Kew's outreach activities, such as the Grow Wild programme	
None of these	

The Royal Botanic Gardens, Kew has many unique assets and runs high profile science, horticulture and visitor-related activities, including:

- a major centre of botanical and conservation work;
- the largest living plant collection of any botanic garden in the world;
- one of the largest and most diverse global collections of dried, pressed plant specimens and the largest fungarium in the world;
- two beautiful botanic gardens, at Kew Gardens in west London, a UNESCO World Heritage Site, and Wakehurst, Kew's wild botanic garden in West Sussex, which aim to provide knowledge, inspiration and understanding of why plants and fungi matter to everyone;
- the Millennium Seed Bank, the world's largest wild plant DNA bank;
- unique and historic glass houses (e.g. Palm House, Temperate House), buildings (e.g. Great Pagoda) and a royal palace (Kew Palace);
- a botanical art collection comprising 200,000 works of art and a library containing over 500,000 items;
- a centre for scientific and horticultural education;
- events such as Christmas at Kew, Kew the Music, and the Science Festival.

3) Why do you think the Royal Botanic Gardens (RBG), Kew may or may not have value to you? Please rate your agreement with the following statements on a scale of 1-10 where 1 = "Strongly disagree" and 10 = "Strongly agree"

RBG Kew has no value to me at all	
I value RBG Kew just because it exists, regardless of whether or not I have visited – or will ever visit	
I value RBG Kew as a gift to future generations	
I value RBG Kew because I may want to visit (or visit again) in the future	
Other (please specify and rate on the scale 1-10)	

Note: the following questions are designed to capture the value that you place on the Royal Botanic Gardens, Kew. They **are not** an indication that existing levels of taxes or services will change.

It is important that you try to answer these questions to enable us to place a value on RBG Kew and the services they provide.

- 4) All UK taxpayers pay towards the upkeep and development of Royal Botanic Gardens (RBG), Kew through taxes. On average, each UK income tax payer currently pays roughly £1.20 a year towards RBG Kew through taxes.

In general terms, would you be in favour of:

a) Increasing the amount of funding to RBG Kew	
b) Reducing the amount of funding to RBG Kew	
c) Keeping funding of RBG Kew at the present level	

Only one option may be selected

[If answer a go to Q5. If b go to Q6. If c go to Q7]

- 5) You've indicated you believe funding to the Royal Botanic Gardens, Kew should be increased. If you had to choose between two possible ways of increasing this funding would you prefer to:

a) Reduce the funding of other government funded services (e.g. grants to other cultural attractions, or spending on the NHS, schools or transport)?	
b) Increase taxes	
c) Reduce funding of other government services and increase taxes	

Only one option may be selected

IF Q4 is a or b ask Q6:

- 6) As indicated on average, each UK income tax payer currently pays roughly £1.20 a year towards the Royal Botanic Gardens (RBG), Kew through taxes.

If you were free to choose how much you would pay in tax to maintain RBG Kew, what would be the maximum you would be willing to pay, through taxes, each year, to maintain RBG Kew?

Maximum amount you would be willing to pay per year in taxes to maintain RBG Kew (in pounds and pence)	
--	--

- 7) What is the basis for your answer to the previous question?
Please tick all that apply

I value RBG Kew highly	
I think existing funding is insufficient	

I have never or I am unlikely to use RBG Kew	
I am happy with the current allocation of my taxes	
I do not value RBG Kew	
I do not believe you can use surveys to address this sort of question	
Other (please specify)	

Other _____

APPENDIX 3: RESULTS COMPARISON

A number methodological refinements have been implemented during this update, which mean that the results are not directly comparable to those from our 2016 study.⁷⁹ In particular:

- We have modified the educational value calculations to more accurately reflect the year when students may enter the labour market, and to increase the retirement age to 68 by 2044.
- Feedback on our 2016 study identified that the costs used in the BCR calculation included costs relating to certain revenue-generating activities, but the associated revenue benefits were not included in our analysis. To achieve greater consistency between the costs and benefits, in this study we have included revenues relating to retail outlets, catering, licensing and a number of other sources as described in Chapter 10.
- The previous study excluded costs related to the Kew Foundation which, at that time, was a separate accounting entity. This has now been incorporated into the Royal Botanic Gardens, Kew organisation and the associated costs are incorporated within the overall operating costs of Kew used in our BCR calculations.
- It was identified that the Living Collections make a substantive contribution to Kew's scientific research, and so a proportion of the operating costs for that part of the organisation should be included in our estimates of scientific value.

To facilitate comparison of our updated results with those from our earlier study, we have re-calculated our earlier results to incorporate the changes made for this update. These are presented in Fig. 21.

⁷⁹ Oxford Economics, "Economic Valuation of the Royal Botanic Gardens, Kew," *A total economic value approach*, April 2016 <<https://www.oxfordeconomics.com/my-oxford/projects/330449>> [accessed May 2019]

Fig. 20. Summary of costs and benefits of Royal Botanic Gardens, Kew

Costs and benefits	2018/19	2014/15 original	14/15 revised
	£ million	£ million	£ million
Costs	73.7	54.3	57.9
Of which:			
Research and conservation	48.0	39.0	39.0
Visitor activities	12.9	9.5	9.5
Other	12.8	5.8	9.4
Quantified UK benefits	245	182	189
Quantified total benefits	261	190	197
Of which:			
Value to UK Kew Gardens visitors	50.3	46.6	46.6
Value to international Kew Gardens visitors	13.1	7.2	7.2
Value to Wakehurst visitors	5.4	3.0	3.0
Value to international Wakehurst visitors	0.5		
Value to attendees of special events	10.4	6.2	6.2
Non-use and option value for UK residents	61.1	44.3	44.3
Scientific value	76.3	56.2	60.9
Educational value for UK students	27.5	25.8	19.4
Education value for international students	1.5	0.7	0.6
Other income	14.4		8.4
Ratio of quantified UK benefits to costs	3.3	3.4	3.3
Ratio of quantified benefits to costs (including international benefits)	3.5	3.5	3.4



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