OXFORD ECONOMICS

Royal Botanic Gardens Kew

THE ECONOMIC VALUE OF ROYAL BOTANIC GARDENS, KEW

DECEMBER 2023

TABLE OF CONTENTS

Executive summary 4

1. Introduction 12

2. Calculating the total economic value of Royal Botanic Gardens, Kew 14
2.1 The principle of welfare economics 14
2.2 Total economic value 14
2.3 Study scope 15

3. Value to UK visitors of Kew Gardens and Wakehurst 18
3.1 Our approach 18
3.2 Data 19
3.3 Quantifying consumer surplus of Kew Gardens 19
3.4 Quantifying consumer surplus of Wakehurst 22
3.5 Total visitor value at Kew 24

4. Value to special events visitors 26
4.1 Quantifying the consumer surplus of special events 26
4.2 Total UK value of special events 28

5. Educational value in the UK 30
5.1 An overview of education at Kew 30
5.2 The lifetime earnings approach to valuing education at Kew 32
5.3 Total value of education at Kew to UK-based students 32

6. Value to UK science 36
6.1 Approach to Valuing Kew's investments in science 36
6.2 Results 37

7. Non-use and option value 42
7.1 What is the non-use and option value of Kew and how do we measure it? 42
7.2 Non-use survey 42
7.3 The hypothetical scenario 43
7.4 Survey results 43
7.5 Estimated non-use value of Kew 44

8. International value 48
8.1 International visitors 48
8.2 International students 49
8.3 International value of science 49

9. Social cost-benefit analysis 54
9.1 Total gross value of Kew 54
9.2 Cost of running Kew 54
9.3 Kew's 'benefit-cost ratio' and 'net benefits' 54
9.4 Unquantified benefits 55

Appendix 1: Travel cost modelling 60

Appendix 2: Non-use survey 65

Appendix 3: Valuing Kew's educational programmes 71

EXECUTIVE SUMMARY

KEY POINTS

- This report finds that, in 2022/23, Kew generated £369 million in benefits to UK society—a real terms increase of 31% compared to 2018/19. Key benefits include the value of Kew's scientific activities; the value to visitors of Kew Gardens and Wakehurst; the value of Kew's educational offering; and the value of Kew to wider society.
- This can be set against the costs of running Kew, which amounted to £97 million in 2022/23 to give a "benefit-cost ratio" of 3.8. This means that for every £1 spent to run Kew, it generated £3.81 in benefits to UK society.
- Whilst this report has sought to be as comprehensive as possible in capturing the benefits to society provided by Kew, it was not possible to do so for all of Kew's programmes and assets. Instead, case studies were used to provide qualitative insights into the types of impacts that these programmes and assets are likely to have. For example, it was not feasible to value in full Kew's significant collections of plants and fungi.

ABOUT ROYAL BOTANIC GARDENS, KEW

The mission of the Royal Botanic Gardens, Kew, (henceforth referred to as "Kew") is to "understand and protect plants and fungi for the well-being of people and the future of all life on Earth".[1]

Kew operates two popular botanic gardens which collectively received 2.3 million visits in 2022/23. Kew Gardens, the larger of the two in terms of visitor numbers, is a botanic garden in south-west London with over 200 years of history, that has been granted UNESCO World Heritage Status. Wakehurst is Kew's wild botanic garden in West Sussex.

Kew's extensive collections, scientific expertise, and global partnerships give it a leading role in the study of plants and fungi. Kew possesses one of the largest and most diverse collections of plant and fungal specimens in the world, and conducts research across a wide variety of areas of global importance, including food security, climate change mitigation, and biodiversity loss. Kew collaborates with over 400 institutions from more than 100 countries.[2]

Kew also offers thousands of students educational opportunities in its areas of expertise. These range from school visits to complete postgraduate courses. For example, over 90,000 schoolchildren were able to visit Kew Gardens as part of school visits in 2022/23.

Kew's ambitions are embodied in its Manifesto for Change, which sets out its five priority areas to deliver on its mission.[3] Summarised in brief these are to:

1. deliver knowledge and solutions to protect biodiversity and use natural resources sustainably;

2. inspire people to protect the natural world;

3. train the next generation of experts;

2.3 million

Total number of visitors to Kew Gardens and Wakehurst in 2022-2023.

4. extend Kew's reach, including by disseminating its knowledge and collections physically and digitally; and

5. influence national and international opinion and policy in its areas of competence.

PURPOSE OF THE STUDY

This study is an update to the 2019 report assessing the economic value of Kew for Kew's financial year 2022/23 (henceforth referred to as 2022/23).[4,5] It undertakes a "cost-benefit analysis" of Kew, setting the benefits Kew delivers to UK society across all five of its priority areas against the costs of running it. To do this, we use a "total economic value" (TEV) framework to set out the ways in which Kew creates value. Per the TEV framework, we consider the value Kew creates in terms of:

- its "users"—those who visit Kew, and who are educated at Kew;
- those who use Kew "indirectly"—chiefly beneficiaries of its scientific output and resources; and
- those who have not been to Kew nor used its resources but who may still value the site and its work, or "non-users".

The report builds on previous work by reflecting how Kew has expanded its reach through increased investment in scientific research, new programmes, and events, as well as by drawing on methodological innovations in techniques underpinning cost-benefit analysis.

[1] Kew, "Kew Science", accessed October 2023.
[2] Kew, "Where we work", accessed October 2023
[3] Kew, "Our manifesto for change. 2021-2030", accessed October 2023.
[4] Oxford Economics, "The economic value of Royal Botanic Gardens, Kew: a Total Economic Value approach", 2019, accessed September 2023.
[5] Kew's financial year runs from 1 April to 31 March.

KEY FINDINGS

We consider the benefits Kew delivers to UK society across a number of dimensions, and summarise our key findings with respect to each of these, as well as the overall cost-benefit analysis, below.

Total value to UK visitors

Most visitors to Kew Gardens and Wakehurst pay to enter the attractions, either as members who pay a yearly fee, or as one-off visitors. Considering UK visitors only, Kew Gardens received 1.1 million visits in 2022/23, and Wakehurst received 228,000 visits. Kew also hosts special events, such as Christmas at Kew and Glow Wild at Wakehurst which, collectively, received over 400,000 visits in 2022/23.

The price paid to enter either of the attractions typically only partly captures the value that an individual gets from their visit. Indeed, the majority of visitors would be willing to pay more than the ticket price, and so the true value they ascribe to either Kew Gardens, Wakehurst, or one of Kew's special events is higher. Economists refer to this concept as "consumer surplus".

£84 million

Total value to UK visitors to Kew Gardens, Wakehurst, and special events in 2022-2023.

The report uses statistical modelling to quantify the consumer surplus for the average visitor of Kew Gardens and of Wakehurst, as well as for Kew's special events hosted. We find that the consumer surplus for the average visitor of Kew Gardens is £45. For Wakehurst this figure is £23. For special events, it ranges from £17.34 for Christmas at Kew to £6.55 for Glow Wild and £5.81 for Summer Cycle.

Combining the value to UK visitors of Kew Gardens, Wakehurst, and special events gives a total UK visitor value in 2022/23 of £83.6 million.

Educational value to UK students

In 2022/23, Kew provided educational opportunities to over 90,000 individuals, including school pupils, university students, and professionals. Kew's educational offering is broad, and includes school visits, apprenticeships and internships, a three-year higher educational diploma, postgraduate courses and supervision of PhD students, and continuing professional development for scientists, academics, and teachers.

We assess the value of these educational programmes by considering the average wage uplift associated with gaining a particular qualification, compounded over the course of an individual's life.[6] For example, Kew offers a Master of Science in Biodiversity and Conservation, the value of which we assess by considering the average wage uplift of going from having an undergraduate to a postgraduate degree.

In this way, we assess the total educational value of Kew to UK students in 2022/23 to be £22.5 million.

Value to UK science

Kew acts as a global resource for plant and fungal knowledge, possessing one of the largest and most diverse collections of specimens in the world. Through these collections, its scientific expertise, and the global partnerships it holds, it plays a leading role in the study of plants and fungi.

[6] Estimates for wage uplifts come from academic literature and grey literature including government-sponsored research. For some programmes, it is necessary to scale the share of the wage uplift attributable to Kew's relative contribution to the qualification.

Assigning a value to Kew's scientific output is difficult. Academic research shows that the research and development (R&D) undertaken by the public sector has a social return which is greater than the size of the investment, as it generates knowledge which others can use, and draws in additional private sector investment. We use academic literature which measures the social return to public R&D spending through the impact it has on private sector productivity.

In 2022/23, Kew spent £25.1 million on core research activities.[7] **Based on this level of expenditure, we estimate that Kew's scientific activities in 2022/23 could deliver a £90.4 million increase in the UK's long-term economic output.**

Non-use and option value

People who have not visited Kew nor used its resources may still value it and be willing to contribute towards its preservation and development. We refer to this group as "non-users" of Kew. Non-users may be willing to support Kew for a variety of reasons, including to maintain the option to visit in the future or in recognition of the conservation and research activities Kew undertakes. We estimate total non-use and option value[8]—which represents how much all non-users of Kew in the UK value it—using a survey-based approach.

The survey showed that 45% of non-users would be willing to donate to maintain Kew's recreational opportunities and its activities in education and science, under a hypothetical scenario in which Kew had to rely on donations to secure funding.[9] **Non-users' mean average willingness-to-donate is estimated at £2.81 per year. By applying this average value to the resident UK population, we estimate that Kew's total non-use value in 2022/23 is £155.1 million.**

£90 million

Total value to UK science created by Kew's scientific research.

Value of other services

Kew also undertakes a number of other revenue-generating activities, including retail, catering, venue hire, and licensing.

In total, the income received by Kew from these activities was £17.8 million in 2022/23.

International value

Whilst we have thus far focussed on the benefits Kew delivers to UK society, Kew also creates value internationally, through international visitors to Kew Gardens and Wakehurst, international students gaining higher-level qualifications at Kew, and through its contribution to global science.[10]

In 2022/23, we estimate that there were around 200,000 overseas visitors to Kew's two botanic gardens, who in total valued their visits at £10.2 million. The educational value to international students was £2.1 million. **Considering the value of international visitors and the value to international students gives a total international value of £12.2 million.[11]**

£155 million

Estimated value of Kew to non-users to preserve Kew and the option to visit in the future.

[7] Kew's total research and conservation budget is higher than this at around £57 million. However, to align with the academic research which is used to calculate the return on public research expenditures, we exclude a number of spending lines which do not constitute direct spending on scientific research. These include supporting expenditure such as HR, IT and Legal functions.
[8] For brevity, we refer to non-use and option value simply as non-use value.
[9] Based on a sample of just over 2,000 respondents which was weighted to be representative of the UK population.
[10] We focus principally on the benefits to UK society, following HM Treasury's Green Book definition that, when appraising or evaluating a policy intervention, the scope of costs and benefits considered is UK society as a whole, which generally includes UK residents and not visitors. See 5.2 of HM Treasury, "The Green Book (2022)", 2022, accessed September 2023.
[11] International value of overseas visitors (£10.2m) and educational value to international students (£2.1m) sum to £12.2m and not £12.3m due to rounding.

We also consider the important contribution Kew makes to global science through a qualitative case study lens, where we consider, among other things, Kew's role in shaping global policy in its areas of expertise.

Social cost-benefit analysis

Aggregating all of these value streams, we arrive at a total gross value to UK society for Kew in 2022/23 of £369.4 million (see Fig. 1). Adding the international benefits that we have been able to quantify gives a total of £381.7 million.

To deliver on these benefits, Kew incurred costs in the form of operating expenses of £97.0 million in 2022/23. From this we can calculate a *benefit-cost ratio*, which tells us, for each pound spent on running Kew, how many pounds of benefit were delivered.

Focussing first on UK society, the benefit-cost ratio of Kew in 2022/23 was 3.81. **This means that for every pound spent to run Kew, £3.81 worth of benefits were generated for UK society.** This increases to £3.93 once the quantifiable international benefits are considered.

"For every pound spent to run Kew, £3.81 worth of benefits were generated for UK society. This increases to £3.93 once the quantifiable international benefits are considered."

Kew's contribution can also be viewed through the lens of *net benefits* (or benefits minus costs) to give a sense of the scale of its contribution to UK society. From the perspective of UK society, Kew delivered £272.4 million worth of net benefits in 2022/23. Compared to the previous study, this represents a real terms increase in net benefits of £75.2 million.[12]

The results presented should be viewed as conservative, as Kew delivers significant benefits through a number of programmes and activities which it was not possible to quantify. These have instead been explored qualitatively through the use of case studies, and include:

- the international value of Kew's scientific research and its collections, including its rapidly expanding digital collections;
- Kew's role in helping to shape global policy in areas such as biodiversity and conservation through, for example, its role as Strategic Science Lead for the Global Centre on Biodiversity for Climate;
- Kew's involvement in a number of projects abroad aimed at protecting biodiversity and helping communities adapt to climate change;
- Grow Wild, Kew's flagship outreach programme which provides grants to communities and young people to undertake projects which aim to foster a sense of community belonging and connection to nature; and
- volunteering at Kew, which helps support Kew's operations.

[12] Benefits and costs calculated in the previous study were inflated to 2022 prices which resulted in total net benefits of £197.2 million. Oxford Economics, "The economic value of Royal Botanic Gardens, Kew: a Total Economic Value approach", 2019, accessed September 2023.

Fig. 1: Summary of costs and benefits of Royal Botanic Gardens, Kew, 2022/23

	£ million
Costs	**97.0**
Of which:	
Research and conservation	57.5
Visitor activities	22.2
Other	17.3
Quantified UK benefits	**369.4**
Quantified total benefits	**381.7**
Of which:	
Value to UK Kew Gardens visitors	63.2
Value to international Kew Gardens visitors	10.0
Value to UK Wakehurst visitors	6.1
Value to international Wakehurst visitors	0.2
Value to UK attendees of special events	14.3
Non-use and option value for UK residents	155.1
Scientific value	90.4
Educational value for UK students	22.5
Educational value for international students	2.1
Other income	17.8
Ratio of quantified UK benefits to costs	**3.81**
Ratio of quantified benefits to costs (including international benefits)	**3.93**

Source: Oxford Economics

1. INTRODUCTION

Royal Botanic Gardens, Kew (hereafter referred to as Kew), plays a leading role in global research on plants and fungi in areas such as climate change mitigation, biodiversity loss and food security. It operates two botanic gardens: Kew Gardens and Wakehurst. Founded over 250 years ago, Kew Gardens is a UNESCO World Heritage site with over 19,000 species represented in its living collection alone. Wakehurst is Kew's wild botanic garden, featuring diverse landscapes and plants from across the globe. Collectively, the sites received over 2.3 million visits in 2022/23, including over 23,000 visitors on low incomes who were able to visit via Kew's £1 ticket scheme, which is designed to increase access to underrepresented communities.[13] Kew, under its statutory functions, looks after globally significant national collections such as the Herbarium, which contains 7 million plant specimens, the Fungarium, and the Millennium Seed Bank, which contains almost 2.5 billion seeds. Kew also has a research site in Madagascar, which works to protect the country's unique flora.[14]

This study is an update to Oxford Economics' 2019 report on the economic value of Kew.[15] As with the previous study, we have undertaken a social cost-benefit analysis (SCBA) to assess Kew's contribution to society.

SCBA is recognised as a best-practice approach to compare the benefits that a project, policy, or institution delivers to society relative to its costs.[16] Kew provides a number of benefits to society that go beyond what is captured in its accounts as revenues. For example, visitors to Kew Gardens and Wakehurst may enjoy their extensive collections, as well as their substantial grounds and historical buildings. Kew's collections and its investments in scientific research make an important contribution to science, in turn impacting on economic productivity. Kew also plays a role as an educator, at levels ranging from school visits all the way up to higher education, including PhD level.

Individuals who have never visited Kew may also nevertheless value it. For example, they may value that others enjoy Kew, or that future generations will be able to visit Kew (examples of "non-use value"). They may value Kew's research and conservation activities, as well as its role as an educator, even if they themselves do not benefit from either of these directly. They may also value being able to visit Kew at some point in the future (known as "option value"). The importance of these concepts in assessing the economic value of cultural and heritage capital is recognised by government.[17]

Kew also makes a number of other important contributions. On the international stage, its global scientific research helps to address, and mitigate against, the twin challenges of climate change and biodiversity loss. Its world-leading collections are important resources for scientists and researchers across the globe, and it plays a role in shaping and influencing national and international policy in areas such as conservation and biodiversity. Kew also carries out outreach activities by, for example, supporting community-led groups in disadvantaged areas to transform spaces with native plant life. These are examples of benefits which are viewed as more difficult to robustly place a monetary value on. As such, this report describes them qualitatively using case studies and recognises that its overall assessment of Kew's economic and social value may be conservative as a result.[18]

[13] Unless stated otherwise, data points cited in this chapter draw on Kew's Annual Report and Accounts for the year ending March 2023. Kew Gardens, "Royal Botanic Gardens, Kew. Annual Report and Accounts for the year ended 31 March 2023", 2023, accessed September 2023.
[14] Kew, "Kew Madagascar Conservation Centre", accessed October 2023.
[15] Oxford Economics, "The economic value of Royal Botanic Gardens, Kew: a Total Economic Value approach", 2019, accessed September 2023.
[16] HM Treasury, "The Green Book (2022)", 2022, accessed September 2023.
[17] Department for Digital, Culture, Media & Sport, "Valuing culture and heritage capital: a framework towards informing decision making", 2021, accessed September 2023.
[18] Case studies are adapted from content provided by Kew. Oxford Economics has not attempted to verify any information provided by Kew for use in case studies.

To deliver on the range of benefits described, Kew incurs operating costs, which in 2022/23 amounted to £97.0 million, of which 23% was spent on visitor activities, and 59% on research and conservation.[19] The purpose of this study is to quantify the "value for money" delivered by Kew by setting the benefits it delivers against these costs.

We consider benefits and costs for Kew's financial year 2022/23, focussing first and foremost on the benefits Kew delivers to UK society.[20] However, Kew also has a global impact which the report recognises separately by considering the roughly 200,000 international visitors Kew received in 2022/23, Kew's contribution to global science, and its role as an educator of non-UK residents.[21]

The report continues by introducing the "total economic value" framework used to undertake the social cost-benefit analysis of Kew. We then assess the benefits delivered by Kew to visitors of Kew Gardens, Wakehurst, and Kew's special events; the value of education received at Kew; the value of Kew's scientific contribution; the value to "non-users" of Kew; and the international value of Kew. We conclude by setting out the results of the SCBA in full.

[19] The sum of unrestricted (£71.2m) and restricted expenditures (£26.2m) on charitable and fund-raising activities. Includes depreciation, but excludes capital expenditures and shares of expenditure by associates (£0.4m).
[20] HM Treasury's Green Book defines the relevant scope for appraisal to be UK society as a whole, which consists of UK residents, but not potential residents or visitors. As such, we use this as our primary measure of the social value created by Kew.
[21] Estimate of number of international visitors is from Oxford Economics' analysis of Kew survey data.

2. CALCULATING THE TOTAL ECONOMIC VALUE OF ROYAL BOTANIC GARDENS, KEW

2.1 THE PRINCIPLE OF WELFARE ECONOMICS

Our approach to assessing Kew's economic value is grounded in the theory of welfare economics. We consider Kew's value in terms of its impact on social welfare by, as far as possible, taking account of everything Kew does which impacts on the welfare, or wellbeing, of society as a whole.[22] Doing so allows us to quantify the total social benefit delivered by Kew, which we then compare to the costs of running Kew to calculate a measure of the "net benefit" of Kew. This gives us an idea of the scale of value created by Kew after netting out the cost of running it. We can also calculate a ratio of benefits to costs, which gives us an indication of the efficiency of Kew, telling us how many pounds of social benefit Kew delivers for each pound spent to run it.

As market prices (e.g., the cost of a ticket) are not typically appropriate to quantify social welfare in full, this report draws on specialist techniques to quantify the non-market value of the services provided by Kew.[23] These are described in brief at the start of each chapter.

2.2 TOTAL ECONOMIC VALUE

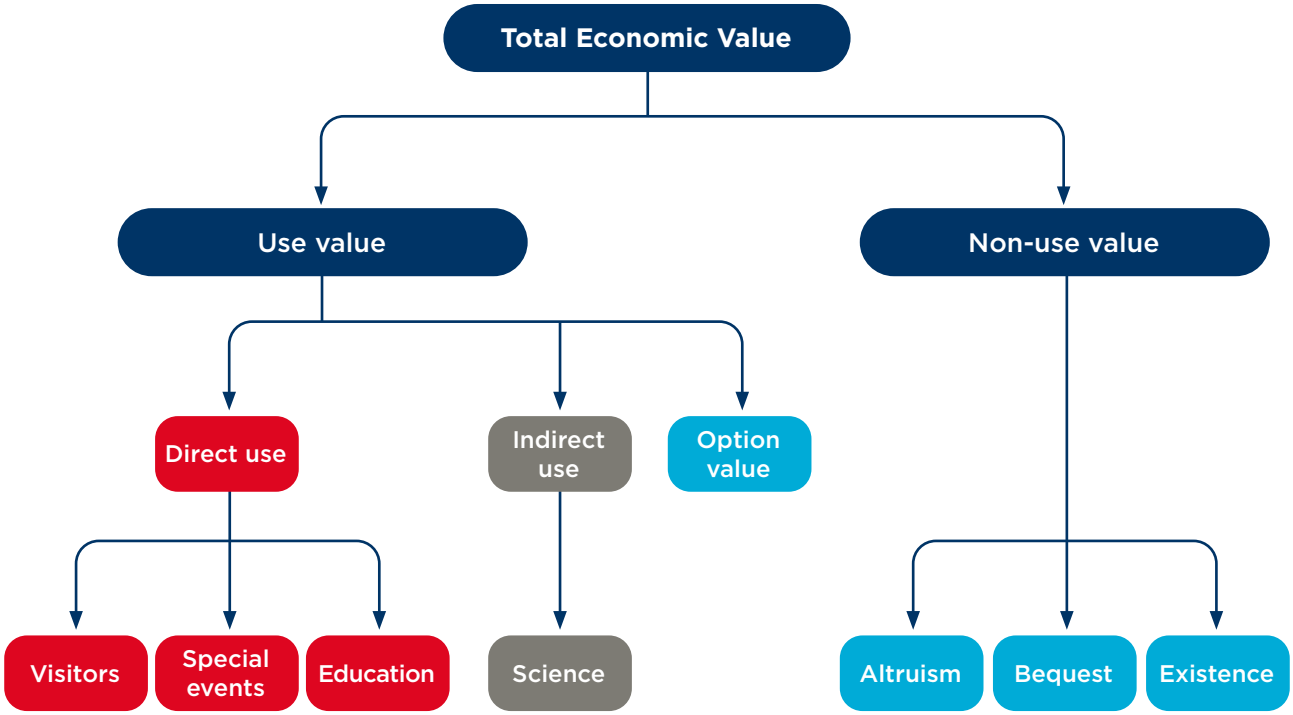
Kew is a complex institution which provides benefits to society in a number of ways. To map out the value created by Kew in a way which is compatible with the theory of welfare economics, we have used a total economic value (TEV) approach described in Fig. 2.

The TEV approach has been outlined in publications by the OECD[24] and the UK's Department for Environment, Food and Rural Affairs.[25] TEV was first developed to appraise assets in the natural environment but has since also been applied to institutions similar to Kew.[26] It considers benefits that arise from "direct use", "indirect use", and "non-use", which we define and map to Kew as follows:

- **Direct use** refers to individuals who make actual use of the services provided by Kew. This includes visitors of Kew Gardens and Wakehurst, and attendees of special events. It also includes pupils, students, and professionals who receive education at Kew.
- **Indirect use** refers to value created by services provided by Kew but not through actual use. In Kew's case, its scientific outputs are used not just by Kew's researchers, but also by the wider scientific community as knowledge created by Kew "spills over" to the rest of the economy.
- **Option value and non-use value** refer to the value that individuals who do not use Kew ascribe to it for one or more of several reasons.[27] Individuals may place an option value on Kew, as they may value the possibility of visiting Kew in the future even if they have never been before. They may also value the fact that others are able to enjoy visiting Kew ("altruism value"), that future generations will have the chance to go to Kew ("bequest value"), and the fact that Kew exists at all given, for example, its scientific research in areas such as climate change and biodiversity ("existence value").

[22] The report recognises that for some of Kew's interventions it is either disproportionate, or not sufficiently robust, to estimate the associated impact on social welfare. Where possible, the report uses case studies to demonstrate the scale and potential impact of these interventions instead.
[23] For a summary of some of the techniques used, see Annex A1 of HM Treasury, "The Green Book (2022): A1. Non-market Valuation and Unmonetisable Values", 2022, accessed September 2023.
[24] OECD, "Cost-Benefit Analysis and the Environment: Recent Developments", 2006, accessed September 2023.
[25] Department for Environment, Food and Rural Affairs, "An introductory guide to valuing ecosystem services" 2007, accessed September 2023.
[26] See for example: Oxford Economics (on behalf of the Canadian Museums Association), "Value study of GLAMs in Canada", 2019, accessed September 2023.
[27] Though option value is an example of a use value as it is associated with visiting Kew, it is difficult in practice to disentangle option value from non-use value. As such, this report considers them collectively, but does attempt to provide insights into how important the respective elements of option and non-use value are (see Appendix 3).

Fig. 2: Total economic value framework applied to Kew[28]



Source: Oxford Economics

2.3 STUDY SCOPE

An important consideration when undertaking any social cost-benefit analysis is the scope of the costs and benefits to be considered in terms of geography, the relevant population, and the time period. For example, the broadest definition may define costs and benefits globally, or costs and benefits may be analysed according to a particular locale.

In line with HM Treasury guidance, this report refers to the "population of standing"—i.e., those for whom benefits and costs are quantified—as being UK society as a whole, defined as all residents of the UK.[29] However, we recognise that Kew makes an important contribution internationally. As such, we also report our social cost-benefit analysis results separately for this larger group.

Benefits and costs, as well as most data points cited, refer to Kew's financial year 2022/23, and represent an annual flow of benefits and costs.[30] Kew's 2022/23 financial year ran from April 2022 to March 2023, and was chosen to align with Kew's financial reporting period.

[28] Adapted from Figure 4.1 of Department for Environment, Food and Rural Affairs, "An introductory guide to valuing ecosystem services" 2007, accessed September 2023.
[29] See 5.2 of HM Treasury, "The Green Book (2022): A1. Non-market Valuation and Unmonetisable Values", 2022, accessed September 2023.
[30] This does entail some methodological adjustments versus a more traditional appraisal assessing the net present social value of a policy change, taking account of benefits and costs over a number of years. For example, depreciation would typically not be accounted for as the residual value of any assets at the end of the appraisal period is reflected when considering costs. As our analysis only considers benefits and costs arising from one year of Kew's operations, we include depreciation estimates in our costs to capture the decreasing value of Kew's capital assets over time.

Vent-Axia

3. VALUE TO UK VISITORS OF KEW GARDENS AND WAKEHURST

In 2022/23, a total of 1.3 million paid visits were made to Kew Gardens, of which we estimate 1.1 million were made by UK visitors.[31],[32] Just over half (56%) of paid visits to Kew Gardens were made by members, who typically pay £77 for an annual membership. Non-members who visit Kew typically pay an entry fee of £17 per visit.[33,34]

A further 236,000 paid visits were made to Wakehurst, Kew's wild botanic garden in Sussex High Weald, 228,000 of which we estimate were made by UK visitors.[35],[36] Almost 90% of visits to Wakehurst were made by members of Wakehurst, Kew Gardens, and the National Trust. For non-members, the typical entry price was £16.50 per visit.[37]

This chapter describes the methodology used to assess the value of Kew Gardens and Wakehurst to their visitors, and the results of the analysis.[38]

3.1 OUR APPROACH

A first step to quantifying the value of Kew as a visitor attraction could be to use market prices, which in this case would be the typical ticket price paid by visitors. However, in practice this approach falls short as most visitors will feel that their experience is worth more to them than the cost of their ticket, a concept known as "consumer surplus".

To understand this intuitively, imagine Kew Gardens were to raise its standard ticket price by £1 from £17 to £18. In this case, many of its visitors would still be expected to attend as they value the experience in excess of £18. However, their consumer surplus would be reduced by £1. To recover a measure of this consumer surplus, an alternative approach is needed.

To determine the value that visitors place on amenities such as Kew Gardens and Wakehurst, researchers look to estimate their "willingness-to-pay" (WTP). An individual's WTP is the maximum amount they would be willing to pay to visit Kew Gardens, which reflects the value an individual places on their visit to Kew Gardens. A visit to Kew Gardens will only be considered "worth it" if the value they derive from the visit (i.e., their WTP) exceeds the cost (captured by both the entrance fee and the travel cost to the venue). The difference between a person's WTP and the price they pay is their consumer surplus.

One commonly used approach to do this is known as "revealed preferences", which uses data on individuals' actual behaviour to infer their WTP. For the purpose of this study, we have implemented a revealed preference approach using a travel cost model (TCM).

The basis of the TCM is that the cost of visiting Kew Gardens or Wakehurst is greater than just the entry fee. Visitors also incur costs to travel to and from the venue, such as fuel costs, vehicle depreciation, and the opportunity cost of time spent travelling.[39] Differences in travel costs faced by visitors can be used to infer the rate at which visitor numbers would decrease if entrance fees were increased which can, in turn, be used to estimate the average consumer surplus per visit. Further information is provided in Appendix 1.

[31] Paid visits refers to day-paying and member visits but excludes students and teachers as well as complimentary admissions, corporate clients, reciprocal entries, carers, community groups, and coach drivers.
[32] The split of UK and international visits are calculated using visitor survey data collected by Kew and applied to overall Kew Garden visitor numbers provided by Kew.
[33] This relates to the price of an adult membership which includes one family guest. Kew, "Become a Kew member", accessed September 2023.
[34] Price of adult ticket purchased in advance without donation during peak season. Kew, "Tickets and prices", accessed September 2023.
[35] Paid visits refers to day-paying and member visits but exclude students and teachers as well as complimentary admissions, corporate clients, reciprocal entries, carers, community groups and coach drivers.
[36] The split of UK and international visits are calculated using visitor survey data and applied to overall Wakehurst visitor numbers provided by Kew.
[37] Price of adult ticket for Wakehurst. Kew, "Wakehurst tickets and prices,", accessed September 2023.
[38] The value to attendees of special events as well as the value to international visitors to Kew Gardens and Wakehurst are described separately in Chapters 4 and 8 respectively.
[39] By visiting Kew Gardens, an individual is choosing to spend time travelling to and from Kew Gardens instead of using that travel time for another purpose. Opportunity cost reflects the value of the next best use of an individual's time which is foregone as a result of the travel to and from Kew Gardens.

3.2 DATA

To model visitors' consumer surplus, we drew on visitor survey data for both Kew Gardens and Wakehurst.[40] Visitors were asked how many times they had visited in the past 12 months, their place of residence, questions relating to their experience at one of Kew's sites, and their demographics. Survey results were weighted to be representative of visitors according to the type of ticket purchased and when they visited.

3.3 QUANTIFYING CONSUMER SURPLUS OF KEW GARDENS

Respondents to the Kew visitor survey were asked how many times they had visited Kew Gardens in the past 12 months. Fig. 3 shows the number of visits made by each respondent, split by members and non-members. Almost 80% of non-members visited Kew Gardens just once in the previous 12 months whereas repeat visits were more common for members, with over one-third having visited Kew Gardens more than 10 times in the past 12 months.

We estimated separate models for members and non-members as this analysis demonstrates that visit patterns are very different for members and non-members.

3.1.1 Results

The modelling approach briefly outlined in 3.1 and described in detail in Appendix 1 estimates that the consumer surplus per visit was around £49 for members and around £37 for non-members. Taking a weighted average of these two estimates suggests an average consumer surplus per visit of around £45 for all UK visitors to Kew Gardens.[41]

In 2022/23 there was an estimated total of 1.1 million paid UK visitors to Kew Gardens, indicating that the overall consumer surplus for paid UK visitors to Kew Gardens in 2022/23 was £49.5 million.[42,43]

Fig. 3: Number of visits to Kew Gardens in the past 12 months

Source: Oxford Economics analysis of Kew visitor survey

[40] Provided to Oxford Economics by Kew and carried out on behalf of Kew by BVA BDRC. A total of 3,488 visitors were surveyed over the period 1-April 2022 to 31-March 2023: 2,173 for Kew Gardens and 1,315 for Wakehurst.
[41] Weighted by overall number of visits made by members and non-members during 2022/23.
[42] Using estimated split of UK and international visitors from visitor survey.
[43] This estimate excludes non-paying visitors such as students and teachers as well as complimentary admissions, corporate clients, reciprocal entries, carers, community groups, and coach drivers. These visitors may be expected to derive some consumer surplus from their visit but this was not quantified for this study.

COMMUNITY ACCESS

Kew's Manifesto pledge of "Extending Reach" is concerned with making Kew accessible to all, regardless of background. To this end, Kew has introduced several programmes designed to improve accessibility for underrepresented communities. These programmes contributed to Kew receiving in excess of 92,000 visitors from underrepresented groups in 2022/23.[44]

Appreciating that the standard entry prices to Kew make it prohibitive to visit for some, Kew launched the **£1 Ticket Scheme** for those on Universal or Pensions Credit. In the year 2022/23, Kew welcomed over 23,000 visitors through the scheme, helping to boost visitor numbers amongst those who would otherwise be unlikely to attend.

The Community Access Scheme (CAS) at Kew Gardens helps organisations that provide services to people who would typically face barriers to visiting Kew independently to do so as part of self-guided tours. CAS-supported organisations help individuals with a range of barriers such as learning or physical disabilities, people experiencing mental health issues, and other excluded, vulnerable, or isolated members of society.

As of 2022/23, CAS had 370 member organisations, and over 9,000 individuals visited Kew Gardens as part of the scheme at a heavily discounted rate. 600 free tickets were also given to CAS members to visit Christmas at Kew.

The 2022 CAS survey showed that member organisations believed there was a positive impact on participants connecting with nature and being physically active. One member organisation said that visiting Kew Gardens as part of CAS was "the most popular thing on [their] activities calendar; clients look forward to it and stay as long as they can".

Focussed specifically on improving access for young children, the **Family Learning and Early Years programme** includes a mixture of outreach nature-based sessions, as well as nature-based workshops and family days at Kew, which are targeted at families in London from underrepresented groups. An example of this is the "Little Explorers" sessions for children aged 2-5 years, which encourages children to investigate nature through interactive storytelling, outdoor exploration, and hands-on activities. One parent described it as "a beautiful idyllic setting and brilliant session leaders and teachers".

In the 2022/23 period, there were 12,600 participants in the Family Learning and Early Years programmes.

[44] Figure includes: concessionary tickets for disabled visitors and senior citizens, £1 ticket scheme, Community Access Scheme; Family Learning and Early years; Youth programme; and other free tickets.

3.4 QUANTIFYING CONSUMER SURPLUS OF WAKEHURST

Fig. 4 illustrates the number of visits to Wakehurst made by each respondent in the visitor survey, split by members and non-members. As with Kew Gardens, repeat visits were much more common for members. Over a quarter of members visited Wakehurst 10 times or more in the past 12 months, whereas over half of non-members visited Wakehurst only once in the previous 12 months.

3.4.1 Results

As with Kew Gardens, we estimated separate models for members and non-members due to differences in visit patterns. Using the modelling approach briefly outlined in 3.1 and described in detail in Appendix 1, our modelling suggests the consumer surplus per visit is similar for members and for non-members at £22 and £23 respectively.[45]

In 2022/23 there were a total of 228,000 UK visitors to Wakehurst, meaning the total consumer surplus for UK visitors to Wakehurst in 2022/23 was £5.2 million.

Fig. 4: Number of visits to Wakehurst in the past 12 months

Source: Oxford Economics analysis of Kew visitor survey

[45] As such, the weighted average across members and non-members is also around £23, where weights were constructed based on overall number of visits made by members and non-members during 2022/23.

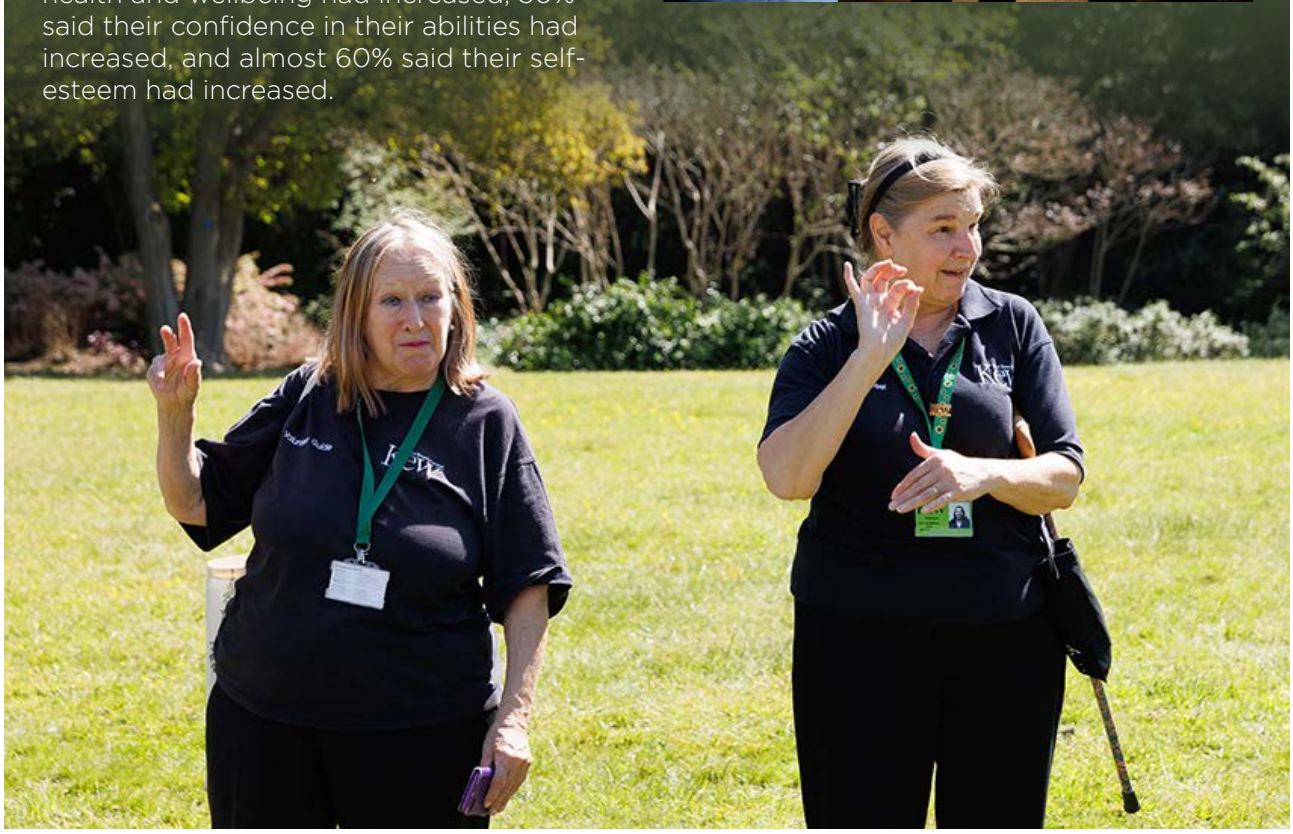
VOLUNTEERING AT KEW

In 2022/23, around 800 volunteers supported Kew's work in a variety of ways, donating in excess of 100,000 hours in the process. Volunteers act as guides, provide horticultural support, and support teams across Kew including those focussed on schools, families, galleries, community learning, and science. They are an integral part of the organisation having, for example, led 2,000 guided walking tours across Kew Gardens and Wakehurst in 2022/23.

Whilst there is clearly a benefit to Kew in terms of the monetary saving of drawing on a volunteer community, which Kew estimate was worth around £1.8 million in 2022/23, there are also numerous possible benefits to the volunteers themselves.

Recent academic research has shown that volunteering may lead to improvements in wellbeing.[46] Survey evidence on Kew's volunteers suggests at least some of Kew's volunteers may benefit in this regard as well. Over 40% of respondents said their general health and wellbeing had increased, 50% said their confidence in their abilities had increased, and almost 60% said their self-esteem had increased.

The positive impact that individuals report seems to bear out in practice as well with the scheme enjoying a high retention rate of 85% year-on-year, and 56% of those having volunteered at Kew for six years or more. Furthermore, 96% of volunteers rated their volunteering experience in the role where they are placed as either excellent or good.



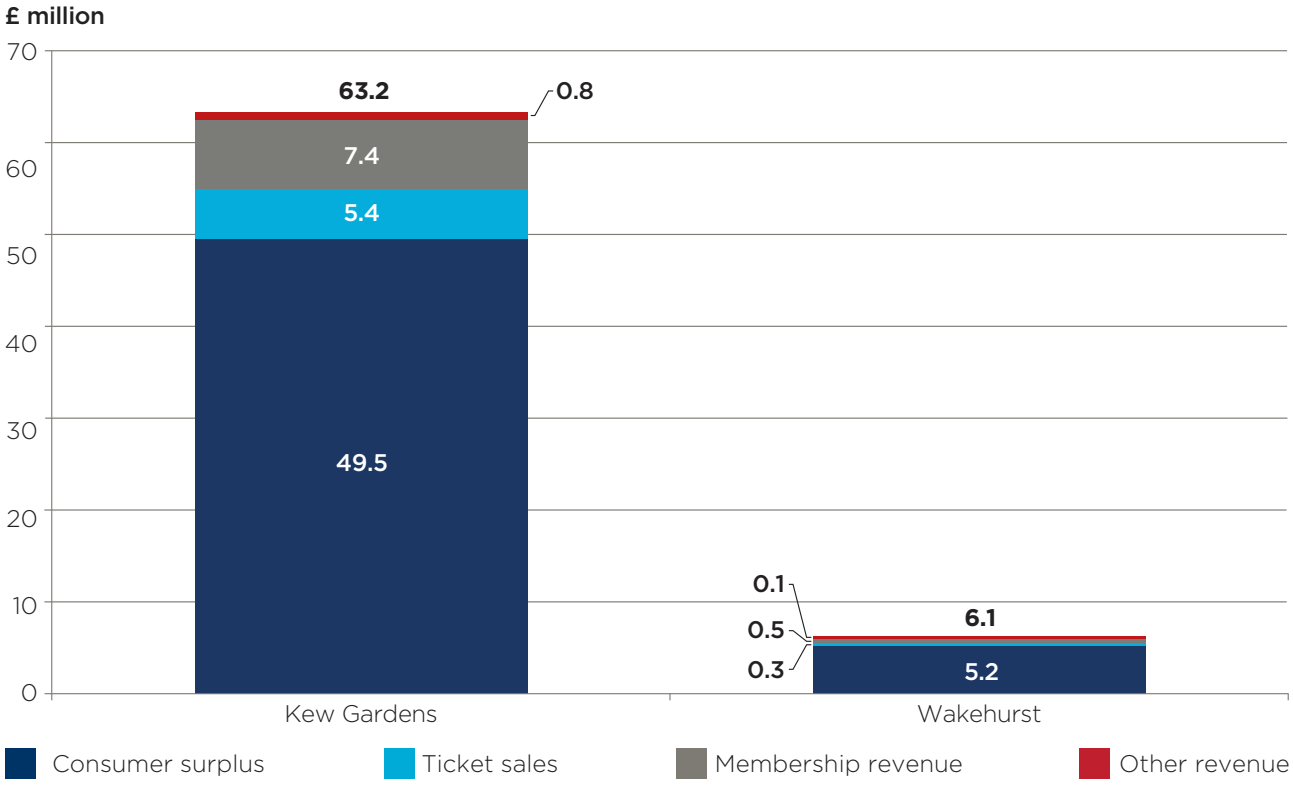
[46] Lawton et al., "Does volunteering make us happier, or are happier people more likely to volunteer? Addressing the problem of reverse causality when estimating the wellbeing impacts of volunteering" Journal of Happiness Studies, (2021), 22(2), pp.599-624, accessed September 2023.

3.5 TOTAL VISITOR VALUE AT KEW

The analysis above estimated the consumer surplus derived by UK visitors to both Kew Gardens and Wakehurst. However, the overall visitor value from a cost-benefit perspective also includes the value Kew Gardens earns in the form of revenues from ticket sales, membership revenue, and other visitor-related revenue.[47] In 2022/23, the share of these revenue sources apportioned to UK visitors totalled £13.6 million for Kew Gardens and £0.9 million for Wakehurst.[48]

Combining these values with the consumer surplus estimates implies that the overall gross value to UK visitors of Kew Gardens and Wakehurst in 2022/23 was £63.2 million and £6.1 million, respectively (see Fig. 5 for breakdowns).

Fig. 5: Gross value of Kew Gardens and Wakehurst to UK visitors, 2022/23



Source: Oxford Economics

[47] Other entry-related income includes car parking, Gift Aid, and tours.
[48] Ticket sales are distributed between UK and international visitors based on the split of non-member visits. Membership revenue is distributed between UK and international visitors based on the split of member visits. Other revenue is distributed between UK and international visitors based on the split of visits (both member and non-member), except for Gift Aid which is entirely allocated to UK visitor revenue.

4. VALUE TO SPECIAL EVENTS VISITORS

Kew also hosts a range of special events at its Kew Gardens and Wakehurst sites. In 2022/23 this included:[49]

- **Christmas at Kew**—a winter lights festival at Kew Gardens.
- **Glow Wild**—a winter lantern trail at Wakehurst.
- **Kew the Music**—a week of live outdoor music concerts from world-famous acts.
- **Theatre at Kew**—an independent theatre production hosted at Kew Gardens.
- **Kew the Movies**—five days of film screenings shown on a big screen in at Kew Gardens.
- **Richmond Run**—a range of running races starting in Kew Gardens.
- **Summer Cycle**—visitors can cycle through Kew Gardens during a summer evening.
- **Nourish: After Hours**—an evening of entertainment at Wakehurst including art installations that explore the future of plants and food, and live performances.

To quantify the value visitors derive from attending special events requires information about the number of visitors to each event and their place of residence. We estimated the value visitors derive from attending three special events, namely, Christmas at Kew which attracted 342,000 visitors in 2022/23, Glow Wild at Wakehurst which attracted over 70,000 visitors, and the Summer Cycle at Kew Gardens which attracted over 2,500 visitors. Collectively, these events accounted for over 80% of event attendees at Kew Gardens and Wakehurst.

Ticket sales data were available for other events but either the event was not large enough to robustly estimate the consumer surplus or the event could be attended with standard entry tickets and therefore the consumer surplus of such visitors would already be captured in the analysis conducted in Chapter 3.

4.1 QUANTIFYING THE CONSUMER SURPLUS OF SPECIAL EVENTS

We again use the travel cost model method to estimate the consumer surplus of attendees to special events. In this case, given the data available, the model is a "zonal travel cost model", which differs slightly to that used in Chapter 3, but is based on the same underlying principles.[50] For more detail on the zonal travel cost model see Appendix 1.

For the analysis, we were provided with sales data which contained the number of tickets purchased for each event, and the home postcode of the attendee. We then grouped visitor numbers into concentric zones, based on travel time to Kew Gardens or Wakehurst, and calculated "visit rates", which we define as the share of the corresponding resident population within each zone that attended the event.

Taking Christmas at Kew as an example, Fig. 6 presents the relationship between visit rates and travel time for Christmas at Kew. As would be expected, visit rates fall for zones further away from Kew Gardens.

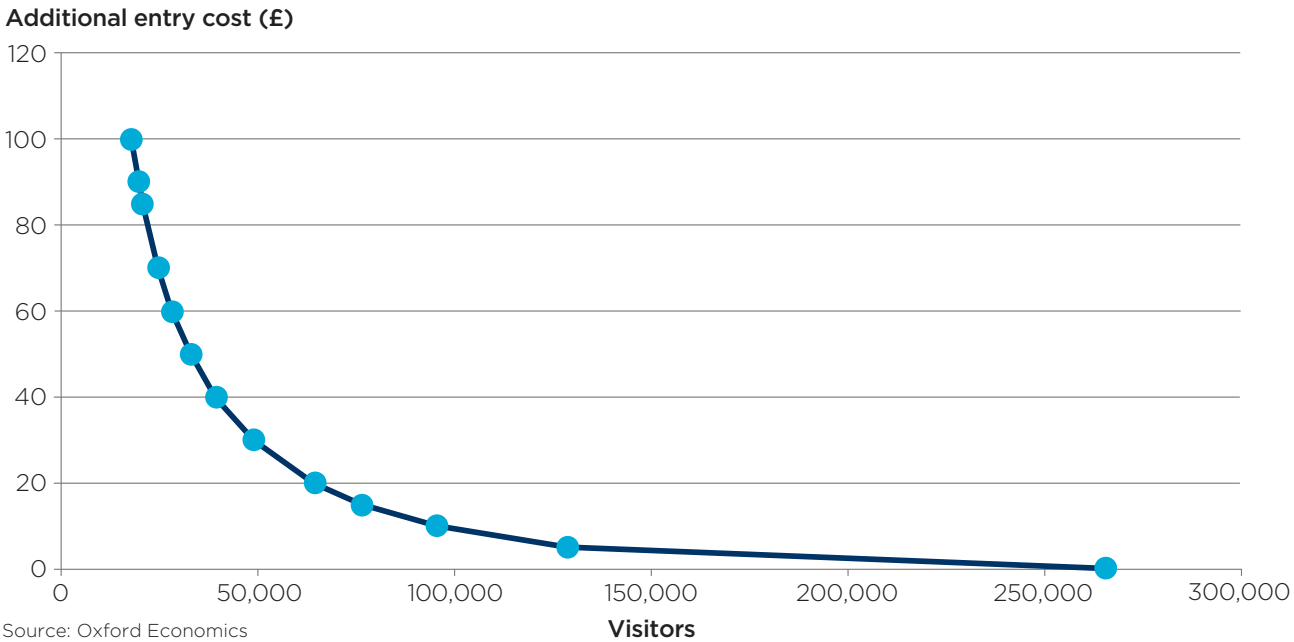
The relationships between visit rates and the implied travel cost are used to separately construct a demand curve for each of the three special events, with the demand curve for Christmas at Kew presented as an example in Fig. 7.

[49] Events with fewer than 1,000 attendees in 2022/23 are not included in this list.
[50] The detailed survey data on Kew and Wakehurst visitors, which were used in Chapter 3, were not available for special events. It was therefore not possible to develop an individual travel cost model for these events.

Fig. 6: Visit rates to Christmas at Kew

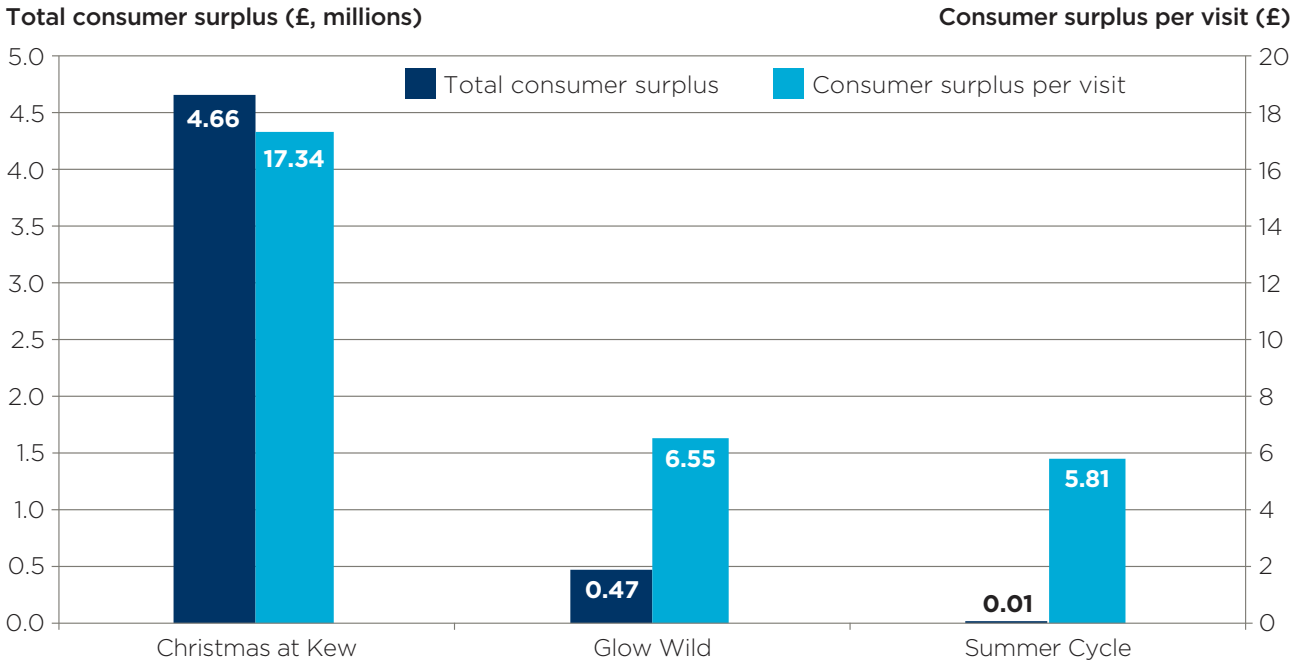
Travel time to Kew Gardens	Visit rate (per 1,000 population)	Proportion of UK Christmas at Kew attendees
0 – 10 mins	171.6	6%
10 – 15 mins	84.5	9%
16 – 20 mins	40.0	6%
21 – 25 mins	23.6	9%
26 – 30 mins	21.5	7%
31 – 40 mins	21.3	19%
41 – 50 mins	12.0	12%
51 – 60 mins	8.1	9%
61 – 70 mins	6.4	7%
71 – 80 mins	4.1	4%
81 – 90 mins	2.6	3%
91 – 100 mins	2.1	1%
101 – 110 mins	1.7	1%
111 – 120 mins	1.2	1%
121 – 150 mins	0.7	2%
151 – 180 mins	0.5	1%
181 – 240 mins	0.3	2%

Fig. 7: Demand curve for Christmas at Kew



Source: Oxford Economics

Fig. 8: Consumer surplus of special events, 2022/23



Source: Oxford Economics analysis of Kew visitor survey

From these demand curves we estimate the consumer surplus per visitor to Christmas at Kew to be £17.34, per Glow Wild visitor to be £6.55, and per visitor to the Summer Cycle to be £5.81 (see Fig. 8). Scaling these values by the estimated number of UK-based attendees to each of the events gives an overall consumer surplus to UK-based attendees of special events of £5.1 million. Of this, £4.7 million relates to Christmas at Kew and £0.4 million to Glow Wild.

4.2 TOTAL UK VALUE OF SPECIAL EVENTS

Kew also generated £9.2 million in revenue from visitors attending their events at both the Kew Gardens and Wakehurst sites.[51] Adding this to the consumer surplus value above gives a total overall value to UK attendees of special events of almost £14.3 million.

However, since we have only estimated consumer surplus for three special events, this represents a conservative estimate of the total UK value of all special events hosted by Kew.

[51] For Glow Wild we were able to estimate the split of revenue between UK and international visitors because ticket sales data identified the country of residence for each ticket purchase. For Christmas at Kew and Summer Cycle, data did not contain country of residence. We have assigned all ticket revenue from these events to UK value.

5. EDUCATIONAL VALUE IN THE UK

Kew hosts school visits and delivers a range of higher and further education courses and programmes—independently and in partnership with universities. We quantify the value of these activities to the students and participants by estimating the future wages that they are expected to earn as a result of education received at Kew.

The rationale behind this "lifetime earnings" valuation approach is that education at Kew provides students and professionals with skills, capabilities, and qualifications that are valued in the labour market and therefore reflected in participants' future earnings. This is supported by research literature which shows that, on average, individuals typically earn higher wages for each additional qualification gained.

5.1 AN OVERVIEW OF EDUCATION AT KEW

5.1.1 School visits

Kew hosts day visits by groups of school children at both Kew Gardens and Wakehurst. In 2022/23, over 90,000 school pupils visited either Kew Gardens or Wakehurst, with about 90% of these visits taking place in Kew Gardens. Just over half of visits (53%) are led by Kew teachers, and sessions are curriculum-linked and tailored to each key stage.[52] For instance, key stage 5 students attend a range of biology and geography sessions on topics such as evolution and climate change.[53]

5.1.2 Diploma in Horticulture

Kew offers a self-accredited three-year Diploma in Horticulture as a higher education qualification comparable to an undergraduate degree.[54] Students studying for the diploma are Kew employees meaning they receive a salary for the duration of the course, and do not pay any tuition fees. The curriculum includes practical experience working with Kew's botanic collections as well as theoretical study. In 2022/23, 33 students were enrolled in the diploma course.

5.1.3 Internships

Kew provides opportunities for undergraduates and recent graduates to gain practical work experience through several types of internships across its science departments.[55] It offers 12-month paid "sandwich" placements for undergraduate students, two-month paid summer internships for undergraduates and recent graduates, and project-specific internships lasting between two and 12 months.

In 2022/23, 23 interns were enrolled in Kew's various internship programmes. Interns receive training in research skills from Kew's experts and have access to Kew's collections of plants and fungi, its library, and research facilities.

5.1.4 Apprenticeships

Kew provides three two-year practical horticulture courses. Apprentices receive a salary and on-the-job training covering practical skills, as well as travel scholarship opportunities, including visits to botanical gardens abroad and study trips to learn about conservation of countries' native plant species. Kew employed 16 apprentices in 2022/23.

[52] Kew, "Browse Kew's Education Sessions", accessed September 2023.
[53] Kew, "Key Stage 5 sessions", accessed September 2023.
[54] Kew, "Kew Diploma in Horticulture", accessed September 2023.
[55] Kew, "Internships", accessed September 2023.

5.1.5 Postgraduate courses

Kew also offers three one-year postgraduate taught programmes in partnership with London universities.[56] These are the Master of Science (MSc) in Biodiversity and Conservation; the MSc in Global Health: Food Security, Sustainability and Biodiversity; and the MSc in Plant and Fungal Taxonomy, Diversity, and Conservation. Modules are taught either at Kew or at the partner university, depending on the content. Just under 60 graduates spent part of their programmes at Kew during their postgraduate courses.

5.1.6 Co-supervision of PhD students and externally funded students

Kew works in collaboration with universities providing PhD students with access to its collections, facilities, and expertise.[57] These students are affiliated both to a university and to Kew. The university confers the PhD but the majority of their research is conducted at Kew, with Kew academics supporting and mentoring students throughout their research. In 2022/23, just under 100 PhD students were co-supervised at Kew.

Kew also hosts externally funded students. These range from undergraduate to postgraduate students and are funded by other organisations—typically their university—to conduct research at Kew. While on placement, Kew provides the entirety of supervision and support. In 2022/23, 55 externally funded students were on placements at Kew, with an average duration of more than six months.

5.1.7 Group day visits by university students

Kew also hosts day visits by groups of university students on undergraduate or postgraduate courses. These consist of a variety of talks and tours of Kew, and are a mix of teaching and information on working in a biodiversity institute. Kew hosted 376 such visitors in 2022/23.

5.1.8 Specialist certificates and CPD

Kew offers seven one-year full-time courses that award specialist certificates in horticultural training.[58] In 2022/23, nine students were enrolled in these courses.

Kew also provides Continuing Professional Development (CPD) for working professionals.[59] These are short courses lasting one or two weeks aimed at academics and scientists to update their skills. In 2022/23, 46 professionals completed CPD courses run by Kew.

5.1.9 Teacher training

Kew trains teachers, in groups or individually, on site at Kew Gardens on day courses. Activities include subject masterclasses on topics such as evolution, plant science, and plant adaptation, and teacher CPD courses, both aimed at primary and secondary school teachers.[60] In 2022/23, 480 teachers completed teacher training at Kew.

5.1.10 Introduction to Horticulture

Kew offers a paid one-year training programme covering an Introduction to Horticulture. Participants on the course combine time spent working hands-on at Kew with study days. The programme is aimed opening up horticulture to people from ethnic minority background who are under-represented in horticulture.[61]

[56] Kew, "Postgraduate taught programmes", accessed September 2023.
[57] Kew, "Doing a PhD at Kew", accessed September 2023.
[58] Kew, "School of Horticulture", accessed September 2023.
[59] Kew, "Continuing Professional Development (CPD)", accessed September 2023.
[60] Kew, "Teacher training", accessed September 2023.
[61] This was not able to be included in the total value of education. Kew, "Review of the Year 1 April 2021 – 31 March 2022", accessed November 2023

5.2 THE LIFETIME EARNINGS APPROACH TO VALUING EDUCATION AT KEW[62]

To value the expected future returns to the pupils, students, and professionals taking part in the various programmes Kew offers, we firstly assigned an equivalent qualification or level of education to each programme.[63]

Secondly, we considered—for each programme—Kew's contribution towards students' completion of the course. In some cases, such as Kew's Diploma in Horticulture, participants gain the qualification fully at Kew, which in this case is comparable to an undergraduate degree. In other cases, only a part of the course is held at Kew and so we assume that the future benefit of the qualification is proportional to the share of the course held at Kew.

We undertook a literature review of the lifetime wage uplift earned by individuals as a result of each incremental qualification gained.[64] For instance, we identified through our literature review that someone who attends an undergraduate degree course earns 20% more over their career compared to someone who is eligible to enrol for a degree but does not.[65]

We used data from the Office for National Statistics to estimate the lifetime earnings of someone qualified at the "base level" of education—that is, the total earnings that students would be expected to earn in the future if they did not complete the course they are enrolled on at Kew.[66] We then applied the percentage wage uplift identified in the literature to this lifetime earnings estimate, which gives a measure of how much additional income Kew's students are expected to earn on average as a result of completing their courses at Kew.[67]

Finally, we multiply the lifetime wage uplift for the average student on a given course by the number of students enrolled on the course.[68] Summing across all courses gives us an estimate of the value supported by Kew's educational programmes.

For each type of course, we also received from Kew, or in some cases estimated, the share of participants that are UK students. The estimated value of the returns to education for UK students is presented in this chapter, while the value to international students is presented in chapter 8.[69]

Further details of the approach described in this subsection along with an example can be found in Appendix 3.

5.3 TOTAL VALUE OF EDUCATION AT KEW TO UK-BASED STUDENTS

We estimate the UK value of Kew's educational provision in 2022/23 at £22.5 million. This is the value in 2022 of the wage uplifts that students currently enrolled in Kew's courses will earn over their careers as a result of the qualifications they are pursuing.

Almost three-quarters of this value (74%) comes from school visits, of which there were over 90,000 in 2022/23. A further 11% comes from Kew's Horticulture Diploma and the hosting of externally funded undergraduate students.

Kew's three MSc courses then account for another 7% of the total value to UK students.

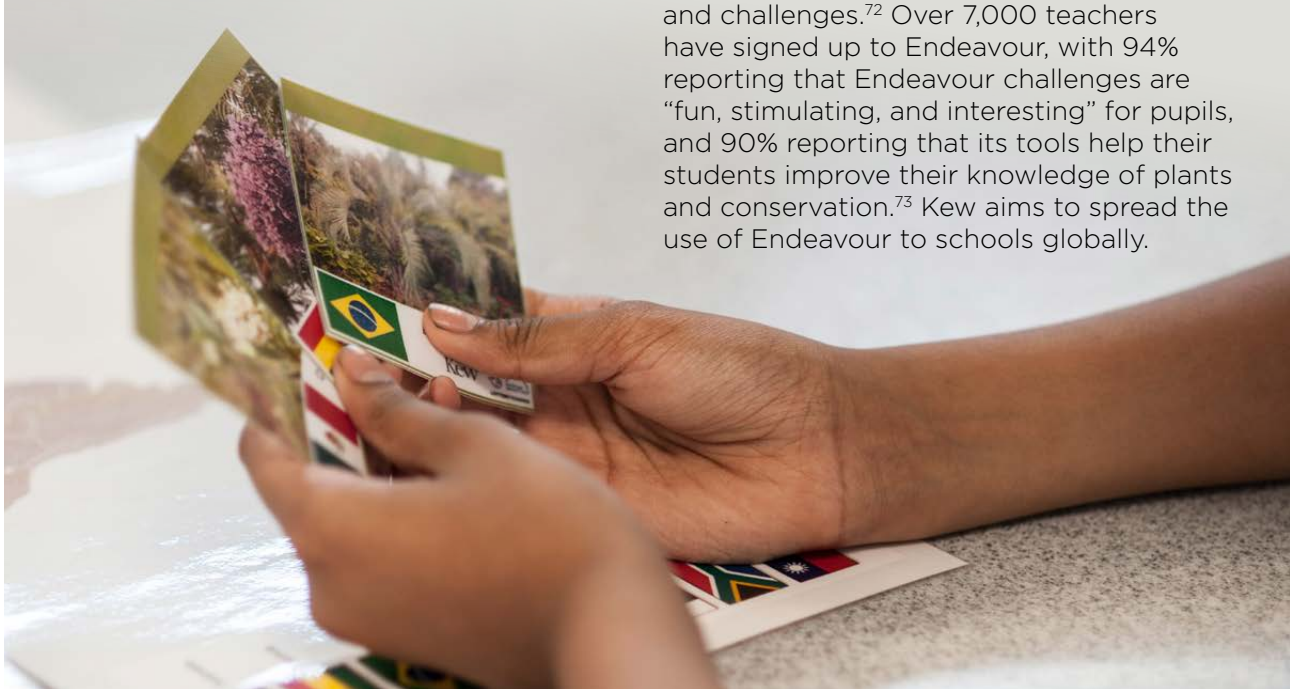
[62] A detailed overview of the approach is presented in Appendix 3.
[63] The approach that we take is similar to the approach taken in Department for Education, Measuring the Net Present Value of Further Education in England 2018/19, 2021.
[64] Wage uplifts are commonly referred to in the academic literature as "wage premia".
[65] See Appendix 3 for further details.
[66] ONS, "Graduates in the UK Labour Market: 2017", 2017, accessed September 2023.
[67] For programmes delivered only in part by Kew, we only attribute to Kew the proportion of the course that it delivers.
[68] An implicit assumption of this approach is that all students enrolled in the various courses at the time that the enrolment data is captured will successfully complete them.
[69] We make the simplifying assumption that UK students will earn all of their wages in the UK, while international students will earn their wages abroad. In practice, this will be a conservative assumption if UK students are less likely to leave the UK than international students are to remain following their education at Kew.

KEW'S WIDER EDUCATIONAL OFFERING

Kew runs several initiatives which we have not been able to place a value on. These initiatives engage numerous students in formative activities and could help inspire students to further their knowledge in science.

One such initiative is **Kew's Youth Programme,** which engages young people aged 14 to 17 in a series of activities aimed at building participants' confidence and skills. The programme's **Youth Explainers scheme** trains 40 young people each year, for one day a week over six months, to volunteer for 10 sessions in Kew Garden's glasshouses, where they are available to provide visitors with more information about the collections.[70] **Earthwise**, also part of the wider Youth Programme, is a two-week summer programme for young people in London in which about 40 students develop practical fieldwork skills, explore the laboratories and collections in Kew Gardens and Wakehurst, and hear from experts in biodiversity science and conservation.[71] Another of the Programme's initiatives, **Kew in Focus**, is aimed at young people who face physical, sensory, psychological, or social barriers to visiting Kew. It offers photography training and the opportunity of exploring the gardens while taking photographs of collections.

In 2018, Kew's experts and teachers also developed **Endeavour**, a freely accessible interactive library of teaching resources about plant science and the environment. The aim of Endeavour is to help school teachers deliver engaging lessons that improve students' knowledge of science, and inform their attitudes and values around plants and conservation. Resources are tailored for pupils from ages 5 to 18 and are aligned to the national curriculum. They include videos, discussion cards, infographics, card matching, quizzes, and challenges.[72] Over 7,000 teachers have signed up to Endeavour, with 94% reporting that Endeavour challenges are "fun, stimulating, and interesting" for pupils, and 90% reporting that its tools help their students improve their knowledge of plants and conservation.[73] Kew aims to spread the use of Endeavour to schools globally.



[70] Kew, "Youth Explainers", accessed September 2023.
[71] Kew, "Earthwise: Kew's summer programme", accessed September 2023.
[72] Kew, "Endeavour Teaching toolkit", accessed September 2023.
[73] Kew, "Endeavour", accessed September 2023.

6. VALUE TO UK SCIENCE

Kew is a global resource for plant and fungal knowledge, possessing one of the largest and most diverse collections of plant and fungal specimens in the world. The combination of extensive collections, databases, scientific expertise, and global partnerships give Kew a leading role in research on plants and fungi. Kew's research covers issues of global importance such as food security, biodiversity loss, and climate change prevention and adaptation. Its resources and materials are used by researchers and other stakeholders worldwide.

Research undertaken by Kew scientists focusses 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.

6.1 APPROACH TO VALUING KEW'S INVESTMENTS IN SCIENCE

Attributing a value to the diverse scientific research that Kew undertakes and enables is challenging.[74] To assess the value of research activity we would ideally like to identify output-based metrics capturing real-world changes that have occurred due to Kew's research. For example, estimating the extent to which research has increased the yield of a particular crop, and the monetary value associated with that increase, which in this case could be the value of the additional crop produced.

This approach may be suitable for a small number of Kew's research projects but is not feasible for valuing the entire research activity undertaken given the lack of information of the universe of users of Kew's collections, their subsequent research, and the impact of that research. Furthermore, impacts of research may not materialise until many years later and may be spread across different geographies.

Given these challenges, we therefore estimate the value of Kew's scientific research following the input-based approach adopted in previous TEV studies of Kew.[75,76]

It is commonly observed that investments in research and development (R&D) can generate benefits to society which exceed those which accrue to the organisation carrying out the research. Economists call these wider benefits to society "externalities".

Research has been undertaken to quantify the size of these externalities, relative to the size of the investment. For example, Haskel et al. look at how public science funding can drive productivity improvements in the private sector.[77] They find that public sector R&D has a 20% rate of return to the UK economy. A recent review of the literature as well our own research suggests that this remains the most reliable estimate.[78]

We therefore applied the finding from Haskel et al. 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.

[74] For a full review of potential approaches see Oxford Economics, "Economic valuation of Royal Botanic Gardens, Kew", 2016, accessed September 2023.
[75] Ibid.
[76] Oxford Economics, "The economic value of Royal Botanic Gardens, Kew", 2019, accessed September 2023.
[77] Jonathan Haskel, Alan Hughes, Elif Bascavusoglu-Moreau, "The economic significance of the UK science base: a report for the Campaign for Science and Engineering", 2014, accessed September 2023.
[78] Frontier Economics, "Rate of return to investment in R&D", 2023, accessed September 2023.

6.2 RESULTS

In 2022/23 Kew's total science expenditure on core research activities was £25.1 million, reflecting the costs of the Science directorate allocated directly to scientific research, and a proportion of the cost of managing the Living Collection, deemed to support scientific research.[79],[80] Applying the social rate of return estimated by Haskel et al. to this expenditure suggests that Kew's research spending contributes to an increase in UK economic output of £5.0 million in the first year.[81]

To assess the lifetime value of Kew's scientific output beyond the first year, researchers need to account for knowledge becoming less valuable (or "depreciating" in value) over time. This may occur if the knowledge generated becomes less relevant as new R&D investment renders it obsolete. The overall lifetime value of R&D expenditure thus depends on the assumed rate of depreciation of the benefits of public R&D.[82] Studies typically apply a 15% depreciation rate for returns to private knowledge. However public investments are typically assumed to not depreciate or to depreciate at much slower rates as the knowledge generated is assumed to be built on incrementally, rather than rendered obsolete by new innovations.[83,84,85]

To maintain consistency with Kew's 2019 TEV report, we apply a 2% depreciation rate. The discount rates applied are consistent with HM Treasury Green Book guidance and decline over time. Applying these rates suggests that Kew's research activities in 2022/23 has a present discounted value of £90.4 million.

[79] Kew's total research and conservation budget is higher than £25.1 million at around £57 million. However, to align with the academic research which is used to calculate the return on public research expenditures, we exclude a number of spending lines which do not constitute direct spending on scientific research. These include supporting expenditure such as HR, IT and legal functions, as well as depreciation and impairment.

[80] £1.5 million was attributed to science spend as the proportion of expenditure on managing the Living Collection that was deemed to support scientific research. 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 40% of the expenditure associated with the Living Collections in 2022/23 supported scientific research.

[81] The impact of public R&D investment on productivity occurs with a three-year lag in the study by Haskel et al. Jonathan Haskel, Alan Hughes, Elif Bascavusoglu-Moreau, "The economic significance of the UK science base: a report for the Campaign for Science and Engineering", 2014, accessed September 2023.

[82] It also depends on the discount rate applied to future benefits, where there is arguably less contention.

[83] A recent literature review identifies that the majority of studies assume a 15% depreciation rate for returns to private knowledge. Frontier Economics, "Rate of return to investment in R&D", 2023, accessed September 2023.

[84] A review sponsored by Department for Business and Trade (then BIS) of rates of return to investment in science and innovation discusses standard assumptions around depreciation rates for public R&D. Frontier Economics, "Rates of return to investment in science and innovation", 2014, accessed September 2023.

[85] For example, Haskel et al. assume no depreciation to public R&D such that increases in public knowledge are infinitely lived and permanently raise the stock of knowledge.

KEW'S COLLECTIONS

Dating back to 1847, Kew's science collections represent one of the largest and most diverse botanical and mycological collections in the world, containing over 8.5 million items and representing approximately 95% of the world's vascular plant groups and 60% of fungal groups (Fig. 9). These resources provide insights into a number of areas including the distribution of plants across time and space, evolution and origins, genomics, and biochemistry.

Kew's Herbarium collections are estimated to hold representatives of around 70% of species, many of which are unavailable elsewhere, providing an evidence base to support research into some of the most critical challenges facing humanity such as climate change, food security, and human health.

Kew's also houses an extensive collection of living plants at both Wakehurst and Kew Gardens, known collectively as Kew's Living Collections, include nearly 19,000 species, and are, according to one measure, the most diverse of any botanic garden in the world.[86] The Living Collections are utilised by scientists and horticulturists for cutting-edge research and conservation, and are also used for education and training purposes.

Around 4.5 million visits also are made annually to Kew's online resources for its collections, and around 500 scientific researchers from across the globe spend a combined 5,000 visiting days benefiting from the resources on site.

Fig. 9: Kew's collections

Collection	Approximate size	Description
Herbarium	7,250,000	Preserved dried vascular plant specimens. The number of species represented is estimated at 70%.
Spirit Collection	76,000	Specimens of plants, plant parts, and fungi preserved in spirit, representing almost 30,000 species.
Fungarium	1,250,000	Preserved dried fungi, lichens, and fungal analogues. The number of species represented is unknown, but the current Fungarium catalogue, which covers 40% of the collection, contains 52,000 species.
Living Collection	68,000	Contains more than 68,000 living plant specimens, including nearly 19,000 species.
Library	300,000	Collection of botanical reference books, journals, and pamphlets
Economic Botany Collection	100,000	A broad range of samples documenting use of plants by people, including 42,000 wood collections. Approximately 20,000 species are represented.
Seed Collection	86,000	Living seed collections held in the Millennium Seed Bank
DNA and Tissue Bank	58,000	Plant genomic DNA and dried tissue samples
Microscope Slide Collection	150,000	Microscope slides documenting plant and fungal anatomy
In Vitro Collection	6,000	Living plants and fungi cultured on agar

[86] According to information provided by Kew, specimens in the Living Collections are from more than 27,000 taxa, whereas other large gardens contain around 20,000 to 21,000 taxa.

Looking forward, Kew recognises the importance of developing ways to enhance access to their collections, both physically and digitally, to enable maximum usage. A large-scale digitisation programme is currently underway to create an Open Herbarium, with free digital access to be provided to 7.25 million herbarium specimens and 1.25 million fungi. As of October 2023, approximately 1.85 million specimens had been digitised with project completion scheduled for early 2026 at a total cost of around £29 million.[87]

Open digital access to these collections will greatly reduce the access cost to users across the globe, which is expected to result in greater use of these resources for scientific research.

[87] Kew, "Digitising Kew's collections", accessed October 2023.

7. NON-USE AND OPTION VALUE

7.1 WHAT IS THE NON-USE AND OPTION VALUE OF KEW AND HOW DO WE MEASURE IT?

So far, this report has focused on the value of Kew to its visitors and to participants of educational programmes at Kew, as well as on the impact of its scientific research. However, individuals who do not visit Kew nor use its resources may value it and be willing to financially contribute towards its preservation and development.

"I have never been to Kew and I might never visit, but I think it's still worth preserving."

Non-user in Yorkshire and the Humber

We refer to this group as "non-users". Non-users may value Kew—and be willing to fund it—for several reasons. They may want to preserve Kew so that they have the option to visit it in the future, known as an "option value". They might otherwise wish to preserve it so that others can visit ("altruism value"), which could include both current and future generations (the latter known as a "bequest value"). Or they might simply value the fact that it exists, regardless of any plans to visit it themselves or for altruistic reasons ("existence value").[88] Non-users of Kew may equally value it because of its research and conservation activities, as well as its role as an educator, even if they themselves do not benefit from these directly.

The preferred approach for estimating non-use values for institutions like Kew is the "stated preference" method. This consists of:[89]

- surveying a representative sample of the population;
- presenting survey respondents with a hypothetical scenario in which the institution for which the non-use value is being estimated will undergo a change;[90]
- asking respondents how much they would be "willing to pay" (e.g., as a donation, or in tax) to avoid the change presented under the scenario; and
- aggregating individuals' average willingness-to-pay values to the relevant population (e.g., all UK adults).

For instance, the value of a wing of a museum to non-users could be valued by describing it to a sample of non-users through a survey and asking them to imagine that the wing would have to close unless the museum secured additional funding. It could then ask respondents how much they would be willing to donate to avoid the closure of the wing. We adopt a similar approach in this study.

We estimate average non-user willingness-to-pay for Kew and its activities in a representative sample of the UK population. We do this using a survey that asks non-users how much they would be willing to pay to support Kew in a hypothetical scenario in which Kew requires additional external funding to maintain its current level of services and activities. We then aggregate our estimated average to the UK population level. This provides us with an estimate of Kew's total non-use value in the UK.

7.2 NON-USE SURVEY

The survey was designed by Oxford Economics and fielded by YouGov on 31 August and 1 September 2023. The sample was weighted to be representative of the UK population according to characteristics including age, gender, educational qualification, region, and social grade.[91] The sample size achieved was 2,043 respondents. The survey consisted of nine questions—the full questionnaire can be found in Appendix 2.

[88] Strictly speaking, option value is a type of user value, while altruism, bequest, and existence values are types of non-user values. In the analysis presented in this chapter we capture both non-use and option values, and for simplicity we refer simply to "non-use value".
[89] For an overview of the steps see: OECD, "Cost-Benefit Analysis and the Environment Further Developments and Policy Use", 2018, accessed October 2023; HM Treasury, The Green Book (2022); or HM Treasury, Green Book supplementary guidance: stated preference techniques, 2013, accessed October 2023.
[90] For example, a survey could describe to respondents a new bridge that would improve traffic in their home city, and ask respondents how much they would be willing to pay for the bridge to be constructed. Or it could ask respondents to imagine an existing bridge in their home city being closed, and ask how much they would be willing to pay to avoid the closure.
[91] Other characteristics are respondents' vote in the 2019 general election and the 2016 EU referendum.

7.3 THE HYPOTHETICAL SCENARIO

We presented to respondents a fact-based description of Kew and its activities such that they were able to provide an informed value for Kew. Responses to the survey are therefore conditional on respondents being informed about Kew and its activities.[92] This is a standard procedure in stated preference surveys.[93]

Respondents were asked to imagine that Kew had no other sources of government or private funding and had to rely on individual donations. They were then asked to state what their maximum willingness-to-pay was as an annual donation to maintain Kew, including its recreational opportunities and education and science activities. Respondents were reminded to carefully consider affordability given their living costs. They were then presented with a so-called "payment card"—that is, a list of values from which to choose representing their maximum willingness-to-pay.[94] The options also included an option which read, "I would not be willing to support the Royal Botanic Gardens, Kew through an annual donation"; an "other" amount to freely input a value that was not included among the options; and a "don't know" option.

Using donations as the means of payment (or "payment vehicle") has several advantages over taxation, which is also often used in contingent valuation studies. For instance, taxes can attract a high share of protest values—i.e., people saying they are not willing to pay even if in reality they value the good, just because they are against increases in taxation.[95]

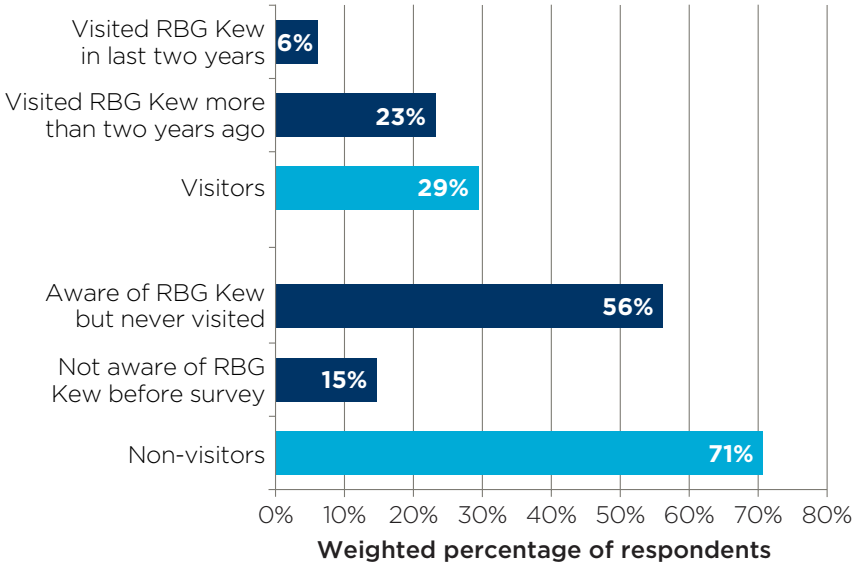
7.4 SURVEY RESULTS

7.4.1 Use and awareness of Kew

Just under 30% of respondents had visited Kew in the past. Of these, a fifth (6%) had visited Kew in the last two years.

Of the approximately 70% of respondents who had not visited Kew in the past, most were aware of Kew. Out of all respondents, 15% were not aware of Kew before taking the survey.

Fig. 10: Percentage breakdown of visitor types



Source: Oxford Economics analysis of survey data fielded by YouGov.

Notes: Sample is 2,043 respondents. Responses are weighted to be representative of the population.

[92] With respect to market research type surveys which typically ask for views and perceptions without providing prior information, this is in a sense an experimental survey design.
[93] See section "The steps in estimating money values" in HM Treasury, Green Book supplementary guidance: stated preference techniques" 2013, accessed September 2023.
[94] The values presented to respondents were informed by the distribution of willingness-to-pay values from the previous study. Oxford Economics, "The Economic Value of Royal Botanical Gardens, Kew", 2020.
[95] Additionally, it is challenging to build a credible scenario to elicit values through taxation given that Kew already relies partially on public grants, without giving respondents an indication of how much of the average taxpayer's taxes funds Kew, which would anchor respondents to such a value.

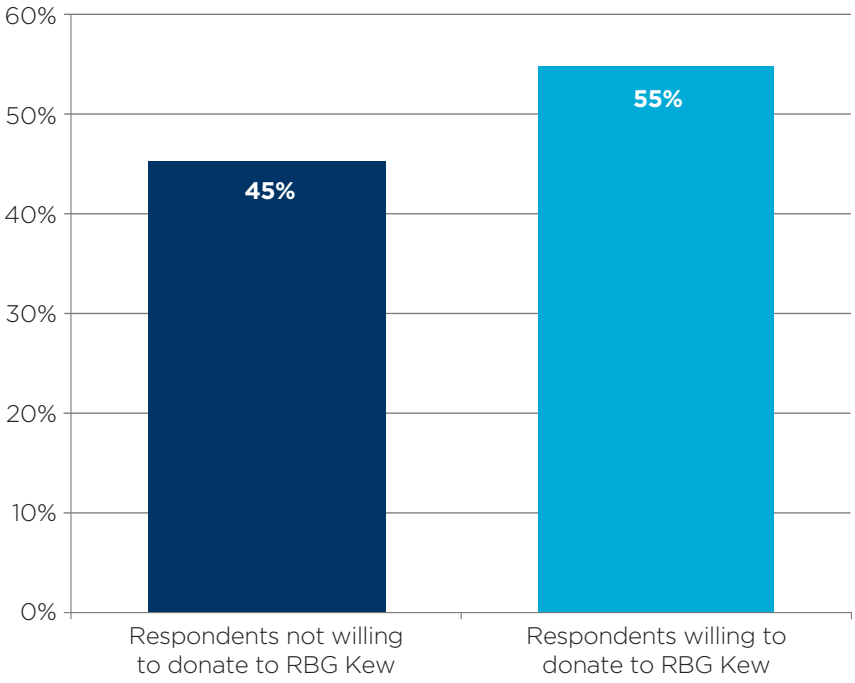
7.5 ESTIMATED NON-USE VALUE OF KEW

In the survey we ask respondents if they would be willing to make an annual donation "to maintain the Royal Botanic Gardens, Kew, including the recreational opportunities that it offers and the educational and research activities that it conducts".

Across the sample, just over half of respondents were willing to pay a donation to Kew (55%). In this calculation and the analysis that follows, we exclude respondents who respond "don't know" to the willingness-to-pay question and those who provide inconsistent responses.[96]

Fig. 11: Share of respondents willing to donate to Kew

Weighted percentage of respondents, excluding "don't know" and inconsistent responses



Source: Oxford Economics analysis of survey data fielded by YouGov.

Notes: Sample is 1,309 respondents. Responses are weighted to be representative of the population. Responses are the result of an experimental design which describes Kew and its activities to respondents before the question is asked. "Don't know" responses to the willingness-to-pay question are excluded. Respondents with inconsistent follow-up responses are also excluded.

The purpose of the non-use survey is to elicit willingness-to-pay values from non-users of Kew. Consideration was taken around who non-users are considered to be, given that Kew is not only a place that offers recreational opportunities for visitors, but also offers and conducts activities in education and science, of which non-visitors may make use. Some introductory questions were therefore included to comprehensively identify users.

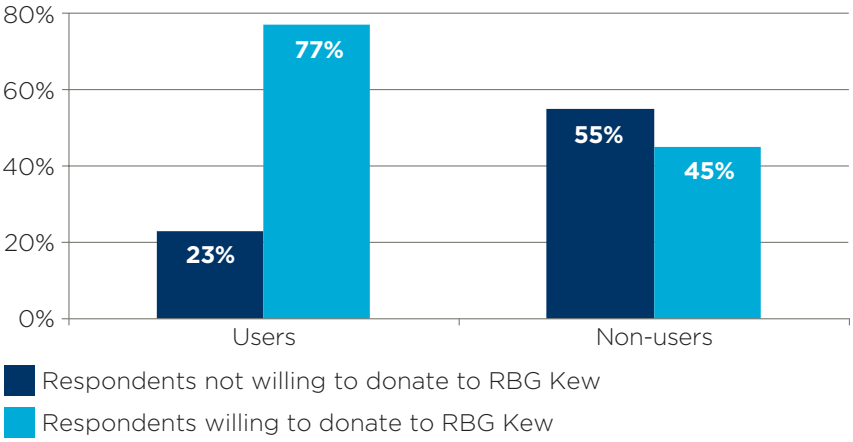
The survey identified a small minority of non-visitors who said they were either members of Kew or had donated to Kew in the past (1.3%); had used Kew's online resources (10.7%); or had participated in Kew's outreach activities (1.3%). As we ask respondents to value not only Kew's recreational opportunities, but also its educational programmes and activity in science and conservation, we define users to be past visitors *and* non-visitors who have used Kew's online resources or participated in any of its outreach activities. Thus, we define non-users as non-visitors who also have not used Kew's online resources or participated in any of its outreach activities.[97]

[96] Inconsistent responses refer to the following:
Individuals not willing to pay are excluded if they follow up by saying they value Kew "a great deal" or "a fair amount"; or if they don't believe surveys can answer these sorts of questions.
Individuals willing to pay a positive amount are excluded if they follow up by saying they "probably" or "definitely" would not really pay the amount, or if they don't know if they would pay; if they don't value Kew "at all" or "don't know" if they value Kew; if they believe Kew shouldn't rely on donations; if they believe surveys can't answer these questions; or if they state they cannot afford to donate to Kew.

[97] We exclude individuals who stated they were members or that they had already donated to Kew in the past (1.3% of the sample) over doubts as to how to interpret their responses. For instance, if they have already donated to Kew, they might reasonably be unwilling to donate any further amounts, but that may not be indicative of how much they value Kew.

Fig. 12: Share of individuals willing to donate to Kew, by user type

Weighted percentage of users and non-users, excluding "don't know" and inconsistent responses

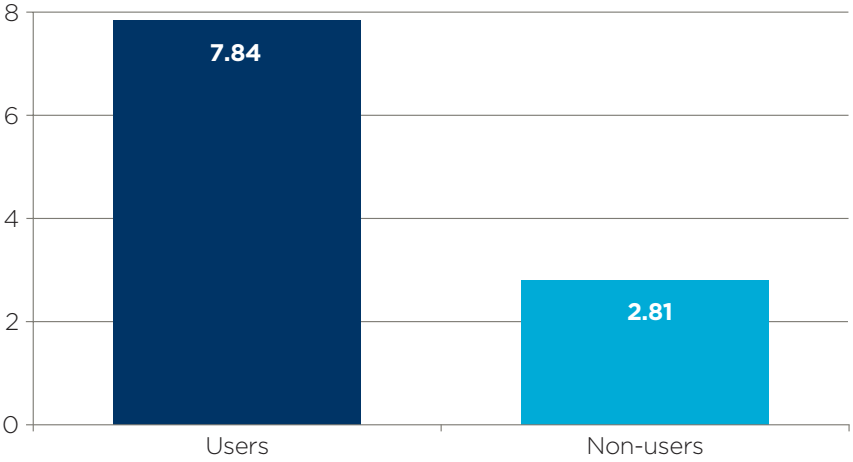


Source: Oxford Economics analysis of survey data fielded by YouGov.

Notes: Sample is 1,309 respondents. Responses respondents (users: 430; non-users: 879). Responses are the result of an experimental design which describes Kew and its activities to respondents before the question is asked. Responses are weighted to be representative of the population. "Users" are defined as those who have visited RBG Kew in the past, plus non-visitors that have either used RBG Kew's website or have participated in any of its outreach activities. "Don't know" responses to the willingness-to-pay question are excluded. Respondents with inconsistent follow-up responses are also excluded.

Fig. 13: Willingness-to-pay by user group

£ (2022 prices)



Source: Oxford Economics analysis of survey data fielded by YouGov.

Notes: Sample is 1,309 respondents. Responses respondents (users: 430; non-users: 879). Responses are the result of an experimental design which describes Kew and its activities to respondents before the question is asked. Responses are weighted to be representative of the population. "Users" are defined as those who have visited RBG Kew in the past, plus non-visitors that have either used RBG Kew's website or have participated in any of its outreach activities. "Don't know" responses to the willingness-to-pay question are excluded. Respondents with inconsistent follow-up responses are also excluded.

Having defined users and non-users, we then describe Kew and its activities and present the hypothetical scenario in which Kew requires additional funding to continue to operate. Following this, we asked respondents whether—and if so, how much—they would be willing to donate to Kew. Over three quarters of users (77%) were willing to donate to Kew. Among non-users, the share of individuals willing to donate to Kew is just under half (45%).

> **"I have never been to Kew but I know it does a great job conserving species that could be lost due to global warming and human activity."**
>
> *Non-user in Wales*

Mean average willingness-to-pay is £7.84 among users and £2.81 among non-users.[98,99] Only three non-users provided responses greater than the largest value available on the payment card of £20. As these were not considered extreme values, and were reasonably supported by comments, they were kept in the analysis.[100] Among users, willingness-to-pay is greater for more recent visitors (£9.49) than for non-recent visitors (£6.41). Among non-users, people who were aware of Kew before taking the survey were willing to pay more (£3.12) than those who were not aware of Kew (£1.73).

[98] Responses are interpreted as being in 2023 prices and are deflated to be in 2022 prices using a Consumer Inflation Index. The nominal figures (in 2023 prices) are £8.43 and £3.02 for users and non-users respectively.

[99] The mean (and therefore total) non-user values estimated in this study are not directly comparable to those estimated in our 2019 study for several reasons: it uses a different payment method (donations, as opposed to taxation); our latest survey does not provide an indication of the current public resources allocated to Kew, whereas the 2019 study does; and in this study we additionally ask respondents to consider Kew's educational and research activities when asking for their valuation.

[100] Excluding these three responses, mean non-user willingness to pay is £2.70 (in 2022 prices)—that is, 3.9% lower.

7.5.1 Aggregating to the UK population as a whole

Our survey provides us with a non-use value of Kew for the average adult in the UK. To estimate a total non-use value, we applied the average value to the UK adult resident population in line with best practice.[101]

We multiply the non-user mean willingness-to-pay value of £2.81 by the UK resident population aged 16 or above (which we estimate to be around 55 million in 2022[102]) to give an estimate of Kew's total non-use value of £155 million.

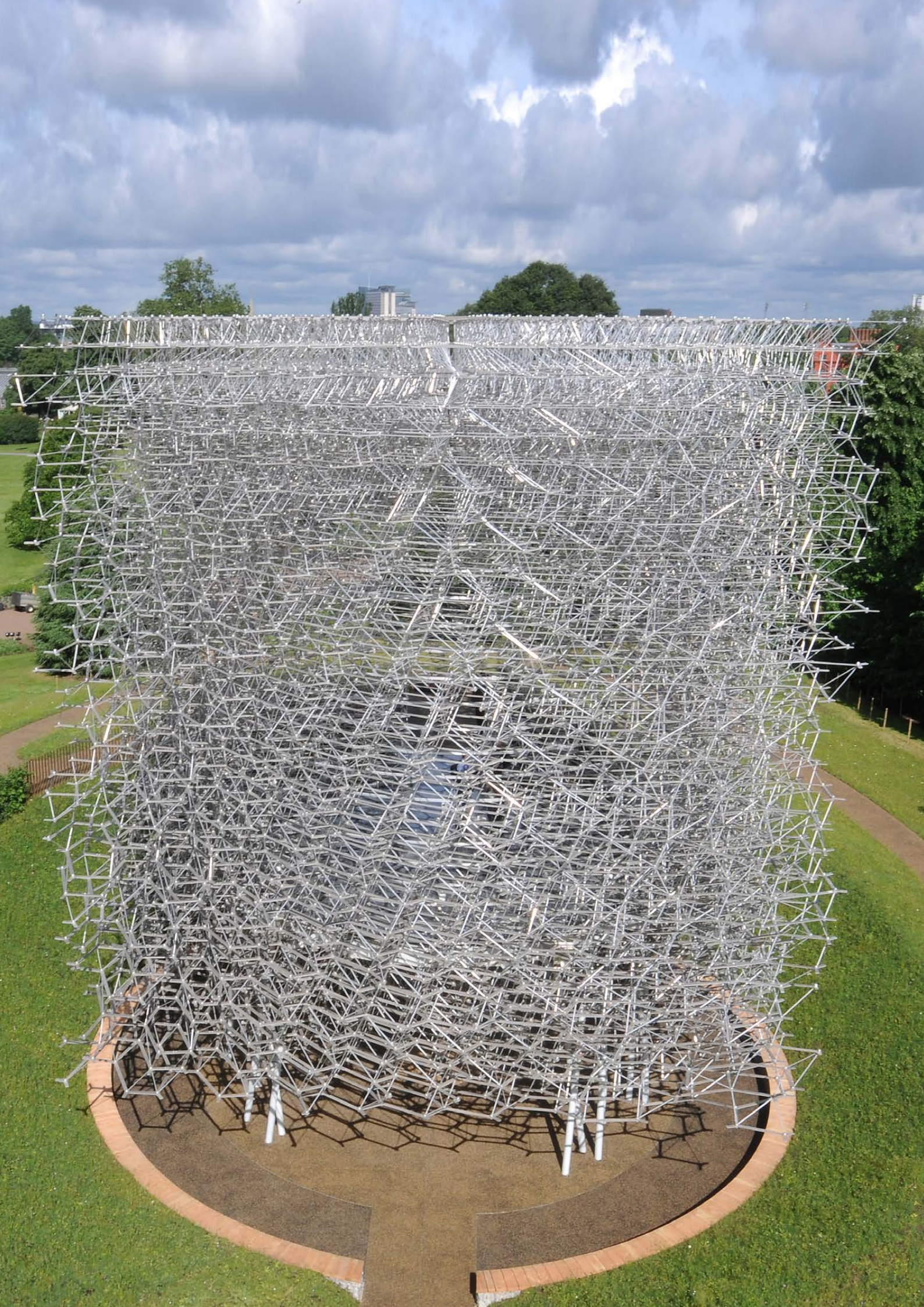
7.5.2 Comparison with non-use values from the literature

We compared our estimated average non-use value with estimates from the literature covering institutions and amenities similar to Kew. Whilst differences in estimates can result from a large variety of factors, these comparisons nevertheless provide a useful benchmark and sense check on our results.[103]

Past research has placed a non-use value of £5.14 per year on the Natural History Museum,[104] and a £12.73 non-use value per year on all parks and greenspaces in respondents' local area.[105]

Aside from methodological variation, the larger magnitude of these non-use estimates compared to that estimated for Kew may, in the case of the Natural History Museum, be due to its status as the most visited tourist attraction in England.[106] The higher valuation of parks and greenspaces in individuals' local areas likely reflects their geographic proximity, which may, for example, enhance the image of the community in which people live.

[101] HM Treasury, The Green Book (2022), "Scope of costs and benefits", 2022, accessed October 2023.
[102] Source: Oxford Economics' calculations based on World Bank data.
[103] Factors influencing willingness-to-pay could include survey-related factors (sample size and representativeness), methodology (payment vehicle, and elicitation format), and the unique characteristics of the valued asset.
[104] Bakhshi et al., "Measuring Economic Value in Cultural Institutions", 2015, accessed September 2023. The value in 2015 prices of £8.29 per family was converted to 2022 prices and adjusted to reflect a value per individual.
[105] Fields in Trust, "Revaluing Parks and Green Spaces", page 26, 2018, accessed September 2023. The authors' estimate was of £1.81 per month, in 2018 prices, per household.
[106] visitbritain.org, "England Visitor Attractions: latest", accessed October 2023.



8. INTERNATIONAL VALUE

The previous chapters presented Kew's contribution, focussing firstly just on UK society in line with appraisal best practices. However, Kew's contribution extends beyond the UK to the rest of the world. In this chapter we look at how Kew contributes globally through its international visitors and students, and through the global impact of its scientific output.

8.1 INTERNATIONAL VISITORS

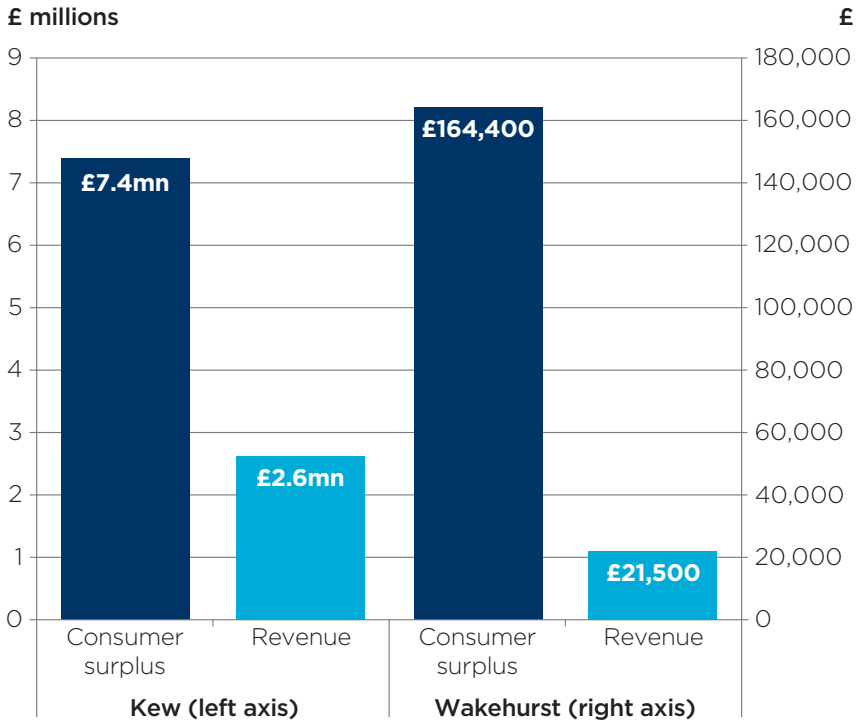
Chapters 3 and 4 estimated the value to UK visitors to Kew Gardens, Wakehurst, and to special events. In 2022/23 there were an estimated 194,000 international visitors to Kew Gardens and a further 7,000 international visitors to Wakehurst.[107,108] These visitors also derive value from visiting the sites in the same way that UK visitors do.

A key requirement of travel cost modelling is that individuals' visits to the site in question are the sole reason for their travel. In cases where individuals' visits to Kew Gardens or Wakehurst are part of some broader trip, it is not possible to fully assign travel costs solely to Kew Gardens or Wakehurst. In the case of international travellers, it is unlikely that the sole purpose of their visit to the UK was to visit Kew Gardens or Wakehurst.[109] This means it would not be appropriate to develop a separate travel cost model for international visitors. We therefore make the relatively conservative assumption that, on average, international visitors have the same consumer surplus per visit as UK visitors.

The analysis in chapter 3 estimated an average consumer surplus per visit to Kew Gardens of around £45 for UK visitors. Re-weighting this to reflect the different composition of members and non-members amongst international visitors suggests that the average consumer surplus per visit to Kew Gardens among international visitors is around £38. A similar exercise suggests an average consumer surplus per visit of £23 for international visitors to Wakehurst.

Scaling these values by the estimated number of international visitors to each site suggests a total consumer surplus for international visitors to Kew Gardens and Wakehurst of £7.4 million and £164,000 respectively (see Fig. 14). Entry-related revenues of £2.6 million to Kew Gardens and £21,500 to Wakehurst are added to estimate the total gross value to international visitors. Doing so suggests the total gross value of Kew Gardens to international visitors in 2022/23 was £10.0 million. The equivalent figure for Wakehurst was £188,000.

Fig. 14: Gross value of Kew Gardens and Wakehurst to international visitors, 2022/23



Source: Oxford Economics

[107] Using estimated split of UK and international visitors from Kew's visitor survey.
[108] A very small number of international visitors attended special events. However the number was too small to estimate significant visitor value.
[109] An alternative approach would be to estimate the proportion of their trip to the UK that was spent at Kew and apply that to the overall travel costs of their visit to the UK, however such data were not available for this study. For example, if a visitor on a seven-day trip to the UK spends one of those days at Kew then one-seventh of their travel costs of their entire trip to the UK could be attributed to Kew.

We have not estimated the value of special events to international attendees due to data limitations. Given the available data, we were unable to identify international visitors to Christmas at Kew and the Summer Cycle.[110]

8.2 INTERNATIONAL STUDENTS

Chapter 5 of this report presented the value of Kew to its UK-based participants in its educational programme. In this section, we present the value to international students supported by the same courses described in chapter 5 and using the same approach.

We estimate that educational visits to Kew and Kew's courses supported £2.1 million in value to international students. This figure represents the uplift to lifetime earnings that international students will earn as a result of gaining a higher qualification.[111]

The largest contributors to the value to international students are Kew's MSc courses (30%), Kew-supported externally-funded undergraduate students (25%), and co-supervision of PhD students (19%).

8.3 INTERNATIONAL VALUE OF SCIENCE

Chapter 6 looked at the value of Kew's scientific research to the UK specifically. However, Kew's research is international in both scope and impact, and so creates value beyond the UK, which may be much greater. Kew's scientists work in collaboration with over 400 institutions from more than 100 countries.[112] The international value of Kew's research can be summarised across two dimensions:

- The applied research Kew undertakes has both a domestic and international "spillover effect", as both domestic and overseas researchers benefit from the knowledge generated by Kew's research in areas such as ecosystem stewardship and climate change adaptation.
- Kew's extensive collections enable research to be undertaken by researchers worldwide. This is particularly relevant given Kew's expanding digital collection, which permits access to researchers based abroad at much lower cost versus purely physical collections. The research enabled by Kew's collections may in turn create substantial economic value.

Quantifying the global value of science at Kew is particularly challenging. Chapter 6 used academic research on the social returns to public R&D spending. However, this only considers social returns from the perspective of the UK and so does not capture any wider international spillovers. To our knowledge, there does not exist any research which quantifies the "global spillovers" of public R&D spending in a country, and as such we are not able to place a monetary value on the international impact of Kew's scientific work.

Case studies on a sample of Kew's international research projects in sustainability and climate change, as well as on Kew's extensive collections, provide qualitative insights as to the global impact of science at Kew. However, we recognise that our estimate of the international value of Kew is conservative given that we do not quantify the global value of science at Kew.

[110] Data were available for Glow Wild which identified the country of residence for each ticket purchase. Fewer than 200 international attendees to Glow Wild were identified. Given the small number of attendees, we have excluded the associated consumer surplus from the analysis.
[111] It is assumed that international students will earn their wages abroad, while UK students will earn their wages in the UK. Due to data limitations, estimates of wage uplifts for international students are based on UK data.
[112] Kew, "Where we work", accessed October 2023.

BIODIVERSITY PROTECTION AND CLIMATE CHANGE ADAPTATION

Kew is involved in a number of projects globally drawing on its expert knowledge of plants to protect biodiversity while at the same time helping communities adapt to climate change.

Protecting biodiversity through improved coffee farm management

Kew scientists have been researching the risks and opportunities of coffee production in a warming climate for a number of years. As coffee drives a multibillion dollar industry worldwide, which provides livelihoods for more than 100 million individuals, future-proofing its supply chain against climate change is essential.[113,114] Recent research by Kew has identified a crop with a similar flavour to high-quality Arabica coffee that is able to grow at a significantly higher temperature, potentially providing a more climate change resilient crop to help derisk coffee farmers against the impacts of climate change.[115] Kew has also been active in on-the-ground projects in a number of countries including Ethiopia, Uganda, and Mexico, helping coffee farmers to adapt to climate change and containing biodiversity loss.

For example, with funding from the Darwin Initiative, Kew recently managed a project helping coffee farmers in Ethiopia, where coffee accounts for almost 40% of Ethiopia's export earnings.[116] The project took place in Yayu Reserve—a forest rich in biodiversity and home to Arabic coffee crops—and sought to increase coffee quality and farmers' access to export markets. This was done with a view to avoiding conversion of the land from forest-based farming systems to non-forest crops, which would have harmed biodiversity in the reserve. Income associated with local coffee production increased by 30%, and, as an example of the project's success, Yayu Forest Coffee is available in over 200 supermarket stores throughout the UK.

Helping communities adapt to climate change and increase food security

Kew has been working on a project funded by the Ellis Goodman Foundation aimed at conserving the diversity of an endangered crop—enset, a relative of the banana—in South West Ethiopia which approximately 20 million people use as their staple food.[117,118] Crop diversity is important as it helps build resilience to climate change, pests and diseases, and volatile markets. As such, it can play a key role in food security.

Enset is an indigenous Ethiopian crop known as the "tree against hunger", as it is perennial and can be planted or harvested at any time of the year. Is is also tolerant to droughts and can be stored for over six months after being processed.

The project team visited 500 farmers from 22 communities and identified 175 different varieties of enset, establishing that 57 of these were critically endangered and required conservation efforts. They then conducted surveys to determine which varieties of enset were rarest in nearby communities.

In collaboration with Addis Ababa University, Kew is compensating farmers for growing and maintaining these endangered varieties of enset through a bidding process. Over 45,000 plants from 52 varieties have been planted, at a cost of £2.16 per plant. Kew hopes that this success means that the project can be scaled up and applied to other crops.

[113] Revenue in the coffee market amounts to $88.3bn in 2023. Statista, "Coffee – Worldwide", accessed October 2023
[114] Kew, "Arabica Coffee", accessed October 2023.
[115] Davis, Aaron P. et al., "Arabica-like flavour in a heat-tolerant wild coffee species", Nature Plants, 7 (2021), pp. 413-418, accessed October 2023.
[116] Ethiopia's total exports in 2021 amounted to $3.06bn, of which $1.19bn, or 39% was coffee (not roasted). World Integrated Trade Solution, "Ethiopia Trade", World Bank, accessed October 2023.
[117] Kew, "Protecting the future with Ethiopia's endangered crops", accessed September 2023.
[118] Borrell, James et al. "Enset in Ethiopia: a poorly characterized but resilient starch staple", Annals of Botany, 123 (2009) pp. 747-766, accessed October 2023.

PLAYING A ROLE IN GLOBAL POLICY

Kew is active in a number of global fora, helping to inform and shape policy in areas such as biodiversity and deforestation. Though we have not been able to place a monetary value on these activities, Kew's role in supporting the global response to issues such as climate change and biodiversity loss should be recognised.

Kew is the **Strategic Science Lead for the Global Centre on Biodiversity for Climate (GCBC)**, a UK government programme that funds research into biodiversity-based solutions to climate change and poverty. Kew's role as Strategic Science Lead is to deliver a research strategy for the programme, oversee the programme's research cycles, and synthesise and disseminate evidence generated by the programme. The research strategy informed the theme for the first research grant call launched in 2023, on sustainable agriculture and natural resource management.

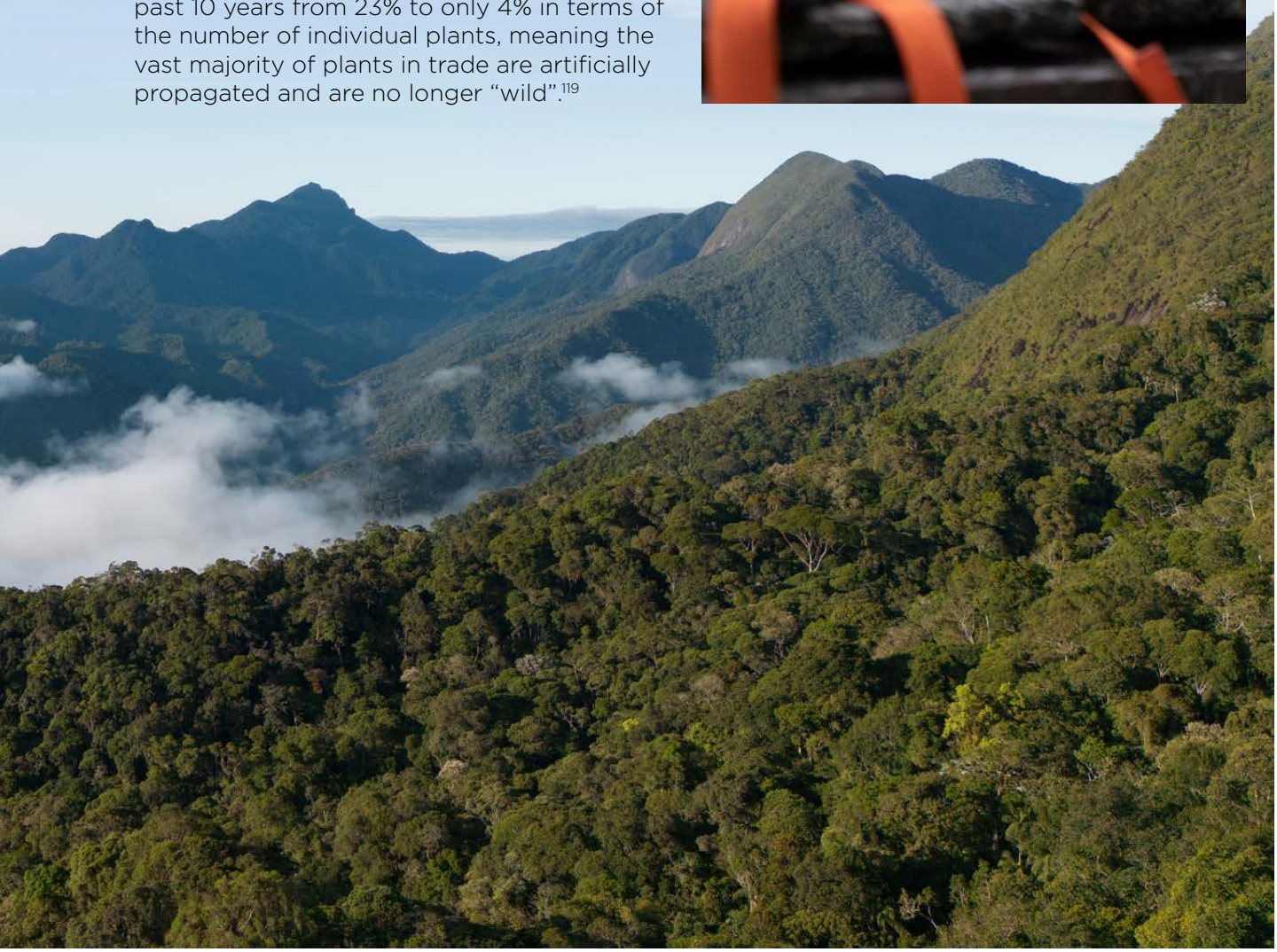
To date, GCBC has funded 15 projects operating in 28 countries, representing an £11.5 million investment in research and development across a broad range of subject areas. Research projects funded by the programme range from a project in Malaysia studying how yields of seaweed aquaculture are affected by climate-induced diseases, to a project in the Amazon Rainforest designed to fill an evidence gap around which parts of the region would be worst impacted by drought and higher temperatures. These projects have been selected to meet the evidence gaps identified in the research strategy.

Kew also acts as the **UK's Scientific Authority for the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)**. CITES is an international agreement between governments which aims to regulate the trade of threatened plant and animal species.

Kew's role is to provide independent scientific advice to government to help develop policy in support of the sustainable international trade of wild plant species. Kew also advises on CITES's licence applications to import or export endangered species.

Kew provides advice on and processes up to 4,000 licence applications annually. It has also published a number of CITES checklists, which act as references for families of plants, and are used by CITES authorities similar to Kew globally.

In its role, Kew has helped support CITES prevent more species becoming threatened by trade. Worldwide, the proportion of wild-sourced plants in trade has decreased in the past 10 years from 23% to only 4% in terms of the number of individual plants, meaning the vast majority of plants in trade are artificially propagated and are no longer "wild".[119]



[119] CITES, "World Wildlife Trade Report", 2022, accessed October 2023.

9. SOCIAL COST-BENEFIT ANALYSIS

We now bring together our estimates of the benefit created by Kew through its various activities, and set these against the costs of operating Kew. This comparison provides us with a useful value-for-money metric with which to assess the returns to the economy and wider society of each pound spent running Kew.

9.1 TOTAL GROSS VALUE OF KEW

In this report we have estimated the value of Kew and its activities to visitors, to students, to science, and to non-users of Kew. We estimate the gross benefits to the UK economy and wider UK society at £369 million. When we include the value to international visitors and students, our estimate of total benefits increases to £382 million.

The largest contributor to UK benefits is Kew's non-use value (41%), estimated at £155 million.[120] Kew's value to science and to UK visitors of Kew Gardens are the next largest contributors to total UK benefits, contributing 24% (£90 million) and 17% (£63 million) respectively.

9.2 COST OF RUNNING KEW

Expenditure for running Kew in 2022/23 amounted to £97 million. This includes £57 million in research and conservation costs and £22 million in costs to fund visitor activities.

9.3 KEW'S 'BENEFIT-COST RATIO' AND 'NET BENEFITS'

By comparing our estimate of total UK benefits to the costs of running Kew, it is possible to determine how many pounds in benefits are generated by Kew for UK society for every pound in costs required to operate Kew. We estimate this benefit-cost ratio at 3.81 for 2022/23, meaning that for every pound spent on running Kew, or for every pound of funding allocated to it, £3.81 of benefits to UK society were created. The ratio increases to 3.93 with the addition of

Fig. 15: Summary of costs and benefits of Kew, 2022/23

	£ million
Costs	**97.0**
Of which:	
Research and conservation	57.5
Visitor activities	22.2
Other	17.3
Quantified UK benefits	**369.4**
Quantified total benefits	**381.7**
Of which:	
Value to UK Kew Gardens visitors	63.2
Value to international Kew Gardens visitors	10.0
Value to UK Wakehurst visitors	6.1
Value to international Wakehurst visitors	0.2
Value to UK attendees of special events	14.3
Non-use and option value for UK residents	155.1
Scientific value	90.4
Educational value for UK students	22.5
Educational value for international students	2.1
Other income	17.8
Ratio of quantified UK benefits to costs	**3.81**
Ratio of quantified benefits to costs (including international benefits)	**3.93**

[120] As a comparison, non-use value for Canada's galleries, libraries, archives, and museums was estimated at just under 20% of total benefits in a 2019 study by Oxford Economics (Oxford Economics, "Value Study of GLAMs in Canada", 2019, accessed September 2023). A study by Deloitte Access Economics found that the non-use value of Sidney's Opera House was 43% of its total social value (See page 7 of Deloitte Access Economics, "Valuing 50 years of Australia's icon", 2023, accessed October 2023). In 2016, Haefele et al estimated that the non-use value of U.S. National Parks was $33.5 billion out of a total economic value of $62 billion—roughly 54% (Haefele et al, "Total Economic Valuation of the National Park Service Lands and Programs: Results of a Survey of the American Public", 2016, accessed September 2023). The non-use value of Australia's Great Barrier Reef was found to be 42% of its estimated total economic value (See page 44 of Deloitte Access Economics, "At what price? The economic, social and icon value of the Great Barrier Reef", 2017, accessed September 2023).

estimated international value. This gives an idea of the efficiency of Kew, in a way which can compared to other uses of public funding.

Alternatively, we can also look at the scale of "net" benefits created by Kew, defined as benefits minus costs. In 2022/23, Kew created £273 million in net benefits to UK society, which increases to £285 million when international users are considered.

9.4 UNQUANTIFIED BENEFITS

Cost-benefit analysis guidance recognises that the benefit from some activities may not be able to be quantified, or monetised, but that the potential benefits should nevertheless be described in qualitative terms.[121]

Kew offers a number of programmes, and holds a range of assets, on which it has not been possible to place a monetary value, but which nevertheless may provide significant benefits to society. For example, it was not feasible to value in full Kew's significant collections of plants and fungi, as this would have required a complete understanding of the scientific research enabled by the collections, as well as the value of this research.

Attributing Kew's impact as part of this would also have been complicated as any given research project is likely to involve input from multiple institutions.

These programmes and assets have instead been explored through case studies, and include:

- Kew's extensive collections, including the Living Collections, Herbarium, Fungarium, Seed Bank, and expanding digital collection;
- Kew's role in a number of programmes to protect biodiversity, and to both address and mitigate against climate change;
- Kew's role in helping to shape global policy through, for example, the Global Centre for Biodiversity and Climate, and CITES;
- Several educational programmes, including Endeavour and the educational Youth Programme; and
- Community outreach programmes such as Grow Wild.

[121] See section 9.5 of HM Treasury's Green Book. HM Treasury, "The Green Book (2022)", November 2022, accessed September 2023.

COMMUNITY OUTREACH

Interested individuals and communities can also engage with Kew through its outreach programme **Grow Wild**. In this way, individuals who are not able to access Kew because of geographical or other barriers can nevertheless learn about and enjoy UK native wildflowers, plants and fungi. The Grow Wild programme currently has two core activities: **community projects and youth projects**.

Firstly, Kew provides grants and training to community groups to undertake **community projects** to transform urban spaces using UK native wildflowers, plants, and fungi, with a particular focus on disadvantaged areas. In addition to transforming disused spaces, the projects also aim to foster a sense of community belonging and connection to nature, as well as provide volunteering opportunities.

To this end, in 2022/23, the projects engaged over 5,000 people through volunteering, participation in project activities, visits to project spaces, and groups' social media. Project leaders and participants donated over 1,200 volunteer hours working on the projects. Community projects have also transformed 15,000 square metres of community space.

Secondly, Grow Wild also provides grants to young people to undertake **youth projects**. Projects ranged from running nature-inspired poetry workshops to organising habitat survey training for peers.

In 2022/23, funded youth projects collectively engaged over 2,000 people. Projects were funded across all four countries of the UK, with half of those funded located in the 30% of the most deprived postcode areas in the UK.

Post-project survey results revealed that 91% of respondents felt more connected to other people since the start of the project, and 100% of respondents stated that their knowledge of UK-native plants and fungi had increased by completing their project.

APPENDIX 1: TRAVEL COST MODELLING

As described in section 3.1, the basis of the TCM is that the cost of visiting Kew Gardens or Wakehurst is greater than just the entry fee. Visitors also incur costs to travel to and from the venue, such as fuel costs, vehicle depreciation, and the opportunity cost of time spent travelling.[122] Travel costs are, on average, greater for visitors as they get further away from Kew Gardens or Wakehurst. As such, the total cost of visiting Kew Gardens or Wakehurst will vary for visitors depending on where they have travelled from.

These differences in total costs can be used be used to plot a demand curve for Kew Gardens and Wakehurst.[123] The rate at which the number of visits decreases as the associated travel cost increases can be used to infer how quickly visitor numbers would decline if entrance fees were increased.[124] The consumer surplus from visits to Kew Gardens and Wakehurst can then be estimated using this demand curve (i.e., the difference between what individuals actually pay to visit Kew Gardens and the maximum amount they would have been willing to pay to visit the gardens—their WTP).

We used the "individual travel cost model" (ITCM) variant to estimate the consumer surplus of visitors to both sites. The ITCM uses statistical modelling to study the relationship between the number of visits made by each visitor and their associated travel cost, whilst controlling for other factors that affect the number of visits made.[125] The modelling results are used to quantify the impact of a marginal change in the cost of visiting Kew on the number of visits. From there, it is possible to estimate the average consumer surplus per visit.

INDIVIDUAL TRAVEL COST MODEL (ITCM)

The ITCM is used to determine the relationship between the number of visits made by an individual visitor to Kew Gardens or Wakehurst in a given period of time and the costs they face in visiting the site. The model controls for other personal characteristics, such as age, which may be expected to influence the number of visits an individual makes.

The sections below detail our approach, starting with how we developed a cost variable using the postcodes of individual visitors to Kew Gardens or Wakehurst which was captured through a visitor survey. We then model the relationship between visit cost and number of visits and use the regression outputs to derive estimates of the consumer surplus per visit.

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.

[122] By visiting Kew Gardens, an individual is choosing to spend time travelling to and from Kew Gardens instead of using that travel time for another purpose. Opportunity cost reflects the value of time foregone as a result of the travel to and from Kew Gardens.
[123] A demand curve represents the relationship between the number of visitors who would be willing to visit Kew Gardens at different entrance fees. Fewer visitors would be expected to visit as the entrance fee increases and this is reflected in a downward-sloping demand curve.
[124] A central principle of the travel cost method of valuation is that people incur the full cost of their trip solely to visit the subject of evaluation, in this case Kew Gardens or Wakehurst. In practice, of course, many people will combine their trip with other visits, and perhaps a weekend break in London. To avoid over-valuing, it is important to identify only travel costs incurred in respect of Kew Gardens or Wakehurst. To do so, we made the assumption that respondents whose travel time to the site they were visiting was greater than four hours (i.e., an eight hour round trip) did not visit as part of a day trip and were therefore excluded from the modelling.
[125] Travel cost includes the direct cost and the opportunity cost of time travelling.

Using information captured in the visitor survey we had the outward postal code (first half of the post code) for each UK-based visitor. We used Google Maps Distance Matrix API to calculate both the distance and travel time from the centroid of every UK outward postal code to both Kew Gardens and Wakehurst.[126]

To estimate the direct travel costs we used the HMRC mileage rate of 45 pence per mile,[127] which takes account of all vehicle costs from fuel and servicing to insurance and depreciation. For survey respondents who indicated that they visited as part of a group, we divided this direct cost evenly across all group members to derive a direct travel cost per person. This was multiplied by two to account for both the outward and return journeys.

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 £6.51 per hour in 2022.[128] For each survey respondent, we multiplied their travel time (in hours) by the hourly value of leisure time to estimate their opportunity cost. Again, this value was multiplied by two to account for the return journey.

Combining the direct travel cost with the opportunity cost gives an estimate of the overall visit cost for each survey respondent.

When running travel cost models, it is important that the estimated travel costs are incurred solely in relation to visiting the site in question (Kew Gardens or Wakehurst) and are not part of a broader trip. The visitor survey available for this study did not explicitly identify whether a respondent visited Kew or Wakehurst on a day trip or as part of a wider trip. Instead, we applied a four-hour travel time threshold (eight-hour round trip) for identifying whether a respondent visited as part of a day trip or not. We therefore exclude visitors whose home postcode is more than four hours driving time from Kew or Wakehurst from our modelling exercise. However, when estimating overall consumer surplus associated with each site, we conservatively assume that each of these visitors derive the same consumer surplus per visit as those considered day trip visitors.

Finally, it is worth noting that the Google Maps Distance Matrix API calculations are based on driving time. In practice, a large number of visitors to Kew 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 for Kew Gardens. Given the location of Wakehurst and its distance from mainline train stations, it is expected that a much greater proportion of visitors will travel by car and therefore the use of driving time in the mapping algorithm is appropriate.

[126] Distance and travel time are calculated on the assumption of travelling by car.
[127] HM Revenue & Customs, "Travel – mileage and fuel rates and allowances", accessed August 2023.
[128] Department for Transport, "TAG data book", accessed August 2023.

Regression model

Once the visit cost variable had been developed, regression analysis was undertaken to determine how sensitive the annual number of visits an individual makes is to the associated visit cost while controlling for other factors which may be expected to influence visit rate. The functional form of the regression is below in equation 1 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 other characteristics such as age. Separate regressions were estimated for members and non-members of each site given the groups exhibit very different visits rates and the different marginal entry costs given the ticketing structure.

(1) $lnV_i = \alpha + \beta_1 TC_i + \beta X_i + \varepsilon_i$

Features of the data determine the appropriate modelling approach to be adopted. 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 are not conditionally normally distributed around the mean. Consequently, econometric models designed for count data were estimated for this study.

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. We estimated regressions using both models and used statistical tests to determine which approach was most appropriate. Further details of this are in the next sub-section.

Since the survey was undertaken on visitors to Kew Gardens and Wakehurst, 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. We therefore "shift" the data by subtracting 1 from the number of visits made by each respondent such that the minimum visits is zero which makes it much better suited to the regression models described above.

Regression outputs

We considered two types of model, a conventional "Poisson" model and a "negative binomial" model. The former assumes the data are equally dispersed, or put another way, the model assumes the mean number of visits is equal to the variance in visits. 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 preferred specifications for each model are presented in Fig. 16 (for members) and Fig. 17 (for non-members).

Fig. 16: Regression outputs of ITCM for member visits to Kew Gardens and Wakehurst

	Kew Gardens		Wakehurst	
	Poisson	Negative binomial	Poisson	Negative binomial
Intercept	1.293 ***	1.076 ***	1.795 ***	1.729 ***
Travel cost	-0.077 ***	-0.02 ***	-0.059 ***	-0.045 ***
Age	0.025 ***	0.022 ***	0.013 ***	0.013 ***
Employed	0.769 ***	0.706 ***	0.31 ***	0.226 **
Statistics				
AIC	11,588	3,070	3,901	2,153
BIC	11,604	3,091	3,917	2,172
Log likelihood	-5,790	-1,530	-1,947	-1,072
Likelihood ratio (alpha)		8,519***		809***

Notes: *** indicates statistical significance at the 1% level; ** at the 5% level; and * at the 10% level.
Source: Oxford Economics

Fig. 17: Regression outputs of ITCM for non-member visits to Kew Gardens and Wakehurst

	Kew Gardens		Wakehurst	
	Poisson	Negative binomial	Poisson	Negative binomial
Intercept	-0.154	-0.250	0.844 ***	0.852 ***
Travel cost	-0.034 ***	-0.027 ***	-0.056 ***	-0.044 ***
Age	0.017 ***	0.014 ***	0.016 ***	0.012 ***
Ticket type - £1 ticket	0.792 ***	0.899 ***	-1.265 ***	-1.19 ***
Ticket type - full price adult	-0.75 ***	-0.687 ***	-1.747 ***	-1.702 ***
Ticket type - other	-0.601 ***	-0.526 ***	0.397***	0.022
Statistics				
AIC	2,974	2,167	3,839	2,515
BIC	3,005	2,203	3,866	2,547
Log likelihood	-1,481	-1,076	-1,913	-1,250
Likelihood ratio (alpha)		1,750***		1,326***

Notes: *** indicates statistical significance at the 1% level; ** at the 5% level; and * at the 10% level.
Source: Oxford Economics

Choice of model

We use the likelihood ratio test to assess whether there is overdispersion in the visit variable. In all regressions (members and non-members to both Kew Gardens and Wakehurst) the test statistic is statistically significant, suggesting that the negative binomial model is more appropriate. Measures of goodness of fit, such as Akaike information criterion (AIC), also indicate the negative binomial model is preferred to the Poisson model.

We therefore use the negative binomial model for both member and non-member visitors to Kew and Wakehurst.

Deriving 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 semi-logarithmic linear model used in this analysis is that it can easily be used to determine the *average* consumer surplus *per visit* as $CS = \frac{-1}{\beta 1}$.[129] Consumer surplus per visit to each site is multiplied by the total number of annual visits to each site respectively to give the aggregate consumer surplus.

ZONAL TRAVEL COST MODEL (ZTCM)

The ITCM described above relies on having data on the number of visits made by each individual plus their characteristics, such as age, which can be used as control variables in the regression analysis. Such granular data were not available in the case of visitors to special events. Therefore, we developed a zonal travel cost model (ZTCM) which determined the relationship between visit rates and the average visit cost for each concentric zone, based on travel time to either Wakehurst or Kew. This model was developed for Christmas at Kew, Glow Wild and Summer Cycle.

The visit cost variable was developed using the same approach as described above based on Google Maps Distance Matrix API calculations for each UK outward postcode. The outward postcodes were grouped into concentric travel time bands, for example 30-45 minutes and 46-60 minutes. The relationship between the visit rate per 1,000 population and average visit cost is used to identify the demand curve.[130,131] The relationship between the total cost of a visit and the visit rate per 1,000 of population is non-linear, with rates dropping very rapidly at short distances from Kew Gardens or Wakehurst and then falling more slowly at greater distances as seen in Fig. 6. Taking the log of visit rate and travel costs produces a linear relationship. We therefore regress the log of the visit rate upon the log of visit costs using OLS, as per equation 2 below where VR_i denotes visit rate.

(2) $$\ln(VR_i) = \alpha + \beta_1 \ln(TC_i) + \varepsilon_i$$

The R-squared values for the regressions for Christmas at Kew, Glow Wild and Summer Cycle were 0.96, 0.84 and 0.97 indicating a good fit of the data. Using the coefficients of the regression analysis, we were able to simulate visitor numbers at a variety of new entry fees to trace the full demand curve (Fig. 7 gives an example for Christmas at Kew), giving the consumer surplus as the area under the demand curve. Average consumer surplus per visit for UK visitors to Christmas at Kew is estimated to be £17.34, for Glow Wild the equivalent figure is £6.55 while for Summer Cycle it is £5.81.

[129] Jeffrey E. Englin et al., "Estimating Forest Recreation Demand Using Count Data Models", Forests in a Market Economy, 2003, accessed August 2023

[130] Visit rate per thousand population is calculated by dividing the number of visitors in each travel time band (sourced from ticket sales data) by estimates of the UK adult population within each travel time band. These population estimates are derived by summing the population in the relevant outward postal codes for each travel time band.

[131] Nomis was used for data on resident population by postcode in 2021. 2021 population data by postcode were multiplied by national population growth for 2021-2022 from Oxford Economics databank to estimate 2022 population by postcode. Nomis, , "Postcode resident and household estimates, England and Wales: Census 2021", accessed September 2023.

APPENDIX 2: NON-USE SURVEY

This appendix provides the result of several consistency and robustness checks that were used to eliminate unreliable responses from our mean non-user value estimate. It also provides some insight into the reasons why non-users are willing or unwilling to donate to Kew, and what they value about Kew. Finally, we present the full survey that was fielded to respondents.

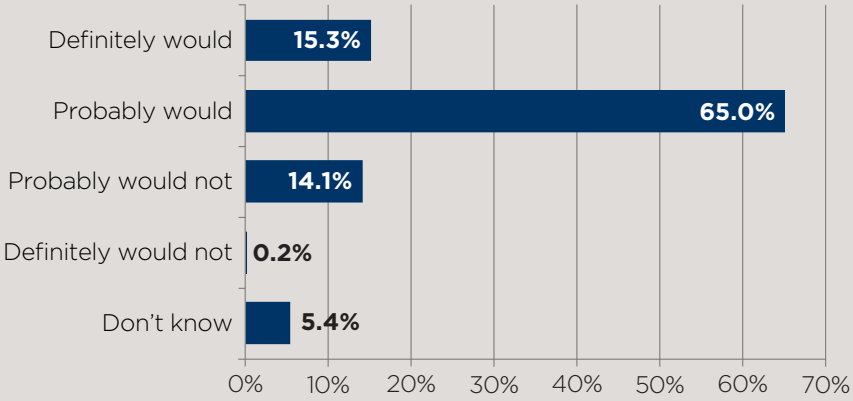
Certainty and consistency checks

As the payment in our survey is only hypothetical and does not occur in reality, we ask respondents how certain they were that they would pay the stated amount in reality. Only 0.2% of non-users who are willing to pay a positive amount "definitely would not pay" the selected amount. Over 80% of willing-to-pay non-users would either "definitely" or "probably" pay the amount they had stated. Only values from respondents selecting they would "definitely" or "probably" pay the stated amount are considered in the mean willingness-to-pay values.

In an additional check we investigate consistency by simply asking respondents how much they value Kew. Just under 40% of non-users stated they value Kew "a great deal" or "a fair amount", with 17% not valuing Kew "at all". Respondents selecting they value Kew "a great deal" or "a fair amount" were excluded from the mean willingness-to-pay estimates if they stated they were not willing to pay. Respondents who selected they did not value Kew "at all" or "don't know" were excluded if they stated they were willing to pay a positive amount.

Fig. 18: Certainty around paying stated amounts in reality

Weighted percentage of non-users willing to pay a positive amount, in response to being asked whether they would pay amount in reality

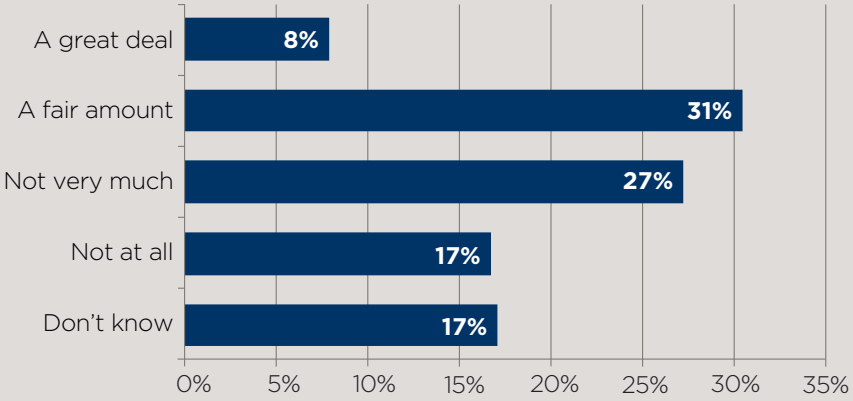


Source: Oxford Economics analysis of survey data fielded by YouGov.

Note: Sample is 475 respondents. Responses are weighted to be representative of the population. Responses are the result of an experimental design which describes Kew and its activities to respondents before the question is asked.

Fig. 19: Extent to which non-users value Kew

Weighted percentage of non-users, in response to being asked to what extent they value Kew



Source: Oxford Economics analysis of survey data fielded by YouGov.

Note: Sample is 1,336 respondents. Responses are weighted to be representative of the population. Responses are the result of an experimental design which describes Kew and its activities to respondents before the question is asked.

Motivations for being willing (and unwilling) to donate to Kew

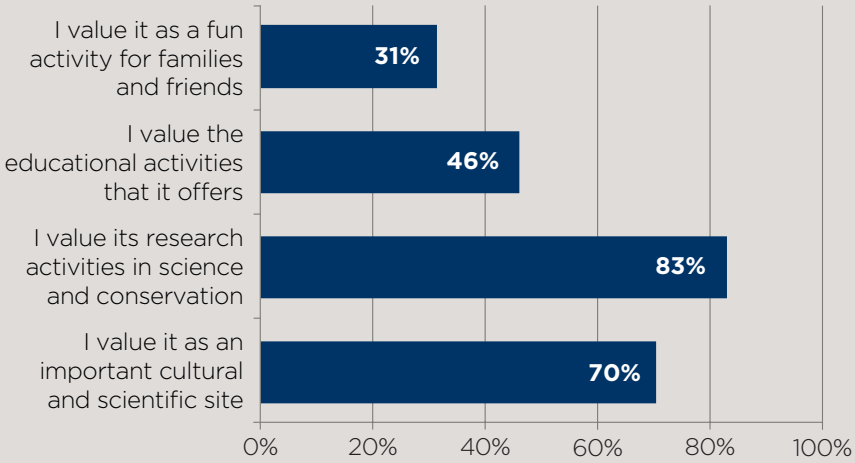
Respondents who are willing to donate to Kew are asked to state what features and activities of Kew they value. Over 80% of willing-to-pay non-users stated they valued Kew for its research activities in science and conservation. Interestingly, Kew's educational activities and its scientific research received higher levels of agreement than Kew's recreational use ("fun activity for family and friends").

Non-users may value Kew simply because it exists, or to preserve for themselves or others the option to visit in the future. A second motivation question tries to identify which element of value drives our estimates the most.

Fig. 21 provides evidence as to which components of non-use and option value are likely to be most important. We present average agreement levels among non-users who are willing to donate against various statements intended to capture elements of non-use and option value. Keeping the option of visiting Kew in the future motivates non-users' valuation the least, while preserving Kew for future generations, simply because it exists, and for other people to enjoy it in the present equally motivate non-users' valuations.

Fig. 20: Features of Kew valued by non-users

Weighted percentage of non-users answering "yes"



Source: Oxford Economics analysis of survey data fielded by YouGov.

Note: Sample is 418 respondents. Responses are weighted to be representative of the population. Responses are the result of an experimental design which describes Kew and its activities to respondents before the question is asked. Respondents who are not willing or don't know if they are willing to donate to RBG Kew, or state that they do not value RBG Kew "at all", are not asked the question.

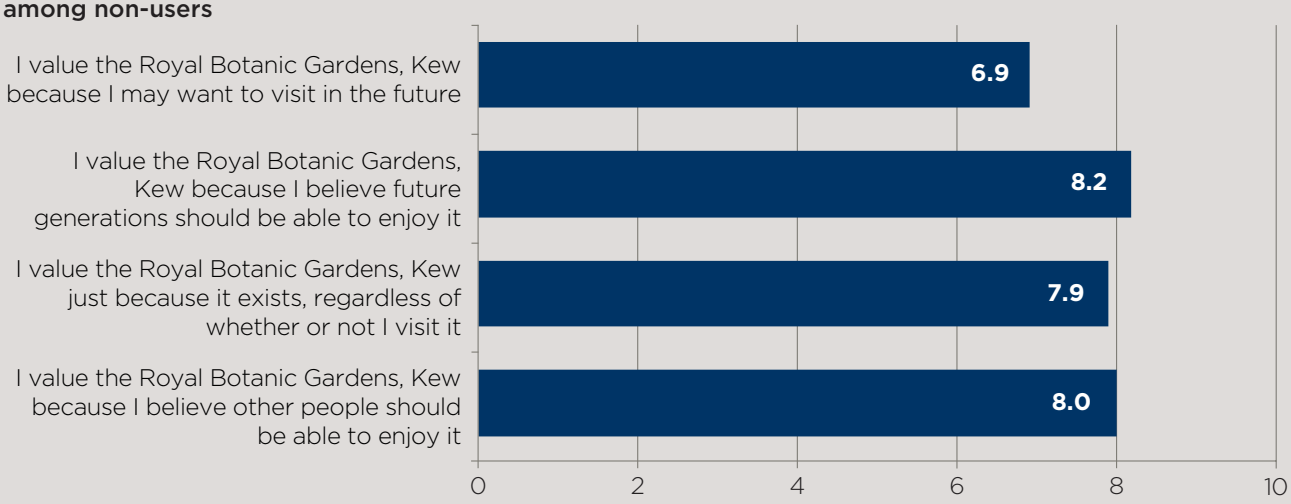
Fig. 22 provides agreement levels of non-users who are not willing to donate to Kew, for a number of motivation options given. The reasons respondents mostly relate to are: considering it unlikely that respondents will ever visit Kew or use its resources; the inability to afford to donate; and prioritising more urgent issues.

Survey completion time

On average, respondents took 26 minutes to complete the survey, with 90% of the sample completing the questionnaire in 10 minutes or longer.

Fig. 21: Motivations for valuing Kew

Level of agreement on a scale of 0 to 10, where 0 is "strongly disagree" and 10 is "strongly agree", among non-users

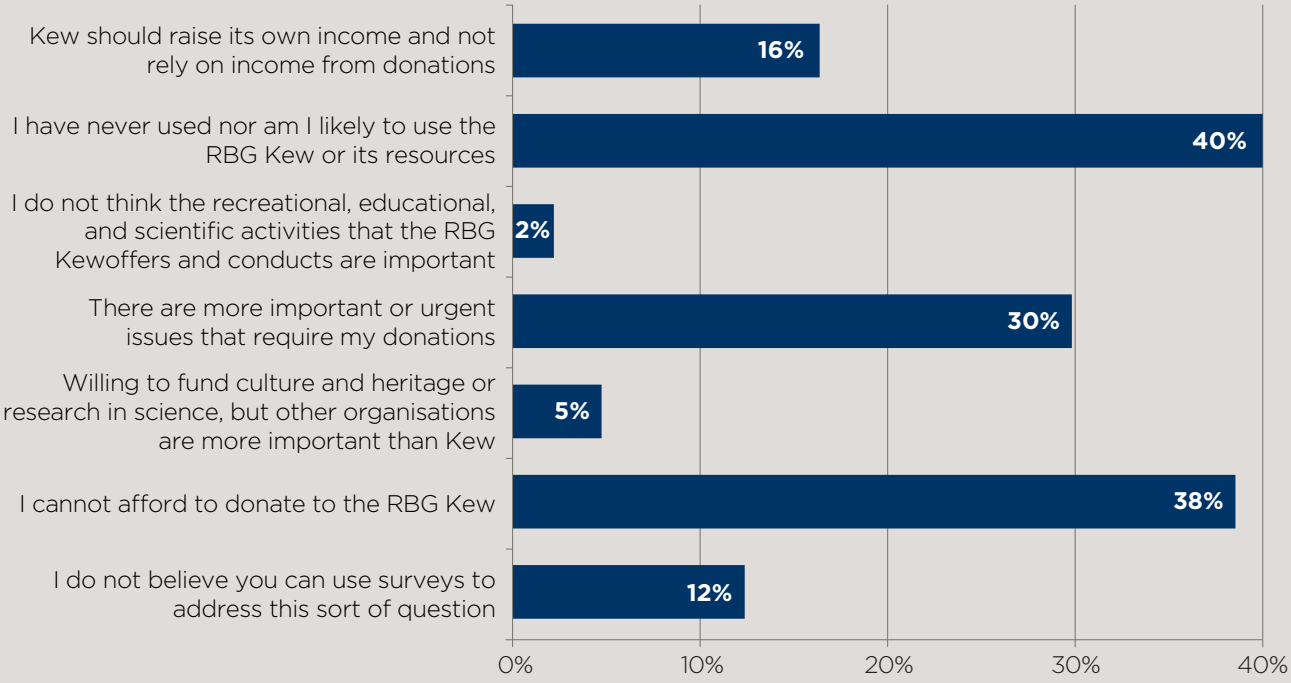


Source: Oxford Economics analysis of survey data fielded by YouGov.

Note: Sample is 418 respondents. Responses are weighted to be representative of the population. Responses are the result of an experimental design which describes Kew and its activities to respondents before the question is asked. Respondents who are not willing or don't know if they are willing to donate to RBG Kew, or state that they do not value RBG Kew "at all", are not asked the question.

Fig. 22: Reasons why non-users are not willing to donate to Kew

Weighted percentage of non-users answering "yes", among respondents willing to donate to RBG Kew



Source: Oxford Economics analysis of survey data fielded by YouGov.

Note: Sample is 861 respondents. Responses are weighted to be representative of the population. Responses are the result of an experimental design which describes Kew and its activities to respondents before the question is asked.

Non-use survey questionnaire

The Royal Botanic Gardens, Kew is undertaking work with Oxford Economics to assess the importance of Kew to UK society and its economy. We are therefore seeking to understand how members of the public view Kew.

1) *What comes to mind when you think about the Royal Botanic Gardens, Kew? [Open text box provided]*

2) *When thinking about the Royal Botanic Gardens, Kew, which of the following best applies to you prior to taking this survey?*

I have visited the Royal Botanic Gardens, Kew in the last two years
I have visited the Royal Botanic Gardens, Kew in the past, but not in the last two years
I was aware of the Royal Botanic Gardens, Kew but I have never visited
I was not aware of the Royal Botanic Gardens, Kew before taking this survey

3) *[Show if Q2=1/2/3] And again thinking about the Royal Botanic Gardens, Kew, which of the following have you ever done? Select all that apply.*

[randomise 1 to 3, anchor 4 and 5]

I am a member of or have donated to the Royal Botanic Gardens, Kew
I have used the Royal Botanic Gardens, Kew website
I have participated in outreach activities of the Royal Botanic Gardens, Kew, such as the Grow Wild programme
None of the above
Don't know

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;*
- *a science research centre that aims to understand the properties and potential of plants and fungi;*
- *one of the largest and most diverse global collections of dried, pressed plant specimens, and the largest fungarium in the world;*
- *two botanic gardens attracting over two million visitors in 2022-23: one at Kew Gardens in Southwest London, a UNESCO World Heritage Site; and one in Wakehurst, Kew's wild botanic garden in West Sussex. Both aim to provide knowledge, inspiration, and understanding of why plants and fungi matter;*
- *the Millennium Seed Bank, which is the world's largest wild plant DNA bank;*
- *unique and historic glass houses (such as the Palm House and the Temperate House) and buildings (such as the Great Pagoda), and a royal palace named 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, and Kew the Music.*

The following questions are designed to capture the value that you place on the Royal Botanic Gardens, Kew.

It is important to take your time and try to answer these questions as accurately and honestly as possible.

4) *In one way or another, most UK residents currently pay towards the annual upkeep and development of the Royal Botanic Gardens, Kew either through taxes, donations, entry fees, or other means.*

   However, imagine that the Royal Botanic Gardens, Kew had no other sources of government or private funding and had to heavily rely on individual donations.

   In such a situation, what is the maximum amount you would be willing to pay each year as a donation to maintain the Royal Botanic Gardens, Kew, including the recreational opportunities that it offers and the educational and research activities that it conducts?

   When answering this question, please think carefully about how much you value the Royal Botanic Gardens, Kew, and how much you can afford given your everyday living costs.

   - *I would not be willing to support the Royal Botanic Gardens, Kew through an annual donation*
   - *£0.25 per year*
   - *£0.50 per year*
   - *£0.75 per year*
   - *£1 per year*
   - *£1.25 per year*
   - *£1.50 per year*
   - *£2 per year*
   - *£2.50 per year*
   - *£3 per year*
   - *£5 per year*
   - *£10 per year*
   - *£15 per year*
   - *£20 per year*
   - *Other amount [box provided where respondent can input a different value]*
   - *Don't know*

5) *If asked, do you think you would or would not pay [amount selected in Q4] per year to support the Royal Botanic Garden, Kew.*

Definitely would
Probably would
Probably would not
Definitely would not
Don't know

6) *To what extent, if at all, would you say you value the Royal Botanic Garden, Kew?*

A great deal
A fair amount
Not very much
Not at all
Don't know

7) *[show if Q6 is different to "not at all" AND Q4 is different to zero or "don't know"] You said you value the Royal Botanic Gardens, Kew. Which of the following best describes why that is? Please select all that apply.*

   [randomise 1 to 4, anchor 5 and 6]

I value it as a fun activity for families and friends
I value the educational activities that it offers
I value its research activities in science and conservation
I value it as an important cultural and scientific site
Other [open text box provided]
Don't know

8) *[show if Q4 is "not willing to pay" OR Q6 is "not at all"] What are the reasons for which you are not willing to support the Royal Botanic Gardens, Kew through an annual donation? Please select all that apply.*

[randomise 1 to 8, anchor 9]

Kew should raise its own income and not rely on income from donations
I have never used nor am I likely to use the Royal Botanic Gardens, Kew or its resources
I do not think the recreational, educational, and scientific activities that the Royal Botanic Gardens, Kew offers and conducts are important
There are more important or urgent issues that require my donations
I am willing to fund culture and heritage or research in science, but I think other organisations are more important than Kew
I cannot afford to donate to the Royal Botanic Gardens, Kew
I do not believe you can use surveys to address this sort of question
Other (please specify) [provide box]
Don't know

9) *[show if Q6 is different to "not at all" AND Q4 is different to zero or "don't know"] Please rate your agreement with the following statements on a scale of 0-10 where 0 = "Strongly disagree" and 10 = "Strongly agree".*

[randomise]

I value the Royal Botanic Gardens, Kew because I believe other people should be able to enjoy it
I value the Royal Botanic Gardens, Kew just because exists, regardless of whether or not I visit it
I value the Royal Botanic Gardens, Kew because I believe future generations should be able to enjoy it
I value the Royal Botanic Gardens, Kew because I may want to visit in the future

APPENDIX 3: VALUING KEW'S EDUCATIONAL PROGRAMMES

This appendix provides a technical overview of our approach to valuing Kew's educational programmes.

WAGE PREMIA SELECTED FROM THE LITERATURE

Several recent studies have estimated the wage uplift, in percentage terms, of reaching a given level of education in the UK.

The estimates that we use in this report are produced in studies that, compared to older studies, take further steps to isolate the impact of additional education on future earnings by holding constant other factors that are correlated with remaining in education and that also affect future wages (such as students' ability).

The returns to obtaining a qualification can vary throughout someone's working life. They can be lower at the start of a career as employers trade off greater experience among less qualified staff and higher education in more qualified employees. For this reason, we mostly rely on studies that estimate the uplift to lifetime earnings, rather than the uplift at any specific age.

Returns to an additional year of schooling

For the impact of an additional year of schooling we rely on a paper by Franz Buscha and Matt Dickson who estimate that an additional year of education is associated with higher lifetime earnings of 7%.[132] We apply this estimate to value school visits to Kew, under the assumption that a day spent at school contributes one out of the number of days in an academic year towards completing an additional year of education.

Returns to an undergraduate degree

For the returns to an undergraduate degree, we use an estimate produced in a report published by the Department for Education and the Institute for Fiscal Studies.[133] The study estimates that an undergraduate degree leads to a gain in lifetime earnings of 20%. We apply this estimate to value several of Kew's courses.[134]

Returns to a Level 2 apprenticeship

To value the wage uplift associated with completing Kew's apprenticeship, we use an estimate of the wage premium associated with obtaining a Level 2 apprenticeship published by the Department for Education in 2021, of 12%.[135,136]

Returns to a master's degree and PhD

The evidence of the impact on future wages of getting a master's degree or a PhD using UK data is inconclusive. A study published in 2011 for the Department for Business Innovation and Skills by Conlon and Patrignani from London Economics found returns of 10% and 17% respectively, compared to having an undergraduate degree as highest qualification.[137] However, a more recent study published by the Department for Education and the Institute for Fiscal Studies[138] found no returns to a Master's degree[139] and slightly negative returns to a PhD.[140,141] Because of this mixed evidence, we take an average across the two sources—5% for a Master's degree and 8% for a PhD—as estimates of the lifetime uplift to wages for completing a Master's and a PhD compared to finishing studies at undergraduate level. We use these estimates to value Kew's master's courses, the short university visits by graduate students, externally funded graduate students, continuous professional development courses, teacher training, and supervision of PhD students.

[132] Franz Buscha and Matt Dickson, "The Wage Returns to Education over the Life-Cycle: Heterogeneity and the Role of Experience", 2015.
[133] Jack Britton et al, "The impact of undergraduate degrees on lifetime earnings", 2018.
[134] Horticulture diploma, all internships, short university visits by undergraduates, and externally funded undergraduate students.
[135] Department for Education, "Measuring the Net Present Value of Further Education in England 2018/19", 2021.
[136] This estimate is based on observing wages three to five years after completion of the apprenticeship. We assume that this value coincides with the average uplift over a full career.
[137] Gavan Conlon and Pietro Patrignani, "The Returns to Higher Education Qualifications", 2011.
[138] Jack Britton et al, "The earnings returns to postgraduate degrees in the UK", 2020.
[139] More specifically, 2% for women and -2% for men, which we average to 0%.
[140] 8% for women and -9% for men, which we average to -0.5%.
[141] One caveat of this study is that it only estimates returns to a master's and PhD observed during people's thirties. We make the simplifying assumption that the same earnings differentials would be observed over a lifetime.

ESTIMATION OF LIFETIME EARNINGS

Data

We obtain average annual gross wages earned at every age between 21 and 64 in the UK by people qualified at GCSE level, A-level, and degree level as their highest qualification. The latest release of such data is the Office of National Statistics' (ONS) "Graduates in UK Labour Market: 2017" release.[142]

Method

For each course we make an assumption about the year when students will enter the workforce based on information or assumptions about their average age while on the course. For example, we assume that individuals studying for Kew's Horticulture Diploma were on average 25 years of age in 2022, and, as the course lasts three years, we assume they will enter the workforce at age 28 in 2025. We then assume that in the year of entry into the workforce, their counterfactual earnings (what they would likely earn if they do not complete the course) is the figure at the same age provided by the ONS data at the level of qualification below the level they are studying for (following the example above, we assume that students in the horticulture diploma course would have earned the average wage for people qualified at A-level).

Adjustments

As the figures from the ONS are in 2016 salary terms, we adjust them to be in 2022 salary terms using nominal growth in gross earnings between 2016 and 2022—this gives gross wages in each future year in 2022 salary terms. We then grow this series using our in-house real growth rate forecast for the UK, giving gross wages in each future year in the salary terms of that year.

The final adjustment is to discount all adjusted wages earned beyond 2022 to 2022 prices, reflecting a preference for receiving money immediately rather than in the future, holding the amount constant. We use the discount rates published by HM Treasury.[143] Applying discount factors to future wage streams provides the "net present values" of the equivalent future sums.

These adjustments provide us with the value in 2022 and in 2022 salary terms, for each level of qualification and for every age, of gross wages earned in the future. By summing these values from the assumed age of entry into the workforce to retirement age (assumed to be 67) we obtain the net present value in 2022 of lifetime gross earnings that a person qualified at a given level will earn.

APPLICATION OF WAGE PREMIUM TO LIFETIME EARNINGS

We calculate the net present value of lifetime earnings for the level of education below the level students are studying towards on the course at Kew, and we assume they would earn this amount if they did not complete the course. To this amount we apply the wage premia percentages selected from the literature to represent the wage uplift earned from completing the course.

If a course is delivered only partly at or by Kew, we apply to the net present value of lifetime earnings only the fraction of the wage premia attributable to Kew. For instance, according to Kew about 80% of the one-year MSc in Plant and Fungal Taxonomy, Diversity, and Conservation is delivered by Kew. We therefore only attribute 80% of the wage uplift associated with completing a master's to Kew.

Similarly, for courses delivered over a longer period than one year we only apply the fraction of the wage premium uplift that can be attributable to their studies in 2022. For example, the diploma in horticulture lasts three years, and so we only apply a third of the associated wage premium to the associated net present value of counterfactual lifetime earnings.

[142] ONS, "Graduates in the UK Labour Market: 2017", 2017.
[143] HM Treasury, "Intergenerational wealth transfers and social discounting: supplementary Green Book guidance", 2008.

VALUING SCHOOL VISITS

To value school visits, we use the fact that students spend one out of an assumed 190 days in a school year at Kew. We then apply the 7% estimate of the returns to an additional year of schooling to lifetime earnings associated with having GCSEs as highest level of education.

Example (valuing the returns to completing Kew's Horticulture Diploma)

- According to the ONS, a 28-year-old whose highest qualification was A-levels in 2016 earned on average £19,431 in annual gross wages.
- ONS data suggest that gross earnings in the UK grew by 22% between 2016 and 2022 in nominal terms. That means that the average person aged 28 qualified at A-level earned an estimated £23,641 in 2022.
- Growing this figure by an estimate of UK real wage growth, we estimate that the average person aged 28 qualified at A-level will earn £24,020 in 2025, in 2022 salary terms.
- The students enrolled in Kew's Horticulture Diploma are assumed to be 25 years of age on average. The course lasts three years, so they are assumed to start working at age 28 in 2025, when they will earn £24,020 in real gross wages (in 2022 salary terms).
- According to HM Treasury Green Book discount rates, it is equivalent to receive £24,020 in 2025 or 90.19% of that sum in 2022. So the net present value in 2022 of £24,020 in 2025 is £21,664.
- We assume that the student will work until the age of 67—i.e., until 2063.
- Summing the net present values of gross wages earned in each year between 2025 and 2063 gives a lifetime earnings net present value in 2022 of £617,298.
- This is how much we assume the Horticulture Diploma student would earn in their lifetime if they didn't complete the Horticulture Diploma. We assume the Diploma generates similar returns to an undergraduate degree, which we assume will lift lifetime earnings by 20% compared to dropping out of education after A-levels. However, because the course lasts three years, we attribute a third of this premium to studies completed in 2022.
- Therefore, we estimate that by completing Kew's Horticulture Diploma, Kew supports the average student in earning an additional £41,153 over their lifetime compared to a scenario in which they had left education after school.

OXFORD ECONOMICS

Oxford Economics was founded in 1981 as a commercial venture with Oxford University's business college to provide economic forecasting and modelling to UK companies and financial institutions expanding abroad. Since then, we have become one of the world's foremost independent global advisory firms, providing reports, forecasts and analytical tools on more than 200 countries, 100 industries sectors, and 8,000 cities and regions. Our best-in-class global economic and industry models and analytical tools give us an unparalleled ability to forecast external market trends and assess their economic, social and business impact.

Headquartered in Oxford, England, with regional centres in New York, London, Frankfurt, and Singapore, Oxford Economics has offices across the globe in Belfast, Boston, Cape Town, Chicago, Dubai, Dublin, Hong Kong, Los Angeles, Mexico City, Milan, Paris, Philadelphia, Stockholm, Sydney, Tokyo, and Toronto. We employ 600 staff, including more than 350 professional economists, industry experts, and business editors—one of the largest teams of macroeconomists and thought leadership specialists. Our global team is highly skilled in a full range of research techniques and thought leadership capabilities from econometric modelling, scenario framing, and economic impact analysis to market surveys, case studies, expert panels, and web analytics.

Oxford Economics is a key adviser to corporate, financial and government decision-makers and thought leaders. Our worldwide client base now comprises over 2,500 international organisations, including leading multinational companies and financial institutions; key government bodies and trade associations; and top universities, consultancies, and think tanks.

December 2023

The modelling and results presented here are based on information provided by third parties, upon which Oxford Economics has relied in producing its report and forecasts in good faith. Any subsequent revision or update of those data will affect the assessments and projections shown.

To discuss the report further please contact:

Christopher Warner: cwarner@oxfordeconomics.com

Oxford Economics
4 Millbank,
London
SW1P 3JA, UK

Tel: +44 (0) 203 910 8000

OXFORD
ECONOMICS

Global headquarters
Oxford Economics Ltd
Abbey House
121 St Aldates
Oxford, OX1 1HB
UK
Tel: +44 (0)1865 268900

London
4 Millbank
London, SW1P 3JA
UK
Tel: +44 (0)203 910 8000

Frankfurt
Marienstr. 15
60329 Frankfurt am Main
Germany
Tel: +49 69 96 758 658

New York
5 Hanover Square, 8th Floor
New York, NY 10004
USA
Tel: +1 (646) 786 1879

Singapore
6 Battery Road
#38-05
Singapore 049909
Tel: +65 6850 0110

Europe, Middle East and Africa

Oxford
London
Belfast
Dublin
Frankfurt
Paris
Milan
Stockholm
Cape Town
Dubai

Americas

New York
Philadelphia
Boston
Chicago
Los Angeles
Toronto
Mexico City

Asia Pacific

Singapore
Hong Kong
Tokyo
Sydney

Email:
mailbox@oxfordeconomics.com

Website:
www.oxfordeconomics.com

Further contact details:
www.oxfordeconomics.com/about-us/worldwide-offices