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Access Economics



A walk through the gardens

An economic, social and cultural contribution
of the Royal Botanic Gardens & Domain Trust

July 2018

Limitation of our work

General use restriction

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Executive summary

Many NSW residents and tourists have visited and enjoyed the Royal Botanic Gardens and Domain Trust (RBGDT) facilities on one or more occasions in their lives. Many more indirectly benefit from the RBGDT's scientific research or appreciate the breadth of cultural and historic value generated by the RBGDT over the course of its 200 year existence. The Royal Botanic Garden Sydney provides universally accessible green space in the heart of Sydney's CBD and is part of a broader ecosystem of internationally recognised landmarks of cultural and historical significance.

This report assesses the economic, social and cultural, and scientific contribution of the RBGDT. This includes the direct and indirect financial and employment value the RBGDT adds to the NSW economy, as well as its use value and non-use value to residents of NSW. This assessment includes the following three sites under the management of the RBGDT:

- Royal Botanic Garden Sydney and The Domain
- Australian Botanic Garden Mount Annan
- Blue Mountains Botanic Garden Mount Tomah.

The purpose of this report is to highlight the economic, social and cultural value of these vital green spaces and the scientific research rather than commodify the gardens themselves. This report is just one input that can assist decision making about funding and maintenance of the Botanic Gardens.

The three Botanic Gardens play an important role as a green space with an extensive living collection of plants in the Sydney CBD and greater Sydney. These spaces and living collection has been found to have beneficial effects on mental health and the amount of physical activity undertaken by regular visitors. **The three sites are part of a collection of significant icons in Sydney CBD such as the Sydney Opera House, Sydney Harbour Bridge and Greater Sydney attractions including the Blue Mountains.**

There are many varied reasons that Sydney residents and tourists enjoy visiting Botanic Gardens positioned across the Sydney landscape. The diverse reasons can be distilled into three broad categories that consist of:

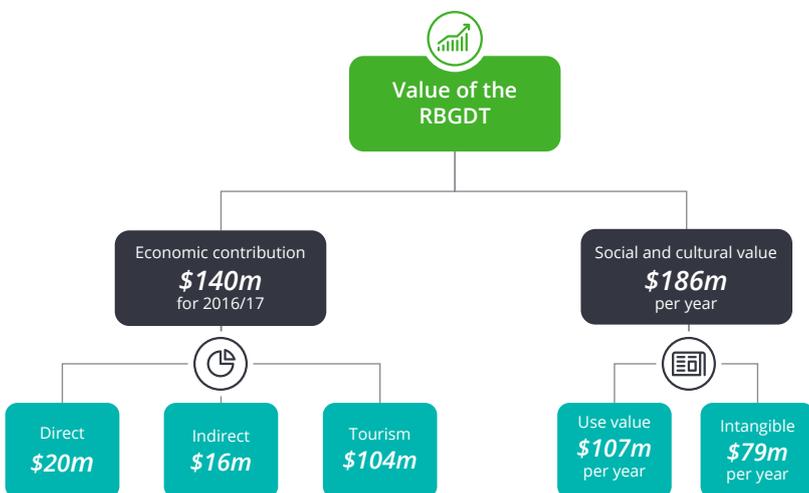
1. Exercise and recreation

2. Enjoy the green space and the living collection in the urban environment
3. Learn about the native environment and indigenous heritage.

Economic contribution

The economic contribution of the RBGDT consists of its direct contribution, indirect contribution, and tourism spend which totals **\$140 million for 2016-17 financial year** (see figure i).¹

Tourism is a key driver of the RBGDT's economic contribution. The Royal Botanic Gardens Sydney is one of the top ten most visited destinations in Australia for international visitors. There was a total of **5.8 million** (both domestic and international) recorded visits to the three Botanic Gardens in Sydney during 2016-17. As the Royal Botanic Garden Sydney forms part of a bundle of activities that tourists come to Sydney to enjoy, it can be assumed that a portion of the tourists visiting Sydney extended the length of their stay to visit the Botanic Garden. This extended stay and associated expenditure led to an estimated contribution of **\$104 million** to the NSW economy over the 2016-17 financial year. Figure i: Value of the RBGDT as at 2016/17²



Source: Deloitte Access Economics

¹ Modelling for the economic contribution was completed using financial data from the RBGDT in 2016-17 and tourism data in 2015-16 financial year as these were the most recent data available at the time of modelling.

² The value provided in the economic contribution and social and cultural value are not additive. This is because the economic contribution partially reflects the value visitors derive from the gardens. The social and cultural valuation provides a broader concept than economic contribution by measuring a population's willingness to pay. Whereas the economic contribution will only capture what has actually been paid, including via taxation, as opposed to the 'willingness to pay'.

The RBGDT makes an important economic contribution to the NSW economy. The RBGDT is estimated to contribute **\$19.6 million** a year in total direct value added to the NSW economy. 'Value added' measures the output (i.e. goods and services) generated by the entity's factors of production (i.e. labour and capital) as measured as the income to those factors of production. The sum of value added across all entities in the NSW economy equals gross state product.

The RBGDT also contributes indirectly to the NSW economy through the reach of its supply chains into others sectors. The indirect contribution is estimated to be over **\$16 million** in the 2016-17 financial year. Furthermore, **for every full-time equivalent (FTE) employed directly by the RBGDT, more than three additional FTEs are employed indirectly** such as those employed in the tourism sector.

The **scientific research and facilities** of the RBGDT also provides a significant economic contribution. While the effect of this research output cannot be comprehensively quantified it continues to contribute to improved land productivity and conservation efforts. Separate valuation of the RBGDT scientific facilities also provide an indication of their value to

the community. The Australian PlantBank owned by the RBGDT has over 10,500 seeds in its collection and a current replacement value of **\$50 million** for both the facility and the seeds themselves. The National Herbarium also contains well over **1.425 million species** samples with a replacement value of approximately **\$200 million**. Ecosystem restoration has received substantial investment by various State and Commonwealth Governments over the past 20 years. The Restore & Renew project has the potential to contribute to the evidence base in this field and thus optimise the value of these investments and the decisions in these areas.

The RBGDT's scientific research connects with the global scientific community as well. The National Seed Science Forum was held in 2016 at the Australian PlantBank and drew 200 leading seed scientists from across Australia and internationally.

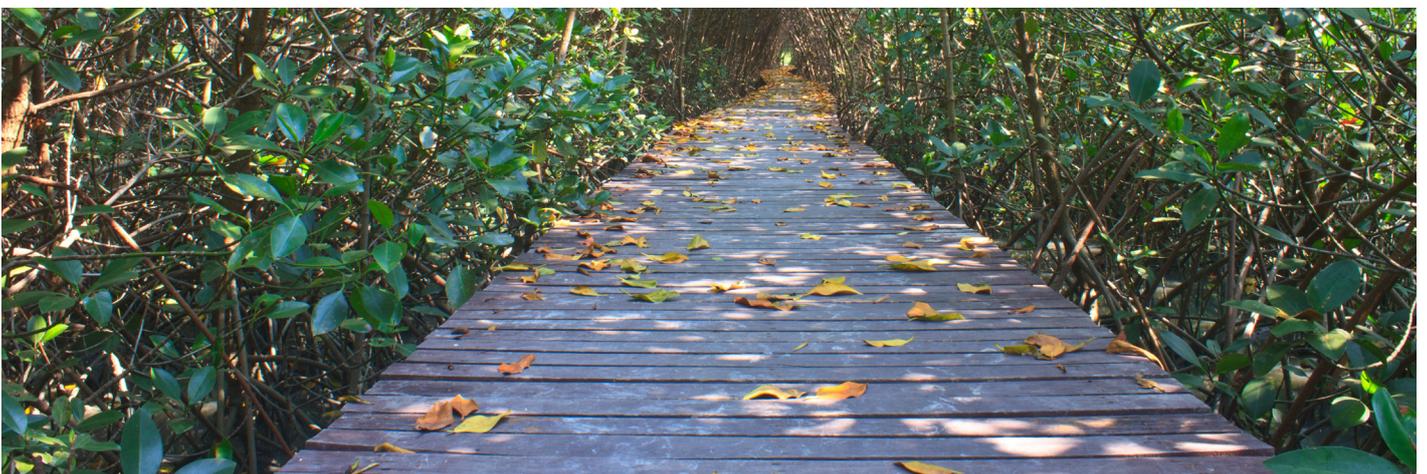
Social and cultural contribution

As a Sydney icon and tourist destination, RBGDT's value is much greater than its economic contribution. The total social and cultural asset value of the three Botanic Gardens under RBGDT management is estimated to be worth over **\$186 million per annum**.

The majority of this value is derived from those NSW residents and workers who visit the Botanic Gardens, who derive what is called 'use' value. This includes the value of undertaking activities in the RBGDT grounds such as: exercise, enjoying green space, seeing native flora and fauna, and attending educational programs or cultural events in the gardens. The use value of the RBGDT is estimated at **\$107 million per annum**.

There is also a broader value for NSW residents that have not recently visited the RBGDT facilities but value its existence or iconic status, termed the 'non-use' value. This has been estimated at over **\$79 million per annum**. This result is based on a previous survey asking non-users about the value they place on the botanic gardens in NSW.

It should be noted that the economic contribution and social and cultural contribution are **not additive**. This is because the estimates of social and cultural value do not net out the research grants or funding provided by governments. The social and cultural asset valuation is also broader than the economic contribution. The social and cultural asset value goes beyond financial resources to consider the value individuals place on the RBGDT facilities through measuring a



³ The travel-cost methodology is a revealed preference technique used to estimate the visitor use value of a non-traded good using information from related markets.

person's willingness to pay for the facilities. Accordingly, these estimates should be considered as gross benefit measures of the RBGDT's contribution to society.

Scientific research

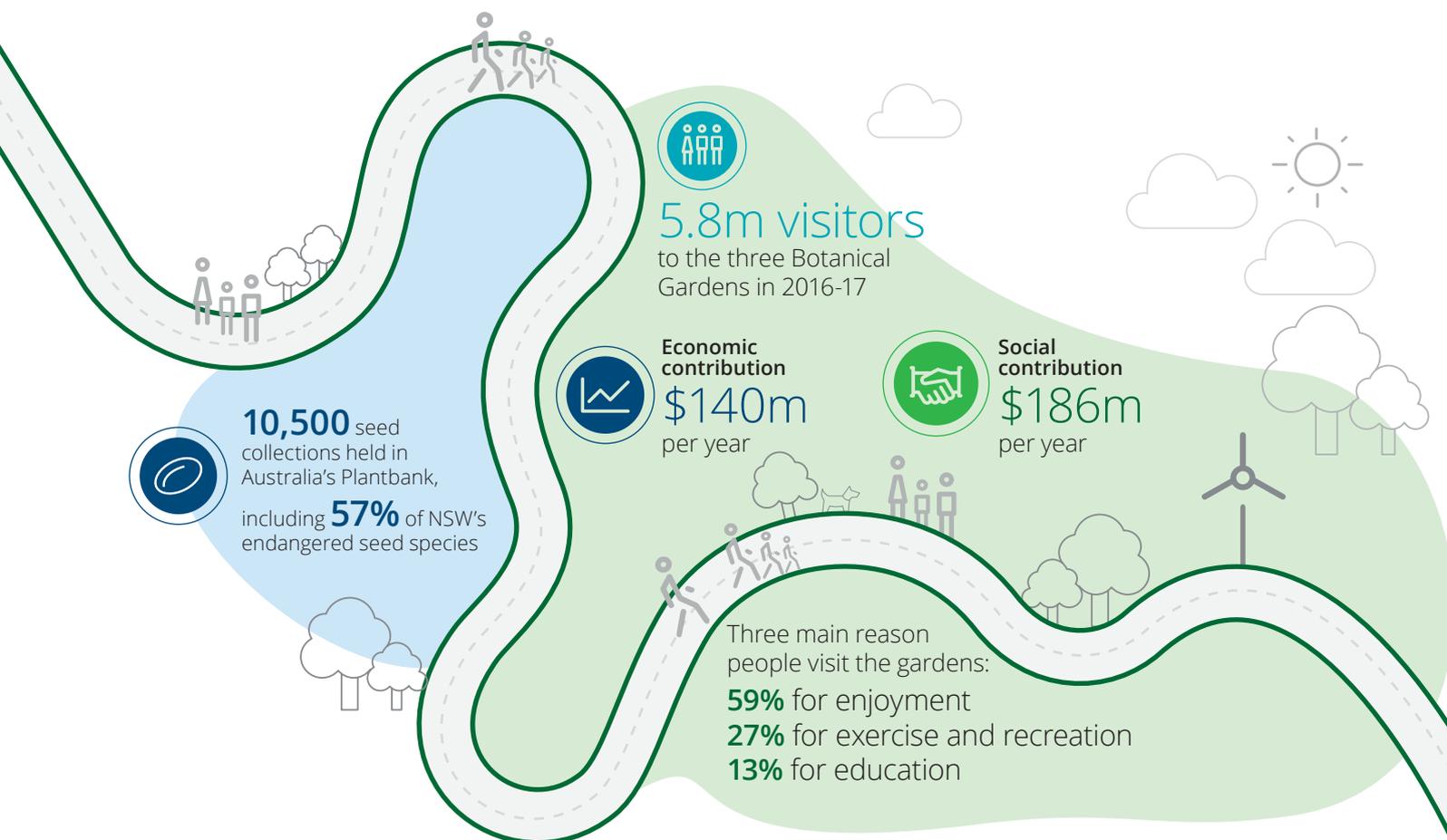
Scientific research and discovery contributes to the productive capacity of an economy which helps drive growth in living standards. The research focus for RBGDT focuses on Botanic and horticultural science – as well as conservation research and best practice land management techniques for Australian plants and fungi (Royal Botanic Garden Sydney 2017). Two programs that are explored in this report focus on developing new conservation practices to improve

ecological outcomes. The **Australian PlantBank** located in Sydney's South-West at the Australian Botanic Garden, Mount Annan stores about **57% of endangered NSW seeds species** through freezing and drying techniques. The entire collection and facilities have a current value of **\$50 million**. The PlantBank also conducts research to ensure other seeds not amenable to drying or freezing can be effectively stored as well.

The **Restore & Renew** program, managed by the RBGDT, is using new genomic sequencing technologies to identify local ecosystems in NSW that certain plant species would be suited to thrive in. This knowledge is already producing important

results relevant to our changing natural environment and is globally recognised as a leading edge methodology in this field. On the flipside, the program will assist the recovery of damaged ecosystems by recommending which plants would be best, considering the deteriorated conditions. Given the results of this report, it is clear that the services delivered by the RBGDT represent **a significant economic and social dividend to the state of NSW**.

Deloitte Access Economics



1. Introduction

Background

The Royal Botanic Gardens and Domain Trust (RBGDT) forms a key component of Sydney's urban environment. As Australia's oldest ongoing scientific institution, with a history spanning over 200 years, the economic contribution and cultural value of RBGDT for NSW is significant.

More than 5.8 million visits were made to the three sites under RBGDT management in the 2016-17 financial year. To manage the use of sites and the associated facilities located within, RBGDT was established under the *Royal Botanic Gardens and Domain Trust Act 1980*. Operationally, it has been integrated with the Centennial Park and Moore Park Trust to capture strategic

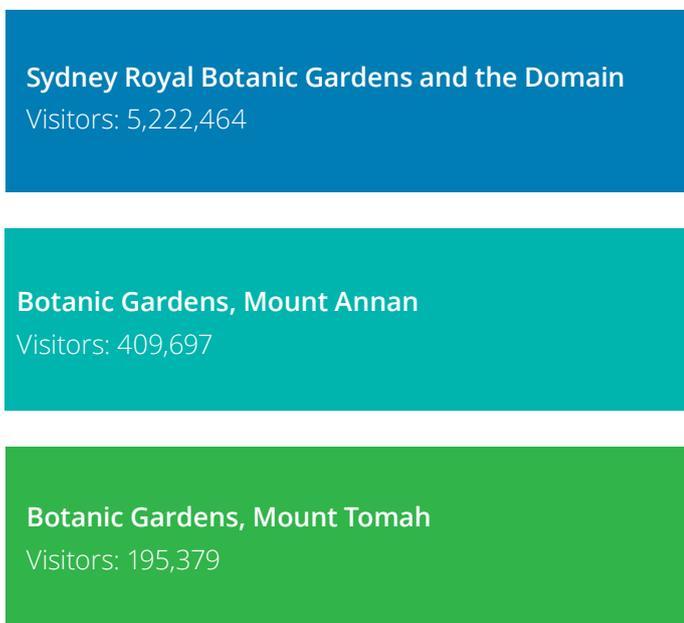
and operational benefits, with internal governance arrangements in place to accommodate the respective needs of each managing Trust.

To understand the total contribution of the RBGDT requires an understanding of what the RBGDT produces and the facilities embedded on its physical sites. The RBGDT is responsible for three Botanic Gardens around Greater Sydney which consists of the following sites:

- **Royal Botanic Garden, Sydney** covers 30 hectares in the heart of Sydney CBD and incorporates **The Domain**, the **National Herbarium of NSW** and the **Calyx** onsite

- **The Australian Botanic Garden, Mount Annan** covers 416 hectares between Camden and Campbelltown in Sydney's south-west, making it the largest Botanic Garden in Australia. The **Australian PlantBank** which houses the NSW Seedbank is also located on this site
- **Blue Mountains Botanic Garden, Mount Tomah** features 252 hectares of gardens with plants from around the world.

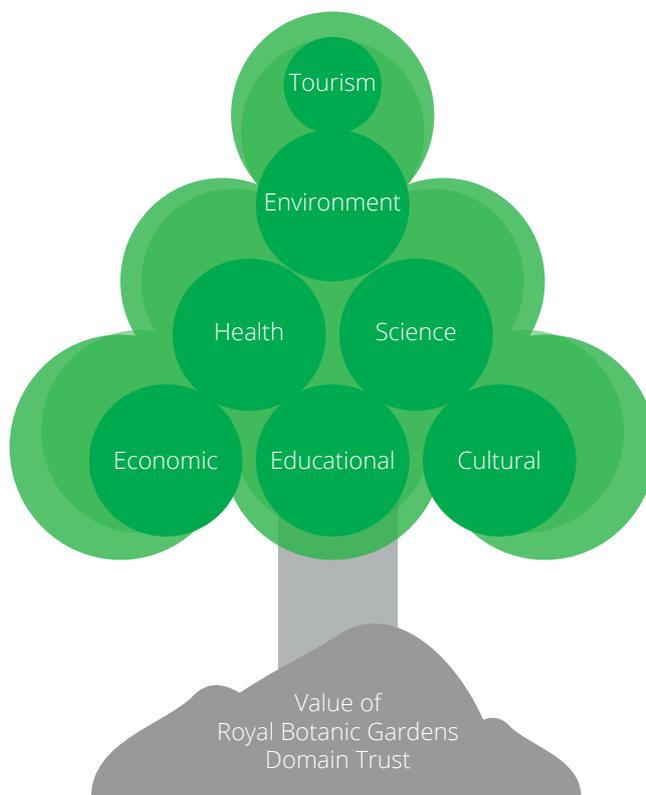
Figure 1.1: Location of the three sites under management of the RBGDT



Source: Deloitte Access Economics

The three Botanic Gardens and The Domain have been valued in financial terms at \$510.2 million. This includes the land, buildings, infrastructure and cultural collections⁴. What is not captured through this financial valuation is the key role the RBGDT plays in promoting and developing the cultural, historical and scientific attributes of the three Botanic Gardens and The Domain which shown in Figure 1.2 will be explored further in this report.

Figure 1.2: Contribution of the RBGDT



Source: Deloitte Access Economics

Economic contribution

The RBGDT makes a significant contribution to the NSW economy through its direct value added, which is a measurement of the output (i.e. goods and services) generated by the entity's factors of production (i.e. labour and capital) as measured by the income to those factors of production. The sum of value added across all entities in the economy equals gross domestic product.

RBGDT also contributes indirectly through the reach of its supply chains into others

sectors. The indirect contribution is estimated to be over **\$16 million** in the 2016-17 financial year.

Tourism

The three Botanic Gardens administered by the RBGDT play a vital role in Sydney's vibrant tourism ecosystem. With unique and aesthetic locations, the Botanic Gardens attract large numbers of tourists – local, domestic and international – to the Greater Sydney area. As a testament to its enduring appeal, NSW Tourism named the Royal Botanic Garden

Sydney a Gold Winner as the state's best major tourist attraction in 2017. The Royal Botanic Garden in Sydney's CBD overlook some of Australia's most iconic monuments, the Sydney Opera House, Sydney Harbour Bridge and Sydney Harbour foreshore. The proximity of the Royal Botanic Garden Sydney to these landmarks means they form part of the main tourist precinct in the city of Sydney and strengthen their collective appeal. The three Botanic Gardens also contribute to the assorted attractions in the Greater Sydney region, simply due to its sheer

⁴ This valuation does not include the PlantBank or the National Herbarium

size and diversity, as well as via key infrastructure, such as the Australian PlantBank. Similarly, the Botanic Garden in Mount Tomah add to the appeal of the Blue Mountains area by providing attractive natural settings and infrastructure for visitors to learn about the flora and fauna native to the region.

Health

The benefits of green space in urban environments is well documented (see Kendal et al. 2016). With over 730 hectares of open space within the three Botanic Gardens and The Domain, the health benefits of the space – both physical and psychological – are enjoyed by both residents and visitors to Sydney. For a densely populated city with 4.8 million people (ABS 2017) or 390 people per square kilometre this space alleviates the crowdedness and congestion common amongst major cities like Sydney.

Educational programs

Education programs for both primary and secondary school students are also provided at each of the three Botanic Gardens. One program at the Royal Botanic Garden Sydney called 'Aboriginal People and Plants' gives students an opportunity to identify a wide variety of local native plants. The students explore Aboriginal plants as well as their application to food, medicine, utensils and weapons.

Environment

In terms of the ecological role, the three Botanic Gardens and The Domain play a role in carbon storage. The collection of native and international flora in the Botanic Gardens includes approximately 64,000 trees with some rare species. The Botanic Gardens are also home to native fauna including birds, mammals (e.g. possums), spiders, reptiles, frogs, fish, crustaceans and insects.

Cultural events

The Royal Botanic Garden Sydney were founded by Governor Macquarie in 1816. The RBGDT hosted one of the first intercolonial cricket matches between NSW and Victoria, held in The Domain in 1857 (NSW State Library 2016). More recently, major events such as **Vivid** attracted over 390,000 people through the gates of the Sydney Botanic Gardens to enjoy a multitude of light displays spread throughout the Gardens.

Scientific

As the oldest scientific institution in Australia, the Botanic Gardens has established itself as the preeminent Botanic and horticultural research centre in Australia and internationally. Scientific research facilities include the National Herbarium, the Australian PlantBank and other research programs they are delivering important collaborative output with local and international partners. For example, the **Hollows as Homes Program** was launched in partnership with the Australian Museum and Sydney University last year.

RBGDT in an international context

There are Botanic Gardens and major parks in nearly every major city around the world with an estimated 2,500 registered Botanic Gardens (Shackleton 2010). Some examples of international Botanic Gardens around the world include:

- **Kew Royal Botanic Garden:** which has been valued at £190 million (\$331 million in inflation adjusted Australian dollars) total gross value to the UK economy in 2014/15 and has about 1.5 million visitors per year (Oxford Economics 2016). This includes the social and cultural contribution of the Botanic Gardens.

- **Edinburgh Botanic Garden:** has been estimated to have an economic contribution of £23 million per year in 2009 (\$45 million in inflation adjusted Australian dollars) with 600,000 visitors (DTZ 2009). This is a purely economic contribution rather than a broader social and cultural contribution.

These estimations were calculated using various methodologies creating difficulty in providing precise comparisons with figures derived for the RBGDT. The value placed on the Botanic Gardens by residents and visitors is a key to understanding the use and non-use values of the RBGDT.

Purpose of this report

All these various attributes – cultural, education, health, environment, scientific and tourism – overlay to form a broad view of the total contribution of the RBGDT.

The RBGDT has commissioned Deloitte Access Economics to conduct an economic contribution study and assess the social and cultural contribution of RBGDT and their associated facilities.

The report is structured as follows:

- **Chapter 2** assesses the direct and indirect economic contribution of the three Botanic Gardens, The Domain and associated facilities. It will also measure the tourism impacts of the RBGDT for the NSW economy
- **Chapter 3** explores the broader social and cultural contribution that RBGDT has on local residents and visitors to the four sites
- **Chapter 4** frames the scientific role that RBGDT plays in the broader scientific community and provides two case studies of scientific programs undertaken by the RBGDT researchers.

2. Economic contribution

An economic contribution study provides an estimation of the contribution of an entity to an economy at a given point in time.

The direct economic contribution of the RBGDT to the NSW economy is measured by its value added to the economy: the difference between that entity's operating revenue and the cost of its intermediate inputs. This value added is measured by summing the returns to capital (through Gross Operating Surplus or GOS) and returns to labour (wages).

In addition to this direct component, the demand for upstream inputs and further interlinkages with other sectors of the economy are modelled. Using Input-Output modelling it is possible to estimate the indirect value added by entities in the supply chain.

Methodology

The economic contribution of the RBGDT for the financial year 2016-17 is split into direct and indirect components for the NSW economy.

The **direct contribution** is the value added to the NSW economy by the RBGDT. By excluding the value of inputs (which are part of revenue) the direct contribution isolates the value specifically created by the RBGDT.

The returns to capital is determined using Gross Operating Surplus (GOS). This is the difference between operating revenue (total revenue excluding investment revenue and 'other' revenue) and operating expenses. The returns to labour is all personnel services expenses, which is largely wages and superannuation.

The RBGDT's **indirect contribution** creates value added in the economy through the purchase of intermediate goods, which stimulates demand for goods and services. The indirect contribution calculates the value add created by all the industries in

the RBGDT's supply chain. It is based on the profit and wages in NSW that are generated as a result of the RBGDT expenditure in these industries.

Further details about the methodology of economic contributions can be found in Appendix A.

Direct Contribution

Table 2.1 outlines the RBGDT direct economic contribution in 2016-17. That year the RBGDT generated a **direct economic contribution of \$19.6 million**. Of this, \$23.7 million accrued to labourers as wages and other employee benefits and -\$4.1 million accrued to owners of capital as GOS.

Low or negative GOS is not uncommon for not-for-profit institutions as, by their nature, they are not attempting to create profit over time. They generally match their expenditure to their revenue. It should be noted that GOS does not include the RBGDT's investment revenue of \$7.0 million or the depreciation cost of \$5.0 million.

Table 2.1: Direct economic contribution of the Royal Botanic Gardens, 2016-17

Direct Contribution	
GOS	-\$4.1m
Labour income	\$23.7m
Value added	\$19.6m
Employment (number of FTEs)	231

Source: Deloitte Access Economics, RBGDT

Indirect Contribution

Table 2.2: Indirect economic contribution of the Royal Botanic Gardens, 2016-17

Indirect Contribution	
GOS	\$6.1m
Labour income	\$10.3m
Value added	\$16.4m
Employment (number of FTEs)	135

Source: Deloitte Access Economics, RBGDT

Economic contribution of scientific research

Scientific research undertaken by the RBGDT plays an important economic role. Scientific research and discovery contributes to the productive capacity of an economy which helps drive growth in living standards.

For instance, analysis by Deloitte Access Economics estimates that the stock of technology and knowledge attributable to Australia's universities contributed approximately \$160 billion to GDP in 2014 (Deloitte Access Economics 2015). In the UK, research suggests that for every £1 (\$1.65 Australian dollars) spent by the government on R&D output rises by 20p (\$0.33 Australian dollars) per year in perpetuity by raising the knowledge base of society. In Australia, while the Productivity Commission's (2007) report on public science and innovation does not estimate the productivity benefits from research and development, it notes there is evidence the benefits are likely to exceed the costs.

The research undertaken by the RBGDT contributes to improving the productivity of conservation efforts and the use of natural resources. While difficult to measure quantitatively, this research is valuable for an economy. Research into the Kew Botanical Gardens in the UK quantified the value of its scientific research by considering the effects of productivity improvements in the private sector. This led to an estimated £3 million (\$5 million in Australian dollars) per year increase in economic output generated by Kew's scientific activities (Oxford Economics 2016).

Through the purchase of intermediate goods and services such as equipment, telecommunication services and books and publications, the RBGDT demand generates additional economic activity. The indirect contribution estimates the value added in the supply chain associated with this activity.

Table 2.2 shows the indirect contribution of RBGDT. In 2016-17, the RBGDT was associated with an **indirect value added of \$16.4 million**. This value added was divided up into \$6.1 million of GOS and \$10.3 million of labour income.

The relatively high portion of labour income reflects the high proportion of expenditure on professional, scientific and technical services (labour-intensive industries).

Tourism

The Royal Botanic Garden Sydney is one of the top 10 most visited destinations in Australia for international visitors. In addition, NSW Tourism named the Royal Botanic Garden Sydney a Gold Winner as the state's best major tourist attraction. As one of Sydney's premier attractions, it helps bring in tourism to the NSW economy.

The tourism contribution estimates the economic contribution of tourism facilitated by the RBGDT. It assumes that the RBGDT facilities, as part of a bundle of activities to do in Sydney, encourages visitors to spend more time than they otherwise would in NSW. The contribution estimates the value added from the spending of tourists during this additional time spent in NSW.

The Tourism Satellite Accounts (TSA) are used to estimate direct value added that comes from direct expenditure on goods and services by tourists (such as travel or dining) and the indirect value added associated with the inputs for these goods and services (such as petrol and food, respectively).

The tourism contribution only estimates the contribution of interstate and international visitors to the Gardens, as tourist spending by NSW residents is simply a redistribution of resources within the state.

Future of Sydney tourism and the RBG

The Royal Botanic Garden Sydney is part of a broader ecosystem of tourist attractions that draws visitors to Sydney. Sydney has a unique mixture of lifestyle, cultural and sporting attractions which the Gardens operate within.

The Royal Botanic Garden Sydney provide an important green space right on the harbour's edge with aesthetic views of the city skyline and out across the harbour. The Gardens align with DestinationNSW's vision of green space and are also conveniently located within walking distance from the iconic Sydney Opera House and Sydney Harbour Bridge.

With relatively higher population densities in most Asian cities, the Botanic Gardens offer natural physical beauty in the urban environment to the

increasing number of tourists visiting Sydney that originate from Asia.

More recently, events like Vivid have been able to utilise the prime location of the Gardens and its unique landscape to offer a new experience for visitors to Sydney. The event attracted over 390,000 people in 2017.

And the idea of "Sydney" is changing to incorporate more than the CBD. With continued growth in Western Sydney, the Mount Annan and Mount Tomah sites are going to become even more important tourist destinations for visitors to Sydney.

The PlantBank facilities in Mount Annan, with its educational programs on conservation and state-of-the-art research facilities, attracts curious

minds to the Gardens in Sydney's South West. Mount Tomah Botanic Garden offers a complementary natural beauty set amongst the heritage listed Blue Mountains.

Looking forward, the three sites will continue to play an important role in bringing tourism to Sydney. These green spaces will continue to offer a contrast to the urban and suburban surrounds.

Approach and sources

The RBGDT visitor data does not break down the visitors into demographics (e.g. international visitors or locals). However, the National Visitor Survey (NVS) and International Visitor Survey (IVS) does provide a breakdown of tourists who visited Botanic Gardens. This provides an estimate of international and interstate tourists who visited the Botanic Gardens in 2015-16.⁵ This was the most recent data available at the time of modelling. Consequently, the results do not reflect the growth in visitation to the RBGDT sites to total 5.8 million in 2016-17 financial year.

The NVS and IVS were then used to estimate the typical daily spending of such tourists by product type.

A Deloitte Access Economics (2015) study of the South Australian Botanic Garden was used to estimate the interstate tourist activity facilitated by the RBGDT. The survey of South Australian tourists found that the South Australian Garden were the main reason for travelling to the state for 7% of **interstate** tourists. It further found that the Gardens were a factor in extending their stay for 4% of interstate visitors. It was assumed that the RBGDT facilitates attract the same proportion of interstate tourist activity as the South Australian Botanic Garden.

A Deloitte Access Economics survey of **international** tourists found that 19% of tourists ranked the RBGDT as their most preferred attraction on a day in Sydney out of Darling Harbour, the Sydney Fish Market, Circular Quay, Chinatown, Darling Harbour, Sydney Opera House, Pitt St Mall, RBGDT or None. Based on this survey, it was assumed that 19% of international visitors to RBGDT extended their trip by one day due to the Gardens. It was further assumed that the remaining 81% of international visitors extend their trip in Sydney by half a day in order to visit the Garden.

The presence of the RBGDT encourages visitors to stay longer in NSW than they might otherwise have. When determining how long to stay in NSW – which is usually decided before arriving – it is assumed that visitors will look at the bundle of attractions on offer in the State of NSW. Having a host of attractions, such as such as the RBGDT, encourages visitors to plan longer trips. In this manner RBGDT has a marginal impact on visitors' length of stay. The assumption of half a day attributed to the RBGDT represents a proxy for the additional time (and its associated expenditure) spent in NSW due to visiting the Botanic Gardens.

Direct tourism contribution

Table 2.3 outlines the **direct contribution of tourist expenditure** facilitated by the RBGDT. Tourists helped facilitate roughly a **\$60 million** contribution to the NSW economy, associated with **491 FTEs**.

The majority of this contribution (\$49.9 million) came from international tourists, who are more likely to visit the Botanic Gardens than interstate visitors.

Table 2.3: Direct tourism contribution, 2015-16

	Domestic	International	Total
Value added	\$9.7 million	\$49.9 million	\$59.7 million
Employment (number of FTEs)	87	404	491

Source: Deloitte Access Economics, RBGDT

Table 2.4 shows the **indirect tourism contribution** facilitated by interstate and international visitors to the RBGDT. The product of inputs required for the goods and services that tourists purchased has a **value added of \$44 million**. This economic activity is further associated with **259 FTE jobs**.

Table 2.4: Indirect tourism contribution, 2015-16

	Domestic	International	Total
Value added (\$millions)	\$7.5m	\$36.6m	\$44.2m
Employment (number of FTEs)	44	215	259

Source: Deloitte Access Economics, RBGDT

This results in a **total contribution of \$104 million**, supporting roughly **750 FTE jobs**, as detailed in Table 2.5.

Table 2.5: Total tourism contribution, 2015-16

	Domestic	International	Total
Value added (\$millions)	\$17.3m	\$86.6m	\$103.9m
Employment (number of FTEs)	131	619	750

Source: Deloitte Access Economics, RBGDT

⁵ In a state-based tourism contribution study, expenditure from intra-state visitors is excluded since this expenditure is treated as a transfer.

Conclusion

The RBGDT contributes to the NSW economy in a number of ways (see Figure 2.1):

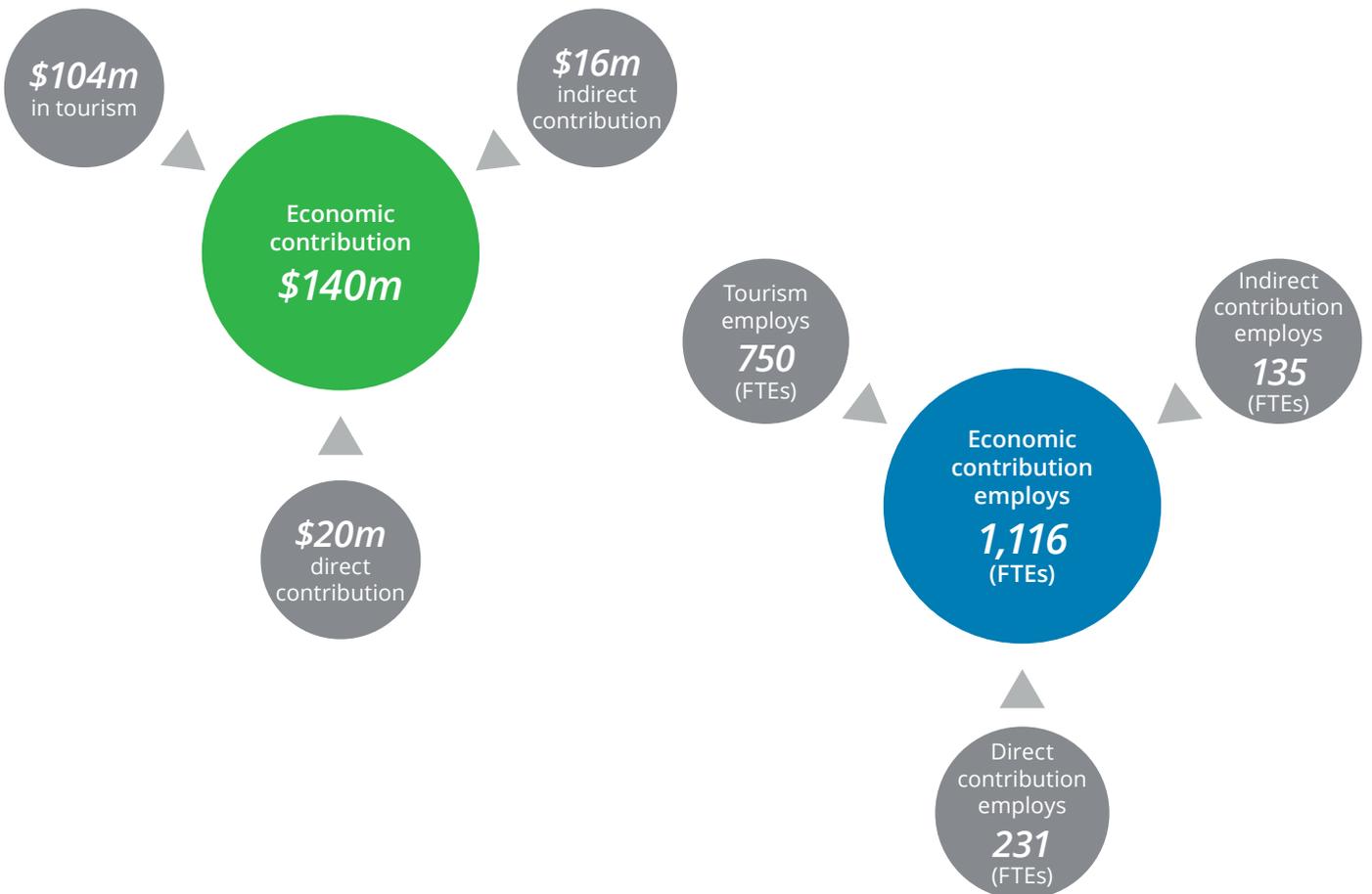
- Firstly, the value added it directly produces, \$19.6 million in 2016-17. The RBGDT also indirectly contributes through its purchases of its input goods

(for example scientific equipment) from suppliers. This indirect contribution is estimated to be \$16.4 million in the 2016-17 financial year.

- For every worker the RBGDT directly employs, there is another half a worker employed indirectly in the supply chain and three and a half in the tourist sector.

- The RBGDT's unique collection and beauty attracts many visitors to Sydney CBD and the greater Sydney area. The total contribution facilitated by tourism is estimated to be \$103.9 million in 2015-16. This contribution consists of \$59.7 million from direct tourist contribution and \$44.2 million from indirect tourism contribution.

Figure 2.1: Economic contribution of the RBGDT, annual



Source: Deloitte Access Economics

3. Social and cultural contribution

The three sites over which the RBGDT has stewardship make a significant social and cultural contribution to the residents of NSW. The social and cultural contribution can be split into the **visitor use value** and **non-use** values. This visitor use value is attributed to those who undertake activities within the three Botanic Gardens sites.⁶

The non-use value is attributed to those who do not directly use the three Botanic Gardens sites, and is composed of the existence value, altruist value and

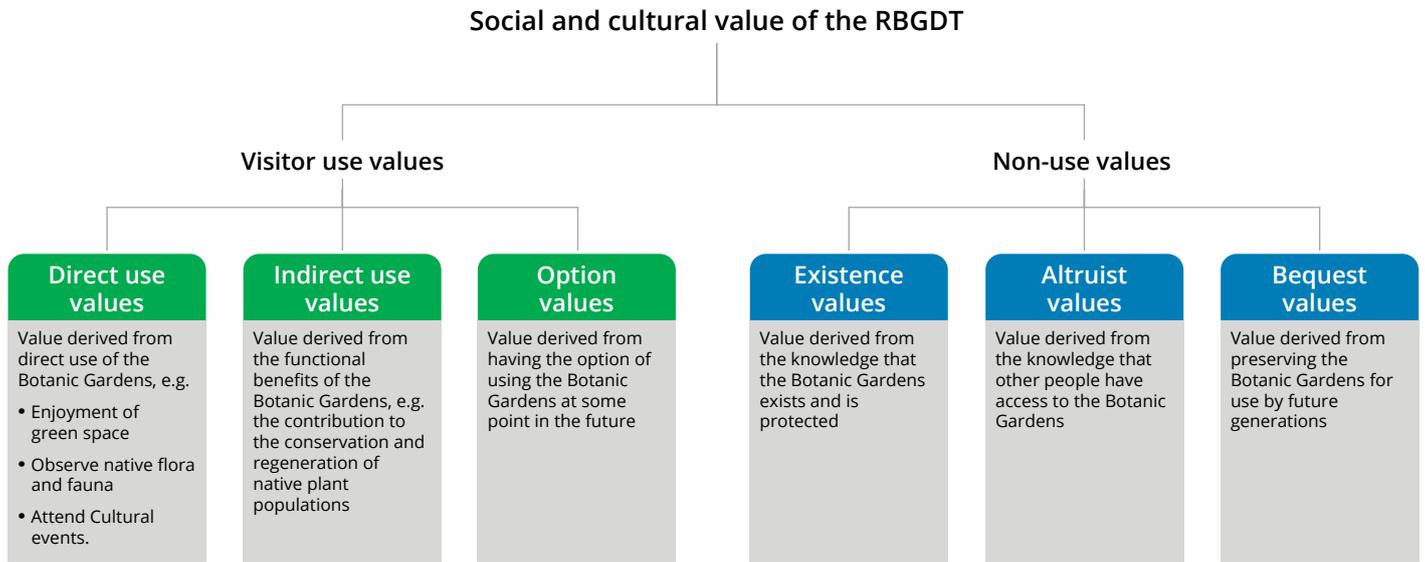
bequest value. Figure 3.1 illustrates these components of value for the residents of NSW.

As individuals are not required to make direct payments for use, access or for the existence of the three Botanic Gardens sites, the value that residents attribute to these facilities is not immediately observable from market transactions. Instead, non-market valuations techniques can be used to quantify the social and cultural contribution of the three Botanic Gardens sites for residents in monetary terms.

Drawing from the existing literature, this chapter provides evidence of the social and cultural contribution of the three Botanic Gardens sites for both users and non-users living in NSW.

It should also be recognised that alongside annual funding to RBGDT another cost to the community for the RBGDT is the setting aside of the significant land to deliver the services and benefits described in this report.

Figure 3.1 Components of values for individuals from the RBGDT's facilities



Source: Deloitte Access Economics, adapted from Kumar (2010)

Reasons why individuals value the three Botanic Gardens sites facilities

There was an estimated visitation of 5.8 million to the three Botanic Gardens sites in 2016-17, representing an 20% increase on the previous year.⁷ The value to the visitors and residents who visit the Royal Botanic Garden Sydney consists of many varied

sources ranging from recreational walks to attending events held in The Domain. In 2012, survey of 1,600 visitors to three Australian Botanic Gardens (Melbourne, Adelaide and Sydney) was undertaken to determine the main reason for visiting these types of gardens (Mwebaze and Bennett 2012). To better understand trends

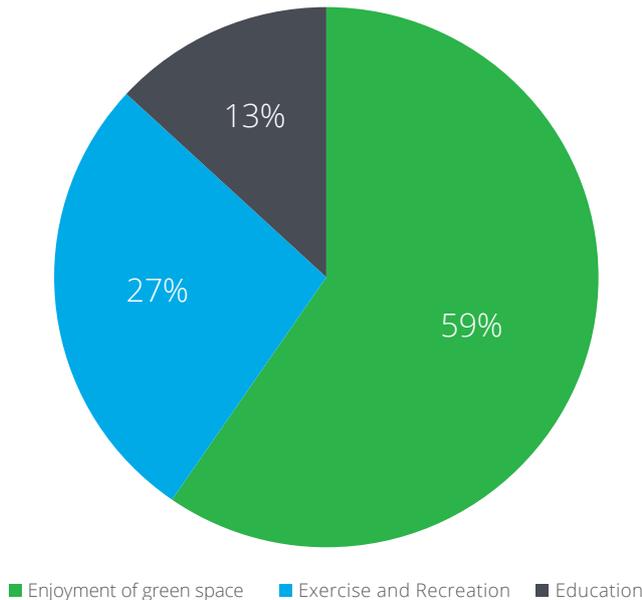
of visitors, the reasons for visiting were then aggregated to the following three reasons (see Chart 3.2):

1. **Enjoy the green and the living collection in the urban environment**
2. **Exercise and recreation in the Botanic Gardens**
3. **Learn about the native environment and indigenous heritage.**

⁶ This chapter does not include the Domain in these quantitative values due to the lack of a robust data source. We do however consider the broader benefits of the Domain supported with qualitative evidence.

⁷ This estimate of visitor numbers is conservative due to difficulty in capturing the number of recreational users of the Domain during the day, especially for lunch time sports activity and at events.

Chart 3.2: Reasons for visiting the Botanic Gardens



Source: (Mwebaze and Bennett 2012), Deloitte Access Economics

Enjoying benefits of green space and the living collection in an urban environment

According to research by the RBGDT in 2015, one quarter of visitors cited going to the Botanic Gardens to take a break from daily life stress. This was cited by 34% of 35-54 year olds. For those earning under \$30,000 per annum over half of all respondents used the Botanic Gardens to help reduce stress, which was a higher frequency than all other income brackets.

This perception that green space can lead to lower volumes of stress is supported by academic research. For example Sugiyama et al. (2008) found that those who perceive their neighbourhoods as highly green were 1.6 times more likely to have better mental health, respectively, compared with those who perceived the low greenness in their environment.

Relatedly, Mass et al. (2009) found that being within a 1km distance of green space reduced the prevalence of particular diseases. This includes cardiovascular, musculoskeletal, mental, respiratory neurological and digestive conditions.

A well-designed, high-quality, connected public system of green spaces also has the potential to raise property values, enhance economic vitality and increase the state’s tax base. For example, in the case of Bryant Park in New York, the properties directly adjacent to improvements in natural asset facilities experienced an approximate 5-7% increase in value (CABE Space 2005).

For a significant proportion of visitors, being able to regularly visit areas with large amounts of native flora and fauna is a factor in their decision to visit the RBGDT. This reason could become more salient in the future, as Australia has suffered the largest documented decline in biodiversity of any continent for the past two hundred years (ABS 2015).

Voluntary support for the Gardens

The value visitors extract from the RBGDT facilities is supported by the number and efforts of volunteers who assist RBGDT staff in the operations of the three Botanic Gardens.

The 630 volunteers who contributed about 51,500 hours during the 2016-17 financial year obviously obtain their own value from efforts donated to the RBGDT. They also facilitate additional value for other visitors to RBGDT facilities who enjoy the fruits of their efforts. For instance, volunteers showcased the Botanic Gardens and PlantBank to more than 10,000 visitors via a combination of paid and free-guided tours in addition to assistance during major events such as New Years’ Eve.

Volunteers also assist with internal operations of the RBGDT such as scientific research. They provide assistance to staff with fieldwork and research for projects such as the Rainforest Conservation Project by setting up and recording seed germination experiments and assisting staff in Tissue Culture Laboratory. This is in addition to other efforts such as archiving and digitising historic collections of photographs for library displays.

The Foundation & Friends of the Botanic Gardens Ltd, a non-for-profit organisation with 5,000 members, was established to encourage community interaction with the RBGDT facilities. This includes the scientific, educational, horticultural, cultural and recreational aspects of the RBGDT. The Foundation contributed \$3.5 million of funds for RBGDT facilities in the 2015-16 financial year.

Pollution reduction from the Botanic Gardens

Green spaces such as the Botanic Gardens also provide benefits to broader ecosystem. The three Botanic Gardens have a total of 65,000 trees under its management (with approximately 3,800 in Sydney, 55,000 in Mount Annan and 6,000 in the Blue Mountains). This vegetation along with over 730 hectares of green space provided by RBGDT facilities in and around Sydney contribute to the overall air pollution reduction and act as a natural method for carbon storage.

The ability for trees to act as a carbon sink is well documented (Australian Chief Scientist 2017). Using the North Sydney City Council carbon storage calculator and assuming an average circumference of 80cm per tree, the RBGDT facilities provides approximately 8,905 tonnes of carbon storage

(or 137kg of carbon stored per tree). More generally, for city environments with large levels of pollution, the trees can contribute to air pollution reduction. For example, it has been estimated by the U.S. Forest Service that over a 50 year lifespan, a tree generates almost \$USD 32,000 worth of oxygen (\$AUD 40,522), providing \$USD 62,000 (\$AUD 78,511) worth of air pollution control (Roloff 2017).

In addition, the Royal Botanic Gardens Sydney may play a role in mitigating the urban heat island effect. The urban heat island effect describes where heat is trapped due to materials and structures found in cities absorbing and trapping heat. It should be noted that estimating the precise effect of the RBGDT facilities on heat in Sydney and the CBD is not the purpose of this study and would

require further investigation alongside the interaction of Sydney Harbour and the Royal Botanic Gardens Sydney.

However, heat-related morbidity in cities is a major public health concern (WHO 2017), with studies suggesting that parks may mitigate urban heat in surrounding urban areas by 1-4°C (Bowler et al., 2010, Davern et al., 2017). Despite literature in this field highlighting the difficulty in measuring the willingness to pay to avoid temperature increases, there is evidence that individuals would be willing to pay between 1% and 3% of their incomes to avoid a one degree Fahrenheit (0.02°C) increase in summer temperature (Baylis 2015).

Exercise and recreation in the Botanic Gardens

The RBGDT facilities provide an opportune area for physical exercise in the city and in its outer suburban locations. There are several formal exercise activities that take place within the Royal Botanic Garden Sydney and The Domain including numerous fun runs with an estimated 90,000 people by participating in fun runs last year that ran through Royal Botanic Gardens (see Chart 3.3).

Chart 3.3: Participation numbers of fun runs taking place in the three Botanic Gardens and The Domain sites



Source: RBGDT (2017)

The opportunities for exercise, both formal and informal, represent substantial health benefits for the residents around the Royal Botanic Garden Sydney and the estimated 450,000 workers in the Sydney CBD (City of Sydney 2017).

A study found that even irregular exercise, for example, going for a run once a fortnight, can lead to a reduction in hazard ratios for cardiovascular diseases and some forms of cancer (Donovan et al. 2017). These health benefits are also gained for residents near these parks as well. Bell et al. (2008) found that higher levels of green open space were significantly associated with lower Body Mass Index (BMI) scores in children and also lower odds of increasing BMI scores.

There are also productivity benefits derived from exercise for workers near the Royal Botanic Garden Sydney. The many cognitive benefits of regular exercise include: improved concentration, sharper memory, quicker learning, prolonged mental stamina, enhanced creativity, and stress reduction (Costa 2015). One study found workers who spent 30 to 60 minutes at lunch exercising experienced an average performance boost of 15%. A majority said their time management skills, mental performance, and ability to meet deadlines improved on days when they exercised. The employees who worked out were also less likely to suffer from post-lunch fatigue (Stenson 2005).

In addition to the opportunity for exercise, the RBGDT provides facilities, in particular The Domain, which offer opportunities for recreation. Nearly 900,000 visitors attended events at the Royal Botanic Garden Sydney and The Domain in 2016-17 financial year. The Domain hosts numerous events that are important to the Sydney cultural calendar. Carols in the Domain has been held since 1983 and has been broadcast around Australia for many years. The music festival, Field Day, is held annually on New Years' Day and attracts local and international hip-hop, house, indie and electronic artists.

More recently, events like Vivid have leveraged the prime location of the Royal Botanic Gardens Sydney and its unique landscape to offer a new experience for visitors to Sydney. In 2017, the event attracted over 390,000 people through the gates.

On a smaller scale, numerous weddings take place in the Gardens each year. In 2016-17, there were 285 wedding ceremonies and 37 wedding functions hosted at the Royal Botanic Garden Sydney. The newly completed education and exhibition centre, The Calyx, has a mix of indoor and outdoor areas built around the site of the Arc Glasshouse. In addition, numerous cafes and restaurants located within and around the Royal Botanic Garden Sydney provide additional amenity to users.

Cultural events in the Botanic Gardens: The Lysicrates Prize

In addition to The Domain, the Botanic Gardens also hosts cultural events. One example is the Lysicrates Prize, a playwright competition, which has been held annually in the Royal Botanic Garden Sydney since 2015.

The playwright competition is held in the Conservatorium of Music with the prize presented to the winner at the replica of the Lysicrates Monument in the Royal Botanic Gardens Sydney.

Both the monument and competition is closely associated with the practices of ancient Greece. The original monument was built in 334 BC in Athens, in commemoration of a wealthy sponsor of one of the winning playwright. Like other playwright competitions in Ancient Greece, the winners of the Lysicrates Prize are determined democratically with each audience member placing a single token in a large jar for their favourite play.

The monument has its own history as it was paid for by John Martin (who gave his name to Martin Place). In 1940, when the Federal Government decided to resume the land Martin occupied, and led a campaign for the monument to be moved to its current position in the Royal Botanic Garden Sydney.

After decades of erosion under salt winds and rain a group of philanthropists, organised by John and Patricia Azarias, decided in 2015 to raise the funds and restore it. A year later, the Lysicrates Foundation was established to repair the monument and also to revive the ancient Athenian drama festival.

The 2018 competition saw over 500 people attend the free event at the Royal Botanic Gardens Sydney. The winning playwrights take home a \$15,000 commission to complete their play, a trophy and two return tickets to Athens.

Learn about the native environment and indigenous heritage

The RBGDT also has educational programs that are designed to inform students, visitors and residents of the environmental significance and indigenous and colonial heritage preserved in and around the Royal Botanic Garden Sydney as well as plants and plant science more generally.

Participation in the RBGDT's formal education program increased by nearly 14,000 students across all the three gardens during the 2016-17 financial year to bring the total students engaged to 32,240. This is expected to increase with

the recently completed Calyx centre which will be used to drive formal education programs and community education on conservation issues.

The RBGDT has a broader educational role represented by its scientific research into ecology, botany and conservation. This will be explored more fully in the following chapter on the RBGDT's scientific contribution to society.

Total social and cultural asset value

The estimated total social and cultural value of the three Botanic Gardens sites is **\$186 million** per annum (see Table 3.1).

Table 3.1 Social and cultural asset value of the three Botanic Gardens sites

Component	Number ('000s)	Value attributed (\$)	Annual aggregate (\$)
Visitor use value	2,925 ⁸	36.6 ⁹	107.0 million
Non-use value	7,739 ¹⁰	10.2	79.1 million
Total social & cultural value	-	-	186.1 million

Source: Deloitte Access Economics

The **\$107 million attributed to visitor use value** can be interpreted as the value realised by all visitors (including local, interstate and international visitors) from the use of the three Botanic Gardens sites. The figure for visitor use value was derived from a survey of 650 visitors to the Royal Botanic Garden Sydney in 2010 (Mwebaze and Bennett 2012). There is a **non-use value of \$79 million attributed** which consists of the existence, altruistic and bequest values that residents of NSW prescribe to the three Botanic Gardens sites in Sydney.

Visitor use value

Visitor use values represent those benefits that accrue from the actual use of some good. For the three Botanic Gardens sites, this use may include the enjoyment of green space, exercise and recreation, observing native flora and fauna and the attendance of cultural events.

To assess the visitor use value of the three Botanic Gardens sites, a travel-cost methodology was employed, derived from a survey which was designed to collect information on trip motivation, travel

Community Greening Program

The Community Greening Program is a joint initiative between the RBGDT and Department of Family and Community Services. The program involves RBGDT staff going to disadvantaged and remote areas to create community gardens across NSW.

The objective of the program is to ensure the physical and psychological benefits of green space are enjoyed by those who have limited access to such areas in their local environment. The program also has health benefits associated with the gardens producing fresh vegetables for consumption by the communities. The program also has a youth initiative in partnership with the Eden Foundation that includes youth aged 12-25 years old.

Almost 20,000 people participated in the program in 2015-16, which represents an increase of 17% on the previous year. The program has already had a long term impact, with 340 Community Greening projects established since it started in 2001, with records indicating that 71% of the gardens are still active.

⁸ Number of intra-state visitors to the three Botanic Gardens sites was calculated using the proportion of the NSW population that visit Botanic Gardens (ABS 2014) applied to the total NSW population in 2016. For the purposes of this analysis and due to data constraints, the visitor use value is the value that the citizens of NSW attribute from using the three Botanic Gardens sites.

⁹ The visitor use value attributed is a weighted average between multiple and single site visitors. See table 3.2 for a detailed breakdown.

¹⁰ Similarly, the latest total NSW population (June 2016, ABS 2017) was used in deriving the non-use value. Methodology sourced from Productivity Commission (2014) Environmental Policy Analysis: A guide to non-market valuation pg. 25.

costs, travel time and on-site expenditures (Mwebaze and Bennett, 2012). The travel-cost methodology is a revealed preference technique used to estimate the visitor use value of a non-traded good using information from related markets. In essence, the travel cost is used as a proxy for an entry price, with a change in price causing a change in consumption.

One important point to note when using the travel-cost methodology is that individuals often visit multiple venues in the course of their visit to a Botanic Gardens site. When individuals visit multiple locations in the same vicinity, the use value attributed to all three sites must be shared across these multiple locations. This is especially true of the Royal Botanic Garden Sydney, where multiple attractions are in the same vicinity, for example, an individual who also visits the Sydney Opera House before or after the Royal Botanic Garden Sydney, would only have half of their use value being reasonably attributed to the Royal Botanic Gardens.

As Table 3.2 shows, Mwebaze and Bennet (2012) find that the average use value per trip for visitors to the Royal Botanic Garden

Sydney to be \$51.90 (scaled up from \$45.80) for single-site visitors and \$20.50 (scaled up from \$18.10) for multiple-site visitors. As the surveys were conducted in 2010, these values were indexed using growth in the Consumer Price Index (CPI) to 2016.¹¹

For these values to be attributable to NSW residents, two assumptions were made. Firstly, that the utility visitors derive from visiting the three Botanic Gardens sites remain unchanged between 2010 and 2016. Visitors' utility is dictated by the inherent qualities and characteristics of the good considered, as well as any change in the supply of adequate substitute or complementary sites. Considering the scarcity of green space development in the urban environment during this period, it is unlikely that this assumption has been violated.

Secondly, the average use values for visitors from Mwebaze and Bennet (2012) were a result of surveys conducted at the Royal Botanic Garden Sydney site. Hence, they do not reflect the use value from visits to any of the remaining the two Botanic Gardens sites (Australian Botanic Gardens,

Mount Annan and Blue Mountains Botanic Gardens Mount Tomah). Given that these remaining sites play crucial roles in the conservation and regeneration of native flora and fauna in NSW, it is likely that these values do not fully capture the extent that visitors actually attribute to all of the three Botanic Gardens sites. However, as 89% of total visits in 2015/16 were to the Royal Botanic Garden Sydney, the extent of this underestimation is likely to be small.

Table 3.2 details the breakdown used to calculate the annual aggregate of the total visitor use value for the three Botanic Gardens sites. An estimated 37.8% of NSW's population visited one of the three Botanic Gardens sites in 2016 (ABS 2014), equating to 2,925,445 visitors from NSW. Of these, approximately 51% were single-site visitors, with the remaining visiting multiple-sites during their trips (Mwebaze and Bennett 2012). Multiplying the average visitor use value by the number of visitors leads to an estimated annual visitor use value of \$77.5 million for single-site visitors and; \$29.5 million for multiple-site visitors.

Table 3.2 Breakdown of the total visitor use value

	Single-site	Multiple-site	Total visitor use value
Average visitor use value per trip	\$51.90	\$20.50	-
Estimated number of visitors	1,491,977	1,433,468	-
Visitor use value	\$77.5 million	\$29.5 million	\$107.0 million

Source: Deloitte Access Economics, Mwebaze and Bennett (2012), ABS (2014)

¹¹ 2016 was used as there were finalised visitor numbers available and also for consistency with the economic contribution analysis presented previously.

As noted earlier, when individuals visit multiple sites, the use value must be shared across these multiple venues, hence the lower estimated use value for multiple-site visitors. Summing the annual visitor use values for single-site visitors and multiple-site visitors leads to the aggregate annual visitor use value of \$107.0 million.

Non-use value

Further, public institutions such as the three Botanic Gardens sites may provide value to people who do not directly use their services – termed non-use value. This non-use value can be composed of existence values, altruist values or bequest values. To capture the non-use value of the three Botanic Gardens sites, contingent valuation (CV) methodology was applied using a survey conducted by Deloitte Access Economics (2015) of visitors to the Adelaide Botanic Gardens. Similar to the travel-cost methodology employed in the use value, CV is a method of placing a market value on a non-market good. However, in contrast to the travel-cost

methodology, CV is a stated preference technique where respondents are asked their willingness to pay to fund a change in the quality or quantity of a good. For an overview of CV literature see Appendix D.

This willingness to pay value is based on a 1,800 person survey conducted with visitors to the Adelaide Botanic Gardens (Deloitte Access Economics 2015). Respondents were asked the amount they were willing to contribute on average per year to Adelaide Botanic Gardens through taxation funding.

This survey found that South Australian residents who had not visited the Adelaide Botanic Garden in the last 12 months were willing to pay \$8.50. In order to apply this value to NSW residents, the differences in weekly earnings between the states was used as a scaling factor (ABS 2017). After scaling, the willingness to pay for the three Botanic Gardens sites was found to be \$10.20 per person for NSW residents (see Chart 3.3.)

Table 3.3 Willingness to pay across state Botanic Gardens

Component	South Australian Botanic Gardens (2013)	New South Wales Botanic Gardens (2016)
Willingness to pay per person	\$8.50	\$10.20

Source: Deloitte Access Economics

This figure was then multiplied with the total NSW population of 7.8 million (ABS 2017) to generate an annual non-use value of \$79.1 million. For the willingness to pay figure from the South Australian survey to be attributed to the three Botanic Gardens sites, it is assumed that the NSW population places equivalent value on the three Botanic Gardens sites as the South Australian resident population places on the South Australian Botanic Gardens.

This is not a strong nor unreasonable assumption to make. The underlying characteristics of both assets, namely that

they provide green space for recreation in a dense urban environment, are reasonably similar.

Moreover, a previous study found that the willingness to pay for funding maintenance of the Sydney Opera House were comparable for residents in New South Wales (\$6.80) and outside of New South Wales (\$6.70) (Deloitte Access Economics 2013). This indicates that resident populations across states tend to have similar preferences regarding the value of iconic institutions in Australia.

4. Scientific research

The Royal Botanic Gardens is the **oldest scientific institution in Australia** and continues to play an important role in progressing conservation research and activities. Scientific research and discovery contributes to the productive capacity of an economy which helps drive growth in living standards. Analysis by Deloitte Access Economics estimates that the stock of technology and knowledge attributable to Australia's universities contributed approximately \$160 billion to GDP in 2014 (Deloitte Access Economics 2015). In this context, this chapter provides an overview of the RBGDT's research activities and presents two case studies of research programs.

Discoveries and research to date

The **National Herbarium of NSW** located in the Royal Botanic Garden Sydney location contains approximately **1.425 million plant specimens**, including collections and samples gathered during the voyage of the Endeavour along the East coast of Australia in 1770. The replacement value of the Herbarium is **\$200 million**.

This large collection offers an opportunity for scientists to focus on taxonomy (naming of plants) and systematics (relationships between species and groups) with 65 new species identified and described in the 2015-16 financial year.

The RBGDT is also the authority of plant names in NSW and uses their research to collect valuable data that is disseminated through online portals such as Atlas of Living Australia, which is used by researchers, government and the public. In addition, the RBGDT provides free plant identification products online, (e.g. PlantNET).

Within the Herbarium is the **Daniel Solander Library** – one of the premier Botanic and horticultural library in Australia, with a world class collection of botanic, taxonomic and horticultural

literature. The library also contains an original edition of the 1859 edition of *On the Origin of the Species* written by Charles Darwin.

The RBGDT research findings are also published in two peer reviewed journals – *Cunninghamia* and *Telopea* – as well as a range of independent international journals. There were 121 scientific publications, articles and presentations by RBGDT researchers in 2016-17 financial year.

While specifically tailored to NSW and Australian context, the RBGDT scientific output takes place in a broader international research agenda. This means there are often opportunities for collaboration with other researchers and organisations. One example is the National Seed Science Forum which was held in 2016 at the Australian PlantBank and drew 200 leading seed scientists from across Australia and internationally.

The RBGDT also provides avenues for external researchers to use their facilities in three ways:

1. Scientific visitors using the Herbarium, library or other facilities on a short term basis (i.e. 1-3 days). There are approximately about 5 visitors per week for this reason
2. Visiting researchers for longer periods, which can vary from 1 to 12 month stays. This often involves early career researchers (post-doctoral) funded by external sources (usually international) for training and development in research. There are up to five visitors on a longer term basis as well as periodic research sabbaticals taken by visiting university academics in the RBGDT
3. Post graduate students (PhD students), both local and international, on average, stay with RBGDT for between 12 and 36 months.

Economic contribution of RBGDT's scientific research

While difficult to measure quantitatively, the research undertaken by the RBGDT also makes an economic contribution. Its focus on ecological and conservation research contributes to the scientific base in Australia with outputs of both intrinsic and instrumental value, including some with a direct commercial application.

The difficulty in measuring the monetary effect of scientific research means that scientific research can only be partially captured through the RBGDT's economic contribution – mainly through research grants and wages to scientists. Yet this does not incorporate the benefits or outputs of the scientific research undertaken by the RBGDT. And while scientific research could play a role in the visitor's value and non-use value of other residents, this is a subjective measure that may not account for the objective scientific productivity improvements derived from RBGDT research activities.

Modelling by the Productivity Commission (2006) estimates around a 25% rate of return to public research and development (R&D) realised as productivity gains for the Australian agricultural sector. This will include some gains that occur through environmental improvements (such as increased biodiversity) but is not designed to fully account for these gains. Moreover, the gains for agricultural productivity from R&D may sometimes be adverse for the environment.

The agricultural sector represents about 15% of the Australian economy with over \$32 billion in industry value added and nearly half a million employed (ABS 2017 cat no. 8155). As will be evident from the case studies below, RBGDT research projects such as PlantBank can have significant benefits for agricultural industries – such as bananas and Macadamia nuts. This is mostly from

a biosecurity perspective such as the identification of weeds and pathogens at early stages which may avoid substantial damage to flora and fauna. One specific example includes the identification of a pathogen for pine trees in Australia leading to steps to mitigate the pathogen. The cost avoidance was estimated at \$2 million in control and eradication over two years. Further research and innovation in this sector will continue to grow in importance as world population and associated demand for food continues to grow (Piesse and Thirtle 2010).

Research that improves the efficiency for land management and ecological restoration practice could also lead

to substantial financial savings for government and the economy. There has been major investment by various State and Commonwealth Governments in this area over the past two decades. The Restore & Renew project has the potential to support optimal decision-making in resource allocation in this field.

The Australian PlantBank case study

The Australian PlantBank, located in the Australian Botanic Garden, Mount Annan in South-West Sydney, centres on the conservation and horticulture of Australian plants, particularly threatened species and populations with economic potential. The particular focus is long-term conservation of ‘germplasm’, that is, any part of the

plant that can be regenerated to form another plant. Germplasm includes seeds, embryos, buds and other tissues. The research also includes work on cultivation requirements, reproductive strategies and seed biology.

To facilitate the conservation of unique Australian flora, the seeds of endangered plants are stored and researched as a safeguard to extinction. The repository comprises 5,400 Australian species and 10,500 collections in the seed vault (see Table 5.2). Moreover, PlantBank currently stores 57% of threatened NSW plant species, with a goal of obtaining collections of all threatened NSW plant species by 2020.

Table 4.1: Current PlantBank collection statistics

As of August 2017	
Total seed collections	10,508
Total species	5,485
Threatened NSW seed collections	807
Threatened NSW species	346
% NSW seedbearing species	45%
% Threatened NSW species	57%

Source: RBGDT (2017)

Chart 4.1 shows the progress of PlantBank in collecting and storing the seeds of flora since 1990. In recognition of this substantial progress, PlantBank was awarded the prize for the “greatest progress in seed conservation” by the Botanic Gardens Conservation International at the 6th Global Botanic Garden Congress in July 2017.

Chart 4.1: Progress of the PlantBank in seed collection



Source: RBGDT (2017)

Such information is essential to effective conservation, whether in the wild or in cultivation. Horticultural research also provides valuable information on the propagation and cultivation Australian plants for the nursery and floriculture industries. For example, research into conserving plant species affected by Myrtle Rust such as Eucalyptus. The overall aim of this research is to bring a range of native plant species into cultivation and thus contribute to the conservation of biodiversity by increasing community appreciation of the Australian flora.

The role of the PlantBank in conservation

PlantBank's conservation effort contribute, primarily, in three ways:

- As the primary repository for threatened NSW plant species in order to prevent extinction
- Provide seeds for replanting and translocating, particularly the endangered NSW seeds into wild habitats as part of the NSW government's *Saving Our Species program*
- Research and develop innovative germplasm storage techniques to support plant research programs. One notable research program is the **Rainforest Conservation Program**. Rainforest plants around the world are under threat from habit fragmentation, weeds, disease and climate change. Using various seed banking techniques, the program focuses on how to store the 1,200 estimated rainforest species seeds in Australia that are unsuitable for conventional storage techniques.

Industry & Research collaboration

PlantBank's research has found practical applications across a host of different industries, particularly agricultural industries, such as Macadamia nuts and finger limes. Moreover, PlantBank links with industry groups, such as the Australian Coal Association Research Program

(ACARP), to assist in the regeneration of threatened native plant populations. In particular, their work with the woody shrub genus *Persoonia* has been effective in restoring native environments.

PlantBank plays a prominent role in knowledge sharing across the network of national and global seed banks. Members of this international network leverage other institutions' research and facilities to contribute to the global knowledge of ecology and biology. One example of this collaboration is with the Millennium Seedbank in Kew, with each organisation agreeing to replicate each other's seed vault as an additional safeguard. Another important research link has been with exponents of cryogenic seed storing, such as the U.S. Department of Agriculture (USDA). These techniques have been used in the Rainforest Conservation Program, with the potential for wider applications in the future.

Restore & Renew case study

The Restore & Renew project aims to provide land management organisations with an easily accessible source of information about the genetic suitability of a vast array of plant species to certain environments. The project represents a world first in the scale of information available, by collating information on over 250 plant species around New South Wales, Queensland and Victoria. This information will inform long-term landscape management strategies and improve decision making in this area. The importance of this project cannot be overstated with substantial investment by various State and Commonwealth Governments into land restoration practices over the past 20 years.

The Restore & Renew program uses Diversity Arrays Technology (DArT) genomic sequencing and environmental modelling to develop effective solutions to management practices. Effectively the

Conserving the Wollemi Pine

The recovery of the Wollemi Pine, termed the 'Dinosaur tree', has been recognised as one of the greatest botanical discoveries of our time by the likes of David Attenborough and typifies the work of the PlantBank.

The Wollemi Pine (*Wollemia nobilis*) is one of the World's rarest and most threatened tree species. Until the recent discovery of a small population – fewer than 100 adult trees – in the Blue Mountains it was thought extinct. The recovery team of PlantBank scientists study wild Wollemi Pines in their natural habitat and in cultivation, with the aim of understanding how this ancient species has survived over millions of years. This may help us predict how plants will cope with environmental challenges in the future. This collection has been used to produce plants for gardens around the world, ensuring the security of wild plants in their natural habitat.

Scientists at the RBGDT also study the evolutionary biology and management of diseases that can threaten rare plants like the Wollemi Pine. This study can also lead to addressing the economically important pathogens that cause significant crop loss. Finally, the work of the PlantBank has led to the Wollemi Pine being highly sought after in the horticultural industry worldwide. The PlantBank's work with the Wollemi Pine is now considered a model for conservation across the World.

program aims to equip land care managers with easily accessible evolutionary, environmental and ecological information that has previously been missing from their tool kits. An improved understanding of plant evolutionary patterns is likely to increase the success and efficiency of restoration projects.

The role of the Restore & Renew in conservation

The research undertaken through the Restore and Renew project also incorporates environmental modelling to predict where certain species are likely to be suitable to the environment in the future. The impacts of climate change, land degradation, natural disasters, and urban development all influence the local environment’s ability to sustain particular species of plant. Through incorporating some of these factors through modelling, the Restore & Renew project will be able to predict how plants respond and adapt to a rapidly changing environment.

This project has the potential to save time and resources by increasing the chances

that newly planted areas are genetically suitable and likely to flourish over time. The project will have direct and indirect impacts for industry (e.g. mining, construction), land management, community groups (e.g. Landcare) and researchers.

Outcomes

The Restore & Renew project will provide data to researchers and practitioners of land restoration and management. The outputs from the research will mean increasing efficiency in restoration or replanting projects in a range of biological contexts – from protecting at risk species to minimising environmental impacts of development projects.

Despite the project commencing relatively recently, it has investigated over 6,000 genetic samples from over 500 collection events leading to 40 different species collected.

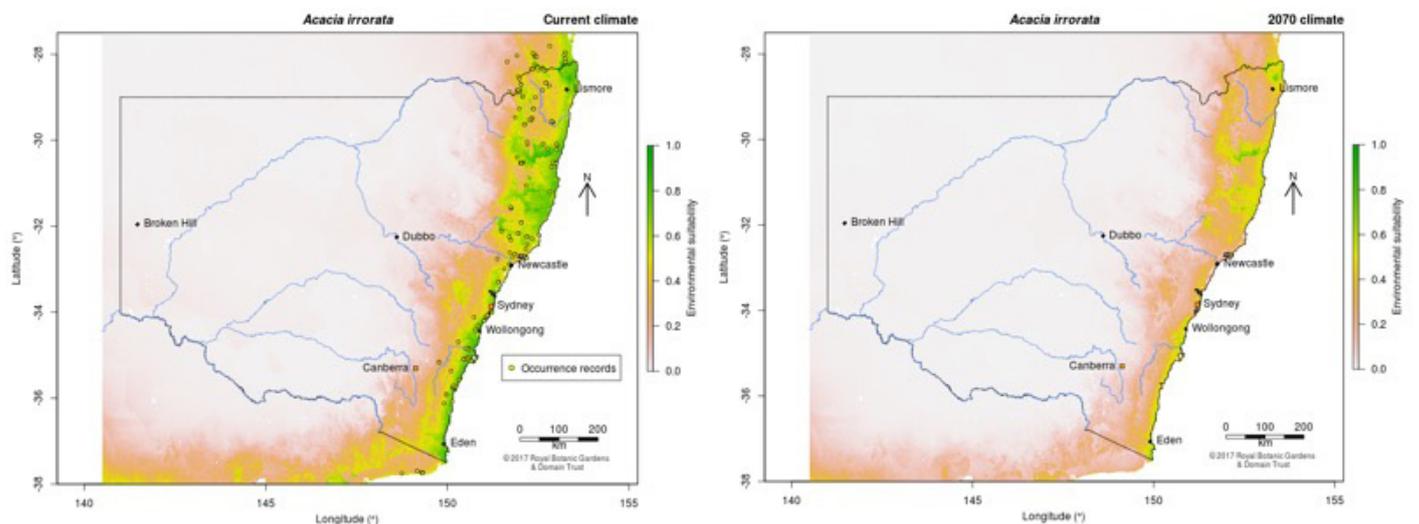
The Restore and Renew program aims to display its genomic and environmental analyses on a user friendly website. On the Restore & Renew website users will

be able to enter the location of their restoration project and select species of interest. Alternative practical scenarios will be presented showing how much diversity can be gathered by varying the locations and numbers of source plants sampled. Providing such tailored answers for each species, at each location (rather than generalisations) will ensure that evolutionary-suitable material is used and that resilient, self-sustaining populations are restored.

Part of the website will involve the development of mapping to guide decision making. Figure 4.1 presents a map indicating the genetic suitability of a particular species of wattle in NSW. The map below uses environmental modelling to estimate the genetic suitability of the same species in the forecasted 2070 climate.

These successes have supported obtaining additional sources of funding to expand the scope of the Restore & Renew project, meaning this important conservation work will continue into the future.

Figure 4.1: Genetic suitability of *Acacia Irrorata* (a species of wattle) in NSW currently and in predicted 2070 climate



Source: RBGDT (2017)

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Appendix A – Economic contribution studies

Economic contribution studies are intended to quantify measures such as value added, exports, imports and employment associated with a given industry or firm, in a historical reference year. The economic contribution is a measure of the value of production by a firm or industry.

Value added

Value added is the most appropriate measure of an industry's/company's economic contribution to gross domestic product (GDP) at the national level, or gross state product (GSP) at the state level.

The value added of each industry in the value chain can be added without the risk of double counting across industries caused by including the value added by other industries earlier in the production chain.

Other measures, such as total revenue or total exports, may be easier to estimate than value added but they 'double count'. That is, they overstate the contribution of a company to economic activity because they include, for example, the value added by external firms supplying inputs or the value added by other industries.

Measuring the economic contribution

There are several commonly used measures of economic activity, each of which describes a different aspect of an industry's economic contribution:

- Value added measures the value of output (i.e. goods and services) generated by the entity's factors of production (i.e. labour and capital) as measured in the income to those factors of production. The sum of value added across all entities in the economy equals gross domestic product. Given the relationship to GDP, the value added measure can be thought of as the increased contribution to welfare.

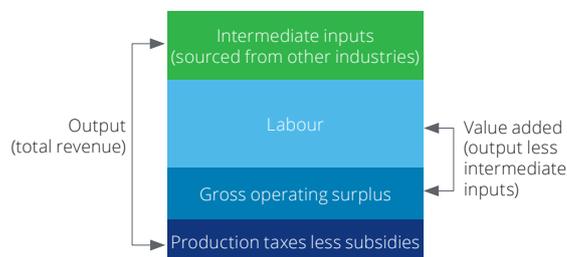
Value added is the sum of:

- Gross operating surplus (GOS). GOS represents the value of income generated by the entity's direct capital inputs, generally measured as the earnings before interest, tax, depreciation and amortisation (EBITDA)
- Labour income is a subcomponent of value added. It represents the value of output generated by the entity's direct labour inputs, as measured by the income to labour

- Tax on production less subsidy provided for production. This generally includes company taxes and taxes on employment. Note: given the returns to capital before tax (EBITDA) are calculated, company tax is not included or this would double count that tax
- Gross output measures the total value of the goods and services supplied by the entity. This is a broader measure than value added because it is an addition to the value added generated by the entity. It also includes the value of intermediate inputs used by the entity that flow from value added generated by other entities
- Employment is a fundamentally different measure of activity to those above. It measures the number of workers that are employed by the entity, rather than the value of the workers' output.

Figure A.1 shows the accounting framework used to evaluate economic activity, along with the components that make up gross output. Gross output is the sum of value added and the value of intermediate inputs. Value added can be calculated directly by summing the payments to the primary factors of production, labour (i.e. salaries) and capital (i.e. gross operating surplus, 'GOS', or profit), as well as production taxes less subsidies. The value of intermediate inputs can also be calculated directly by summing up expenses related to non-primary factor inputs.

Figure A.1: Economic activity accounting framework



Source: Deloitte Access Economics

Direct and indirect contributions

The **direct economic contribution** is a representation of the flow from labour and capital within the sector of the economy in question.

The **indirect contribution** is a measure of the demand for goods and services produced in other sectors as a result of demand generated by the sector in question. Estimation of the indirect economic contribution is

undertaken in an input-output (IO) framework using Australian Bureau of Statistics input-output tables which report the inputs and outputs of specific sectors of the economy (ABS 2010).

The total economic contribution to the economy is the sum of the direct and indirect economic contributions.

Limitations of economic contribution studies

While describing the geographic origin of production inputs may be a guide to a firm's linkages with the local economy, it should be recognised that these are the type of normal industry linkages that characterise all economic activities.

Unless there is significant unused capacity in the economy (such as unemployed labour) there is only a weak relationship between a firm's economic contribution as measured by value added (or other static aggregates) and the welfare or living standard of the community. Indeed, the use of labour and capital by demand created from the industry comes at an opportunity cost as it may reduce the amount of resources available to spend on other economic activities.

This is not to say that the economic contribution, including employment, is not important. As stated by the Productivity Commission in the context of Australia's gambling industries:

- Value added, trade and job creation arguments need to be considered in the context of the economy as a whole ... income from trade uses real resources, which could have been employed to generate benefits elsewhere. These arguments do not mean that jobs, trade and activity are unimportant in an economy. To the contrary they are critical to people's well-being. However, any particular industry's contribution to these benefits is much smaller than might at first be thought, because substitute industries could produce similar, though not equal gains
- In a fundamental sense, economic contribution studies are simply historical accounting exercises. No 'what-if', or counterfactual inferences – such as 'what would happen to living standards if the firm disappeared?' – should be drawn from them

- The analysis — as discussed in the report — relies on a national input-output table modelling framework and there are some limitations to this modelling framework. The analysis assumes that goods and services provided to the sector are produced by factors of production that are located completely within the state or region defined and that income flows do not leak to other states
- The IO framework and the derivation of the multipliers also assume that the relevant economic activity takes place within an unconstrained environment. That is, an increase in economic activity in one area of the economy does not increase prices and subsequently crowd out economic activity in another area of the economy. As a result, the modelled total and indirect contribution can be regarded as an upper-bound estimate of the contribution made by the supply of intermediate inputs
- Similarly the IO framework does not account for further flow-on benefits as captured in a more dynamic modelling environment like a Computable General Equilibrium model.

Input-output analysis

IO tables are required to account for the intermediate flows between sectors. These tables measure the direct economic activity of every sector in the economy at the national level. Importantly, these tables allow intermediate inputs to be further broken down by source. These detailed intermediate flows can be used to derive the total change in economic activity for a given sector.

A widely used measure of the spill-over of activity from one sector to another is captured by the ratio of the total to direct change in economic activity. The resulting estimate is typically referred to as 'the multiplier'. A multiplier greater than one implies some indirect activity, with higher multipliers indicating relatively larger indirect and total activity flowing from a given level of direct activity.

The IO matrix used for Australia is derived from the ABS IO tables. The industry classification used for input-output tables is based on ANZSIC, with 111 sectors in the modelling framework.

Appendix B – Tourism contribution

Tourism Satellite Account Framework

The Australian Bureau of Statistics supply and use tables for the Australian economy provide the foundation for which data of visitor expenditure (demand) and industry output (supply) are integrated and made consistent with national accounts through benchmarking. The derived regional multipliers provide the means by which direct tourism gross value added, GRP and employment can be calculated. These regional input-output tables provide a robust tool for further analysis and economic modelling of the sub-regional impact of tourism.

Direct contribution of tourism

A direct impact occurs where there is a direct relationship, both physical and economic, between the visitor and the producer of the good or service. Direct tourism output is essentially tourism consumption at basic prices less the intermediate costs to retailers of domestic goods sold directly to visitors (including wholesale and transport margins for domestic supply).

In the case of retail goods purchased by visitors, only the retail margin contributes to direct tourism output, value added and Gross Regional Product. This is because it is deemed that only the retailer has a direct relationship with the visitor and is therefore part of the tourism industry. As a consequence the output, and consequently value added, attributed to other (than retail) industries is excluded from the value of direct tourism output. Direct tourism output is therefore equal to internal tourism consumption at basic prices less the cost to retailers of domestic goods sold directly to visitors.

The implication of this treatment is that only the value added generated from retail trade activities provided to visitors will be considered as a direct effect. All other trade flows will form part of the net indirect impacts for each region.

Regional tourism activity data from the TRA International Visitor Survey (IVS) and National Visitor Survey (NVS) is used to derive itemised tourism consumption, or demand, in each region. DAE's regional IO database (derived from the ABS' national 2006-07 IO tables and data from the Census of Population and Housing) provides the cost structure and all required information to derive the supply side of the tourism sector in the regional TSAs.

The aggregate regional supply and demand elements are then calibrated to the state TSA data, such that the summing conditions between regions and State are satisfied.

Direct tourism gross value added and direct tourism GRP are the major economic aggregates derived in the regional TSA.

Direct tourism gross value added shows only the 'value' which a producer adds to the raw material goods and services it purchases in the process of producing its own output. Direct tourism gross value added is measured as the value of the output of tourism products by industries in a direct relationship with visitors less the value of the inputs used in producing these tourism products.

Direct tourism GRP, on the other hand, measures the value added of the tourism industry at purchasers' (market) prices. It therefore includes taxes paid less subsidies associated with the productive activity attributable to tourism. While direct tourism GRP is useful for comparison against the national accounts, it is not comparable across industries or between countries (due to the inclusion of taxes).

Indirect contribution of tourism

The indirect effect of tourism consumption is a broad notion that covers downstream and supplier effects of tourism demand. Intermediate inputs represent those goods and service which support the supply of the tourism product – the cleaning services that are inputted to the hotel sector; the fuel that is inputted to the aviation industry; the fruit and vegetables that are inputted to the restaurant industry. Together with any downstream impacts, it is these flow-on effects which determine the tourism industry's indirect contribution.

Whether flow-on economic impacts are captured at the local level hinges on the region's capacity to supply intermediate inputs to the tourism sector. In order to assess this – and, therefore, to rigorously quantify the indirect impacts at a regional level – DAE has utilised a gravity modelling technique based on parameters that define the intermediate inputs relevant to each tourism characteristic ANZSIC industry and a corresponding analysis of the local industry base in each Tourism Region.

The inclusion of indirect effects in the regional TSA framework provides a more complete view of the total contribution of tourism to regional New South Wales. Both the direct and indirect effects have been calculated using input-output analysis methods. The IO analysis method provides a breakdown of the supply and demand of commodities in the regional economy. As the tourism sector by nature does not have its own multiplier, a correspondence

between the tourism consumption bundle and production industries is used to calculate a weighted tourism industry multiplier.

The multipliers measure the individual contribution of the supply industries and thus provide the benchmark for estimating direct and flow-on effects for tourism output, GVA, GRP and employment.



Appendix C – Travel cost methodology

The travel-cost methodology is a revealed preference technique used to estimate the visitor use value of a non-traded good using information from related markets. In essence, the travel cost is used as a proxy for an entry price, with a change in price causing a change in consumption.

To estimate the visitor use value for RBGDT facilities, survey results of visitors from Mwebaze and Bennett (2012) administered at three selected Botanic Gardens: the Australian National Botanic Garden in Canberra, the Royal Botanic Garden Melbourne and the Royal Botanic Gardens Sydney was used. To ensure a valid and attributable use value, a number of sampling strategies were used to achieve a representation of the

visitor population. One problem often encountered with on-site surveys is that they are conducted when a trip is still in progress and respondents may not be able to provide reliable data on total costs (Upneja et al. 2001).

Descriptive statistics of the survey sample for the Royal Botanic Gardens Sydney are summarised in Table C2. Visitors sampled were more likely to be women (57%), on average to be 31 years old and have a relatively high average annual income of \$84,000. On average, respondents visited the selected botanic gardens roughly 7 times a year, with each trip lasting over two hours.

Parameters	Royal Botanic Gardens Sydney
Trip demand (visits/year)	6.82
Travel cost (\$)	20.94
Travel time (hours)	0.75
Length of trip (hours)	2.61
Multiple sites (yes = 1, no = 0)	0.49
Annual Income ('000 \$)	83.88
Age (years)	30.87
Male (Male =1; Female = 0)	0.43
Sample size (n)	650

The travel-cost methodology assumes that an individual must visit a botanic garden to consume its services. The non-market benefits accruing to the individual from the botanic garden can then be inferred from the relationship between travel-cost expenditures and the number of visits to the botanic garden.

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