**Department of Planning and Environment**

dpie.nsw.gov.au

# Framework for Valuing Green Infrastructure and Public Spaces

## Technical appendices for recommended approaches

October 2023

# Acknowledgement of Country

The Department of Planning and Environment acknowledges that it stands on Aboriginal land. We acknowledge the Traditional Custodians of the land and we show our respect for Elders past, present and emerging through thoughtful and collaborative approaches to our work, seeking to demonstrate our ongoing commitment to providing places in which Aboriginal people are included socially, culturally and economically.

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Framework for Valuing Green Infrastructure and Public Spaces

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**More information**

For more information about the framework, contact the department via email at: vgipsframework@dpie.nsw.gov.au

# Contents

# 1 Introduction

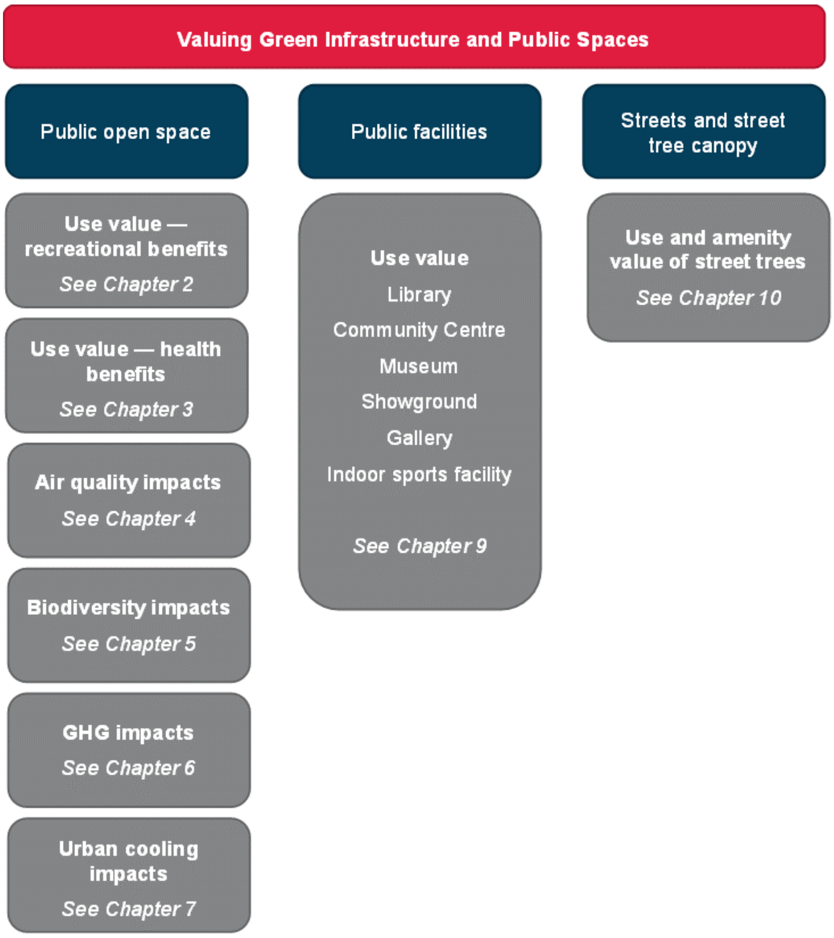
The Framework for Valuing Green Infrastructure and Public Spaces (the framework) is intended to support practitioners in undertaking cost-benefit analysis of projects, programs and policies relating to green infrastructure and public space. This document forms the technical appendices to the framework.

The purpose of the technical appendices is to provide the evidence behind the approaches and parameters values used in the framework. This will allow for these approaches and evidence to be built on as further work is undertaken.

Please refer to the framework for an outline of green infrastructure and public space and the applicable asset classes.

Figure 1.1 summarises the impacts related to public open space, public facilities and streets for which parameter values are included in the framework.

#### Figure 1.1. Summary of impacts included in Framework for Valuing Green Infrastructure and Public Spaces




Data source: CIE.

# 2 Use value (recreational benefits) of public open space

Public open space includes parks and gardens, play spaces, sportsground, bush reserves, waterways and beaches.

An important benefit people gain from new, existing or improved public open space is use value, which they experience through activities such as:

- walking and cycling
- picnics
- playing sport and games (organised and casual)
- swimming
- boating and fishing.

Calculating the use value of public open space will require:

- understanding the determinants of use value
- identifying a suitable valuation approach
- applying appropriate benefit transfer where primary studies are not available.

## 2.1 Determinants of use value

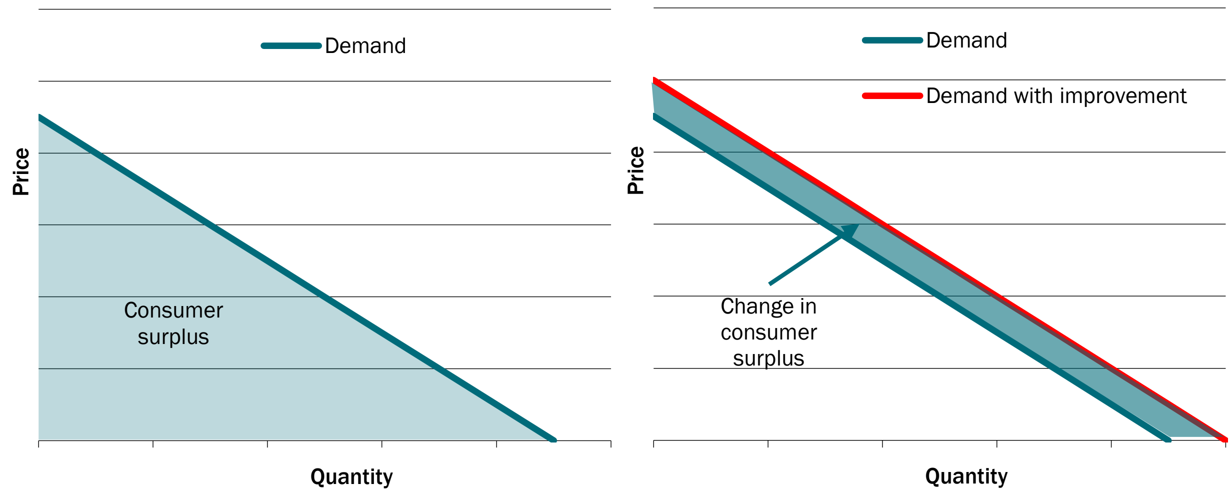
The key determinants of the use value of **new** or **improved** public open space include:

- the types of uses and diverse function that the place allows
- upgrade in the quality of an existing or the level of quality of new public open space
- whether there are few or many other nearby public open spaces that offer similar or diverse uses and have capacity to accommodate open space and recreation use
  - If there is already a wide availability of public open space, then it would be expected that the value of new public open space will be less.
- the amount of people accessible and well connected to the existing or new public open space.

Use value captures the area under the demand curve for a particular public open space. For the purposes of cost benefit analysis, this covers the demand curve for a **new** public open space, or how the demand curve changes from an **improvement to an existing** public open space. This is shown in Figure 2.1, for free public open space — that is, where there is no entry fee.

- The left-hand panel shows the value of use for an existing or new public open space. This is the total area under the demand curve.
- The right-hand panel shows the value of use for an improvement to a public open space, which is the area between the demand curve and demand with the improvement

Figure 2.1. Measuring consumer surplus from public open space




Source: The Centre for International Economics CIE

## 2.2 Approaches to measuring use value

There are a number of possible approaches to measure the value people place on using public open space:

- **revealed preference valuation methods** — these use people's actual decisions to infer their valuation. The two possible methods are:
  - hedonic analysis — using house or land prices versus a range of explanatory variables (including green space variables) to understand the impact of green space on house or land value. This will pick up an estimate of whether being near green space, or having more green space, is of value to people living in an area.
  - travel cost method — the travel cost method records information on how much it costs people to get to a public open space. This can then be used to derive a demand curve. For example, if people within 1 km of a park visited 20 times per year, people within 2 km visited 10 times per year and people within 5 km visited 5 times per year, then the cost associated with each distance can be estimated (such as the cost of time). This becomes the 'price' in the demand curve, while the visitation per person becomes the quantity. The area under the demand curve, such as in the left-hand panel of Figure 2.1 can then be measured.

This method can only be used for measuring the value of existing public open space. If this is to be used for cost benefit analysis of future investments, values from existing public open space would have to be applied in some way to new or improved public open space.

- **stated preference methods** — these ask people questions to understand their stated preferences. Methods include:
  - contingent valuation — asking people to state how much they would be willing to pay for using a public open space

- choice modelling — presenting people with choices about **new** or **improved** public open space, and payment mechanisms. Their choices are then used to infer the value of the new or improved public open space

- **subjective wellbeing** — this asks people about their level of well-being and a range of other characteristics. It then measures how different characteristics impact on wellbeing. To obtain a monetary measure of the value of public open space, it compares an estimated wellbeing effect from access to public open space to the estimated wellbeing effect from additional income.

The different approaches will measure different types of benefits. For example, hedonic analysis would be expected to capture private benefits related to visual amenity and urban cooling for houses near a public open space. Table 2.1 sets out what is being measured in each approach[1].

The methods also differ in:

- whether they capture all use value. Hedonic modelling will not capture use value for more distant users, and is best at identifying benefits for people located very close to public open space
- the extent to which they account for available substitutes, quality and capacity of public facilities
- whether they are measuring benefits related to existing or new public open space. Revealed preference methods (hedonic analysis and travel cost) are applied to existing public open space. To use these for new projects involves a robust way to apply the benefit of an existing space to a new or improved space
- the metric being developed. For example, a travel cost approach will provide a metric per user, while hedonic modelling will provide a metric related to property value or area.

As a general rule, revealed preference techniques will provide more accurate estimates of value because they are based on people's actual decisions[2]. However, they are unlikely to provide information on the value of different characteristics about public open space and require considerable adjustment to apply to new projects compared to undertaking stated preference surveys.

Stated preference techniques are based on hypothetical choice scenario which can lead to unintended consequences and biases being reflected in results. This can be mitigated through strong survey design and applying validity tests. More information can be found in TPG23-08 NSW Government Guide to Cost-Benefit Analysis.

## 2.3 Steps in cost-benefit analysis

Table 2.1 briefly outlines the key steps in a cost-benefit analysis. Detailed information is available in the NSW Government Guide to Cost-Benefit Analysis (TPG23-08).

[1] This does not include subjective wellbeing as there is only one study that has used this method.

[2] NSW Treasury, *NSW Government Guide to Cost-Benefit Analysis*, TPG23-08, p. 50, https://www.treasury.nsw.gov.au/sites/default/files/2023-03/tpg23-08_nsw-government-guide-to-cost-benefit-analysis_v2.pdf, 2023.

### Table 2.2. What is being measured in each approach

| | Revealed preference techniques | | Stated preference techniques |
|---|---|---|---|
| | Hedonic analysis | Travel cost method | |
| Types of use value measured | | | |
| For all users | No. Only captures value for people living very close to a public open space. | Yes | Yes, if survey is well designed. |
| For new and improved public open space | The method is based on existing public open space. A benefit transfer approach is required to apply to new and improved public open space. | The method is based on existing public open space. A benefit transfer approach is required to apply to new and improved public open space. | Yes |
| Accounts for quality of facilities, available substitutes and capacity | Measures will reflect 'average' quality, capacity and substitutes unless specific explanatory variables are included in the hedonic analysis. | Measures will reflect characteristics of whichever facility the method is applied to. A benefit transfer technique may be able to adjust for a new facility. | Yes, depending on survey design |
| Provides a value per user or a value per person in catchment | Value per person in catchment | Value per users | Could do either depending on specification |
| Types of benefits included | | | |
| Visual amenity of public open space to non-users | Yes | No | Maybe — this may be implicit in values estimated |
| Private component of urban cooling and air pollution impacts | Yes | No | Maybe — this may be implicit in values estimated |
| Other non-use values (biodiversity, avoided GHG emissions) | No | No | Maybe — this may be implicit in values estimated |

Source: The CIE.

The travel cost method is the most robust method for measuring the value of use of existing public open space.

The travel cost method is preferred over other methods for estimating use value because:

- it only measures use value, rather than also including other types of benefits
- it measures the use value for all users
- it relies on people's actual decisions.

Robust benefit transfer techniques are required to apply value measures from travel cost studies to new and improved public open space. In some instances, it will be difficult to apply estimates from a travel cost study of an existing public open space to a new or improved public open space. In these cases, other methods will have to be applied.

## 2.4 Applying part studies to future changes in public open space

The type of public open space projects that could be undertaken include:

- a **new** public open or blue space. For example, South Creek in Western Sydney is envisaged as part of the Strategic Open Space Program by the Department.
- an improvement to an **existing** public open or blue space, which could include:
  - adding built infrastructure, such as:
    - upgrade of parks as part of the Strategic Open Space Program by the Department
    - upgrade to play space, shade, BBQ or toilet facilities or, lighting to a local park
    - upgrade to sportsgrounds including lighting and associated infrastructure providing a new or upgraded playground and associated landscaping
    - a walking or biking track in a National Park
    - new lookouts in National Parks
    - new or improved camping areas or amenities in a National Park
    - improving the green characteristics of a park, such as through tree planting or irrigation
    - improving the maintenance or surface of a sporting field, or improving the quality of the playing surface through irrigation.
    - improving water quality so an area becomes suitable for swimming or fishing.
- improving access to an existing green or blue space, such as through pedestrian and cycleway links, or parking.

The travel cost method generates values per visit to a public open space and is the preferred method where it can be reasonably applied to a new project. Based on the literature identified, the travel cost method will be able to be applied to new and existing National Parks and protected areas (Table 2.2). The travel cost model developed in Heagney et al 2019 is recommended. This approach would be suitable for strategic level analysis. The approach would need to be complemented with an understanding of issues specific to the investment being assessed, such as:

- the level of use against capacity of a specific campsite would be required to consider a project to expand the number of campsite places
- the level of natural beauty and length of walk would be required for new tracks or look-outs.

For an existing park for which characteristics are being altered, it is possible to measure benefits through using the public results of Heagney et al 2019 and data on use. For a new park, this would require engagement with the authors, as there is significant complexity to add a new protected area to the modelling.

Estimates of per visit benefits based on travel cost studies would not be able to be used for:

- new urban district and regional parks, because visitation data would not be available, and because of the wide range for valuations
- existing urban district and regional parks, because the travel cost valuation literature has not identified the value of improvements to existing parks
- new urban local parks because there is no visitation data or valuation data per visit

- existing urban local parks, because the travel cost valuation literature has not identified the value of improvements to existing parks
- blue spaces, because the travel cost valuation literature has not identified the value of improvements to existing blue spaces.

For these types of investments, default parameters will have to use a different approach than applying per visit benefits from a travel cost model.

**Table 2.2. Valuation based on per visit travel cost estimates**

| Type of public open space | New | | Existing | |
|---|---|---|---|---|
| | Visitation data | Valuation | Visitation data | Valuation |
| National Park/protected areas | No, but this can be proxied using existing network model in Heagney et al (2019) | Understand a new park can be added to network model in Heagney et al (2019) | Yes | Yes<br>Heagney et al (2019) provide strategic level parameters for built facilities value |
| Urban District/ regional parks | No | Yes (wide range) | Yes | No |
| Urban local parks | No | No | No | No |
| Blue spaces | No | Yes (wide range) | Visitation data will be available for some waterways and beaches, but not all. | Yes<br>Anning (2012) provides estimates of consumer surplus for beach visits to two Sydney beaches. |

Note: Blue indicates approach can be used, pink indicates approach cannot be used and grey indicates that this is not relevant.

For investments in types of public open space for which there is not an applicable travel cost study, the options are:

- to use broad hedonic studies that consider the amount of green space in particular areas and the impact on property prices, and/or
- to use stated preference results to understand the valuation of particular aspects of green or blue spaces.

The former will provide only an indicative guide to value because the public open space in question may differ from that used in the hedonic studies in terms of its quality and available substitutes. The latter is currently available for a selection of particular characteristics within parklands and sports fields, but not available in any level of detail about the particular characteristics of alternative public open space. There are some studies available for blue space.

## 2.5 Recommended approaches and values

The recommended valuation approach for urban parks has two components:

- Base value — the approach to estimate the base value for urban parks and sport fields is highly generic and is based off a study undertaken in London. This study has been chosen because it links the amount of an area that is parks to the property prices in the area, which can be applied in a straightforward manner.

- Value of additional facilities — apply WTP estimates for additional facilities such as playspace, BBQ facilities, cricket nets and walking tracks.

### 2.5.1 Estimating base value of urban parks and sport fields

The lower bound from this study has been chosen as a benchmark, because a hedonic study may capture non-use aspects of urban parks, such as urban cooling and amenity[3]. These factors are separately measured in the framework.

A reasonable question is the extent to which a UK estimate is applicable to Australia.

- London has a higher population density — this is accounted for to a large extent because the approach is linked to property values, and higher population density means more properties and a higher property value to which the impact is applied.
- London has less public open space per person than Sydney (and likely also other NSW urban areas). However, much of the public open space in Sydney is not urban parks, but protected areas, unlike in London[4]. These would tend to have much lower use benefits for a given size, and the method suggested does not apply to these areas.
- There are no directly comparable studies in Australia. The closest is Rossetti (2013)[5], which uses an Enhanced Vegetation Index. This is not straightforward to interpret and covers much more than just urban parks (any vegetation on private properties and streets will also impact on this measure). Rosetti (2013) uses an example of Albert Park to test the intuitive size of benefits. This finds that Albert Park would have an impact of 8.6% to 15.6% on property prices in the postcode area. Using the recommended approach of a 0.3% impact per 1 percentage point increase in area that is urban parks leads to an estimated 14% increase. This seems reasonable given that Rosetti (2013) is accounting for all green space and assets and a number of Australian studies have shown that public green space has a larger impact on property prices than private green space[6].

The recommended approach does not allow for a lower value to be applied if there is a large amount of existing parkland and a higher amount if there is a scarcity of parkland. This is an important omission. Ideally, the approach could:

- scale up the impact in circumstances where there is a relative scarcity of green places
- scale down the impact in circumstances where there is a relative abundance of green places.

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[3] Air pollution is included as a separate explanatory variable in the model, so is not implicitly included in green space. Also note that urban cooling is less relevant in London than for Australian cities.

[4] Versus website, accessed October 2021, https://versus.com/en/london-vs-sydney/green-area-per-person.

[5] Rossetti, J. (2013), Valuation of Australia's green infrastructure: Hedonic pricing model using the enhanced vegetation index, Thesis Monash University, October, https://datainspace.org/wp-content/uploads/2017/04/Joe-Rossetti-2013-Thesis-1.pdf.

[6] Pandit, R., Polyakov, M. & Sadler, R. (2014). Valuing public and private urban tree canopy cover. Australian Journal of Agricultural and Resource Economics, Vol. 58, pp. 453-470; Pandit, R., Polyakov, M., Tapsuwan, S. & Moran, T. (2013). The effect of street trees on property value in Perth, Western Australia. Landscape and Urban Planning, Vol. 110, pp. 134-142.Tapsuwan, S. & Moran, T. (2013). The effect of street trees on property value in Perth, Western Australia. Landscape and Urban Planning, Vol. 110, pp. 134-142.

At this stage the Framework does not have specific guidance on this and project-specific work is encouraged to fill this gap.

### 2.5.2 Estimating value of additional facilities at urban parks and sport fields

The approach to estimate the base value of urban parks and sport fields is highly generic. It does not reflect differences in the quality of the green place and the existing amount of green space.

A choice modelling study by CaPPRe (2022) estimated the value NSW households place on additional facilities provided at an urban park or sports field.7 The value of providing certain additional facilities at new parks can be estimated using these available WTP estimates from CaPPRe (2022) (see Table 2.3) or through a broad approach to open space augmentation based on capital expenditure levels (see 2.5.2.1). A rmaining key omission of this recommended approach to estimate the base value is it does not allow for a lower value to be applied if there is a large amount of existing parkland and a higher amount if there is a scarcity of parkland.

**Table 2.3. Household WTP by characteristics at urban park or sports field**

| Characteristic | Urban park 2022$/household | Sports field 2022$/household |
|---|---|---|
| Picnic shelter and BBQ facilities | 29.0 | 34.1 |
| Playspace (standard) [8] | 29.3 | 30.0 |
| Cycling or walking track | 23.0 | NA |
| Lighting | 12.5 | NA |
| Outdoor fitness area | 16.5 | 25.0 |
| Skatepark | 9.4 | 16.6 |
| Event space | 12.5 | NA |
| Dog off-leash area | 29.3 | NA |
| Basketball and netball court | NA | 20.2 |
| Bike tracks | NA | 23.3 |
| Basketball court | NA | 8.7 |
| Cricket nets | NA | 6.0 |

Source: Community and Patient Preference Research (CaPPRe), 2022, *Willingness to pay for green infrastructure and public spaces in NSW,* Final Report prepared for the Department of Planning and Environment.

The estimated willingness to pay (WTP) values per household should be applied to each additional characteristic for the households located within the 'nearest catchment'. The 'nearest catchment' contains all households for which the proposed characteristic is the nearest. Table 2.4 provides example of 'nearest' catchment for a proposed new skatepark. In this example, the nearest existing skatepark is one kilometre from Household 1 and 5 kilometres from Household 2. The proposed new skatepark will be two kilometres from Household 1 and 2. The proposed new skatepark will be the

[7] Community and Patient Preference Research (CaPPRe), 2022, Willingness to pay for green infrastructure and public spaces in NSW, Final Report prepared for the Department of Planning and Environment.

[8] It is recommended this value be applied to playspaces which are of a standard quality. The description for Playspace provided in the Discrete Choice Experience was "Playspaces for difference age groups and abilities, including shade, access and seating". See page 78 of Community and Patient Preference Research (CaPPRe), 2022, *Willingness to pay for green infrastructure and public spaces in NSW,* Final Report prepared for the Department of Planning and Environment.

nearest for Household 2, but not for Household 1. Only Household 2 should be included in the 'nearest catchment' when applying the WTP of $9.40 per household for a new skatepark in an urban park (Table 2.4).

**Table 2.4 Defining the 'nearest' catchment for characteristics at urban parks or sports fields**

| Additional attribute provided | Household 1<br>km | Household 2<br>km |
|---|---|---|
| Distance to nearest existing Skatepark | 1 | 5 |
| Distance to proposed new Skatepark | 2 | 2 |
| Include household in 'nearest catchment' | No | Yes |

Source: The CIE.

#### 2.5.2.1 Estimating value of varying qualities of parks

The WTP estimates for specific attributes capture some aspects of quality but not others. An alternative approach where a new park is augmented to a lower or higher quality than standard or where an existing park is embellished is to scale the base park amenity factor by the level of expenditure. For example, if a new park has capital expenditure of $100 per m2, compared to a standard capital expenditure of $200 per m2, then the base park amenity factor would be halved from 0.3% per additional 1 percentage point share of open space to 0.15%.

This approach has the advantage that it can control for varying levels of quality of the embellishments for a park. The disadvantage is that higher or lower expenditure than standard could simply reflect the level of efficiency with which a park is developed.

In general, where a park is spending much less than the benchmark capital expenditure amount, it is reasonable to consider a downward adjustment to the base amenity factor. Where a much higher level of expenditure is being contemplated for the embellishment of an existing park, the reasonableness of applying an upward adjustment to the amenity factor could be tested against the expected change in visitation.

### 2.5.3 Recommended valuation methods by type of space

Table 2.5 outlines the recommended valuation methods for new and existing assets by types of space.

### Table 2.5 Recommended valuation methods

| Type of space | New | Existing |
|---|---|---|
| National Park/protected areas | Apply travel cost model from Heagney 2019. The average per visit value should not be applied — the model should be used to estimate a value. | Apply travel cost model from Heagney 2019. The average per visit value should not be applied — the model should be used to estimate a value. |
| Urban District/ Regional parks | Hedonic results for amount of green space in catchment.<br>The recommended value is a 0.3 per cent increase in property values per 1 percentage point increase in the share of area that is park, applied to the local government area, from GLA 2003.<br>WTP for additional facilities at new assets | WTP for additional facilities provided at existing assets. |
| Urban Local Parks | Hedonic results for amount of green space in catchment.<br>The recommended value is a 0.3 per cent increase in property values per 1 percentage point increase in the share of area that is park, applied to an approximate catchment, from GLA 2003.<br>WTP for additional facilities at new assets | WTP for additional facilities provided at existing assets. |
| Blue spaces (rivers and inland waterways) | No method recommended. There are not likely to be new blue assets in the sense of new rivers and beaches. There are likely to be new blue assets that are part of parks (such as lakes and detention basins) and which would ideally be factored into the use value of a park. There may also be improvements in accessibility to waterways. | Apply values from stated preference surveys for changes in use of waterway of:<br>$3.45 for moving from 50 km to 70 km of swimmable waterway<br>$2.65 for moving from 70 km to 100 km of swimmable waterway<br>$0 for increases above 100 km<br>These are per household per km of additional swimmable waterway per year for ten years in 2022$[9].<br>The catchment to be applied should be the population for which this is the closest natural swimming area of comparable quality. |
| Blue spaces (coastal) | | Apply consumer surplus of $18.04 per beach visit (2022 dollars).<br>Based on average of consumer surplus estimate for Collaroy-Narrabeen and Manly Ocean Beach.<br>Relevant for projects involving changes to water quality and/or coastal erosion impacts on beaches. |

Note: Blue indicates approach can be used, pink indicates a gap.

[9] Indexed using consumer price index.

# 3 Use value (health benefits)

A cost benefit analysis for public open space could include health benefits. The availability of public open space increases the amount of physical activity undertaken by those living nearby. In turn, increased physical activity has been shown to have a positive impact on health and wellbeing, reducing the risks of non-communicable disease such as coronary heart disease, stroke, type 2 diabetes, breast cancer, colon cancer, mental health and cognitive function[10]. In NSW approximately 66 per cent of the population is estimated to be overweight (35 per cent) and obese (31 per cent), based on the body mass index[11].

Health benefit categories could include:

- Improved quality of life or reduced mortality. This includes improvements in mental health.
- Reduced health system cost.

The recommended approaches set out below focus on reduced health system cost, because improved quality of life and reduced mortality is expected to be, at least in part, factored into use value of public open space.

The value of reduced health system costs requires:

1. Determining the change in the quantity of physical activity attributed to the public open space intervention.
2. The impact of physical activity on health costs, and
3. Identifying the health costs that are not accounted for in use and amenity valuations already.

## 3.1 Determining the change in the quantity of physical activity

Improvements in the availability and accessibility of public open space can increase the frequency and duration of physical activity. Attributing health benefits to green infrastructure and public open space requires observing whether increasing the provision of public open space increases physical activity or results in a diversion from other locations and activities. For instance, whether an individual running in a new park is undertaking new activity, or in the base case ran along the road. In order to estimate this benefit, a number of assumptions are required around the change in activity (i.e. the number of times an individual visits parks and for what reason) and user substitution patterns12.

[10] Ding, Lawson, Kolbe-Alexander, Finkelstein, Katzmarzyk, van Mechelen, Pratt (2016), The economic burden of physical inactivity: a global analysis of major non-communicable diseases, The Lancet.

[11] ABS (2018), National Health Survey: First Results, 2017-18, https://www.abs.gov.au/statistics/health/health-conditions-and-risks/national-health-survey-first-results/latest-release.

[12] Varcoe, T., Betts O'Shea, H. and Contreras, Z. (2015), Valuing Victoria's Parks Accounting for ecosystems and valuing their benefits: Report of first phase findings, https://www.forestsandreserves.vic.gov.au/__data/assets/pdf_file/0027/57177/Valuing-Victorias-Parks-Report-Accounting-for-ecosystems-and-valuing-their-benefits.pdf.

Even for more standard sorts of active transport infrastructure, such as walking and cycling paths, the modelling of impacts on the amount of additional activity it enables is in its infancy.

There is evidence that an increase in access to public open space of some types results in increased physical activity. For example:

- Sugiyama et al. (2010) found that having an attractive (but not necessarily large) open space nearby was conducive to undertaking any recreational walking (30-40% higher likelihood), and having a large, attractive (but not necessarily close) neighbourhood open space may help adult residents achieve sufficient amounts of physical activity for health benefits through recreational walking (34% higher likelihood)[13]. his study found that the attractiveness of open space was a key determinant of increased activity, rather than just the presence of open space.
- Giles-Corti 2005 found that people with very good access to large, attractive public open space were 50% more likely to achieve high levels of walking[14]. Both of these studies were in Perth.
- In a Melbourne study, Koohsari e al 2018 found that living within 400m of public open space was not associated with additional walking, but those whose nearest public open space was > 1.5 ha had a 90 per cent higher likelihood of walking for recreation and a 166% higher likelihood of undertaking any walking during the last week[15].

However, there are other studies which found no relationship with distance to the nearest public open space and levels of activity, which may indicate that other features of open space, and not just proximity and size, are important determinants of use. The Heart Foundation provides a good summary of this literature[16]. The Heart Foundation conclusion is that the evidence suggests that having a larger, high-quality green public open space within walking distance may be more important for promoting sufficient walking for health benefits than simply living close to smaller, lower-quality green public open space.

Other types of public spaces may also lead to increased physical activity, such as shadier streets and more walkable neighbourhoods.

There are a number of approaches to measure these impacts:

- for active transport investments, such as a walking path or bike path:
  – use a specific active transport model. For example, Transport for NSW (TfNSW) has a long-term project to incorporate active travel in an Activity Based Model, which would then be able to provide estimates of changes in active travel related to transport infrastructure

[13] Sugiyama T, Francis J, Middleton NJ, Owen N, Giles-Corti B. (2010) Associations Between Recreational Walking and Attractiveness, Size, and Proximity of Neighborhood Open Spaces, Am J Public Heal, Sep; Vol. 100(9), pp. 1752–7, 10.2105/AJPH.2009.182006.

[14] Giles-Corti, B., Broomhall, M. H., Knuiman, M., Collins, C., Douglas, K., Ng, K., … Donovan, R. J. (2005). Increasing walking. American Journal of Preventive Medicine, Vol. 28(2), pp. 169–176. doi:10.1016/j.amepre.2004.10.018.

[15] Koohsari, Javad & Badland, Hannah & Mavoa, Suzanne & Villanueva, Karen & Francis, Jacinta & Hooper, Paula & Owen, Neville & Giles-Corti, Billie. (2018). Are public open space attributes associated with walking and depression?. Cities. Vol. 74, pp. 119-125, 10.1016/j.cities.2017.11.011.

[16] Heart Foundation, Evidence supporting the health benefits of Public Open Space, accessed October 2021, https://www.healthyactivebydesign.com.au/design-features/public-open-spaces/evidence.

- if the above is not available use a simplified catchment approach, such as in the New Zealand Transport Agency Monetised benefits and costs manual[17], and which is recommended by TfNSW for some projects. This is based on calculating population in particular catchments of new active transport infrastructure (400m, 800m and 1600m), using multipliers from the NZTA approach to determine cycling levels and assume a similar increase for walking (Box 3.1). This approach could be applied for moving from no active transport infrastructure to high levels of active transport infrastructure

- for **large or attractive urban parks**, use and adjust estimates from Sugiyama et al of how the presence of parks impact on achieving activity guidelines. The Sugiyama method of analysis was based on splitting parks into two groups (e.g. high/low attractiveness based on public open space audit results, small/large based on median size). The most straightforward way to interpret these is:
  - for a **new large regional-level park** of high quality (such as Parramatta Park, Centennial Park, Sydney Park, Bicentennial Park, or smaller district parks of minimum 5 hectares), there would be an expected increase in the proportion of people within 1.6 km achieving sufficient activity levels of 6 per cent. A somewhat lower impact would be expected for substantial changes to upgrade existing large areas of open space
  - for major augmentations to **smaller local parks** to make them more attractive, there would be an expected 6 per cent increase in the share of people undertaking some walking. This would apply to a smaller catchment, as the study indicated it was only the nearest park. Hence, a catchment of 400 metres is recommended[18]
- for other green infrastructure and public space, there does not appear to be sufficient evidence to measure the changes in physical activity resulting from these investments in any general way. Evidence is mixed that some open space, such as small parks, have any impact. If there are estimates of visitors, then this could be used by multiplying this by a typical time spent, and then adjust this to a per km basis[19]. The level of substitution versus additional activity is a key area of uncertainty.

[17] NZTA 2020, Monetised benefits and costs manual, https://www.nzta.govt.nz/assets/resources/monetised-benefits-and-costs-manual/Monetised-benefits-and-costs-manual.pdf, Section 4.2. Note that TfNSW will replace this approach by an activity-based model when this has been developed.

[18] These estimates are based on adjusting the logs ratio from Sugiyama et al to the mean level of activity for statistically significant estimates.

[19] Commonwealth Department of Health website, accessed October 2021, https://www1.health.gov.au/internet/main/publishing.nsf/Content/health-pubhlth-strateg-phys-act-guidelines

### Box 3.3. Typical green infrastructure and public space benefits

TfNSW has used a method to calculate additional future demand based on the New Zealand Transport Agency (NZTA). The main steps to calculate future demand and benefits relative to the base case of no active transport infrastructure include:

1. Calculating catchment areas (400, 800 and 1,600m) around the proposed active transport link.
2. Calculating the population in these catchments by combining the buffers with travel zone data. Therefore, the benefits will depend on the staging of the infrastructure development and the forecasted population in any given year and buffer zone.
3. Applying the parameter estimates of NZTA for each buffer zone. These parameter estimates are multipliers of the likelihood of new daily cyclist for each catchment area . For example, the likelihood for the population living 400 to 800m away from the active transport infrastructure is 0.54, i.e., 54 percent of the population within this catchment is likely to use cycling path on a daily basis.
4. Applying the mode share for cycling and walking from the household travel survey.

This would then provide estimates of additional walking and cycling to which values would be applied.

Note this methodology does not estimate substitution from other activities. If users substitute from active transport for other forms of exercise the health benefit will be overstated.

## 3.2 Determining the change in the quantity of physical activity

Once an estimate of the change in physical activity has been developed, there are a range of sources for understanding, quantifying, and valuing the health impacts.

- The TfNSW Guidelines for cost benefit analysis set out parameters related to the additional kilometres of walking and cycling.[20]
  - For cycling, the range noted is $0.072 per km to $1.309 per km, with a recommended value of $1.22 per km (2019 dollars).
  - For walking, the range noted is $0.439 per km to $2.435 per km, with a recommended value of $1.83 per km (2019 dollars).

The TfNSW Guidelines do not specify what the health costs comprise in terms of costs to the individual or to the public health system.

- IPART has estimated that the external benefits of walking and cycling (only accounting for the external costs of healthcare) are $0.189 and $0.095 (2014/15$) per km respectively. It has suggested that total values including health are not suitable for measuring the external benefits of active transport, because they rely on evidence which aggregates the private

[20] TfNSW (2020), Economic parameter values, June 2020 Version 2.0, https://www.transport.nsw.gov.au/system/files/media/documents/2020/200527%20-%20TfNSW%20Economic%20Parameter%20Values%20v2.0.pdf.

benefit of reduced mortality and morbidity and in some cases do not consider the healthcare costs at all.[21]

- NSW Health has developed a NSW Active Transport Health Model. The reference case scenarios for this indicate a value of $5.42 per additional walking km and $1.47 per additional cycling km. This uses a 3 per cent discount rate for future health outcomes and a 7 per cent rate for health system costs. Only a very small share of these costs are public health system costs (around 3 cents for walking)
- The Australian Transport Assessment and Planning (ATAP) guidelines set out mortality/morbidity and health system costs related to active transport.[22] Their recommended values are:
  - for walking, a mortality/morbidity cost of $1.81 per km and health system cost of $0.97 per km (2013$)
  - for cycling, a mortality/morbidity cost of $0.89 per km and health system cost of $0.48 per km (2013$)

These benefit estimates do not include any productivity impacts, as the study on which they are based found insufficient evidence of a positive impact of active transport on sick days.

Where estimates of additional kilometres of physical activity in terms of kilometres are not available, an alternative is to use estimates of additional use and time spent doing physical activity and relate this to guidelines for amounts of moderate activity. This approach was used in Varcoe et. al. 2015.23 To apply a value to this approach, ATAP provides estimates of the cost of physical activity as set out in Table 3.1, for:

- inactive – Shifting the inactive group into some moderate physical activity has most benefits in terms of reduced morbidity and mortality. This group can receive full annual benefits by walking at 5 km per hour for 30 minutes, five days per week.
- insufficiently active – The insufficiently active group can receive most of the health benefits of increased activity, even though they already engage in some moderate activity. An additional 20 minutes' physical activity per day for five days per week is required.
- sufficiently active – The sufficiently active group may receive ongoing health benefits and encouragement to maintain physical activity.

[21] IPART (2014), Review of external benefits of public transport, Draft Report, December 2014, p. 57, https://www.ipart.nsw.gov.au/Home/Industries/Transport/Reviews/External-Benefits-of-Public-Transport/External-Benefits-for-Public-Transport/16-Dec-2014-Draft-Report/Draft-Report-Review-of-external-benefits-of-public-transport-December-2014.

[22] ATAP (2016), M4 Active Travel, https://www.atap.gov.au/sites/default/files/m4_active_travel.pdf. Note that these guidelines are being revised in 2023.

[23] Varcoe, T., Betts O'Shea, H. and Contreras, Z. (2015), Valuing Victoria's Parks Accounting for ecosystems and valuing their benefits: Report of first phase findings, https://www.forestsandreserves.vic.gov.au/__data/assets/pdf_file/0027/57177/Valuing-Victorias-Parks-Report-Accounting-for-ecosystems-and-valuing-their-benefits.pdf.

Table 3.1 Benefits for increasing activity for people at different activity levels

| Type of cost | Inactive $/person (2021) | Insufficiently active $/person (2021) | Sufficiently active $/person (2021) |
|---|---|---|---|
| Mortality/morbidity | 1,730 | 1,470 | 259 |
| Health system costs | 929 | 789 | 139 |
| Total | 2,658 | 2,260 | 399 |

Source: ATAP (2016), M4 Active Travel, https://www.atap.gov.au/sites/default/files/m4_active_travel.pdf, inflated to 2021$ applying AIWH Total Health Price Index.

## 3.3 Health impacts that are not accounted for in use and amenity valuations

Increased physical activity may improve how individuals feel (which would be reflected in the use value of public open space infrastructure), but also results in benefits that are not taken into account by an individual. The dividing line between benefits that people factor into their decisions and value as part of use and benefits that are public is not clear. For example:

- many people will factor in how physical activity contributes to their overall health and wellbeing, and this is a major driver for people undertaking physical activity
- people are unlikely to factor in costs related to the public health system incurred as a result of any illness or injury
- people may or may not factor in productivity related impacts of their health, such as number of days off work
- people will likely factor in how their health impacts on their mortality, although whether this is accurately and fully accounted for is not known.

Use and amenity benefits are measured in the framework as set out in other chapters. It is therefore important that health impacts that are already implicitly included within use and amenity values are not double counted for public open space. Given this, and because of the lack of a NSW-specific value, the framework recommends using the ATAP health system costs per km of:

- $0.97 per km of additional walking, inflated to $1.13 in 2021$
- $0.48 per km of additional cycling, inflated to $0.56 in 2021$

The inflation has used the Australian Institute of Health and Welfare’s (AIHW) annual national composite health cost index, as recommended by ATAP.

When NSW-specific parameters are approved that relate to external health costs for active transport, then the guidance would be adjusted to use those.

Where a project is unable to estimate kilometres of walking and cycling, the recommended approach is to apply the health system costs related to levels of inactivity from ATAP (as shown in the previous section), applied to estimated impacts on activity levels. These are:

- $929 per person for moving a person from inactive to sufficiently active
- $789 per person for moving a person from insufficiently active to sufficiently active
- $139 per person for additional activity for people who are already sufficiently active.

Note that the ABS has estimates of the amount of people in these different groups.[24]

The main disadvantage of the ATAP estimates is that there is no consideration of the timing of activity and resultant health system costs. For example, it may take years for a lack of activity to lead to costs related to managing disease associated with this.

## 3.4 Recommended approaches and values

There are three recommended methods for estimating health benefits that could be used based on the available literature, as set out above. These methods are summarised below.

**Method 1: Per km method**

- Measure the amount of additional kilometres of walking and cycling expected as a result of the project.
- Apply values for the health system costs avoided as a result of additional activity of $1.13 per additional km of walking and $0.56 per additional km of cycling (in 2021$). These health values assume use values are being measured separately.
- This approach is most applicable to active transport infrastructure within green infrastructure (or active transport infrastructure in general).

**Method 2: Visitation-based method**

- Measure the amount of expected use (or change in use) of the public space in terms of number of visits.
- Apply an estimate of the average time spent doing moderate intensity exercise per visit.
- Apply a factor for how much of the activity is additional. This will be high where there are few alternatives and low where there are many alternatives. At this stage there is not sufficient guidance on additionality.
- Convert additional minutes of activity into a walking equivalent kilometres, based on 5 kilometres per hour of activity.
- Apply the values for Method 1 of $1.13 (in 2021$) per additional km of walking to the walking equivalent kilometres.
- This approach is applicable if estimates of use are available, such as for new or improved protected areas.

**Method 3: Catchment-based method**

- Measure the population within the catchment of the asset (1.6 km for large parks and 400 metres for local parks).
- For each person for which the project provides the following, use expected impacts as follows:
  - for a new large regional-level park (such as Parramatta Park, Centennial Park, Sydney Park, Bicentennial Park, or smaller high quality regional parks of at least 5 hectares), an increase in the proportion of people within 1.6 km achieving sufficient activity levels of 6 per cent. A

[24] ABS Physical activity 2017-18, https://www.abs.gov.au/statistics/health/health-conditions-and-risks/physical-activity/2017-18.

somewhat lower impact would be expected for substantial changes to upgrade existing large areas of open space

  – for major augmentations to smaller parks to make them more attractive, a 6 per cent increase in the share of people undertaking some walking (i.e. moving from inactive to insufficiently active). This would apply to a smaller catchment, as the study indicated it was only the nearest park. Hence, the framework suggests a catchment of 400 metres[25]

- Apply values of:
  – $929 per person (in 2021$) for moving a person from inactive to sufficiently active
  – $789 per person for moving a person from insufficiently active to sufficiently active
  – The above two values would be applied as a weighted average for the change in people becoming sufficiently active from a new large-regional level park. Based on the 2017-18 Health Survey data (Table 3.3) the weighted average value is $828 per person achieving sufficient activity levels.[26]
  – $139 per person for moving from inactive to insufficiently active. This would be applied to the 6 per cent of people undertaking some walking
  – These health values assume use values are being measured separately.
- This approach is applicable for projects that substantially increase the attractiveness of parks or put in a new attractive large park.
- These health values are from ATAP guidance[27] and assume use values related to recreational benefits are being measured separately. Note that ATAP guidance on values are currently being reconsidered. If these change then updated ATAP values should be used.

### Table 3.2 Proportions of population by physical activity level — Australian 2017-18

| Level of activity | Minutes of physical activity per week | Total 15 years and over Proportion of total population | Share of inactive and insufficiently active population Proportion of sub-population |
|---|---|---|---|
| Inactive | 0 minutes | 14.3 | 38 |
| Insufficiently active | Between 1 and 149 minutes | 23.4 | 62 |
| Sufficiently active | Over 150 minutes | 61.7 | NA |
| Not stated/not known | | 0.6 | NA |
| Total | | 100.0 | 100 |

Source: ABS, 2018, National Health Survey: First Results, 2017-18 — Australia. Table 13 Physical activity — Australia. https://www.abs.gov.au/statistics/health/health-conditions-and-risks/national-health-survey-first-results/latest-release

[25] These estimates are based on adjusting the log ratio from Sugiyama et al to the mean level of activity for statistically significant estimates.

[26] $808 per person is the weighted average value based on shares of the inactive and insufficiently active sub-population, 38 per cent inactive and 62 per cent insufficiently active.

[27] ATAP 2016, M4: Active Travel, https://www.atap.gov.au/sites/default/files/m4_active_travel.pdf, p. 37-38.

# 4 Air quality

Green infrastructure and public open space can lead to improvements in air quality. This has a value because poor air quality leads to health impacts for people.

To measure the magnitude of these benefits, how much green infrastructure and public open space improve air quality and how much people value changes in air quality needs to be understood.

Calculating the value of improved air quality will require:

- identifying the quantifiable reduction in air pollution attributable to trees
- selecting an appropriate valuation approach.

## 4.1 Quantifiable reductions in air pollution from trees

Trees directly influence air quality by:

- capturing pollutants on the plant surface
- absorbing gaseous pollutants (e.g. ozone and nitrogen dioxide) into the leaf
- resuspending particles into the atmosphere that were captured on the plant surface. Nowak et al. (2013) note that vegetation is only a temporary retention site for many atmospheric particles that are likely to be resuspended to the atmosphere, washed off by rain, or dropped to the ground with leaf and twig fall[28]
- emitting particles (e.g. pollen)
- disrupting the dispersion of pollution as a result of wind systems. Vegetation can result in increased local pollution concentrations where it reduces the ventilation that is responsible for diluting emitted pollution, for instance along roads.[29] This negative impact may be larger than the positive air quality benefits of trees and depends on the type of vegetation (low vegetation tends to improve air quality, while porous vegetation has a smaller impact on air flow) and its positioning.[30]

Irga (2007) examined whether higher concentrations of urban forestry in Sydney is associated with quantifiable effects on ambient air pollutant levels, whilst accounting for variations in pollutant concentrations.[31] Key findings were:

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[28] Nowak, D.J., Hirabayashi, S., Bodine, A., Hoehn, R., (2013), 'Modelled PM2.5 removal by trees in ten U.S. cities and associated health effects', Environmental Pollution, Vol. 178, pp. 395-402, https://doi.org/10.1016/j.envpol.2013.03.050.

[29] Vos, E., Maiheu, B., Vankerkom, J. and Janssen, S. (2013), 'Improving air quality in cities: To tree or not to tree?', Environmental Pollution, Vol. 183, pp. 113-122, https://doi.org/10.1016/j.envpol.2012.10.021.

[30] Janhäll, S. (2015), 'Review on urban vegetation and particle air pollution – Deposition and dispersion', Atmospheric Environment, Vol. 105, pp. 130-137, https://doi.org/10.1016/j.atmosenv.2015.01.052.

[31] Irga, P.J., Burchett, M.D., Torpy, F.R, (2015), 'Does urban forestry have a quantitative effect on ambient air quality in an urban environment?'¸Atmospheric Environment, Vol. 120, pp. 173-181, https://doi.org/10.1016/j.atmosenv.2015.08.050.

- all fractions of Particulate Matter ($PM_x$) were significantly negatively correlated with green infrastructure in Sydney, with increasing green infrastructure associated with decreasing particulate matter, even when meteorological and traffic density are taken into account
- no observable trends in concentrations of Nitrogen Oxides (NOX), Total Volatile Organic Compounds (TVOC) and Sulphur Dioxide (SO2) were observed, as recorded levels were generally very low across all sampled areas.32

NSW Health notes that:

- $PM_{10}$ (particles with a diameter of 10 micrometres or less) — these particles are small enough to pass through the throat and nose and enter the lungs. Once inhaled, these particles can affect the heart and lungs and cause serious health effects
- $PM_{2.5}$ (particles with a diameter of 2.5 micrometres or less) — these particles are so small they can get deep into the lungs and into the bloodstream. There is sufficient evidence that exposure to $PM_{2.5}$ over long periods (years) can cause adverse health effects. Note that $PM_{10}$ includes $PM_{2.5}$.[33]

Nowak et al. (2006) modelled the change in $PM_{10}$ due to urban trees within 55 cities across the United States. Across the 55 cities, the reduction of $PM_{10}$ ranged between 1.1 and 8.0 grams per square metre per year, with an average reduction rate of 3.8 grams per square metre per year (Table 4.1). In a later study (2013) they examined $PM_{2.5}$, with impacts also shown in Table 4.1. These are average impacts for urban tree cover. Variation occurs because trees have different amounts of leaf cover — for example, taller denser trees will capture more pollution.

### Table 4.1 Modelled reduction rates of particulate matter due to urban trees

| Range in estimate $PM_x$ reduction | $PM_{10}$ g/m$^2$/yr | $PM_{2.5}$ g/m$^2$/yr |
|---|---|---|
| Minimum | 1.1 | 0.13 |
| Average | 3.8 | 0.25 |
| Maximum | 8.0 | 0.36 |

Note: Measured grams of pollutant per square metre of tree cover per year.

Source: $PM_{10}$ results sourced from Nowak, D.J., Crane, D.E., Stevens, J.C., 2006, Air pollution removal by urban trees and shrubs in the United States, Urban Forestry and Urban Greening 4 (2006) 115-123. $PM_{2.5}$ results sourced from Nowak, D.J., Hirabayashi, S., Bodine, A., Hoehn, R., 2013, Modelled $PM_{2.5}$ removal by trees in ten U.S. cities and associated health effects, Environmental Pollution 178 (2013) 395-402.

The reduction rates in Table 4.1 should be used to estimate the value of air pollution abatement services provided by urban trees in NSW. Only the value for $PM_{2.5}$ should be used, of a 0.25 grams per m$^2$ per year reduction in $PM_{2.5}$, as $PM_{2.5}$ is the part of $PM_{10}$ that has the majority of human health impacts.

Trees provide the greatest air pollution abatement service when they are:

- located near pollution sources — higher pollution concentrations result in higher reduction rates of pollution by urban trees (assuming maximum deposition thresholds are not reached).

[32] Irga, P.J., Burchett, M.D., Torpy, F.R, (2015), 'Does urban forestry have a quantitative effect on ambient air quality in an urban environment?',Atmospheric Environment, Vol. 120, pp. 173-181, https://doi.org/10.1016/j.atmosenv.2015.08.050.

[33] NSW Health website, accessed October 2021, https://www.health.nsw.gov.au/environment/air/Pages/particulate-matter.aspx.

For example, trees near roads will capture more pollution on leaf surfaces, although as noted above, trees may also have other effects on the ability of wind to disperse pollution

- located in areas where there is a larger population — positive health benefits result when the population is exposed to lower ambient air concentrations than otherwise.

This suggests only including tree canopy cover within urban areas. Whether to include tree canopy in bushland within urban areas is not overly clear. Whether there are impacts from shrub and grass cover is also not clear and the specific rates to apply are not known. For simplicity of use, all tree cover within a significant urban area should be included and no impacts included for other forms of greenery.

The quantity of particulate matter deposition to vegetation varies by:

- pollutant size and local ambient pollutant concentrations
- type, size and age of vegetation which influence the leaf area index
- local meteorological conditions (e.g. wind).

The error ranges for these variables determining deposition can be substantial. For example, deposition velocities for $PM_{10}$ to vegetation have been reported to vary by about 3 orders of magnitude.[34] Across the US cities examined in Nowak 2013, the difference was less significant, as shown in Table 4.1.

The alternative to using an average figure such as above is to estimate the air pollution changes using specific modelling or relationships embedded in tools such as i-Tree. This allows for greater accuracy because of the more detailed relationships such as height of trees and density of leaf matter.[35]

## 4.2 Valuing air pollution reduction from trees

The two approaches to estimate the economic value of changes in air quality are the impact pathway approach and the damage cost approach.

### 4.2.1 Impact pathway approach

The impact pathway approach is the most robust valuation approach as it estimates the economic value of impacts associated with changes in ambient air concentrations. The approach follows the pathway from emissions to cost via ambient air quality concentrations, population exposure, and morbidity and mortality health impacts.

The key steps in the impact pathway approach for particulate matter are emission, dispersion, population exposure, impact and then economic valuation (Figure 4.1).

**Figure 4.1 The impact pathway approach for particulate matter**

[34] Litschke, T, Kuttler, W. (2008), 'On the reduction of urban particle concentration by vegetation – a review', Meteorol. Zeit. Vol. 17, pp. 229-240, as sourced in Pugh, T., MacKenzie, A.R., Whyatt, J.D., Hewitt, C.N., (2012), 'Effectiveness of Green Infrastructure for Improvement of Air Quality in Urban Street Canyons', Environ. Sci. Technol, Vol. 46, pp. 7692-7699, https://doi.org/10.1021/es300826w.

[35] I-Tree tool documentation, https://www.itreetools.org/documents/650/Understanding_i-Tree.gtr_nrs200.pdf

| Burden | Dispersion | Exposure | Impact | Damage |
| --- | --- | --- | --- | --- |
| Pollutant emissions | The spread of pollution around the source, and its chemical transformation in the environment | The extent to which the population at risk is exposed to imposed burdens | Impacts on the number of premature deaths, ill health, lost crop production, ecological risk etc | Monetary equivalent of each impact |

Data source: Data source: European Environmental Agency, 2014, Costs of air pollution from European industrial facilities 2008-2012 – an updated assessment, https://www.eea.europa.eu/publications/costs-of-air-pollution-2008-2012.

The impact pathway approach is resource intensive and mostly used for setting air quality standards.[36]

### 4.2.2 Damage cost approach

The damage cost approach applies unit damage costs per tonne of emissions. This approach is less resource intensive than the full 'impact pathway' approach and as such has been used in Australia to evaluate policies and measures that change the quantity of emissions.[37]

The full impact pathway approach can be used to estimate a robust set of unit damage costs, based on location-specific inputs and data, which are subsequently used to evaluate projects, policies and measures.[38] This exercise has been undertaken in many countries and jurisdictions, but as noted by PAEHolmes (2013), damage costs based on the full impact pathway approach have not been estimated for Australian jurisdictions. Rather damage costs used for appraisal in Australia have been transferred from overseas studies.

Damage costs are typically drawn from studies on the health impacts of different pollutants. It is then a matter of undertaking benefit transfer of estimates from other studies to the relevant region and industry.

Potential sources for the value of pollution abatement are shown in Table 4.2.

[36] PAEHolmes, (2013), Methodology for valuing the health impacts of changes in particle emissions final report. Prepared for NSW Environment Protection Authority (EPA), https://www.epa.nsw.gov.au/~/media/EPA/Corporate%20Site/resources/air/HealthPartEmiss.ashx.

[37] PAEHolmes, (2013), Methodology for valuing the health impacts of changes in particle emissions final report. Prepared for NSW Environment Protection Authority (EPA), https://www.epa.nsw.gov.au/~/media/EPA/Corporate%20Site/resources/air/HealthPartEmiss.ashx.

[38] National Environment Protection Council, (2014), Draft variation to the National Environment protection (Ambient Air Quality) Measure: Impact Statement, https://www.awe.gov.au/environment/protection/nepc/nepms/ambient-air-quality/variation-2014/impact-statement.

Table 4.2 Possible sources for damage costs

| Study | Coverage |
|---|---|
| PAE Holmes 2013, *Methodology for valuing the health impacts of change in particle emissions*, Final report, prepared for NSW EPA. | This study was prepared for NSW EPA, with estimates based on translating UK work into an Australian context. The focus is on urban areas. |
| European Environmental Agency, 2014, *Costs of air pollution from European industrial facilities 2008-2012 – an updated assessment.* | Most pollutants |
| ACIL Allen Consulting 2013 (Kulkarni and Boulter), *Load based licence fee comparison,* prepared for NSW EPA. | NOx, VOCs, $PM_{2.5/10}$, coarse particulates, NSW |
| NSW DPE Guidelines for environmental impacts of mining and coal seam gas 2015 http://planspolicies.planning.nsw.gov.au/index.pl?action=view_job&job_id=7312 | This provides calculators for the cost of air pollution from mining, drawing on the methodology of PAE Holmes 2013 |
| ENVALUE database 1995, http://www.environment.nsw.gov.au/envalueapp/ | This provides estimates from a range of previous studies on the cost of air pollution. The studies are generally older, and would need to be augmented by a review of more recent evidence. |
| European Environment Agency 2011, *Revealing the costs of air pollution from industrial facilities in Europe,* Technical report. | Most pollutants |
| Other issues in benefit transfer | Developing appropriate benefit transfer techniques accounting for population density and pollutant differences (for example, often one pollutant is used as a summary indicator for a range, while the actual relationships will be different — e.g., $PM_{2.5/10}$ ratios) |

Source: As noted in table.

The most relevant to pollution reductions from trees and other public open spaces are from PAEHolmes (2013) study, prepared for NSW EPA. In the study, PAEHolmes recommended appraisal of air quality impacts from projects be based on the change in pollutant emissions. Although impacts to human health and the environment is more closely linked to changes in ambient air quality, PAEHolmes recommend an 'emissions based' approach for appraisal of projects due to lack of sufficient and readily available PM emission modelling information to undertake a full impact pathway process.[39]

PAEHolmes estimated unit damage costs by transferring existing estimates from a UK study based on transport emissions[40] and adjusted for population density to estimate unit damage costs weighted for population exposure for each Significant Urban Area (SUA). The local population density is a critical variable. Emission reduction in a densely populated area will have a greater relative health benefit than an equivalent reduction in a less densely populated area.

The damage costs account for variation in population density across significant urban areas. This varies from $280 000 per tonne in Sydney to $8400 per tonne in Camden Haven (Table 4.3).

[39] PAEHolmes, (2013), Methodology for valuing the health impacts of changes in particle emissions   final report. Prepared for NSW Environment Protection Authority (EPA), https://www.epa.nsw.gov.au/~/media/EPA/Corporate%20Site/resources/air/HealthPartEmiss.ashx.

[40] Defra, 2012, Air Quality Damage Costs. Published by Defra. Current damage cost values published at: https://www.gov.uk/government/publications/assess-the-impact-of-air-quality/air-quality-appraisal-damage-cost-guidance with a guidance document on the use of the damage costs at: http://archive.defra.gov.uk/environment/quality/air/airquality/panels/igcb/documents/damagecost-guidance.pdf

### Table 4.3 Damage cost estimates for PM2.5 by significant urban area (2013)

| SUA code | Significant urban area | Area<br>km$^2$ | Population<br>2011 data | Population density<br>No./km$^2$ | Damage cost/tonne of $PM_{2.5}$<br>2011$ |
|---|---|---|---|---|---|
| 1030 | Sydney | 4,064 | 4,028,525 | 991 | 280,000 |
| 1009 | Central Coast | 566 | 304,755 | 538 | 150,000 |
| 1035 | Wollongong | 572 | 268,944 | 470 | 130,000 |
| 1027 | Port Macquarie | 96 | 41,722 | 433 | 120,000 |
| 1013 | Forster - Tuncurry | 50 | 19,501 | 394 | 110,000 |
| 1023 | Newcastle - Maitland | 1,019 | 398,770 | 391 | 110,000 |
| 1014 | Goulburn | 65 | 21,485 | 332 | 93,000 |
| 1003 | Ballina | 73 | 23,511 | 320 | 90,000 |
| 1018 | Lismore | 89 | 28,285 | 319 | 89,000 |
| 1016 | Griffith | 56 | 17,900 | 317 | 89,000 |
| 1033 | Ulladulla | 47 | 14,148 | 303 | 85,000 |
| 1010 | Cessnock | 69 | 20,262 | 294 | 82,000 |
| 1034 | Wagga Wagga | 192 | 52,043 | 272 | 76,000 |
| 1025 | Orange | 145 | 36,467 | 252 | 71,000 |
| 1022 | Nelson Bay - Corlette | 116 | 25,072 | 217 | 61,000 |
| 1012 | Dubbo | 183 | 33,997 | 186 | 52,000 |
| 1017 | Kurri Kurri - Weston | 91 | 16,198 | 179 | 50,000 |
| 1015 | Grafton | 106 | 18,360 | 173 | 48,000 |
| 1004 | Batemans Bay | 94 | 15,732 | 167 | 47,000 |
| 1024 | Nowra - Bomaderry | 202 | 33,340 | 165 | 46,000 |
| 1029 | St Georges Basin - Sanctuary Point | 77 | 12,610 | 164 | 46,000 |
| 1031 | Tamworth | 241 | 38,736 | 161 | 45,000 |
| 1005 | Bathurst | 213 | 32,480 | 152 | 43,000 |
| 1032 | Taree | 187 | 25,421 | 136 | 38,000 |
| 1001 | Albury - Wodonga | 628 | 82,083 | 131 | 37,000 |
| 1011 | Coffs Harbour | 506 | 64,242 | 127 | 36,000 |
| 1028 | Singleton | 127 | 16,133 | 127 | 36,000 |
| 1007 | Broken Hill | 170 | 18,519 | 109 | 30,000 |
| 1019 | Lithgow | 120 | 12,251 | 102 | 29,000 |
| 1006 | Bowral - Mittagong | 422 | 34,861 | 83 | 23,000 |
| 1002 | Armidale | 275 | 22,469 | 82 | 23,000 |
| 1020 | Morisset - Cooranbong | 341 | 21,775 | 64 | 18,000 |
| 1026 | Parkes | 235 | 10,939 | 47 | 13,000 |
| 1021 | Muswellbrook | 262 | 11,791 | 45 | 13,000 |
| 1008 | Camden Haven | 525 | 15,739 | 30 | 8,400 |
| 1000 | Not in any Significant Urban Area (NSW) | 788,116 | 999,873 | 1 | 360 |

Note: PAEHolmes note that the unit damage costs should not applied to significant urban areas with less than 10,000 people.
Source: PAEHolmes, 2013, Methodology for valuing the health impacts of changes in particle emissions - final report, for NSW EPA.

These estimates have been updated to 2022 dollars in Table 4.4, through using data on changes in population density, consumer price inflation and changes in GDP per capita. Note some significant urban areas have also changed.

### Table 4.4 Updated estimates of damage cost for PM2.5

| Significant urban area | Population density (Updated 2021)<br><br>No./km$^2$ | Damage cost/tonne of $PM_{2.5}$ (Updated 2021)<br><br>2022$[41]/tonne |
|---|---|---|
| Sydney | 1,128 | 434,000 |
| Central Coast | 591 | 224,000 |
| Wollongong | 528 | 199,000 |
| Port Macquarie | 510 | 193,000 |
| Forster - Tuncurry | 432 | 164,000 |
| Newcastle - Maitland | 394 | 151,000 |
| Goulburn | 375 | 143,000 |
| Ballina | 352 | 135,000 |
| Lismore | 323 | 123,000 |
| Griffith | 363 | 139,000 |
| Ulladulla | 350 | 134,000 |
| Wagga Wagga | 295 | 112,000 |
| Orange | 283 | 109,000 |
| Nelson Bay | 246 | 94,000 |
| Dubbo | 209 | 80,000 |
| Grafton | 178 | 67,000 |
| Batemans Bay | 173 | 66,000 |
| Nowra - Bomaderry | 190 | 72,000 |
| St Georges Basin - Sanctuary Point | 173 | 66,000 |
| Tamworth | 180 | 68,000 |
| Bathurst | 176 | 68,000 |
| Mudgee | 178 | 68,000 |
| Taree | 141 | 54,000 |
| Albury - Wodonga | 152 | 59,000 |
| Coffs Harbour | 144 | 56,000 |
| Singleton | 126 | 49,000 |
| Broken Hill | 99 | 37,000 |
| Lithgow | 112 | 43,000 |
| Bowral - Mittagong | 96 | 36,000 |
| Armidale | 88 | 34,000 |

[41] Indexed using consumer price index.

| Significant urban area | Population density (Updated 2021)<br><br>No./km$^2$ | Damage cost/tonne of $PM_{2.5}$ (Updated 2021)<br><br>2022$[41]/tonne |
|---|---|---|
| Kempsey | 76 | 29,000 |
| Morisset - Cooranbong | 75 | 29,000 |
| Parkes | 47 | 18,000 |
| Muswellbrook | 47 | 19,000 |
| Camden Haven | 34 | 13,000 |
| Not in any Significant Urban Area (NSW) | 2 | 1,000 |

There are damage costs associated with other pollutants, which tend to be smaller on a per tonne basis. For example:

- NOX has one seventh the impact of $PM_{2.5}$
- Sulphur Oxides (SOX) has one fifteenth the impact of $PM_{2.5}$
- VOCs has one 23rd the impact of $PM_{2.5}$.[42]

These have not been included as the impacts of trees on these pollutants is not available. These would be expected to be smaller than the benefits related to avoided particulates.

As a comparison to the above pollutant costs, Tapsuwan et al use, for their assessment of pollution reduction impacts from trees in the ACT, a value of $22 per metric tonne for carbon monoxide, $4,300 per metric tonne of ozone, $641 per metric tonne of nitrogen dioxide, $234 per metric tonne of sulphur dioxide, and $149,365 per metric tonne of ($PM_{2.5}$).[43] The PM2.5 value is 36 per cent of the value for Sydney recommended above.

## 4.3 Recommended approaches and values

The recommended air pollution reduction benefit per m$^2$ of tree canopy per year is shown in Table 4.5, based on:

- a 2013 study on the costs of particulates to different significant urban areas of NSW, using a damage cost approach that estimates a cost per tonne of pollutants. This was updated to reflect 2021 urban densities, GDP per capita and prices
- a reduction of 0.25 grams of $PM_{2.5}$ per m$^2$ of tree canopy per year based on the average reduction in air pollution estimated for trees across a selection of US cities.

The recommended values do not account for specific project-related factors that may increase or decrease the air pollution effects. For example, trees within close proximity to a road may reduce

[42] The damage costs for NOX and VOCs are estimated by applying the relative ratio of damage costs for these pollutants relative to PM2.5 as estimated by EEA (2014) to the PM2.5 damage cost estimated by PAE Holmes (2013). The damage cost for SOx is estimated as one fifteenth of the damage cost for PM2.5 based on EPA's pollutant weighting. European Environmental Agency, 2014, Costs of air pollution from European industrial facilities 2008-2012 – an updated assessment.

[43] Tapsuwan, S., R. Marcos - Martinez, and H. Schandl 2019, An environmental - economic accounting of services provided by the living infrastructure in the ACT: public urban forests and irrigated open spaces, Final report, prepared for ACT Government, 13 November 2019, p. 34, https://www.environment.act.gov.au/__data/assets/pdf_file/0011/1537661/environmental-economic-accounting-living-infrastructure.pdf.

$PM_{2.5}$ by larger amounts, or trees that are configured in different way may have more or less of a benefit in term of air pollution. There is the potential for further work related to distance of air pollution dispersal and specific location of trees in terms of impact on pollution removal.

### Table 4.5 Recommended parameter values to apply to canopy cover

| Significant urban area | Value per $m^2$ of tree canopy<br><br>$/$m^2$/year<br>2022$ |
|---|---|
| Greater Sydney | 0.109 |
| Central Coast | 0.056 |
| Wollongong | 0.050 |
| Port Macquarie | 0.048 |
| Forster - Tuncurry | 0.041 |
| Newcastle - Maitland | 0.038 |
| Goulburn | 0.036 |
| Ballina | 0.034 |
| Lismore | 0.031 |
| Griffith | 0.035 |
| Ulladulla | 0.034 |
| Wagga Wagga | 0.028 |
| Orange | 0.027 |
| Nelson Bay | 0.024 |
| Dubbo | 0.020 |
| Grafton | 0.017 |
| Batemans Bay | 0.017 |
| Nowra - Bomaderry | 0.018 |
| St Georges Basin - Sanctuary Point | 0.017 |
| Tamworth | 0.017 |
| Bathurst | 0.017 |
| Mudgee | 0.017 |
| Taree | 0.014 |
| Albury - Wodonga | 0.015 |
| Coffs Harbour | 0.014 |
| Singleton | 0.012 |
| Broken Hill | 0.009 |
| Lithgow | 0.011 |
| Bowral - Mittagong | 0.009 |
| Armidale | 0.009 |
| Kempsey | 0.007 |
| Morisset - Cooranbong | 0.007 |
| Parkes | 0.005 |

| Significant urban area | Value per $m^2$ of tree canopy<br><br>$/$m^2$/year<br>2022$ |
|---|---|
| Muswellbrook | 0.005 |
| Camden Haven | 0.003 |
| Not in any Significant Urban Area (NSW) | 0.0003 |

Note: The figures in this table are the estimates from Table 4.4 multiplied by the amount of pollution reduction per $m^2$ of tree canopy of 0.25 grams.

# 5 Biodiversity

Biodiversity encompasses the variety of plant and animal life in a particular area. The term includes diversity of genes, species and ecosystems.[44] Natural systems (both terrestrial and aquatic) support a range of productive functions including food, water, and life support systems. The benefits people obtain from biodiversity are defined as ecosystem services and include:

- provisioning services — material or energetic outputs from ecosystems, including food, water and other resources
- regulating services — mechanisms that regulate the biotic and abiotic environment, including climate, flood, and disease control etc.
- cultural service — non-material benefits, such as spiritual, recreational, and cultural gains, and
- supporting services — that maintain the conditions for life on Earth, such as nutrient cycling and primary productivity.[45]

## 5.1 Biodiversity impacts from green infrastructure

The physical impacts of green infrastructure on biodiversity as a whole are not well understood in the literature, however studies have focused on particular aspects of biodiversity.[46] The provision of urban green infrastructure can enhance biodiversity through planting of diverse plant species which provide habitat and support ecosystems. However, it is worth noting that new green infrastructure may reduce biodiversity, for example when native vegetation is replaced with green infrastructure which has less biodiversity (e.g. open grass areas). Careful consideration should be given to each individual project, to determine whether this benefit is applicable.

Biophysical modelling is used to estimate the environmental outputs that result from changes in either the quantity and/or quality of environmental assets. For example, biophysical modelling can estimate the environmental outputs that are likely to result from improved wetland management. Biophysical modelling is also important to estimate impacts that may cause permanent and/or irreversible change.

Environmental outputs are specified in a range of metrics, however there is no single metric which measures changes in biodiversity in its entirety. For the purpose of economic evaluation, the metrics

[44] Pearce, D. and Moran, D., (1994), The economic value of biodiversity, IUCN – The World Conservation Union, https://www.cbd.int/financial/values/g-economicvalue-iucn.pdf.

[45] Millennium Ecosystem Assessment Board, 2005, Ecosystems and human wellbeing: Biodiversity Synthesis. World Resources Institute, Washington, DC, https://www.millenniumassessment.org/documents/document.356.aspx.pdf.

[46] Bennett, J. 2003, The economic value of biodiversity: a scoping paper, presented to the National Workshop "The Economic Value of Biodiversity" on 22 and 23 October 2003, accessed on 12 September 2016 at https://www.environment.gov.au/resource/economic-value-biodiversity-scoping-paper. This paper is no longer available on this website and can be accessed at the National library of Australia archives at https://pandora.nla.gov.au/.

used to estimate the community's value for biodiversity must align with the metrics used to estimate changes in environmental outputs.

Biodiversity can generate value under three broad categories summarised in Table 5.1.

- Direct use value — Recreational use values include benefits during recreational and tourism activities such as boating, fishing, swimming, bushwalking, picnic and exercising. The benefit of enhanced biodiversity is encapsulated in people's recreational values in Chapter 2. Direct use benefits from the availability of biological resources for pharmaceutical and agricultural products are relevant for certain types of open space, such as national parks and reserves, and are not considered for smaller urban green infrastructure.
- Passive use value — Passive use values from improved air quality, carbon sequestration, and reduced stormwater costs are measured in other chapters. The passive use value of improved water quality (excluding recreational use values from swimming, fishing and boating) from green infrastructure is discussed in this chapter.
- Non-use values — Green infrastructure and public spaces creates indirect benefits which individuals may experience without visiting or interacting with green infrastructure or public spaces. Some sources of non-use value include:
  - Option values – the value to community members of having the option to visit green infrastructure and public spaces in the future
  - Bequest value – the value associated with the knowledge green infrastructure and public spaces will be preserved for future generations
  - Existence value – the benefits gained from knowing green infrastructure and public spaces or biodiversity is conserved.

### Table 5.1 Biodiversity benefit categories

| Benefit category | Benefit description | Treatment in cost benefit analysis framework |
|---|---|---|
| Direct use value | Benefits generated by recreation and tourism activities that are dependent on biological resources | Measured separately in Use Value (Recreational Benefits) |
| | Benefits arising from marketed goods such as agricultural products which are impacted by the diversity and extent of biological resources | Not applicable for urban green infrastructure, but it is applicable for national parks/reserves etc. |
| Passive use value | This includes life support services such as nutrient removal, flood control and climate stabilisation | Passive use values for air quality, carbon sequestration and flood mitigation are measured separately.<br>Passive use values from improved water quality are included in this analysis for biodiversity. |
| Non-use value | The existence value of diverse species and ecosystems | Measured as part of non-use value for biodiversity |
| | Bequest motives, where current generations derive benefit from continuing the availability of a biological resource for future generations | Measured as part of non-use value for biodiversity |
| | Option value (or insurance benefit) that is derived from the protection of a resilient ecological system | Measured as part of non-use value for biodiversity |

Source: Source: Bennett, J. 2003, The economic value of biodiversity: a scoping paper, presented to the National Workshop “The Economic Value of Biodiversity” on 22 and 23 October 2003, accessed on 12 September 2016 at https://www.environment.gov.au/resource/economic-value-biodiversity-scoping-paper. This paper is no longer available on this website and can be accessed at the National library of Australia archives at https://pandora.nla.gov.au/.

## 5.2 Valuing the benefits of biodiversity

Biodiversity has a value because of the services it provides, as well as a non-use value that people place on conservation of biodiversity. This section outlines two approaches to value biodiversity benefits:

- benefit transfer approach — transfers estimated values of biodiversity from previous non-market valuation studies
- replacement cost approach — estimates the value of biodiversity based on the cost of replacing it with a substitute.

Parameter values for both approaches are outlined. Practitioners should present central CBA results applying parameter values using the benefit transfer approach. The benefit transfer approach is the preferred approach in this framework because it is conceptually persuasive compared to the replacement cost approach, despite its limitations, because it attempts to measure the intrinsic value of a change in biodiversity.

Estimates of biodiversity value using the replacement cost approach should be included in sensitivity analysis.

### 5.2.1 Benefit transfer approach

The benefit transfer approach is conceptually persuasive compared to the replacement cost approach, despite some practical limitations, as it attempts to measure the intrinsic value of a change in biodiversity.[47] The benefit transfer approach involves transferring biodiversity benefits estimated from previous studies. The common non market valuation techniques used to estimate values are:

- **Revealed preference techniques**, where values are inferred from observations of people’s actions in markets that are specifically related to the values impacted by biodiversity change (examples include: the production function technique, hedonic pricing techniques and the travel cost method)
- **Stated preference techniques**, where biodiversity values are estimated from a sample of people’s preferences for biodiversity assets (examples include the contingent valuation method and choice modelling).[48]

[47] Bennett, J. 2003, The economic value of biodiversity: a scoping paper, presented to the National Workshop “The Economic Value of Biodiversity” on 22 and 23 October 2003, accessed on 12 September 2016 at https://www.environment.gov.au/resource/economic-value-biodiversity-scoping-paper. This paper is no longer available on this website and can be accessed at the National library of Australia archives at https://pandora.nla.gov.au/.

[48] Bennett, J. 2003, The economic value of biodiversity: a scoping paper, presented to the National Workshop “The Economic Value of Biodiversity” on 22 and 23 October 2003, accessed on 12 September 2016 at https://www.environment.gov.au/resource/economic-value-biodiversity-scoping-paper. This paper is no longer available on this website and can be accessed at the National library of Australia archives at https://pandora.nla.gov.au/.

A practical consideration for non-market valuation studies is linking environmental outputs that can be measured through biophysical modelling to environmental attributes that can be understood and valued by the community.49 Attributes are generally chosen to represent a broader set of positive and negative outputs to understand the trade-offs people are willing to make. For example, the number of native fish may encompass breeding events, spread of invasive animals, and obstruction of fish passages.

Table 5.2 aligns some of the common attributes used in non-market valuation studies to environmental outputs.

### Table 5.2 Aligning biodiversity impacts to attributes included in non-market valuation studies

| Attribute valued in non-market studies | Physical environmental outputs |
|---|---|
| Native fish<br>(either number of species or time to catch a native fish) | life processes triggered (e.g. breeding events and migration)<br>spread of invasive animals and exotic fish species<br>fish deaths and obstruction of fish passages |
| Healthy vegetation<br>(Area of native vegetation in good quality) | changes to soil moisture<br>sedimentation in floodplains or close to river banks<br>seed dispersal and triggering of dormant seeds<br>spread of weed species<br>erosion of rivers and creek beds<br>contamination of soils |
| Native species<br>(Number of native species) | life processes triggered (e.g. breeding events and migration)<br>creation/destruction of breeding habitats |
| Water quality<br>(Kilometres of healthy waterways) | changes to high water flows<br>changes to groundwater, surface water and drinking water supplies<br>pollution, litter and contamination of waterways<br>changes to the natural pattern of water flows, channel bed and bank stability |

Source: The CIE

### 5.2.1.1 Applying benefit transfer from non-market valuation studies

Directly estimating the value of biodiversity using revealed or stated preference techniques for each study case can be costly and time consuming and therefore not always practical. In these circumstances, the benefit transfer method is sometimes used. However, as noted by the Productivity Commission (2014), transferring value estimates from one site to another is likely to be very imprecise (and possibly misleading) unless there is a high degree of similarity between the 'study' and 'policy' contexts (in terms of the environmental features, policy outcomes and population characteristics).[50] Rolfe and Windle (2010) found that even for the iconic Great Barrier Reef, "it is

[49] Kragt and Bennett (2011) found that the 'seagrass area' attribute used as an indicator of estuary water quality was not interpreted by respondents as indented. There was limited responsiveness to the seagrass attribute. In the survey, seagrass was presented as an indicator of 'clean, clear, sunlit waters' and its ecological importance as a habitat for fish species was emphasised on the information paper. However feedback from respondents indicated that seagrass beds can be perceived as a hindrance to recreational activities. Source: Kragt, M. E. & Bennett, J. W. (2011). Using choice experiments to value catchment and estuary health in Tasmania with individual preference heterogeneity. Australian Journal of Agricultural and Resource Economics, Vol. 55, pp. 159-179.

[50] Productivity Commission, Environmental Policy Analysis: A Guide to Non-market Valuation, Staff Working Paper, January 2014, p. 6, https://www.pc.gov.au/research/supporting/non-market-valuation.

difficult to identify single unit values for an environmental amenity that can be easily transferred and extrapolated across geographic regions and scales".[51]

The reliability of benefit transfer is dependent on there being a sufficient range of suitable primary studies to source values. This increases the ability to match the site and context specific characteristics of a primary study to the study site in question. A lack of suitable primary studies in Australia has previously been noted by the Productivity Commission (2014) as a barrier to the reliable application of benefit transfer.

A key principle of benefit transfer is that value estimates should not be transferred to another study context where significant differences are present. As noted by Kragt and Bennett (2011), it is difficult to compare Willingness to Pay (WTP) estimates across attributes of the same study and also across different studies because every study is contextual and disparate measurement units are used for the attributes.[52]

When identifying a primary study for benefit transfer, consider the following:

- Are the environmental attributes considered similar across sites?
- Are the base levels of environmental attributes similar across sites?
- Are the changes/improvements in attributes being evaluated similar across sites?
- Are there differences in the locations and populations?
- What year was the original study completed? Community's value for environmental attributes can differ over time, such as due to environmental conditions such as drought or flooding, or due to improved knowledge of environmental impacts.
- Were the values in the original study estimated for each attribute individually or in a bundle?
- Do respondents have WTP thresholds (i.e. budget constraints) such that over a specified quality of change, or over a time period, households are no longer willing to pay?
- Were the attributes defined as continuous variables and therefore have an implicit assumption that marginal utilities are constant across the range of attribute level-values, as opposed to an alternative of diminishing marginal utility over large ranges of attribute levels?

The majority of non-market valuation studies relating to biodiversity and ecosystem services have estimated the community's value of a species (e.g. waterbirds) or specific ecosystem services (e.g. healthy waterway). Hatton-MacDonald and Morrison (2010) acknowledge that such an approach is useful when the economic value of a species can be combined with integrated systems modelling and ecological response functions. However, in many instances the necessary ecological response functions and system level modelling is not readily available at the scale required for decision making. An alternative method explored by Hatton-MacDonald and Morrison (2010) is to focus on habitat areas (grasslands, shrublands and wetlands) to estimate dollar values estimates that can be used by policy makers.

[51] Rolfe, J. and Windle, J., 2010, Testing for geographic scope and scale effects with choice modelling: Application to the Great Barrier Reef, Environmental Economics Research Hub Research Reports, page 19.

[52] Kragt, M. E. & Bennett, J. W. 2011. Using choice experiments to value catchment and estuary health in Tasmania with individual preference heterogeneity. Australian Journal of Agricultural and Resource Economics, Vol. 55, pp. 159-179.

### 5.2.2 Replacement cost approach

The replacement cost approach estimates the value of biodiversity based on the cost of replacing it with a substitute. Under the NSW Biodiversity Offsets Scheme this replacement cost is represented by the price of biodiversity credits.

In NSW, Biodiversity Offsets Scheme creates a market price for biodiversity through the requirement to purchase offsets. Where markets are efficient, the market value of a good or service reflects a range of factors including community preferences (on the demand side) and the cost of production (on the supply side). It is therefore generally assumed in economic analysis that the market price of a good or service reflects its value to society. However, in the market for biodiversity credits, demand is driven by the government-imposed requirement to offset biodiversity lost through (some) development, rather than the community's 'willingness to pay' for biodiversity. As such, the price of credits reflects the cost of managing land to an agreed standard to offset impacts to biodiversity elsewhere and the opportunity cost of the land, rather than underlying community preferences for biodiversity.

As noted by Bennett (2003), the replacement cost approach does not strictly estimate the value of biodiversity benefits.[53] Rather, it is a surrogate approach. The actual value the community places on any biodiversity loss or gain will not necessarily equal the cost of replacing it.

Using the replacement cost approach, the value of biodiversity primarily reflects the land value at the offset site and associated management costs. Based on current land markets, this is likely to result in biodiversity values being higher in urban areas relative to rural and regional areas, even for similar types of biodiversity.

## 5.3 Recommended approaches and values

**Practitioners should present central CBA results applying parameter values using the benefit transfer approach.** Estimates using the replacement cost approach can be included in sensitivity analysis. Parameter values to be used for each approach are outlined below.

### 5.3.1 Benefit transfer approach

The Cooperative Research Centre for Water Sensitive Cities developed the Investment Framework for Economics of Water Sensitive Cities (INFFEWS) Value Tool (the Tool), a comprehensive list of up-to-date values related to water sensitive systems and practices in Australia. The Tool categorises studies by a range of characteristics including location, benefit type, value type and study factors.

Table 13.3 lists non-market valuation studies from the Tool which are relevant to the valuation of biodiversity and ecosystem services.

Each study was reviewed for the purpose of identifying parameter values for biodiversity. There is no one size fits all environmental attribute used to value biodiversity. In many studies, individual

[53] Bennett, J. 2003, The economic value of biodiversity: a scoping paper, presented to the National Workshop "The Economic Value of Biodiversity" on 22 and 23 October 2003, accessed on 12 September 2016 at https://www.environment.gov.au/resource/economic-value-biodiversity-scoping-paper. This paper is no longer available on this website and can be accessed at the National library of Australia archives at https://pandora.nla.gov.au/.

species are valued for specific contexts, reducing the ability to transfer these values without particular care to ensure contexts are similar.

In order to be used as a parameter value in the framework, selected environmental attributes should be applicable to a wide range of green infrastructure studies. In addition, selected parameter value(s) should be able to be applied with minimal adjustments for site and context characteristics. It is not recommended that parameter values be used for iconic, unique or large investments in biodiversity. In such cases a primary study may be required, or application of alternative values from the non-market valuation literature.

All else equal, values from recent studies and those conducted in NSW are preferred for parameter values. Similarly, a sufficient sample size in the primary study is required. The following criteria were applied to identify attributes suitable for inclusion as a parameter value in the framework:

- attributes have been valued across multiple study sites and locations
- attributes that are iconic or unique are not considered suitable as a parameter value
- attributes relating to the number of native species (fish or fauna) are not considered suitable as a parameter value because green infrastructure projects will not in and of themselves protect a species. Furthermore, values for individual species requires additional information on the existing and the change in the number of species at the project site is required. It is anticipated this level of information will not be available for projects which are applying the framework's parameter values.
- attributes relating to recreational use value are excluded as recreational and amenity use values area estimated separately.

The recommended approach, based on a review of the available literature and the criteria listed above, is to apply community value benchmarks for hectares of good quality habitat area (scrublands, grassy woodlands, and wetlands) and healthy waterways/riverside vegetation per kilometre of waterway to reflect the value held for terrestrial and aquatic biodiversity, respectively.

The proponent should determine whether the benefit transfer approach is appropriate by qualitatively assessing the similarities and differences between the study site (i.e. the site of the non-market valuation study) and the project site (i.e. the project in question). In cases where the recommended parameter values are not appropriate, the proponent can apply alternative values in sensitivity analysis supported by rationale for using alternative values.

The parameter values per household should be applied to 50 per cent of households in the project catchment (i.e. for a NSW cost benefit analysis, the catchment is NSW).[54] This aggregation factor is a conservative estimate based on an average:

response rate across a selection of non-market valuation studies of 42.6 per cent,
extrapolated response rate (accounting for non-respondents likely to have values) of 59.8 per cent.

### 5.3.1.1 Recommended values for terrestrial biodiversity

The recommended parameter values for terrestrial biodiversity are transferred from Hatton MacDonald and Morrison (2010) for three habitat types:

[54] The response rate for the original study was 54.2 per cent.

scrublands — low, thick vegetation such as shrubs and mallee
grassy woodlands — open areas with larger trees
wetlands — areas where water accumulates for short or long periods during the year, and contain open water, rushes and sedges and may have shrubs and trees around their edges.[55]

Parameter values have been indexed to 2022 dollars, adjusted for the time period of payment and impact, adjusted for a ramp up in environmental impact and adjusted for wage differences between South Australia and New South Wales. The annual values (in 2022 dollars) that should be applied are:

$0.0005 per household per hectare of scrublands
$0.0007 per household per hectare of grassy woodlands
$0.0009 per household per hectare of wetland (Table 5.3).[56]

These values should be applied for thirty years after the green asset has been established. The parameter value which most reflects the habitat type of the project should be applied.

Alternatively, a combination of parameter values can be applied where a project relates to multiple habitat types.

#### Table 5.3 Parameter values for terrestrial biodiversity by habitat type

| Habitat type | Original WTP ($ per household per hectare, payment lasting for a 5 year period and gradual increase in impact) | Annualised value ($2022 per household per hectare) |
|---|---|---|
| Scrublands | 0.00072 | 0.0005 |
| Grassy woodlands | 0.00106 | 0.0007 |
| Wetland | 0.00136 | 0.0009 |

### 5.3.1.2 Recommended value for aquatic biodiversity

The recommended parameter value for aquatic biodiversity is a weighted average of the estimated values for riverside vegetation from Bennett et al. (2015). This is equivalent to an annual value of $0.83 per household per kilometre per year for thirty years (in 2022 dollars) (Table 5.4).[57]

#### Table 5.4 Parameter value for aquatic biodiversity

| Change in riverside vegetation | Range (km) | Original WTP ($2015 per household per km) | Annualised value (2022$ per household per km per year) |
|---|---|---|---|
| 50 to 85 kilometres | 35 | 0.67 | 0.67 |
| 85 to 100 kilometres | 15 | 2.28 | 2.30 |
| 100 to 120 kilometres | 20 | 0 | 0 |
| Weighted average | | 0.82 | 0.83 |

[55] D. Hatton MacDonald and M.D. Morrison (2010), Valuing biodiversity using habitat type, Australasian Journal of Environmental Management, 17:4, 235-243, page 237.

[56] Respondents were asked how much they were willing to pay over five years in the form of a levy to ensure that a hectare of good quality scrubland, grassy woodland or wetland habitat area was added to the stock in the Upper South East of South Australia over ten years. Annualized values are calculated based on a linear improvement over ten years coupled with a payment period of 5 years.

[57] The choice survey asked respondents if they were willing to pay for an improved environmental outcome in 2024 relative to the current condition in 2012. The time period for environmental change was not clear in the original study except noting that modelling of river health impacts was undertaken over a 20-year period. As such an annual value has been estimated assuming a linear improvement over the 12 years between 2012 and 2024 and then constant environment condition for an additional 8 years.

#### 5.3.1.3 Scope of projects

Changes in biodiversity may result from new or improved bushland/protected open space. Table 5.5 specifies the project types which the two approaches can be applied to:

- Local, district and regional parks — replacement cost approach can be applied to district and regional parks where the biodiversity conservation area exceeds five hectares to align with area requirements for an offset conservation agreement. The five-hectare threshold is the minimum requirement to ensure that offset conservation agreements will deliver viable biodiversity conservation outcomes. [58]
- Reserves — both approaches can be applied
- National Parks — both approaches can be applied.

In this context, a biodiversity conservation area contains new or improved green infrastructure that contributes to biodiversity. Green infrastructure that contributes to biodiversity is trees, shrubs or a mixture of trees, shrubs and open green space. Green infrastructure which consists predominantly of open green space (i.e. grass) does not sufficiently contribute to biodiversity benefits and therefore should not be included in the estimated biodiversity conservation area. The parameter values outlined below should be applied to the total area (hectares) that is considered a biodiversity conservation area.

**Table 5.5 Application of approaches for different project type**

| Project type | Benefit transfer approach (Central analysis) | Replacement cost approach (Sensitivity analysis) |
|---|---|---|
| Local park | No | Yes, if biodiversity conservation area exceeds five hectares |
| District park | No | Yes, if biodiversity conservation area exceeds five hectares |
| Regional park | No | Yes, if biodiversity conservation area exceeds five hectares |
| Reserves | Yes | Yes |
| National Parks | Yes | Yes |

Note: The benefit transfer approach should not be applied to projects for a local, district or regional park. The non-market valuation studies from which the benefit transfer approach is based were conducted on large scale areas that are not comparable to the scale of a local park, district park and regional park.

Source: DPE

### 5.3.2 Replacement cost approach

The NSW Biodiversity Offset Scheme (BOS) establishes a credit market to offset unavoidable impacts on biodiversity from development. The credit prices represent a replacement cost for biodiversity.

Credit transactions started in 2010 under the BioBanking Assessment Methodology (BBAM). The BBAM was replaced in 2020 by the Biodiversity Assessment Method (BAM). Transitional arrangements allow proponents and landholders to submit a biodiversity assessment report applying either the BBAM or BAM in certain instances.[59]

[58] Biodiversity Conservation Trust, 2020, Guidelines for proponents and consent authorities – using offset conservation agreements: when development consent conditions require the use of conservation agreements to establish biodiversity offsets. Version 2: July 2020.

[59] NSW Government, 2021, The Biodiversity Assessment Method 2020, https://www.environment.nsw.gov.au/topics/animals-and-plants/biodiversity-offsets-scheme/accredited-assessors/biodiversity-assessment-method-2020 Accessed September 2021.

Parameter values for the replacement cost approach are based on historical credit transactions. Over 700 transactions have occurred using the BBAM and just over 50 using the BAM. The BBAM transaction data also provides a greater coverage across the state, with transaction data in 24 IBRA subregions, as opposed to only 8 Interim Biogeographic Regionalisation for Australia (IBRA) subregions for the BAM data (Table 5.6). The parameter values are estimated using both BBAM and BAM transaction data to provide a larger set of data points and greater coverage across the state.

**Table 5.6 High level comparison of transaction data for BBAM and BAM**

| Transaction data | BBAM | BAM |
|---|---|---|
| Period of transactions | 2010-2021 | 2020-2021 |
| Number of trades | 719 | 52 |
| Number of IBRA subregions | 24 | 8 |

Source: Data provided by DPE

#### 5.3.2.1 Parameter values

The parameter values to be used for the replacement cost approach are based on the credit prices from historical trades under the BOS. Table 5.7 outlines the recommended undiscounted dollar per hectare per year parameter values by IBRA subregion and the state-wide weighted average. The parameter values have been estimated:

- using the weighted average credit prices of all transactions under the BBAM and BAM
- by applying a credit to hectare ratio of 10:1 for BBAM credits and 5:1 for BAM credits.

The undiscounted annual values should be applied over 30 years.

There is a large variation in the parameter values per hectare across IBRA subregions. This is primarily due to variation in land value across the state.

Parameter values are not available for all IBRA subregions across the state. An average of values for all IBRA subregions (where values are available) within an IBRA region should be applied to any IBRA subregions that are not listed in Table 5.7. Alternatively, the state-wide weighted average value (excluding the Sydney Basin IBRA Region) can be applied.

**Table 5.7 Recommended parameter values by IBRA subregion for the replacement cost approach**

| IBRA subregion | Parameter value<br>PV $/hectare | Undiscounted annualised parameter value $/hectare/year |
|---|---|---|
| Bateman | 8,690 | 565 |
| Burragorang | 84,212 | 5,478 |
| Clarence Lowlands | 5,331 | 347 |
| Clarence Sandstones | 6,702 | 436 |
| Coffs Coast and Escarpment | 12,253 | 797 |
| Cumberland | 148,435 | 9,656 |
| Hill End | 30,723 | 1,999 |
| Hunter | 22,419 | 1,458 |
| Illawarra | 60,080 | 3,908 |

| IBRA subregion | Parameter value<br><br>PV $/hectare | Undiscounted annualised parameter value $/hectare/year |
|---|---|---|
| Inland Slopes | 21,593 | 1,405 |
| Jervis | 29,013 | 1,887 |
| Karuah Manning | 19,993 | 1,301 |
| Lower Slopes | 11,992 | 780 |
| Macleay Hastings | 27,794 | 1,808 |
| Monaro | 46,268 | 3,010 |
| Murrumbateman | 20,401 | 1,327 |
| Northern Outwash | 7,538 | 490 |
| Oberon | 40,361 | 2,626 |
| Peel | 12,113 | 788 |
| Pilliga | 21,250 | 1,382 |
| Pittwater | 37,674 | 2,451 |
| Richmond | 36,906 | 2,401 |
| Sydney Cataract | 171,635 | 11,165 |
| Upper Hunter | 14,338 | 933 |
| Wollemi | 76,310 | 4,964 |
| Wyong | 47,076 | 3,062 |
| Yengo | 91,191 | 5,932 |
| State-wide weighted average (excl. Sydney Basin IBRA Region) | 13,065 | 850 |

Note: Annualised undiscounted values based on 5 per cent discount rate over a 30 year period. The data reflects transactions from 2010 to 2021 to ensure sufficient number of trades and prices may have changed over this time.

Source: CIE based on data provided by DPE

# 6 Greenhouse gas (GHG) impacts

GHG emissions are a contributor to global warming. Global warming is expected to have a range of costs to the global, Australian and NSW communities.[60] Activities that reduce GHG emissions have a benefit because they can contribute to avoiding temperature increases and the costs associated this. Alternatively, where there are specific government commitments to GHG emissions reductions, activities in one area reduce the need for other activities to reduce GHG emissions.

Forest ecosystems are the largest terrestrial carbon sink on Earth,[61] and afforestation has been recognized as a cost-effective strategy for mitigating greenhouse gas emissions. The benefit from reduced greenhouse gas (GHG) emissions is the amount of reduction in GHG emissions multiplied by the value per tonne.

Calculating the reduced GHG emissions due to carbon sequestration will require:

- identifying the sequestration impact the green infrastructure in question will have on GHG
- selecting an appropriate carbon value to calculate the reduction in GHG.

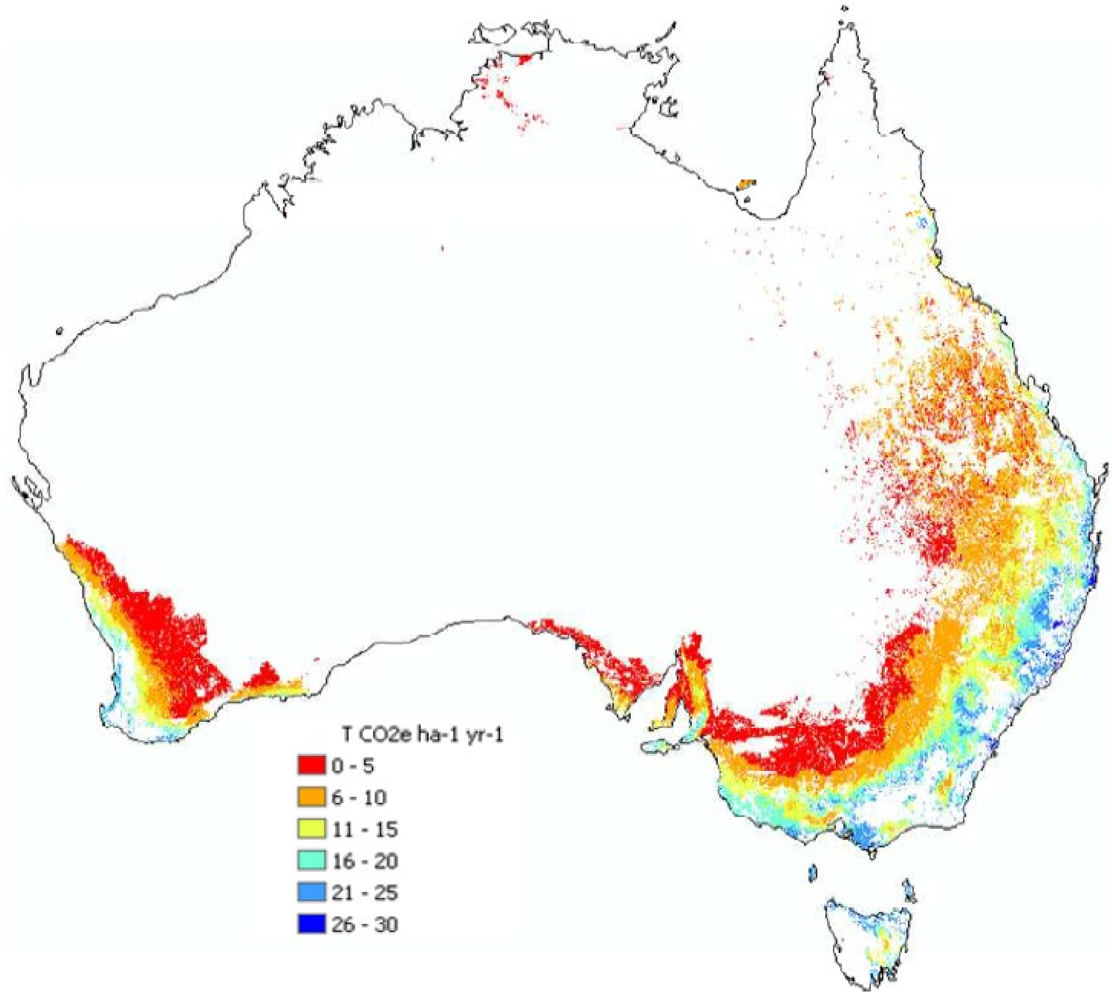
## 6.1 Impact of green infrastructure (trees) on GHG emissions

As trees grow they absorb CO2. The rate at which they do this will depend on the growth of the tree, which is in turn dependent on factors such as species and rainfall. For example, CSIRO modelled potential carbon sequestration rates across Australia for carbon forestry projects (Figure 6.1). The amount of sequestration ranged from less than 0.14 kgs of carbon per $m^2$ per year to 0.82 kgs of carbon per $m^2$ per year, averaged over the first 20 years. Urban tree plantings are likely to be at the upper end because they are likely to be irrigated and in areas of higher rainfall.

[60] Garnaut, R. 2011, The Garnaut Review 2011: Australia in the Global Response to Climate Change.

[61] Pan, Y., Birdsey, R.A., Fang, J., Houghton, R., Kauppi, P.E., Kurz, W.A., Phillips, O.L., Shvidenko, A., Lewis, S.L., Canadell, J.G. and Ciais, P., 2011. A large and persistent carbon sink in the world’s forests. Science, 333(6045), pp.988-993.

Figure 6.1 Carbon sequestration rates for carbon forestry averaged over 20 years




Note: T CO2e ha-1 yr-1 represents tonnes of carbon dioxide equivalent per hectare per year.

Source: CSIRO 2011, Opportunities for carbon forestry in Australia: Economic assessment and constraints to implementation, https://publications.csiro.au/rpr/download?pid=csiro:EP113280&dsid=DS6.

There are also detailed approaches that could be used under carbon farming legislation, Carbon Credits (Carbon Farming Initiative — Reforestation and Afforestation 2.0) Methodology Determination 2015.[62] For example, carbon sequestration credits for forestry projects can use model tools as a validation of the amount of carbon sequestered through the Full Carbon Accounting Model (Fullcam).[63]

The Clean Energy Regulator has developed examples of the amount of carbon sequestered based for environmental plantings, based on approved carbon farming methods (Table 6.1). For Kyogle in NSW, 328 tonnes of $CO^2$ would be abated over 20 years from 1 hectare of environmental planting, equivalent to 0.45 kgs of carbon per $m^2$ per year.[64] Also note that the carbon sequestration rate is

[62] Carbon Credits (Carbon Farming Initiative — Reforestation and Afforestation 2.0) Methodology Determination 2015, https://www.legislation.gov.au/Details/F2015L00682.

[63] Australian Government Department of Industry, Science, Energy and Resources website, accessed September 2021, https://www.industry.gov.au/data-and-publications/full-carbon-accounting-model-fullcam.

[64] Kilograms of carbon per year is calculated as tonnes CO2 divided by 20 years divided by 44/12 (atomic weights of CO2 and C) multiplied by 1000 divided by 10000 ($m^2$ per hectare).

initially low, then increases as trees become larger. The rates for the above example for each period are:

- a rate of carbon sequestration of 0.24 kgs per $m^2$ of area planted with trees for the first 5 years
- a rate of carbon sequestration of 0.61 kgs per $m^2$ of area planted with trees for the second 5 years
- a rate of carbon sequestration of 0.47 kgs per $m^2$ of area planted with trees for years 10 to 20.

Urban tree plantings are again likely to be closer to high rainfall areas given that trees will often be irrigated, and/or urban areas are concentrated in coastal areas of NSW with higher levels of rainfall.

**Table 6.1 Cumulative abatement from 1 hectare of environmental planting (tonnes of CO2e)**

| Number of years | Kyogle, NSW (average annual rainfall 1097.8mm) | Leongatha, Victoria (average annual rainfall 939.5mm) | Gold Coast Hinterland (average annual rainfall 906.7mm) | Central Tasmania (average annual rainfall 499.6mm) | Geraldton WA (average annual rainfall 442.4mm) |
|---|---|---|---|---|---|
| 1 | 1.5 | 1.5 | 1.39 | 1.43 | 1.28 |
| 5 | 43.34 | 43.3 | 26.23 | 36.49 | 9.96 |
| 10 | 155.36 | 155.1 | 92.4 | 130.18 | 33.38 |
| 20 | 328.46 | 327.69 | 194.52 | 274.91 | 71.52 |

Source: Clean Energy Regulator website, http://www.cleanenergyregulator.gov.au/ERF/Pages/Want%20to%20participate%20in%20the%20Emissions%20Reduction%20Fund/Planning%20a%20project/Feasibility%20and%20project%20planning/Land-based-projects%E2%80%93return-on-investment-considerations.aspx, Rainfall data taken from Bureau of Meteorology, Climate data online, http://www.bom.gov.au/climate/data/index.shtml.

For the ACT, Tapsuwan estimates carbon sequestration using the i-Tree model.[65]

- The expected carbon sequestered per year per $m^2$ of tree canopy from the 2018 tree stock was 0.30 kg of carbon per $m^2$ [66]
- The carbon sequestration from future scenarios that increased tree plantings was substantially higher (about double the dollar value) in terms of a levelized benefit per tree per year
  - the carbon sequestration for scenarios that let tree stock decline was much lower than the carbon sequestration estimated for the 2018 tree stock.

Specific to Sydney, there has also been work using i-Tree to evaluate urban tree plantings on the Pacific Highway and Parramatta Road.[67] Using their estimates suggests annual carbon sequestration of 0.3 kgs of carbon per $m^2$ of tree canopy for the Pacific Highway and 0.8 kgs of carbon per $m^2$ of tree canopy for Parramatta Road. Note that this is not sequestration related to new tree plantings, but from existing plantings.

There are also several studies undertaken overseas, particularly in the US, which form some of the foundational work for i-Tree. Nowak found that the sequestration rate varies across literature

[65] I-Tree documentation, https://www.itreetools.org/documents/650/Understanding_i-Tree.gtr_nrs200.pdf

[66] CIE calculations based on Tapsuwan, S., R. Marcos – Martinez, and H. Schandl 2019, An environmental – economic accounting of services provided by the living infrastructure in the ACT: public urban forests and irrigated open spaces, Final report, prepared for ACT Government, 13 November 2019

[67] Ghosh and Yung 2017, Carbon and economic benefits of urban trees in two Sydney transport corridor case studies, UTS, https://opus.lib.uts.edu.au/bitstream/10453/121458/1/Ghosh_Yung-Full-paper-Ecocity-Summit-2017-Final.pdf.

depending on the type of trees, ranging from 0.18 to 0.35 kg carbon/tree crown $m^2$ per year across US cities.[68] There are also indications that between 0.08 and 0.16 kg carbon/tree crown $m^2$ per year is released back into the atmosphere taking into account tree death, removal and decomposition.[69] These estimates are really a steady state carbon sequestration rate for urban tree areas, rather than the impact of new tree plantings. These suggest a net carbon sequestration rate of 0.2 kg carbon/tree crown $m^2$ per year for steady state services provided. Note that this does not account for the timing differences in carbon storage versus release.

The framework recommends that no impact of urban public open space outside of trees is included in relation to carbon sequestration. Outside of trees, there is substantial debate about the net carbon effects of other forms of urban space. Some studies have suggested turf (such as for a golf course) can sequester 0.1 kilograms of carbon per $m^2$, or 0.8 kilograms per $m^2$ after removing the GHG emissions related to management,[70] and that these effects last for a long time. However, this would not be readily applicable to sports fields, where soil is impacted by play, and some studies indicate is a net emitter of carbon.[71] There still appears to be considerable debate about the validity of different estimates.[72]

Wetlands have the potential to sequester carbon within the vegetation and soil profile, yet also produce methane emissions. Mitsch et al (2013) estimated the net carbon retention of 21 wetlands in three different region types, tropical/sub-tropical, temperate, boreal, with an average of 118 g-C $m^{-2}$ $year^{-1}$.[73] The carbon sequestration potential of a wetland, and also whether it is a net carbon sink, is dependent on many site-specific factors including type (coastal, estuarine, seagrass, mangroves), periods of inundation, salinity, vegetation cover, and level of disturbance.[74] Given the variability across wetlands, there is not sufficient evidence to support good default values to estimate the carbon sequestration by the vegetation and soil within a wetland. These could be added later. Carbon sequestration of trees contained within a wetland can be estimated using the recommended default values.

For the purposes of a cost benefit analysis, what is in the study area in the base case will be important, as the study will measure the incremental carbon sequestration relative to the base case. The estimates above are relative to no green infrastructure. If there are existing green infrastructure in the base case, then the base case has its own level of carbon sequestration that would have to be accounted for.

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[68] Nowak, D. and Crane, D. 2002, Carbon storage and sequestration by urban trees in the USA, Environmental Pollution, 116, p. 381-389.

[69] Nowak, D. and Crane, D. 2002, Carbon storage and sequestration by urban trees in the USA, Environmental Pollution, 116, p. 381-389.

[70] Sahu R, 2008. 'Technical Assessment of the Carbon Sequestration Potential of Managed Turfgrass in the United States. Research Report, USA, http://multivu.prnewswire.com/broadcast/33322/33322cr.pdf

[71] Riches et al 2020, Soil greenhouse gas emissions from Australian sports fields, Science of the total environment, volume 707, https://www.sciencedirect.com/science/article/abs/pii/S0048969719344110.

[72] This debate is summarised in Tapsuwan, S., R. Marcos - Martinez, and H. Schandl 2019, An environmental - economic accounting of services provided by the living infrastructure in the ACT: public urban forests and irrigated open spaces, Final report, prepared for ACT Government, 13 November 2019, section 2.2.7.

[73] Mitsch, W. J., Bernal, B., Nahlik, A. M., Mander, Ü., Zhang, L., Anderson, C. J., Jorgensen, S. E., and Brix, H., 2013, Wetlands, carbon, and climate change, Landscape Ecology (2013) 28:583-597.

[74] Department of Sustainability, Environment, Water, Population and Communities, 2012, The Role of Wetlands in the Carbon Cycle, July 2012.

## 6.2 Valuation of GHG reductions

The Technical note to NSW Government Guide to Cost-Benefit Analysis TPG23-08: Carbon value in cost-benefit analysis sets out the method, consistent with the discussion in the NSW Government Guide to Cost-Benefit Analysis (TPG23-08), to calculate carbon values for all initiatives. Table 6.2 outlines the carbon emissions value per tonne to be used in cost benefit analysis. This parameter should be sensitivity tested, recognising it may change overtime.

**Table 6.2 Carbon value per tonne**

| Financial year | Carbon value real<br>A$/tCO2e<br>2022 dollars |
|---|---|
| 2023 | 123 |
| 2024 | 126 |
| 2025 | 128 |
| 2026 | 131 |
| 2027 | 134 |
| 2028 | 137 |
| 2029 | 140 |
| 2030 | 144 |
| 2031 | 147 |
| 2032 | 150 |

Data source: NSW Treasury, 2023, Technical note to NSW Government Guide to Cost-Benefit Analysis TPG23-08: Carbon value in cost-benefit analysis, https://www.treasury.nsw.gov.au/sites/default/files/2023-03/20230302-technical-note-to-tpg23-08_carbon-value-to-use-for-cost-benefit-analysis.pdf.

## 6.3 Recommended approaches and values

The value of reduced GHG emissions should be based on the following formula:

$$GHG\ benefit = m2\ of\ tree\ planting * C^{kgs}\ per\ m2 * \frac{44}{12} * \frac{1}{1000} * CoC$$

Where $C^{kgs}\ per\ m2$ is the incremental carbon sequestered per $m^2$ per year, 44/12 is the atomic weight of carbon dioxide divided by the atomic weight of carbon and CoC is the cost of carbon.

Based on the above studies, there are a few alternatives to estimating carbon sequestration rates related to trees:

- use specific modelling related to the tree plantings being considered.
  - this could be using a tool such as i-Tree or approaches developed as part of carbon farming rules for Australia
- use default values, which would represent average effects through initial tree growth and once a steady-state has been reached.

For the default values, the framework recommends applying:

- a rate of carbon sequestration per $m^2$ of area planted (equivalent to expected maximum tree canopy) with trees for the first 5, 10 and 20 years of 0.24. 0.61 and 0.47kg per $m^2$.
  - this is based on Clean Energy Regulator estimates for environmental planting for Kyogle in NSW
- a rate of carbon sequestration of 0.3 kgs per $m^2$ of tree canopy after the first 20 years.
  - this is based on the ACT estimate of carbon sequestration for its 2018 tree stock and is also the rate estimated for trees along the Pacific Highway in Sydney.

This carbon sequestration value is then adjusted for CO2 by multiplying it by $\frac{44}{12}$.[75]

See section 7.3.1.1 for maximum canopy cover by selected tree species.

Where the carbon sequestration is being measured for existing trees, approximate ages should be used and the values above applied. Where mature trees are planted, the age at which they are planted in the project area will be their relevant starting point.[76]

No carbon sequestration is recommended to be assumed for grassed open space.

The value of carbon sequestered should be based on the Technical note to NSW Government Guide to Cost-Benefit Analysis TPG23-08: Carbon value in cost-benefit analysis and the values shown in Table 6.2.

Note that the GHG reduction benefits may or may not accrue to the NSW community:

- if NSW is seeking to achieve a particular level of GHG abatement, and the green infrastructure or public space can be counted towards this, then it would offset costs that others would have to bear to meet abatement targets
  - in this case the benefits can be assumed to accrue predominantly to the NSW community
- if the impacts are considered as additional, then strictly speaking the majority of benefits accrue outside of the NSW community, as the impacts of global warming are felt across the world.

The framework recommends that the full value of GHG abatement as measured by the above real carbon price is accrued to the NSW community. This is consistent with NSW having overall objectives for GHG abatement within which any green infrastructure and public place investments can fit.

[75] Multiplied by $\frac{44}{12}$ given the atomic weight of CO2 is 44 and the atomic weight of C is 12.

[76] Note that conceptually, carbon accrued prior to a project using a mature tree may be relevant to the project, if the mature tree was otherwise disposed of and carbon released. The guidance does not get to this level of detail, and simple rates once planted in the project area are sufficient.

# 7 Urban cooling benefits

Green infrastructure and public open space can reduce the temperature of surrounding areas. This has benefits related to reduced mortality and morbidity associated with heat, reduced energy costs and reduced GHG emissions from energy use related to cooling.

Calculating the value of urban cooling for use in CBA requires:

- understanding the relationship between urban cooling and health and energy use
- identifying urban cooling benefits not already accounted for in the CBA

## 7.1 The cooling impact of trees and vegetation

The cooling pathways of green infrastructure are well understood in the literature. Trees and vegetation provide a cooling effect through two pathways:

- shading of hard surfaces that would otherwise absorb heat from direct sunlight then re-radiated into the air
- evapotranspiration, as trees release water into the atmosphere from their leaves, surrounding areas are cooled from the evaporation of this water.

The degree of cooling differs across tree species, with greater leaf cover and water content in the soil and vegetation providing the greatest cooling impact. For example, Yu and Hien (2006) reported that the ambient temperature in a park was strongly correlated to the density of plants.[77]

Some studies have calculated the contribution of shading and an evapotranspiration to cooling, which indicate that shading for the vast majority of cooling as evapotranspiration[78] accounts for only around 12 per cent of total energy or temperature reduction.[79] Note this will vary depending on a range of factors, including tree species, climate, soil moisture and climatic conditions.

Across the literature there are varying estimates of the urban cooling impact of green and blue infrastructure. The Greater Sydney Commission has previously reported that on average a 10 per cent increase in green space can reduce temperatures by 1.13°C.[80] The underlying report, on which this parameter is based indicates that the type of vegetation plays a significant role:[81]

- tree cover reduces temperatures by 1.13°Cfor each 10 per cent of area covered

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[77] Doick, K. and Hutchings, J., 2013, Air temperature regulation by urban trees and green infrastructure, Forestry Commission Research Note (FCRN012), https://www.researchgate.net/publication/259889679_Air_temperature_regulation_by_urban_trees_and_green_infrastructure.

[78] Evapotranspiration is the term used to describe the part of the water cycle which removes liquid water from an area with vegetation and into the atmosphere by the processes of both transpiration and evaporation.

[79] Pace, R., De Fino, F., Rahman, M.A. et al., 2021, A single tree model to consistently simulate cooling, shading, and pollution uptake of urban trees. International Journal of Biometeorology, 65

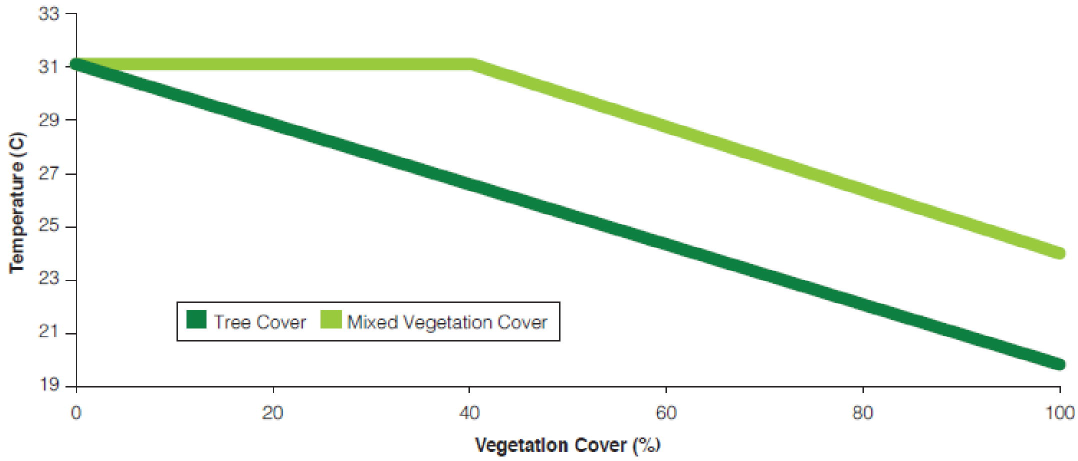
[80] GSC 2018, Our Greater Sydney 2056 Western City District Plan – connecting communities, March, p. 119, https://www.greater.sydney/western-city-district-plan.

[81] Adams, M. A. and Smith, P. L. (2014) 'A systematic approach to model the influence of the type and density of vegetation cover on urban heat using remote sensing'. Landscape and Urban Planning Volume 132, December 2014, Pages 47–54.

- a mixed vegetation cover of over 40 percent can provide temperature reductions, i.e., when the share is over 40 per cent, a 10% increase in mixed vegetation cover would lead to a reduction in temperature of 1.16◦C, but has no influence when the share is below 40 per cent
- the impact of a forest reserve compared to typical parkland is about double (a forest reserve with 70 per cent cover would reduce temperatures by 7.91◦C compared to 3.48◦C for typical parkland
- this study used 1 $km^2$ areas as the basis for analysis.

Graphically, the results of this study are shown in Figure 7.1 and Figure 7.2.

### Figure 7.1 Impact of vegetation cover on temperature




Source: NSW Office of Environment and Heritage 2015, Urban Green Cover Technical Guidelines, https://climatechange.environment.nsw.gov.au/-/media/NARCLim/Files/Section-4-PDFs/Urban-Green-Cover-Technical-Guidelines.pdf?la=en&hash=C7FCADABE417DD2DF67461F067463054D9408E2F, Figure 1. This is based on Adams, M. A. and Smith, P. L. (2014) ‘A systematic approach to model the influence of the type and density of vegetation cover on urban heat using remote sensing’. Landscape and Urban Planning Volume 132, December 2014, Pages 47–54.

## Figure 7.2 Impact of different vegetation covers on temperature

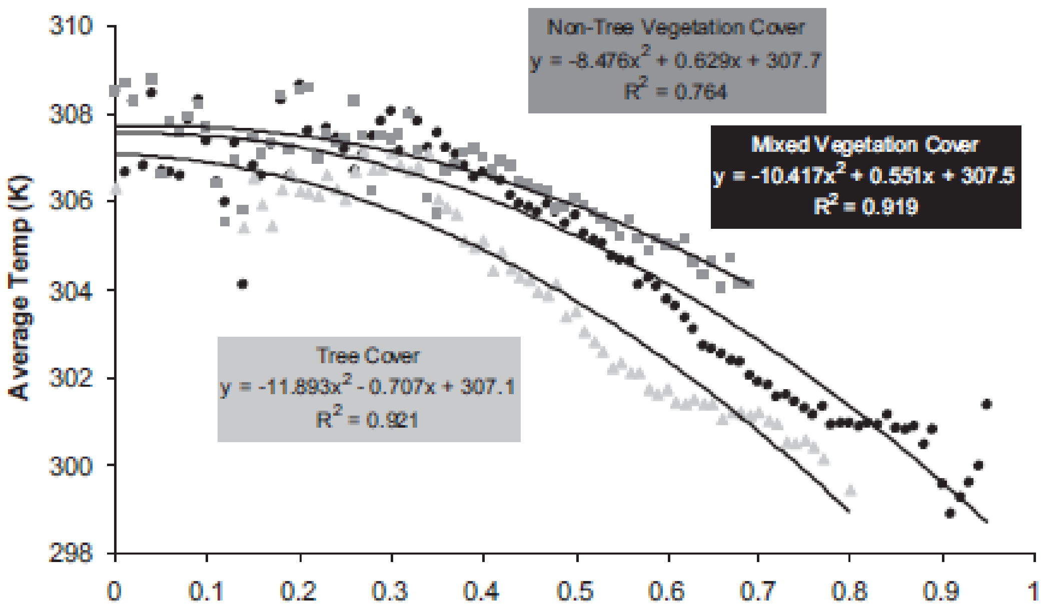



**Fig. 3.** The average LST of vegetation indices tree cover (FPC), mixed vegetation cover (PV) and non-tree vegetation (PV where FPC = 0) fitted with a polynomial regression lines. The ▲ represents FPC (scaled 0–1). The ● represents PV. The ■ represents PV where FPC = 0.

Source: Adams, M. A. and Smith, P. L. (2014) 'A systematic approach to model the influence of the type and density of vegetation cover on urban heat using remote sensing'. Landscape and Urban Planning Volume 132, December 2014, Pages 47–54.

Applying the results of this study is somewhat complicated by the fact that the main results estimate two separate relationships (trees and mixed vegetation). Mixed vegetation includes trees, and in different proportions depending on the area. This makes it difficult to understand the impact of non-tree vegetation cover by itself. It also means that there are really two possible relationships for trees — that of trees within mixed vegetation and that of tree cover estimated independently. Based on Figure 7.2, which separately shows the impact on non-tree vegetation, and the tree-only model the study suggests:

- trees have 1.13°C for each additional 10 per cent of area with tree canopy (based on foliage protective cover)
- non-tree public open space has a much smaller impact of 0.5°C for each additional 10 per cent of area covered.

It does not seem possible to use the mixed vegetation model with a 40 per cent threshold before impacts occur, because it would be inconsistent with the tree-only model. For example, if 40 per cent of an area was mixed vegetation, and half of this was trees, then:

- the tree only model suggests this would lead to a 2.26°C reduction in temperature, plus any impacts from non-tree vegetation
- the mixed vegetation model suggests that this leads to no change in temperature.

These two results can only be correct if non-tree vegetation has an increasing temperature effect, which is not consistent with the evidence presented.

Some research has considered the impact of combinations of greenery and water on urban cooling. Analysis undertaken by UNSW for Sydney Water on mitigating urban heat impacts found:[82]

- greenery reduces cooling degree days (CDD)[83] by between 15 and 29 per cent
- water reduces CDD by between 13 and 30 per cent
- greenery and water together reduce CDD by between 18 and 32 per cent (this implies there is a small added benefit of combining blue and green infrastructure)
- cool materials[84] and water reduce CDD by between 29 and 43 per cent, which may result in an average air temperature reduction of 1.5°C in the area and 10°C close to water
- mitigation techniques using water, greenery and cool materials can reduce the average peak ambient temperature up to 2.5°C.

The US EPA report that the process of evapotranspiration and shading effects from trees can reduce local air temperatures by 1 to 5°C.[85]

In order to apply the values, a relevant catchment for the heat effects will need to be determined. The impacts of choosing a smaller or larger catchment will in most cases not make a substantial difference:

- a large catchment will increase the population impacted
- a large catchment will reduce the temperature impact assessed, because the amount of green space will be a smaller share of the overall area.

A 1 km catchment is consistent with the size of the areas examined in the study used for measuring temperature impacts (1 km grid). Other evidence, such as Knight et al 2021[86] has also concluded impacts can extend to 1.25 km from a park edge (Figure 7.3).

[82] Sydney Water 2017, Cooling Western Sydney - A strategic study on the role of water in mitigating urban heat in Western Sydney, https://www.sydneywater.com.au/content/dam/sydneywater/documents/cooling-western-sydney.pdf.

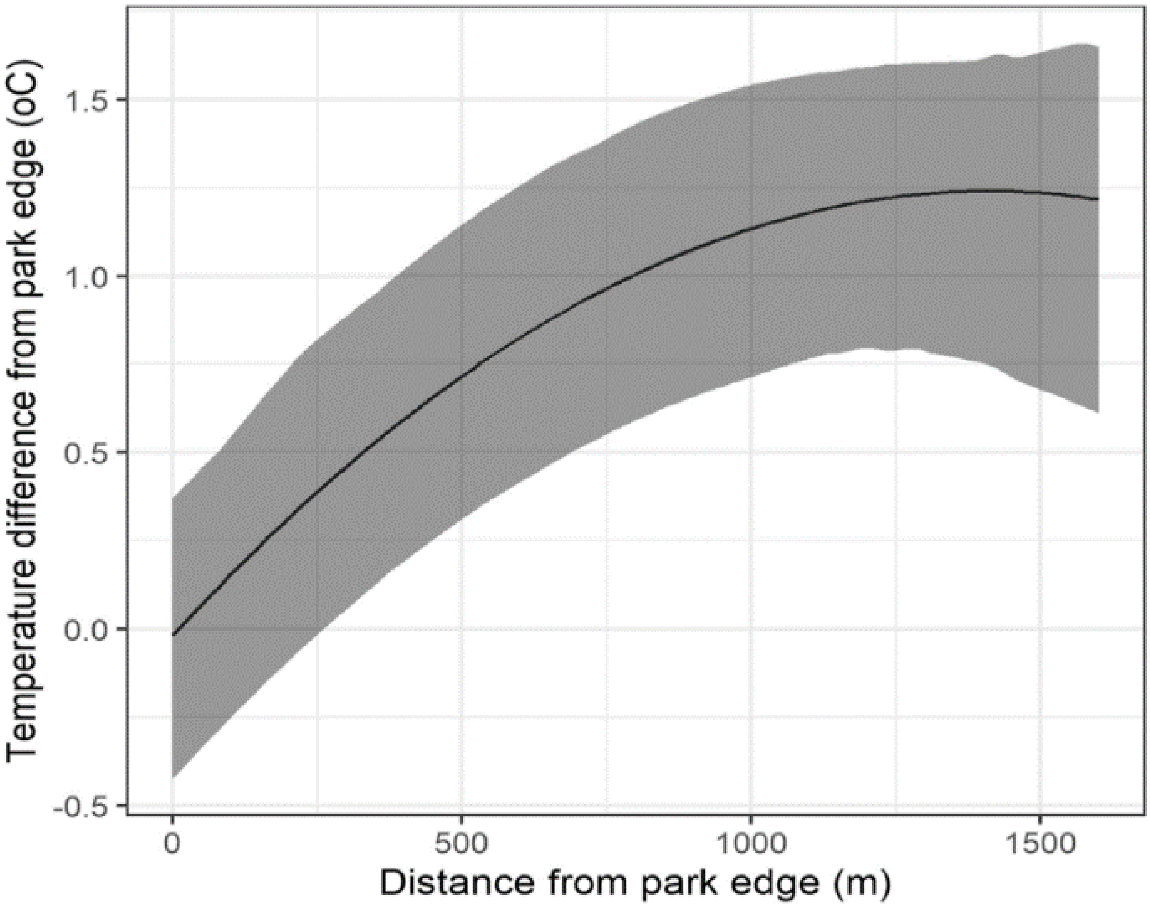
[83] Cooling Degree Days is the number of degrees that a day's average temperature is above a critical temperature.

[84] Materials of high diffuse solar reflectivity and high emissivity value.

[85] US Environmental Protection Agency, Using Trees and Vegetation to Reduce Heat Islands, https://www.epa.gov/heat-islands/using-trees-and-vegetation-reduce-heat-islands Website last updated August 12, 2016

[86] Knight, T., Price, S., Bowler, D. et al. How effective is 'greening' of urban areas in reducing human exposure to ground-level ozone concentrations, UV exposure and the 'urban heat island effect'? An updated systematic review. Environ Evid 10, 12 (2021). https://doi.org/10.1186/s13750-021-00226-y.

Figure 7.3 Impact of distance and temperature effect




Source: Knight, T., Price, S., Bowler, D. et al. How effective is 'greening' of urban areas in reducing human exposure to ground-level ozone concentrations, UV exposure and the 'urban heat island effect'? An updated systematic review. Environ Evid 10, 12 (2021). https://doi.org/10.1186/s13750-021-00226-y.

## 7.2 Benefits from urban cooling

There are three main benefits from urban cooling:

- Reduced mortality, morbidity and health costs related to heat
- Reduced energy use related to cooling
- Reduced GHG emissions from energy use for cooling.

### 7.2.1 Health benefits from urban cooling

Heat-related illnesses include rash, cramps, dizziness, heat exhaustion and heatstroke. Extreme heat is stated to kill more Australians than any natural disaster with heatstroke fatal in up to 80 per cent of cases.[87] In Sydney, heatwaves are associated with substantial increases in mortality

[87] Better Health Victoria, *Heat stress and heat-related illness,* https://www.betterhealth.vic.gov.au/health/healthyliving/heat-stress-and-heat-related-illness. Accessed 10 February 2021.

rates of 10 per cent and extreme heatwaves or 47 per cent.[88] The NSW State of the Environment is expecting heatwave related death to increase dramatically over time.[89]

AECOM 2012 examined incidence rates for different health impacts caused by excessive heat (Table 7.1). This shows how temperatures above 30°C impact on ambulance attendance, transport to hospital, presentation to emergency department and mortality rates. This can then be related to the cooling benefits of green and blue infrastructure to show the impact of the project on the health outcomes.[90]

### Table 7.1 Health impact parameters for urban heat impacts per degree above 30oC

| Health impact parameters | Incidence rate per day for each degree above 30 |
|---|---|
| Ambulance Attendance – heat[a] | 0.09 |
| Transported to hospital | 80% |
| Presentation to emergency department, aged 64-74 yearsa | 0.52 |
| Presentation to emergency department, aged 74+ yearsa | 3.82 |
| Mortalitya | 0.08 |

a Incidence rate per 100 000 persons per 1 degree above 30oC

Source: AECOM, 2012, Economic Assessment of the Urban Heat Island Effect, Prepared for the City of Melbourne, https://www.melbourne.vic.gov.au/SiteCollectionDocuments/eco-assessment-of-urban-heat-island-effect.pdf.

Cost parameters that can be used to quantify benefits are shown in Table 7.2.

The value of statistical life (VSL) is taken from the Office Best Practice Regulation (OBPR) and is applied to persons below the age of 65. For those aged 65 or above, the VSL has been calculated using the value of statistical life year advised by the OBPR ($222 000 per year)[91] and the expected life expectancy for this age group in NSW (14 years).[92] The total cost per death is estimated using these two values assuming that the over 65 year old cohort account for 75 per cent of heat related deaths.[93]

The cost of admitted emergency department (ED) presentations is based on the average cost for NSW reported by the Independent Hospital Pricing Authority, while ambulance costs are based on current NSW Ambulance fees.

Almost all the health benefits of urban cooling are due to the reduction in mortality (around 98 per cent of benefits), given the high value of a statistical life.

88 Tong S, Wang XY, Yu W, et al The impact of heatwaves on mortality in Australia: a multicity study BMJ Open 2014;4:e003579., https://bmjopen.bmj.com/content/4/2/e003579.

89 https://soe.environment.gov.au/theme/built-environment/topic/2016/increased-extreme-weather-events#built-environment-figure-BLT16

90 GSC 2018, Our Greater Sydney 2056 Western City District Plan – connecting communities, March, p. 119.

91 Office of Best Practice Regulation 20121, Best Practice Regulation Guidance Note Value of statistical life, August, https://obpr.pmc.gov.au/sites/default/files/2021-09/value-of-statistical-life-guidance-note-2020-08.pdf.

92 Estimated based on ABS life expectancy by year (3302.0.55.001 - Life Tables, States, Territories and Australia, 2016-2018) and population by year (3101.0 - Australian Demographic Statistics, Jun 2019).

93 Consistent with AECOM assumptions, based on information that between 65% and 90% of mortalities during 2009 Melbourne heatwave were people aged 65 and over. AECOM, 2012, Economic Assessment of the Urban Heat Island Effect, Prepared for the City of Melbourne, p. 28.

### Table 7.2 Health benefit and cost parameters

| Health impact parameters | Incidence rate |
|---|---|
| Value of statistical life <65 years of age ($ million) ($2022) | $5.3 million |
| Value of statistical life >65 years of age ($ million)[a] ($2022) | $3.2 million |
| Cost of admitted emergency department presentation (per person admitted) | $999 |
| Ambulance cost (per person transported) | $436 |

a Calculated based on a life expectancy of 14 years and value of statistical life year of $222 000.

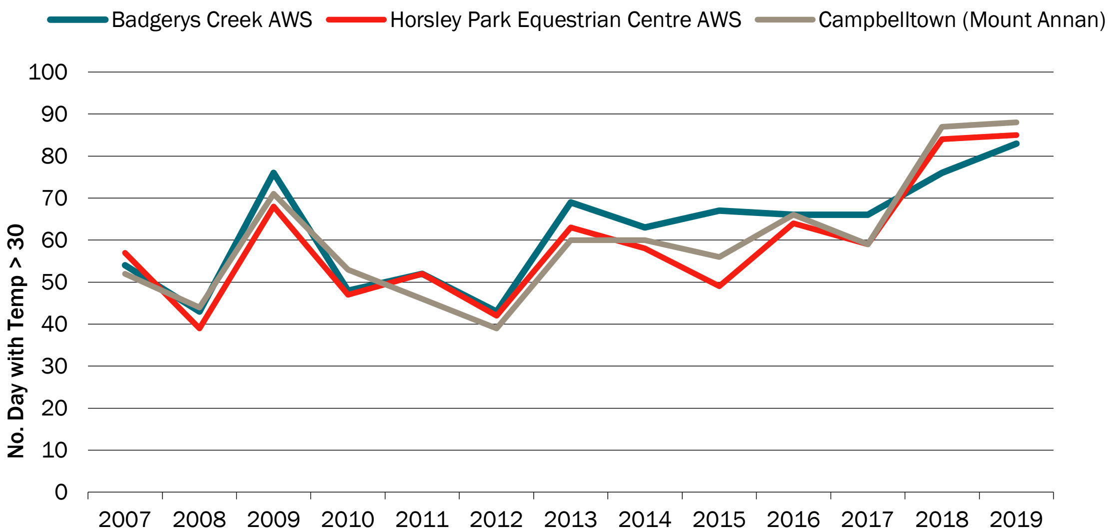
Note: The cost of ED presentations are escalated from $2017/18 to $2022 using CPI. Ambulance cost is based on the current NSW Ambulance fees for NSW residents and includes a fixed and variable per km component. Average trip length is assumed to be 10 km.

Source: Department of the Prime Minister and Cabinet Office of Best Practice Regulation; Independent Hospital Pricing Authority National Hospital Cost Data Collection round 22; NSW Ambulance fees and charges (https://www.ambulance.nsw.gov.au/our-services/accounts-and-fees); CIE.

The estimated parameter value using the above estimates for health cooling benefits is $3.0 for each degree reduction per person in the catchment per year per day above 30 degrees.[94]

The number of days where temperature exceeds 30°C should be sourced from the Bureau of Meteorology for historical and projected forward using expected trends. An example is shown for some temperature stations in Western Sydney in Figure 7.4 Projections of hot days are available from AdaptNSW.[95]

### Figure 7.4 Number of days greater than 30°C




Note: The following weather stations were used: Horsley Park, Badgerys Creek AWS (67108) and Campbell Town (Mount Annan 68257).
Data source: Bureau of Meteorology.

94 This is the incidence rate per degree per 100,000 people for each incident multiplied by the cost, divided by 100,000 to give a cost per person.

95 Adapt NSW, https://climatechange.environment.nsw.gov.au/.

### 7.2.2 Reduced energy use benefits from urban cooling

Canopy cover can reduce energy demand from cooling, by reducing local air and surface temperatures. This results in a cost saving from lower electricity demand, as well as environmental benefits associated with lower greenhouse gas emissions due to electricity generation.

To estimate a cost saving due to reduced energy use and a reduction in greenhouse gas emissions requires:

- understanding how temperature changes from green infrastructure impact on building energy use
- measuring the avoided cost from reducing energy use
- measuring the avoided cost of carbon.

#### 7.2.2.1 The impact of temperature on building energy use

Building energy use will be impacted by temperature changes caused by changes to tree canopy and other green space. The impacts will depend on specifics such as the location of building, shading and the type and age of building. The broad patterns of energy use and temperature in NSW are shown in Figure 7.6.

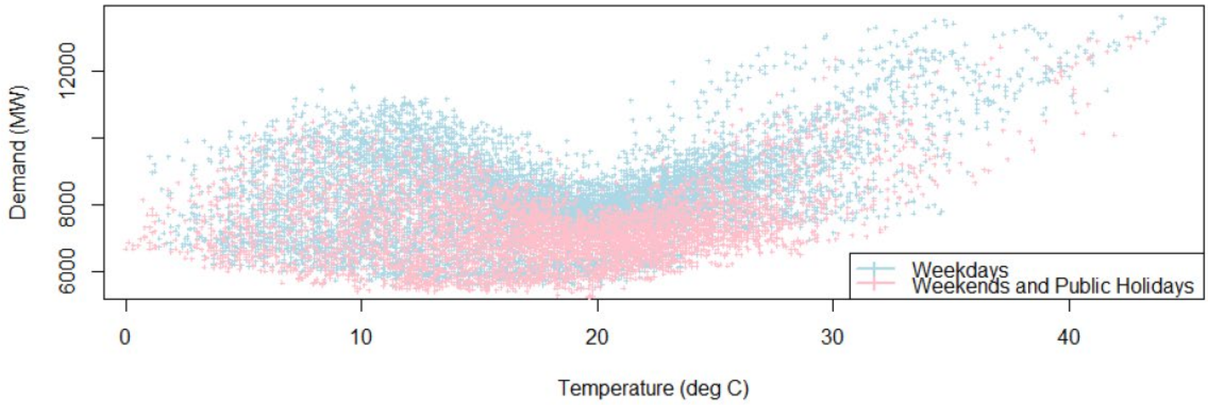
The different options are to:

- use a broad relationship of energy impact per household per degree
- apply different relationships for different buildings, based on their age/quality, type and the type of cooling appliances that they have.

The recommended approach is to apply a broad relationship of energy impact per household.

- There is not good information on different relationships between temperature and different building types and locations across NSW.
- If more detailed parameters were developed, then a project would need to be able to identify these factors within the catchment of the green infrastructure. Systematic data on building type is typically available for existing buildings. However, information on building age/quality and type of cooling appliances is not available. Given that energy savings are a small component of benefits for green infrastructure, seeking this level of information through any primary data gathering would not be proportionate to the significance of the benefit.

Figure 7.5 Temperature and energy use in NSW (2017)




Source: AEMO 2020, Electricity demand forecasting methodology information paper, August, https://www.aemo.com.au/-/media/files/electricity/nem/planning_and_forecasting/inputs-assumptions-methodologies/2020/2020-electricity-demand-forecasting-methodology-information-paper.pdf

To estimate building energy savings can either use simple default values, or specific modelling such as embedded in i-Tree. When going down the first approach, the recommended approach is to apply a parameter of a 1 per cent reduction in energy use for each 1°C reduction in temperature. This is based on:

- AEMO has estimated that each additional cooling degree day leads to a 0.038 per cent increase in per capita residential and commercial energy use.[96]
  - Cooling degree days measure the average temperature across the day less 19.5 degrees. If the average temperature is less than 19.5 degrees then cooling degree days is zero.
- The actual cooling degree days will be different for different areas, depending on their temperatures.
  - as a default, the framework assumes that average temperatures will be above 19.5 degrees for November to March (61 days for the December quarter of AEMO's model and 90 days of the March quarter)
- The cooling degree day reduction from a 1 degree reduction in temperature will also depend on how this is translated across the day.
  - the framework assumes that a 1 degree reduction occurs for 18 hours or three quarters of the day.
- The estimated impact on electricity use is then 1.07 per cent for each degree reduction, or ~1 per cent (61*75%*0.038%+90*75%*0.038%)/4[97]

To calculate the energy saving per household requires estimates of total household energy demand. IPART indicates that median residential electricity usage is 3900 kwh for the AusGrid's distribution area, 4900kWH for Essential's distribution area and 4600 for Endeavour's distribution

96 AEMO 2020, Electricity demand forecasting methodology information paper, August, https://aemo.com.au/-/media/files/electricity/nem/planning_and_forecasting/demand-forecasts/nefr/historical/2015-nefr-forecasting-methodology-information-paper.pdf, Table 5.

97 This is divided by four because the AEMO model is quarterly.

area.[98] Using a value of 4500 kWH per household as representative across these areas means an impact of 45 kWH (1%) saved for each 1 degree temperature reduction.

#### 7.2.2.2 Cost savings due to reduced energy use

The avoided costs (to society) from reducing energy use will reflect the resource cost of providing additional electricity. There are two main approaches used to estimate this:[99]

- Using a retail price of electricity as a proxy for the avoided resource costs
- Measuring avoided costs across the electricity supply chain directly, by:
  - measuring the avoided electricity generation costs based on wholesale electricity prices in generation markets
  - estimating any deferral of infrastructure from changing electricity demand.

The 2015 NSW Energy Efficiency Cost Benefit Analysis Framework recommended applying the latter. In practice, this means just applying a wholesale cost as estimating deferment of infrastructure is very complicated because it can be different for each spatial area and requires examining capacity and forecasting demand across multiple assets at different levels (such as a transmission assets and zone substations). If the wholesale cost is the only cost used, then this is akin to measuring a short run marginal cost for electricity generation, assuming no changes are required to infrastructure.

The implications of the approach used to value reductions in electricity use are substantial. A wholesale electricity cost would be less than one third of the variable component of the retail price — that is benefits of electricity reductions would be one third. This is not expected to be a large issue for green infrastructure where energy savings are a small component of benefits, but would be for energy efficiency projects. For example, programs related to building energy efficiency would have large net costs if using a wholesale price approach — and this assumption effectively implies that the retail price is over-incentivising energy efficiency.

For green infrastructure the appropriate avoided cost should reflect long run marginal costs. This is because:

- green infrastructure are long lasting assets
- the impacts of green infrastructure on electricity demand are likely to be focused on times of peak demand, as peak demand for most electricity assets occurs in summer.

Using a retail price approach is recommended. This is because this is the simplest proxy for the long run marginal cost for electricity.

- in a well-functioning competitive market, the retail price should be a good proxy for the avoided costs in the long term
- the generation of electricity can be classified as a competitive market

98 IPART 2020, *Monitoring the electricity retail market 2019/20,* November, https://www.ipart.nsw.gov.au/sites/default/files/documents/final-report-monitoring-the-electricity-retail-market-2019-20.pdf

99 Many studies confuse these approaches and measure both and add them together. This is never correct.

- other aspects of electricity supply are highly regulated market, such as transmission and distribution services, because they are natural monopolies, so cannot be classified as a well-functioning markets
- the regulations around price aim to replicate competitive market outcomes in the sense that prices should reflect long run marginal costs. [100] Fixed components of costs are recovered through supply charges, not through variable charges
- it will not be plausible for cost benefit analysis of green infrastructure to examine infrastructure deferment on a case by case basis, because of the cost of doing this. This would essentially involve redoing the calculations that distributors make in proving that their prices are aligned to long run marginal costs.

The retail price of electricity for residential users varies depending on specific plans customers are on and the time of day. Cooling savings are most likely to occur during the shoulder (daytime) and peak (early evening) periods. IPART reported the average peak price across plans reviewed in 2019/20 was 40 cents and the average shoulder price was 20 cents.[101] Given this, the framework recommends using a default value of 30 cents per kwh.

The calculated benefit from reduced energy use is valued as:

$$Energy\ cost\ saving = (RP \times \Delta Annual\ demand) \times N$$

Where $RP$ is the retail price and $N$ is the number of households affected by the cooling benefit. Using the default values recommended above gives $13.5 per household per year for each 1 degree reduction in temperature.

This is only available for households as there is limited information linking commercial electricity demand to temperatures.

For reference, the framework also reports the benefits using a wholesale only approach. This gives $4 per household per year for each 1 degree reduction in temperature. The wholesale cost used is the LRMC for electricity generation of $91 per MWh for 2036.[102]

### 7.2.3 Reduced greenhouse gas emissions due to reduced energy use

With an emission factor of 0.81 kg CO2-e/kWh[103] the benefit from carbon reduction of urban canopy from reduced energy use can be valued as below,

$$Carbon\ emmision\ reduction = P_{Carbon} \times (Emission\ factor \times \Delta E \times N)$$

Where $P_{carbon}$ is the social cost of carbon $\Delta E$ is the change in energy demand due to urban cooling impacts and $N$ is the number of households affected by the cooling benefit.

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100 AEMC 2014, National Electricity Amendment (Distribution Network Pricing Arrangements) Rule 2014, *Rule Determination*, https://www.aemc.gov.au/sites/default/files/content/de5cc69f-e850-48e0-9277-b3db79dd25c8/Final-determination.PDF.

101 IPART 2020, *Monitoring the electricity retail market 2019/20,* November, https://www.ipart.nsw.gov.au/sites/default/files/documents/final-report-monitoring-the-electricity-retail-market-2019-20.pdf

102 Frontier Economics, 2018, Western Parkland City (South Creek Catchment) – Land and Water use Strategic Options Business Case, prepared for INSW, p. 203 – 204.

103 Department of Environment and Energy (2019), National Greenhouse Accounts Factors, p71, available at https://publications.industry.gov.au/publications/climate-change/climate-change/climate-science-data/greenhouse-gas-measurement/publications/national-greenhouse-accounts-factors-august-2019.html, accessed 31st July 2020

The separate chapter on GHG emissions sets out the recommended approach to placing a price on carbon. This should be applied to any GHG emissions savings related to reduced energy use.

## 7.3 Recommendations for calculating urban heat benefits

For most projects, the parameters set out below can be used. Where a project has the main objective of urban cooling, and is examining designs to maximise cooling impacts, then specific modelling of how different project options impact on temperatures and energy use may be required.

The benefits are calculated as follows:

$$\begin{aligned} &Health\ benefits\ (from\ cooling) \\ &= number\ of\ people\ within\ impacted\ catchment \times no.of\ days\ above\ 30\ degrees\ per\ year \\ &\times\ reduction\ in\ temperature\ in\ degrees\ (\ \ ^{o}C) \\ &\times\ health\ benefit\ for\ 1^{o}C\ reduction\ in\ temperature\ per\ person\ per\ year \end{aligned}$$

$$\begin{aligned} &Reduced\ cooling\ costs \\ &= number\ of\ households\ in\ catchment \times reduction\ in\ temperature\ in\ degrees\ (\ \ ^{o}C) \\ &\times energy\ benefit\ per\ 1^{o}C\ reduction\ in\ temperature\ per\ household \end{aligned}$$

$$\begin{aligned} &Reduced\ GHG\ emissions \\ &= number\ of\ households\ in\ catchment \times reduction\ in\ temperature\ in\ degrees\ (\ \ ^{o}C) \\ &\times GHG\ benefit\ per\ 1^{o}C\ reduction\ in\ temperature\ per\ household \end{aligned}$$

### 7.3.1 Catchment

Areas 1000 metres from green space or canopy cover are expected to experience cooling benefits. This should be used to guide which geographic areas linked to population data are included. For example, where a project proposes to disperse new trees throughout a park, the catchment can be specified as 1,000 metres from the park's boundary. Alternatively where new canopy cover is proposed for one site the catchment can be specified as 1,000 metres from the site.

It is important to note the size of the catchment does not influence the total value of urban cooling impacts, assuming housing and population densities are constant throughout the catchment. The estimated urban cooling impacts are proportional to the additional area covered by green infrastructure. In simple terms, a larger catchment applies a smaller reduction in temperature to a broader base (i.e. population or households within catchment), whilst a smaller catchment applies a higher reduction in temperature to a smaller base. For example, one hectare of additional tree canopy cover in a 10 hectare catchment is equivalent to a 10 percentage point increase in tree canopy. This is estimated to lead to a 1.13˚C reduction in temperatures. If a larger catchment was used of 20 hectares, then the one hectare is equivalent to a 5 percentage point increase in tree canopy. This is estimated to lead to a 0.665˚C reduction in temperatures. Hence the temperature effect modelled has halved, while the area to which it is applied has doubled.

#### 7.3.1.1 Canopy cover

Canopy cover and growth rates vary by tree species. NSW DPIE's Street Tree Planting Design Manual (2021) lists the size and growth rates (slow, medium, fast) for selected tree species. Size categories for mature trees are:

- small tree — mature height between 6 and 9 metres with spread of 6 metres
- medium tree — mature height between 10 and 15 metres with spread of 8 metres
- large tree — mature height greater than 16m with spread of 12 metres.

The spread is approximately the diameter of a tree's canopy cover. See Table 2 in the Street Tree Planting Design Manual for a detailed list of tree species.

Table 7.3 shows indicative years to reach mature height for a small, medium and large tree. This is based on indicative annual growth rates for slow, medium and fast growing tree and mature height for small, medium and large trees. These are indicative only and do not reflect variation in growth rates due to environmental and geographic factors, species type and genetics. Alternative growth rates can be tested in sensitivity analysis if required.

**Table 7.3 Indicative years to reach mature tree height**

| Tree size | Mature height metres | Slow growth rate<br>30cm/yr | Medium growth rate<br>30cm/yr to 60cm/yr | Fast growth rate<br>60+ cm/yr |
|---|---|---|---|---|
| Small | 6 to 9 | 25 | 17 | 13 |
| Medium | 10 to 15 | 42 | 28 | 21 |
| Large | 16+ | 53 | 36 | 27 |

Note: Midpoint of mature height ranges applied as follows 7.5 metres for small tree, 12.5 metres for medium tree, 16 metres for large tree. Midpoint for growth rates applied as follows: 45 cm/yr for medium growth rate and 60cm/yr for fast growth rate.

Source: NSW DPIE, 2021, *Street Tree Planting Design Manual* and NSW DPE for growth rates.

### 7.3.1.2 Reduction in temperature

The following temperature reductions may be applied if relevant:

- 1.13°C for every additional 10 per cent of catchment covered by tree canopy, compared to no vegetation
- 0.63°C for every additional 10 per cent of catchment that converts from green open space to tree canopy cover
- 0.50°C for every additional 10 per cent of catchment that converts from no vegetation to green open space (not canopy cover)

Values for water are not available. The values for tree and vegetation cover should be applied to the green assets within a wetland.

### 7.3.1.3 Monetised values

The following benefit values may be applied if relevant:

- health benefit from cooling: $3.0 for each degree reduction per person per year per day above 30 degrees
- cooling costs: $13.5 per year per household per degree (C) of temperature reduction[104].
- GHG benefits: $3.7 per year per household per degree (C) of temperature reduction[105].

[104] This is based on the retail electricity price of 30 cents per kwh, because green assets are long lived and will be expected to impact at times of peak demand

[105] This based on a $100 cost of carbon and 0.81 kg CO2-e/kWh marginal GHG per unit of electricity and should be scaled across years of the analysis by the recommended cost of carbon and any expected changes in emissions intensity of electricity generation over time. The Appendices include specific advice about valuation of GHG emissions reductions.

Note that cooling costs and GHG benefits from urban cooling are related, and that care should be taken to avoid double counting.

The parameters are linked to tree canopy cover. For new tree plantings this will initially be small and will increase over time as tree canopy growth occurs

Population and household data for the specified catchment should be sourced from ABS 2021 Census Data https://www.abs.gov.au/census. Digital boundary files are available at Digital boundary files.

# 8 Stormwater management

## 8.1 Green infrastructure's stormwater management services

Green infrastructure reduces stormwater runoff to surrounding areas by absorbing rain and regulating water movement within the catchment.[106] This can result in:

- cost savings associated with lower water stormwater servicing and water filtration costs
- improved water quality due to lower stormwater volumes entering waterways
- reduced impacts from flooding.

Calculating the avoided stormwater management costs for use in CBA requires:

- Understanding the relationship between green infrastructure and stormwater runoff, primarily, how do peak flow rates change with greater provision of green infrastructure within a catchment?
- Identifying the impact, either a reduction in flooding and damage to surrounding assets, or a reduction in stormwater infrastructure built compared to the base case.

The benefits, in particular cost savings, are likely to vary considerably from project to project.

### 8.1.1 Stormwater regulation services provided by green infrastructure

Stormwater runoff flows over the ground and into drains, sewers and waterways. Green infrastructure and other permeable surfaces can reduce runoff and peak flows through absorbing rainwater during a storm event. The captured water is slowly released into the environment.

The volume of stormwater released from Melbourne's metropolitan parks (34 GL per year) was estimated to be half of the volume released compared to if the land was instead used for urban residential development (74 GL per year).[107]

Peak flow rates were estimated for a number of national and State (non-metropolitan) parks in Victoria and compared to peak flow rates under a scenario of cleared land for grazing (Table 8.1). The reduction in peak flow rates attributable to a park ranges from 7 per cent to 115 per cent.

[106] Parks Victoria and Department of Environment, Land, Water and Planning. 2015, 'Valuing Victoria's Parks Accounting for ecosystems and valuing their benefits: Report of first phase findings', p 79, available at:
file:///C:/Users/lcassar/Downloads/Valuing-Victorias-Parks-Report-Accounting-for-ecosystems-and-valuing-their-benefits%20(6).pdf

[107] Ibid.

Table 8.1 Peak flows (m3/s) from parks compared with alternative land use — Victoria

| Park | Peak flows from park land use (ARI_100)<br><br>$m^3/s$ | Peak flows from agricultural land use (ARI_100)<br><br>$m^3/s$ | Reduction in ARI_100<br><br>Per cent |
|---|---|---|---|
| Alpine NP | 3 159 | 3 926 | 24 |
| Yarra Ranges NP | 337 | 726 | 115 |
| Great Otway NP | 321 | 518 | 61 |
| Grampians NP | 266 | 416 | 56 |
| Lerderderg SP | 117 | 154 | 31 |
| Lake Eildon NP | 88 | 108 | 23 |
| Bunyip NP | 87 | 116 | 33 |
| Baw Baw NP | 81 | 87 | 7 |
| Warby Ovens NP | 49 | 54 | 11 |

a ARI_100 = 1:100 Average Recurrence Interval.

Source: MJA 2014, Valuing the Water Services Provided by Victoria's Parks. Report prepared for Parks Victoria.

Source: AECOM, 2012, Economic Assessment of the Urban Heat Island Effect, Prepared for the City of Melbourne, https://www.melbourne.vic.gov.au/SiteCollectionDocuments/eco-assessment-of-urban-heat-island-effect.pdf.

## 8.1.2 Identifying and valuing the impact

Green infrastructure reduces the peak flow rate of stormwater, potentially resulting in:

- reduced flood impacts to surrounding communities and assets, and or
- reduced stormwater infrastructure costs.

As noted, these benefits, in particular cost savings, are likely to vary considerably from project to project. The extent of stormwater management services provided by green infrastructure is site dependent and influenced by the following factors:

- weather factors and catchment typology
- existing proportion of green and blue infrastructure within the catchment
- existing provision of stormwater infrastructure, and
- the type of green infrastructure.

Furthermore, there may be minimal impact if the stormwater infrastructure has already been or will be built regardless of existing or new green infrastructure within the catchment.

### 8.1.2.1 Avoided stormwater infrastructure costs from Melbourne's metropolitan parks

Melbourne's metropolitan parks were estimated to halve the stormwater management infrastructure required compared to a situation where the land was instead used for urban residential development.[108] The benefit of stormwater retention services provided by Melbourne's metropolitan parks was estimated at $46 million per annum, equivalent to $3 000 per hectare per

[108] Ibid.

annum.[109] This was based on hydraulic charges applied to recent development sites of around $28 000 per hectare east of Melbourne and $68 000 per hectare north or west of Melbourne.[110]

#### 8.1.2.2 Benefits of reduced stormwater run-off in the ACT

Tapsuwan et al. 2019 evaluated benefits of reducing stormwater through public urban forests and irrigated areas (as well as other benefits and costs).[111] This used a defensive and correctional expenditure approach. The benefits of reduced stormwater run-off were estimated through the avoided costs of projects to build stormwater wetlands or retention ponds in the ACT. A selection of six stormwater management options were included, and the costs per cubic metre of stormwater run-off managed evaluated. The benefit of reducing run-off was then measured as the avoided cost of having to undertake similar projects.

### 8.1.3 Recommended approach for valuing stormwater management services

This framework does not recommend parameters to value the impacts of green infrastructure on stormwater management because of the inherent site dependencies. However proponents can include this impact in a CBA where the relationship between green infrastructure and a change in stormwater management can be clearly identified. For example where provision of green infrastructure reduces the cost of stormwater management in the catchment, by reducing the requirement for detention or retention basins of nearby development, or reducing the number and/or size of stormwater pits or pipes to be installed. There is no stormwater management impact if stormwater infrastructure is installed or planned irrespective of green infrastructure within the catchment.

[109] Ibid.

[110] Ibid.

[111] S Tapsuwan, R Marcos-Martinez, H Schandl, & Z Yu, 'Valuing ecosystem services of urban forests and open spaces: application of the SEEA framework in Australia' (2021) 65 *Australian Journal of Agricultural and Resource Economics.*

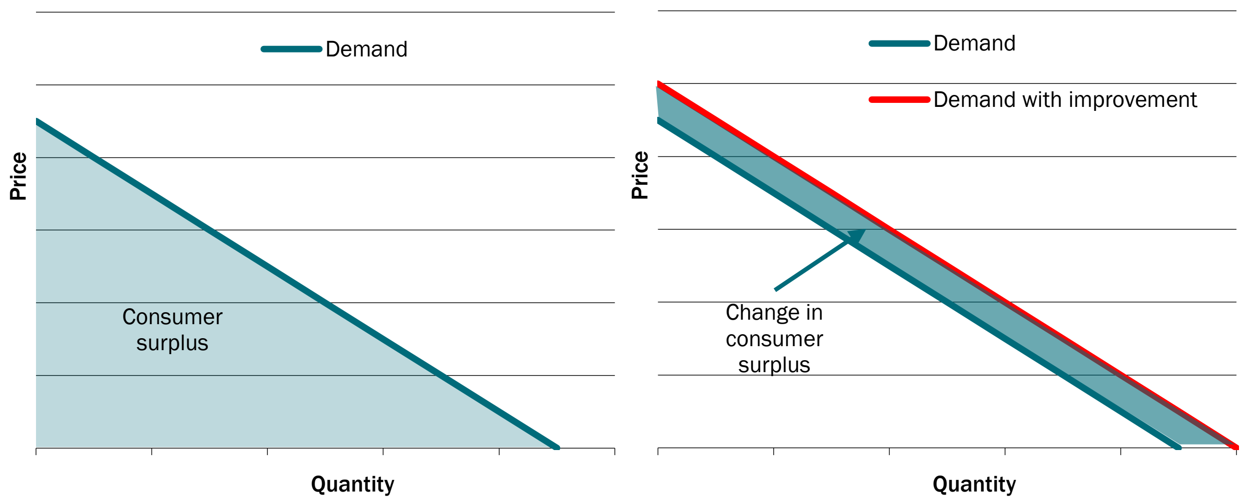
# 9 Use value of public facilities

Public facilities include public libraries, museums, galleries, civic/community centres, showgrounds and indoor public sports facilities.

The 'use' value of a public facility captures the area under the demand curve for a particular facility. For the purposes of cost benefit analysis, this is based on the demand curve for a **new public facility**, or how the demand curve changes from an **improvement to an existing public facility**. This is shown in Figure 9.1, for free public facilities — that is, where the entry fee is zero.

- The left-hand panel shows the total value of use for a new or existing public facility. This is the total area under the demand curve.
- The right-hand panel shows the value of use for an improvement to a public facility, which is the area between the demand curve and demand with the improvement.

**Figure 9.2 Measuring consumer surplus from public facilities**




Source: The CIE.

Calculating the use value of public facilities requires:

- identifying a suitable valuation approach
- applying appropriate benefit transfer where primary studies are not available.

## 9.1 Approaches to measuring use value for public facilities

There are a number of possible approaches to measure the value people place on using public facilities:

- revealed preference valuation methods. Revealed preference methods use people's actual decisions to infer their valuation. The two possible methods are:

- hedonic analysis — using house or land prices versus a range of explanatory variables (including access to public facilities) to understand the impact of the facility on house or land value. This will pick up an estimate of whether being near a public facility, or having more public facilities, is of value to people living in an area
- travel cost method — the travel cost methods records information on how much it costs people to get to a public facility.[112] This can then be used to back out a demand curve. This method can only be used for measuring the value of existing public facilities. If this is to be used in ex ante cost benefit analysis, values from existing facilities would have to be applied in some way to new or improved facilities.

- stated preference methods, including:
  - contingent valuation — asking people to state how much they would be willing to pay for using a new or modified public facility.[113]
  - choice modelling — presenting people with choices about new or improved facilities, and payment mechanisms. Their choices are then used to infer the value of the new or improved public facilities.

The different approaches will measure different types of benefits. For example, hedonic analysis captures benefits only for people very close to a public facility. For public facilities, the main methods that are possible, because of the catchments of these facilities, are the travel cost method and stated preference approaches. As a general rule, **revealed preference techniques will provide more accurate estimates** of value because they are based on people's actual decisions.[114] Hence, the travel cost method is likely to provide the most accurate view of the value of existing facilities. However, this method does not easily provide information on the value of different characteristics of public facilities, and may require considerable adjustment to apply to new projects compared to undertaking stated preference surveys.

The travel cost method is the most robust method for measuring the value of use of existing public facilities.

The travel cost method is preferred over other methods for estimating use value because:

- it specifically measures use value
- it measures the use value for all users
- it relies on people's actual decisions.

Robust benefit transfer techniques are required to apply value measures from travel cost studies to new and improved public facilities. In some instances, it will be difficult to apply estimates from a travel cost study of an existing public facility to a new or improved public facility. In these cases, other methods, such as stated preference methods, will have to be applied.

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112 For facilities with an entry fee, which are outside of the scope of this framework, entry fees would be added to the travel cost to get a generalised cost of accessing a facility.

113 Information on entry fees for facilities, with similar characteristics to the subject of the contingent valuation study, can be used to provide supporting evidence for public facility willingness to pay.

114 NSW Treasury, *NSW Government Guide to Cost-Benefit Analysis*, TPG23-08, p. 50, https://www.treasury.nsw.gov.au/sites/default/files/2023-03/tpg23-08_nsw-government-guide-to-cost-benefit-analysis_v2.pdf, 2023.

## 9.2 Applying values to new projects

The types of projects that could be expected in relation to public facilities include:

- developing new public facilities, such as libraries, indoor sports facilities, galleries and community centres in green field areas, where there may be few existing substitutes
- developing new public facilities, such as new museums in areas where there are existing substitutes
- developing highly unique facilities, such as specialised museums or galleries
- improvements in existing public facilities, such as:
  - refurbishment or extensions of an existing museum or gallery
  - investment in improving museum, gallery and library collections.

In applying benefit transfer approaches to these different projects, the types of elements that are expected to be important include:

- the extent of substitutes — WTP valuations for existing public facilities reflect available substitutes for the subject of the study. Applying those values to investments in locations with fewer substitutes may mean the WTP should be higher and vice versa.
- the change in quality for improvements in public facilities – this is unlikely to be able to be measured for partial upgrades as the WTP of existing facilities do not measure WTP for a change in quality, while studies examining quality, such as for a new museum, are highly specific.
- the uniqueness of facilities – the valuation of unique facilities, such as specialised museum, may be poorly approximated by benefit transfer
- the preferences of the local community with respect to the particular facilities being considered.

## 9.3 Recommended approaches and values

Until recently there was a large gap in primary studies which estimated the value of new and improved public spaces. CIE (2022)[115] estimated the community's willingness to pay for new and improved public spaces for six facility types; libraries, museums, galleries, civic/community centres, showgrounds and indoor sports facilities.

It is recommended the WTP estimates from CIE (2022) are applied for a new facility, complete upgrade of an existing facility and removal of an existing facility, as follows:

- **Willingness to pay for new facilities:**
  - Table 9.1 provides the WTP for a large-sized new facility with parking always being available. WTP differs by travel time of a household from the new facility.

[115] CIE, 2022, *Willingness to pay for new and improved public facilities: Stated preference research.* Prepared for Department of Planning and Environment.

– These estimates of WTP can be adjusted to reflect new facilities with different attributes based on the adjustments in Table 9.2.
– Table 9.3 lists the bundle of attributes by size category for each facility type.

- **Willingness to pay for a complete upgrade of an existing facility:**
  – It is recommended the central estimates in Table 9.4 are applied to value complete upgrades of existing facilities.
  – Insufficient evidence is available to value partial upgrades of existing facilities, or the value of the separate attributes that are enhanced by a complete upgrade.
- **Willingness to accept for the removal of an existing facility**
  – All consumer surplus changes should be accounted for, including the change from loss of one public facility replaced by another. The loss of value associated with existing uses is not implicitly accounted for in the estimated WTP values, so must be separately included.
  – The WTP for a new facility should be applied as an estimate of the WTA for removal of an existing facility. This is likely to be a conservative estimate.

**Table 9.1 Average willingness to pay for a new, large facility, by travel time and parking**

| | Parking rarely available<br><br>$/household/year 2022$ | Parking available half of visits<br><br>$/household/year 2022$ | Parking always available<br><br>$/household/year 2022$ |
|---|---|---|---|
| Library | | | |
| 10 min travel time | 57.04 | 59.28 | 71.56 |
| 20 min travel time | 23.20 | 49.32 | 60.24 |
| 30 min travel time | 13.44 | 39.56 | 50.48 |
| 40 min travel time | 3.68 | 29.80 | 40.72 |
| 50 min travel time | 0.00 | 20.04 | 30.96 |
| 60 min travel time | 0.00 | 10.28 | 21.20 |
| 70 min travel time | 0.00 | 0.52 | 11.40 |
| 80 min travel time | 0.00 | 0.00 | 1.64 |
| 90 min travel time | 0.00 | 0.00 | 0.00 |
| Community centre | | | |
| 10 min travel time | 61.68 | 63.92 | 76.20 |
| 20 min travel time | 27.84 | 53.96 | 64.88 |
| 30 min travel time | 18.08 | 44.20 | 55.08 |
| 40 min travel time | 8.32 | 34.40 | 45.32 |
| 50 min travel time | 0.00 | 24.64 | 35.56 |
| 60 min travel time | 0.00 | 14.88 | 25.80 |
| 70 min travel time | 0.00 | 5.12 | 16.04 |
| 80 min travel time | 0.00 | 0.00 | 6.28 |
| 90 min travel time | 0.00 | 0.00 | 0.00 |
| Gallery | | | |

| | Parking rarely available<br><br>$/household/year<br>2022$ | Parking available half of visits<br><br>$/household/year<br>2022$ | Parking always available<br><br>$/household/year<br>2022$ |
|---|---|---|---|
| 10 min travel time | 53.68 | 55.92 | 68.20 |
| 20 min travel time | 19.84 | 45.96 | 56.88 |
| 30 min travel time | 10.08 | 36.20 | 47.12 |
| 40 min travel time | 0.32 | 26.44 | 37.36 |
| 50 min travel time | 0.00 | 16.68 | 27.60 |
| 60 min travel time | 0.00 | 6.92 | 17.80 |
| 70 min travel time | 0.00 | 0.00 | 8.04 |
| 80 min travel time | 0.00 | 0.00 | 0.00 |
| 90 min travel time | 0.00 | 0.00 | 0.00 |
| Museum | | | |
| 10 min travel time | 60.40 | 62.64 | 74.92 |
| 20 min travel time | 26.56 | 52.68 | 63.60 |
| 30 min travel time | 16.80 | 42.92 | 53.84 |
| 40 min travel time | 7.04 | 33.16 | 44.08 |
| 50 min travel time | 0.00 | 23.40 | 34.32 |
| 60 min travel time | 0.00 | 13.64 | 24.52 |
| 70 min travel time | 0.00 | 3.88 | 14.76 |
| 80 min travel time | 0.00 | 0.00 | 5.00 |
| 90 min travel time | 0.00 | 0.00 | 0.00 |
| Showground | | | |
| 10 min travel time | 56.60 | 58.84 | 71.12 |
| 20 min travel time | 22.76 | 48.88 | 59.80 |
| 30 min travel time | 13.00 | 39.12 | 50.04 |
| 40 min travel time | 3.24 | 29.36 | 40.28 |
| 50 min travel time | 0.00 | 19.60 | 30.48 |
| 60 min travel time | 0.00 | 9.80 | 20.72 |
| 70 min travel time | 0.00 | 0.04 | 10.96 |
| 80 min travel time | 0.00 | 0.00 | 1.20 |
| 90 min travel time | 0.00 | 0.00 | 0.00 |
| Indoor sports facility | | | |
| 10 min travel time | 70.16 | 72.36 | 84.68 |
| 20 min travel time | 36.32 | 62.44 | 73.32 |
| 30 min travel time | 26.56 | 52.64 | 63.56 |
| 40 min travel time | 16.80 | 42.88 | 53.80 |
| 50 min travel time | 7.00 | 33.12 | 44.04 |
| 60 min travel time | 0.00 | 23.36 | 34.28 |
| 70 min travel time | 0.00 | 13.60 | 24.52 |

| | Parking rarely available<br><br>$/household/year<br>2022$ | Parking available half of visits<br><br>$/household/year<br>2022$ | Parking always available<br><br>$/household/year<br>2022$ |
|---|---|---|---|
| 80 min travel time | 0.00 | 3.84 | 14.76 |
| 90 min travel time | 0.00 | 0.00 | 5.00 |

Source: CIE, 2022, *Willingness to pay for new and improved public facilities: Stated preference research.* Prepared for Department of Planning and Environment.

### Table 9.4 Adjusting average willingness to pay for facility size and surroundings

| Adjustment | Impact on WTP<br><br>$/household/year |
|---|---|
| Surroundings | |
| 'Shops or cafes' to 'Residential or commercial buildings' | -6.84 |
| 'Shops or cafes' to 'Green space' | -0.56 |
| Size | |
| Large to medium | -2.16 |
| Large to small | -16.60 |

Source: CIE, 2022, *Willingness to pay for new and improved public facilities: Stated preference research.* Prepared for Department of Planning and Environment.

Note that the size levels (small, medium and large) summarise a range of features specific to each of the six facility types. Each level summarised a range of features specific to each of the six facility types. For example, a library's size levels were characterised by the number of computers, size of the book collection, availability of services such as meeting rooms, and the size of the library measured in terms of the number of houses. A small library is equivalent to the size of an apartment while a medium and large library is equivalent to the size of five houses and 14 houses respectively. Table 9.3 contains the description corresponding to each size level for each facility type.

## Table 9.3 Bundle of features embedded in the 'size' attribute for each facility type

| Size of facility | Description |
|---|---|
| **Library** | |
| Small | About the size of an apartment<br>Small book collection<br>1-4 computers |
| Medium | Around the size of five houses<br>Large book collection<br>5-10 computers and free Wi-Fi<br>Online library services |
| Large | Around the size of 14 houses<br>24/7 online access to entire library collection<br>More than 10 computers and free Wi-Fi<br>Meeting rooms for hire<br>Dedicated areas for children and accompanying programs |
| **Community Centre** | |
| Small | Around the size of one apartment<br>One small hall/room available for bookings<br>Small kitchen (with stove and fridge) and storage<br>No computers |
| Medium | Around the size of two houses<br>One large hall or multiple rooms available for bookings<br>Medium-sized kitchen (with stove and fridge) and storage<br>One or a few computers and Wi-fi |
| Large | Around the size of five houses<br>Halls/rooms available for bookings<br>A fully equipped kitchen, lounge and outdoor amphitheatre/market area<br>Self-service computers and Wi-fi |
| **Museum** | |
| Small | Around the size of one apartment<br>Museum shop or café<br>Conference/convention facilities |
| Medium | Around the size of 5 houses<br>Museum shop or café<br>Venue hire with indoor and outdoor space and kitchen<br>Guided tours available<br>Workshops for children during school terms |
| Large | Around the size of 10 houses<br>Museum shop and café with click and collect option<br>Venue hire with indoor and outdoor space and fully equipped kitchen<br>Self-guided visits (with printed language guides) and group tours with pre-booking options<br>Learning programs/excursions/professional development courses including online resources |
| **Showground** | |
| Small | Powered and unpowered campsites<br>Pavilion and a hall<br>Picnic tables and BBQ |

| Size of facility | Description |
|---|---|
| | Stabling facilities<br>Venue hire for community events |
| Medium | Powered and unpowered campsites<br>Pavilion and a hall<br>Kitchen, picnic tables and BBQ<br>Stabling facilities and a show ring<br>Venue hire for medium events |
| Large | Powered and unpowered campsites<br>Pavilion, concrete and grass outdoor seating areas, stadium, and exhibition halls<br>Fully functional kitchen, canteen with indoor and outdoor serving and seating<br>Stabling facilities, equestrian wash bay, dressage area and jumping arena<br>Venue hire for major events |
| Gallery | |
| Small | Around the size of an apartment<br>Works by local artists with exhibition labels |
| Medium | Around the size of 10 houses<br>Exhibitions and gallery shop<br>Venue hire<br>Guided tour for group and school visits |
| Large | About the size of 25 houses<br>Exhibitions, gallery shop and café/restaurant<br>Venue hire with catering packages<br>Education kits and programs to support school visits<br>Free wifi |
| Indoor sports facility | |
| Small | One indoor space suitable for training, yoga or martial arts |
| Medium | One or two indoor courts for basketball, futsal, gymnastics, indoor cricket or squash<br>Change and shower facilities<br>Kiosk<br>Hireable space |
| Large | Three or more courts for basketball, futsal, gymnastics, cricket and/or squash<br>Change and shower facilities<br>On-site cafe<br>Venue hire for multipurpose events |

Source: CIE, 2022, Willingness to pay for new and improved public facilities: Stated preference research. Prepared for Department of Planning and Environment.

### Table 9.5 Average willingness to pay for full upgrade of existing facility

| Adjustment | Conservative WTP<br><br>$/household/year for 10 years 2022$ | Central WTP<br><br>$/household/year for 10 years 2022$ |
|---|---|---|
| Indoor sports facility | 7.29 | 11.43 |
| Showground | 9.18 | 13.66 |
| Gallery | 9.50 | 14.66 |

| Adjustment | Conservative WTP<br><br>$/household/year for 10 years 2022$ | Central WTP<br><br>$/household/year for 10 years 2022$ |
|---|---|---|
| Library | 5.83 | 10.01 |
| Museum | 8.76 | 13.05 |
| Community Centre | 6.79 | 10.59 |
| All facilities | 7.89 | 12.23 |

Note: Estimates of unconditional mean WTP. Incomplete questionnaire responses have been assigned a WTP of zero. Estimates are per household for the facility of that type that they visit most frequently.

Source: CIE, 2022, *Willingness to pay for new and improved public facilities: Stated preference research.* Prepared for Department of Planning and Environment.

### 9.3.1 Availability of existing facilities

There was insufficient evidence from the survey to estimate how the proximity and characteristics of existing facilities affect WTP. It is expected that WTP is lower for people who have a closer existing substitute than a proposed new facility. It is recommended for proponents to consider using the WTP for an upgrade of an existing facility rather than the value of a new facility for people who have a closer available facility of the same type.

### 9.3.2 Highly unique facilities

The recommended parameters outlined above should not be applied to highly unique facilities, such as state museums and galleries. In these instances it is recommended a primary study should be completed.

### 9.3.3 Example application of WTP for a new library

Estimating the benefits of a new facility requires aggregating WTP across households and over time. In this hypothetical example the WTP estimates are applied to a potential new library. Total WTP for this example is $404 000 per quarter (Table 9.5).

For the purpose of this example, we assume the new Library would be:

- medium in size (and corresponding features)
- surrounded by green space (since there is an adjacent park)
- with parking rarely available.

In the recommended parameters, WTP declines with travel time.[116] For households with a sufficiently high travel time to the proposed new library, WTP decreases below zero, indicating they would derive no benefit from the new facility. This level of travel time defines the ‘catchment’ of the facility. In this example, the estimated benefits are zero for households outside of a 40-minute travel time (Table 9.5).

[116] Note that the choice experiment used to measure willingness to pay did not focus on car, but rather on typical travel time without specifying the mode

To illustrate how unconditional WTP has been calculated from the parameter values above, consider households within 0-10 minutes travel time of this library that have unconditional WTP of $13.58/quarter in table 4:

- the unconditional WTP for households within 0-10 minutes travel time is $14.26/quarter for a library (Table 9.1),
- this is adjusted downward by 0.14 because it is surrounded by green space rather than shops or cafes, and by 0.54 because it is medium-sized rather than large (Table 9.2).

Counts of persons who can access the new Library within various travel times at 10-minute increments are drawn from a travel time matrix. A weighted average is taken across car and public transport travel time for each travel zone to the destination. The weighted average is a demand weighted average of time by each mode. The demand used for this weighted average is AM-peak trip volumes. The estimated number of persons is conservative, since the travel time estimates relate to morning peak traffic. Counts of persons are converted to counts of households using the average household size of 2.6 for the 'Sydney – Ryde' Level 4 Statistical Area.

WTP is aggregated for each travel time ring by multiplying the count of households by average unconditional WTP. Total WTP is calculated by aggregating over all travel time rings. In this example, total WTP is estimated at $404 000 per quarter or $1.6 million per year. The present value of these benefits over 30 years at a discount rate of 5 per cent is $25 million.

### Table 9.6 Aggregating willingness to pay over households

| Travel time | Unconditional WTP | Households | Aggregate WTP |
|---|---|---|---|
| Minutes | $/quarter | No. | $'000/quarter |
| 0 - 10 | 13.58 | 8 411 | 114 |
| 10 - 20 | 5.13 | 28 163 | 144 |
| 20 - 30 | 2.68 | 47 602 | 128 |
| 30 - 40 | 0.24 | 74 053 | 18 |
| 40 - 50 | -2.20 | 69 111 | 0 |
| 50 - 60 | -4.64 | 80 772 | 0 |
| 60 - 70 | -7.08 | 120 984 | 0 |
| 70 - 80 | -9.52 | 114 686 | 0 |
| 80 - 90 | -11.96 | 93 267 | 0 |
| Total | | | 404 |

Source: CIE, 2022, Willingness to pay for new and improved public facilities: Stated preference research. Prepared for Department of Planning and Environment.

# 10 Use value of streets and street tree canopy

This chapter covers the value of improving streets[117]. The value to these spaces includes value for people using them — for example, a pedestrian may have higher value walking down a shaded street than an unshaded one — and amenity value — these places could have visual amenity benefits for users and others. The section has not separated out use and amenity, as these are difficult to disentangle for these types of assets.

This section also covers amenity of public open space (not use value which has been separately developed). However, the recommendation is to include no value related to amenity for public open space. Amenity value would largely be applicable to parks and gardens. However, the hedonic price methodology recommended for valuing urban parks will already incorporate amenity impacts, and this is therefore already factored in jointly with use benefits.

## 10.1 Review of studies related to streets and amenity

There are two strands of work related to valuation approaches for streets and amenity aspects of public open space:

1. the TfNSW approach from the Movement and Place evaluation guide. This involves:
    a. urban design specialists using documentation on the design of the place currently and under project options to develop Pedestrian Environment Review System (PERS) scores
    b. these scores being converted into monetary terms through applying willingness to pay estimates per pedestrian minute to the scores.
2. studies related to how amenity is valued related to street trees, though using hedonic analysis to unpick the extent to which street trees influence property values.

These two approaches are measuring some benefits that are different and some benefits that are the same (Table 10.1).

**Table 10.1 Comparison of PERS and hedonic studies**

| Type of benefit | Pedestrian Environment Review System (PERS) approach | Hedonic studies |
|---|---|---|
| Visual amenity related to walking down street or being in street | Yes | Unclear – property value may partly reflect a use value |
| Visual amenity for people living in area | No | Yes |
| Private urban cooling benefits and air pollution benefits not related to use | No | Yes |

[117] This includes streets, avenues and boulevards, squares and plazas, pavements, passages and lanes, and bicycle paths.

| Type of benefit | Pedestrian Environment Review System (PERS) approach | Hedonic studies |
|---|---|---|
| Private urban cooling benefits and air pollution benefits related to use (e.g. walking in shady street) | Yes | Unclear – property value may partly reflect a use value |
| Urban design aspects unrelated to green | Yes, for users, but not for people living in area outside of use | No, as studies are focused on hedonic value of green attributes |

Note: Blue is yes, pink is no and grey is where this is unclear.

The other main difference between the PERS approach and hedonic approaches is that PERS is much more specific to the project options being evaluated. This also means it is more expensive to implement, because at least two public space auditors would be required to score different urban designs, and data about expected use is required.

Further detail on the approaches and studies is set out below.

### 10.1.1 PERS approach

TfNSW has developed the Movement and Place Evaluation Guide: Estimating placemaking impacts of transport projects in business cases. This includes developing approaches to apply to transport projects that have placemaking impacts. Of most relevance for this Guide is the discussion of amenity:

> "Amenity is the pleasantness, attractiveness or desirability of a place, facility, building or feature. Amenity is very important to communities and other stakeholders at local, district, regional and State levels. The quality of a place includes the aesthetics, the physical design and how the place is used. The concept of urban amenity includes not only the visual and aesthetic qualities of a place, but also a range of more functional considerations such as safety, comfort and convenience. Visual amenity and good urban design principles are recognised as key factors in the development of a liveable city. The amenity benefit is created from the following placemaking attributes
>
> - *Pedestrian zone*
> - *Lighting in open space*
> - *Presence of green space*
> - *Good urban design*
> - *Walkable streets including tree canopy*
> - *Aesthetics of urban design and landscape*
> - *Noise and vibration reduction from traffic street to shared street*
> - *Reduced air pollution and odour by reducing the number of cars on the street."*[118]

The TfNSW guide discusses the various approaches to valuing amenity. The main approach recommended, aside from specific project analysis and surveys, is to apply scores from the Pedestrian Environment Review System (PERS) to a previous willingness to pay survey on these characteristics.

The PERS defined 6 attributes of public spaces:

[118] TfNSW 2020, Movement and Place Evaluation Guide: Estimating placemaking impacts of transport projects in business cases, September, p. 31.

- Moving in the space: Create convenient connections
- Interpreting the space: Create clear and easy to understand routes and spaces
- Personal safety: All users feel safe
- Feeling comfortable: Create streets and spaces for everyone
- Sense of place: Get the detail right
- Opportunity for activity: Create active and passive public spaces.

Each attribute is scored from -3 to 3 by a minimum of two public space auditors. Willingness to pay values are then applied, with the values reported by TfNSW shown in  Figure 10.1 shows an example of 1 point improvement in PERS score.

Table 10.2 in cents per person per minute. For example, moving from a score of -3 for all attributes to a score of +3 for all attributes would have benefits of 2.961 cents per person per minute. Figure 10.1 shows an example of 1 point improvement in PERS score.

### Table 10.7 Amenity benefits for improvements to public space (cents per person per minute, $2022)

| Attribute | -3 | -2 | -1 | - | 1 | 2 | 3 |
|---|---|---|---|---|---|---|---|
| Moving in the space | 0 | 0.132 | 0.266 | 0.398 | 0.446 | 0.492 | 0.540 |
| Interpreting the space | 0 | 0.030 | 0.059 | 0.088 | 0.117 | 0.147 | 0.179 |
| Personal safety | 0 | 0.126 | 0.252 | 0.378 | 0.504 | 0.621 | 0.739 |
| Feeling comfortable | 0 | 0.071 | 0.140 | 0.211 | 0.281 | 0.352 | 0.422 |
| Sense of place | 0 | 0.038 | 0.080 | 0.117 | 0.144 | 0.158 | 0.170 |
| Opportunity for activity | 0 | 0.217 | 0.433 | 0.654 | 0.739 | 0.824 | 0.911 |
| Sum | 0 | 0.613 | 1.231 | 1.847 | 2.230 | 2.594 | 2.961 |

Source: Tsai 2019, https://www.australasiantransportresearchforum.org.au/sites/default/files/papers/ATRF2019_resubmission_38.pdf as reported in TfNSW 2020, Movement and Place Evaluation Guide: Estimating placemaking impacts of transport projects in business cases, September. Values indexed to 2022 dollars using ABS, 2023, Consumer Price Index Australia, Cat. No 6401.0.

### Figure 10.1 Example of a 1 point improvement in PERS score

*Data source:* Tsai 2019, https://australasiantransportresearchforum.org.au/wp-content/uploads/2022/03/ATRF2019_resubmission_38.pdf

To apply the values the estimated number of pedestrians and the amount of time they spend in a place is required. This could be estimated using pedestrian counts for existing places. For new places, this will be more difficult. The most straightforward approach would be to use estimates for similar existing place.

The main weakness of the valuations set out above is that they were developed in a UK context, are fairly dated with the stated preference surveys conducted in 2005 and hence whether these values are applicable to NSW residents today is not clear. These values are already part of NSW practice. They have also been applied in New Zealand.

### 10.1.2 Literature on value of street trees

There are a large number of studies undertaken on the use and amenity valuation of green and blue places, including many related to street trees. Gunawardena et al 2017 summarised these as part of the CRC for Water Sensitive Design.[119] This included 48 studies estimating recreation and amenity value, of which:

- 11 were Australian and the remainder international
- 29 used hedonic analysis, 15 used stated preference techniques, none used travel costs and 4 used other methods
- the type of green infrastructure covered varied from street trees, to parks to forests, and
- the type of benefits captured ranged from recreational use to visual amenity.

The set of studies related to street trees are shown in Table 10.3.

[119] Gunawardena, A., Zhang, F., Fogarty, J., Iftekhar, M. S., (2017). Review of non-market values of water sensitive systems and practices: An update. Melbourne, Australia: Cooperative Research Centre for Water Sensitive Cities, https://watersensitivecities.org.au/wp-content/uploads/2017/12/WP-1.1-NMV-Report_FINAL.pdf.

### Table 10.3 Summary of studies on street tree valuation

| Study | Approach | Type of space | Factors accounted for and metric |
|---|---|---|---|
| Plant et al. (2017)120, Brisbane | Hedonic analysis | Footpath tree canopy | Home-buyers willingness to pay 3.73% more for houses in streets with target levels of footpath tree cover (50% tree canopy coverage within 100 m). |
| Donovan and Butry (2010)121, US | Hedonic | Street trees | On average, street trees add $8,870 to the sale price of a home (in 2007) |
| Sander et al. (2010)122, US | Hedonic | Tree canopy within 100m | A 10% increase in tree cover within 100 m of a property added $1,371 to the average property price but that at a distance of 250 m a 10% increase in tree cover added only $836 in value |
| Sander and Haight (2012)123, US | Hedonic | Tree cover | 10% increase in tree cover within each of these four neighbourhoods from their mean values (evaluated at the mean home sale price) Increased house price by $1,853 (0.581%), $1,030 (0.323%), $1,947 (0.610%), and $1,102 (0.345%), respectively |
| Rossetti (2013), 124Australia | Hedonic | Enhanced vegetation index | A one standard deviation increase in the EVI (0.074) increases house prices by 8.6 to 15.6 per cent. EVI covers all forms of greenery. |
| Pandit et al (2014)125, Perth | Hedonic | Tree cover on private and public space | A 10 per cent increase in tree cover on public space was associated with a $14,500 value (1.8 per cent property price increase).<br>Trees on neighbouring private space was associated with a reduction in property value. |
| Pandit et al (2013)126, Perth | Hedonic | Tree on street verge | A broad leaved tree on street verge in 2006 increases median property price of a house by AU$ 16,889 (4.27%). |
| AECOM (2017)127, Sydney | Hedonic | Tree canopy cover | An extra 10 per cent canopy cover for a suburb led to a $50 000 increase in the value of each property. |
| CIE (2020),128 Sydney | Hedonic | Vegetation cover | An additional 1 per cent of land area covered with vegetation leads to a 0.01 per cent increase in land values. |

Source: As noted in table.

There is a fairly wide range to these valuation studies and a variety of approaches to valuation. For example, in some studies, each tree impacts on any property within a specific distance (such as

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[120] Plant, L., Rambaldi, A. & Sipe, N. 2017. Evaluating Revealed Preferences for Street Tree Cover Targets: A Business Case for Collaborative Investment in Leafier Streetscapes in Brisbane, Australia. Ecological Economics, 134, 238-249.

[121] Donovan, G. H. & Butry, D. T. 2010. Trees in the city: Valuing street trees in Portland, Oregon. Landscape and Urban Planning, 94, 77-83.

[122] Sander, H., Polasky, S. & Haight, R. G. 2010. The value of urban tree cover: A hedonic property price model in Ramsey and Dakota Counties, Minnesota, USA. Ecological Economics, 69, 1646-1656.

[123] Sander, H. A. & Haight, R. G. 2012. Estimating the economic value of cultural ecosystem services in an urbanizing area using hedonic pricing. Journal of Environmental Management, 113, 194-205.

[124] Rossetti, J. 2013. Valuation of Australia's green infrastructure: Hedonic pricing model using the enhanced vegetation index, https://datainspace.org/wp-content/uploads/2017/04/Joe-Rossetti-2013-Thesis-1.pdf.

[125] Pandit, R., Polyakov, M. & Sadler, R. 2014. Valuing public and private urban tree canopy cover. Australian Journal of Agricultural and Resource Economics, 58, 453-470.

[126] Pandit, R., Polyakov, M., Tapsuwan, S. & Moran, T. 2013. The effect of street trees on property value in Perth, Western Australia. Landscape and Urban Planning, 110, 134-142.

[127] AECOM 2017. Green infrastructure: A vital step to brilliant Australian cities, https://aecom.com/content/wp-content/uploads/2017/04/Green-Infrastructure-vital-step-brilliant-Australian-cities.pdf.

[128] The CIE 2020, Western Sydney Place Based Infrastructure Compact. Prepared for Greater Sydney Commission, Appendix A, https://gsc-public-1.s3-ap-southeast-2.amazonaws.com/s3fs-public/appendix_6_-_economic_evaluation_pic_2.pdf?YI2OKoda1ZmXFIXYZH3cXVDJurKoxcM.

100m), in others a tree valuation is linked only to the nearest property and in others the effects are suburb-wide. Also, in some cases the valuation is based on the number of trees and in others on the size of the tree canopy.

## 10.2 Applying values to new projects

The types of projects that could be expected in relation to streets include:

- including street trees on existing or new streets
- more wide ranging changes to a streetscape, such as footpath width, lighting etc
- urban design changes focused on a street. These could be:
  - part of transport projects, such as Circular Quay Renewal or Parramatta Road Urban Transformation Strategy
  - part of precinct development projects, such as the redevelopment of the Sydney Fish Market, or public space aspects of the other parts of the Bays Precinct area redevelopment projects
  - stand-alone projects, such as related to improving harbourside outside public spaces, or improving the Jindabyne town centre.

In applying benefit transfer approaches to these different projects, the types of elements that are expected to be important include:

- the amount of use — a more used street would attract a higher level of benefit for a given improvement in quality
- the particular preferences of the local community
- the level of change in the quality of the street.

The PERS approach is already a fully developed benefit transfer technique, that accounts for the use of the space and the degree of quality change.

For street trees, the most applicable benefit transfer approach would:

- use tree canopy not number of trees — tree canopy will be a better measure as a larger tree will have more amenity impacts than a small tree, and impacts will increase as trees mature
- not double count with effects already measured such as air pollution, reduced cooling requirements and avoided heat-related health costs, which would all be presumed to be factored into housing values
- be as relevant to NSW as possible
- be simple to apply. For other benefit categories using measures of the share of the area that is tree canopy have been preferred because these are simple to apply and will be fairly invariant to the scale of area being considered. i.e. if the catchment used is larger, then the impact per property will be smaller.

Given the above, the recommended approach is to apply the parameters developed in Plant et al 2017. This study was undertaken in Brisbane, is relatively recent, has been peer reviewed and is relatively straight forward to apply. To avoid double counting, for street tree evaluation, air pollution benefits and private components of urban cooling benefits (energy savings and health impacts) should not be measured for street trees. The estimates in this method based on the percentage of footpath area covered by street trees within 100m, excluding the direct footpath outside a house. Given this will be applied strategically, the recommended approach is for every 1 percentage point increase in the footpath area that has tree canopy, an increase in the property value in the project area of 0.1 per cent would be applied. For example, if the overall footpath space of an area was 1 hectare, and tree canopy cover was increased from 50 per cent to 60 per cent, then a value would be applied of a 1 per cent increase in the property values of the area.

## 10.3 Recommended approaches and values

Based on the discussion above, the recommended approaches and parameters are as follows:

- for medium to large projects related to streets, the PERS approach should be applied, as used by TfNSW
  - in order to apply the PERS approach, data on the pedestrian numbers and minutes in the area are required. This will be more straightforward for changes to existing streets, but will be difficult for completely new streets. Approximate benchmarking would be required for the latter
  - as a guide to what is small and what is medium/large, the NSW Treasury guidance expects cost benefit analysis for projects above $10 million.
- for very large projects related to streets, a specific stated preference survey could be considered, if this assists in decisions about option selection
- for projects related to street tree canopy, broad hedonic approaches should be applied. The values recommended are for every 1 percentage increase in the footpath area that has tree canopy, an increase in the property value in the project area of 0.1 per cent would be applied.[129]
  - The project area's total property value should be calculated by multiplying the NSW average property value for established houses and attached dwellings (Table 10.5) with the number of detached and attached dwellings in the project area.
  - Where this value is applied, no air pollution benefits should be included or private benefits from urban cooling (health and energy saving). Note that this does not include benefits related to people not living in close proximity who use the street
- for projects related to street urban design outside of street trees, if these undergo cost benefit analysis, PERS should be applied. An additional value related to street tree should be included as per the above street tree approach. There is a small element of double counting in this, because a person living near the street tree will be included in the estimation of pedestrian counts. However, the level of overlap is expected to be sufficiently small to be able to be disregarded.

[129] Based on Plant, L., Rambaldi, A. & Sipe, N. 2017. Evaluating Revealed Preferences for Street Tree Cover Targets: A Business Case for Collaborative Investment in Leafier Streetscapes in Brisbane, Australia. Ecological Economics, 134, 238-249.

**Table 10.4 NSW weighted average value of established house and attached dwelling**

| House type | NSW weighted average median price (2022) [130]<br><br>$’000 |
|---|---|
| Established house | 971 |
| Attached dwelling[131] | 732 |

For small projects related to streets, evaluation using the above is not likely to be cost effective. These projects are not likely to use cost benefit analysis in any case.

In some circumstances, street investments will be within broader urban development programs. Where the value of the street is already being factored into sale prices for the urban development, then it should not be separately measured. For example, if sale prices for an urban renewal project are specifically adjusted because of high quality public domain, then this will already factor in some of the value measured using the above approaches — the value accruing to people living in the area and/or businesses operating in the area. In this case, any measure using PERS would need to be reduced to only measure use unrelated to the residents and businesses located in the area.

Note that where a project has transport-related benefits, such as travel time savings, then these would be valued consistent with TfNSW guidelines.

[130] NSW weighted average median price for 2022 based on median price and number of transfers of established houses and attached dwellings in Sydney and Rest of NSW. Data source: ABS, 2022, 6432.0 Total Value of Dwellings, Table 2: Median Price and Number of Transfers (Capital City and Rest of State).

[131] Attached dwellings includes flats, units and apartments plus semi-detached, row and terrace houses

# 11 Annexure A: Review of studies undertaken on use value

There are a large number of studies on the use valuation of public open space, using the different approaches set out above. Gunawardena et al 2017 summarised these as part of the Cooperative Research Centre for Water Sensitive Design[132]. This included 48 studies estimating recreation and amenity value, of which:

- 11 were Australian and the remainder international
- 29 used hedonic analysis, 15 used stated preference techniques, none used travel costs and 4 used other methods
- the type of public open space covered varied from street trees, to parks to forests, and
- the type of benefits captured ranged from recreational use to visual amenity.

Table 11.1 sets out a summary of those studies most relevant to measuring the use value from public open spaces, and including a range of studies not included in Gunawardena et al 2017, particularly travel cost studies and valuations of the use of blue spaces. The studies included in Table 11.1 from Gunawardena et al 2017 are those that are Australian and relevant for public open space such as parks. Those related to street trees are included in a separate chapter. For each study, the table sets out the key characteristics of the study, in terms of approach, type of public open space, factors accounted for and what the final metric is that the study arrives at. Studies have been categorised in this way because:

- the approach is important for understanding what benefits are being measured and what are not
- the type of space is important for benefit transfer
- the factors accounted for are important for benefit transfer
- the metric is important, as the information available for a new project will almost certainly include population forecasts within the catchment and property within a catchment, but will not necessarily include data on the number of visitors for a new or upgraded facility.

[132] Gunawardena, A., Zhang, F., Fogarty, J., Iftekhar, M. S., (2017). Review of non-market values of water sensitive systems and practices: An update. Melbourne, Australia: Cooperative Research Centre for Water Sensitive Cities, https://watersensitivecities.org.au/wp-content/uploads/2017/12/WP-1.1-NMV-Report_FINAL.pdf.

Table 11.1 Summary of studies on public open space use value

| Study | Approach | Type of space | Factors accounted for and metric |
|---|---|---|---|
| Heagney et al. (2019),133 NSW | Travel cost | Network of protected park areas | A range of natural and built infrastructure across national parks. Built infrastructure includes paths and walking tracks, lookouts, roads, retail outlets, built accommodation, day-use areas, camping areas, parking areas and amenity blocks.<br>Metrics are reported as average consumer surplus in $ per user, as well as the underlying model parameters. |
| Lockwood and Tracy (1995),134 NSW | Travel cost and contingent valuation | Centennial Park, Sydney | This study measures the value for Centennial Park, with its particular characteristics.<br>Travel cost estimates are between $23 and $34 per visit (2020$).<br>The contingent valuation is $82 per household per annum. This includes use and non-use values (2020$). The non-use value was 34 per cent of the use value. |
| Read et al. (1999) 135(Victoria) | Travel cost | Parks, both urban and National Parks | $4.90 per visit for Metropolitan park (based on 30 large Metropolitan parks) (2020$).<br>$19.80 per visit to a non-Metropolitan park (mainly National Parks) (2020$). |
| Varcoe (2015)136, Victoria | Benefit transfer from Read 1999 | Parks, both urban and National Parks | Adapted from Read 1999, values were estimated at (in 2020$):<br>$35 per visit for a National Park<br>$29 for a natural features wildlife hunting reserve<br>$22 for a wilderness park<br>$17 for Port and coastal facilities<br>$15 for Reservoir Parks<br>$14 for natural features reserves<br>$13 for historic reserves<br>$12 for state parks<br>$10 for metropolitan parks and<br>$10 for other terrestrial parks. |
| Zhang (2015)137, Queensland | Travel cost | Gold Coast beaches | Consumer surplus per beach visit (2022$):<br>Locals sample — between $12.89 and $18.36<br>Visitors sample — between $21.38 and $25.62<br>Entire sample — between $24.97 and $33.00 |

[133] Heagney, E.C., Rose, J.M., Ardeshiri, A., & Kovac, M., 'The economic value of tourism and recreation across a large protected area network' (2019) 88 *Land Use Policy*.

[134] Lockwood, M., & Tracy, K., 'Nonmarket Economic Valuation of an Urban Recreation Park' (1995) 27(2) *Journal of Leisure Research*.

[135] Read, Sinden, Branson and Sturgess (1999), Economic assessment of the recreational values of Victorian Parks, Consultancy undertaken for Department of Natural Resources and Environment, April 1999, https://ideas.repec.org/p/ags/aare99/124541.html.

[136] Varcoe, T., Betts O'Shea, H. and Contreras, Z. (2015), Valuing Victoria's Parks Accounting for ecosystems and valuing their benefits: Report of first phase findings, https://www.forestsandreserves.vic.gov.au/__data/assets/pdf_file/0027/57177/Valuing-Victorias-Parks-Report-Accounting-for-ecosystems-and-valuing-their-benefits.pdf.

[137] Zhang, F., Hua Wang, X., Nunes, P.A.L.D., and Chunbo, M., 2015, *The recreational value of gold coast beaches, Australia: An application of the travel cost method,* Ecosystem Services 11 (2015) 106-114.

| Study | Approach | Type of space | Factors accounted for and metric |
|---|---|---|---|
| Gillespie Economics (2012),138 NSW | Travel cost | Parramatta Park | $3.91 per visit to Parramatta Park (2020$). |
| Anning (2012),139 NSW | Travel cost | Sydney beaches | Consumer surplus per beach visit for two locations (2022$):<br>Collaroy – Narrabeen<br>$3.71 (travel cost only)<br>$14.01 (travel cost and value of travel time cost)<br>Manly Ocean Beach<br>$12.54 (travel cost only)<br>$22.06 (travel cost and value of travel time cost)<br>Average across two sites<br>$8.13 (travel cost only)<br>$18.04 (travel cost and value of travel time cost)<br>Note that this is not policy relevant to new green or blue space projects, but is relevant for issues that could remove beaches such as coastal erosion or water quality. |
| Pascoe (2019),140 NSW | Travel cost | Sydney beaches | $10 per visit (2020$), plus additional if undertaking other activities like surfing.<br>Note that this is not policy relevant to new green or blue space projects, but is relevant for issues that could remove beaches such as coastal erosion or water quality. |
| Mahmoudi et al (2013)141 Adelaide | Hedonic | Range of types | This study measured the impact of different types of green space, in terms of distance and area of green space in Adelaide.<br>Results include that a 1m decrease in the distance to:<br>A linear park increases property prices by $0.50 (in 2020$)<br>Adelaide parklands increases property prices by $1.94 (in 2020$)<br>An active recreation park increases property prices by $1.97 (in 2020$).<br>Changes in the size of parks also makes a difference to valuations. |
| CIE (2020)142, Western Sydney | Hedonic | Active open space | This analysis found a 1 per cent reduction in the distance to open space increased the land price by 0.06 per cent. |

[138] Gillespie Economics (2012), *Regulatory Impact Statement for Parramatta Park Trust Regulation 2012.*, as reported in Barangaroo Delivery Authority (2015), Barangaroo Delivery Authority Regulation 2015: Regulatory Impact Statement, May, https://www.productivity.nsw.gov.au/sites/default/files/2019-10/Barangaroo%20Delivery%20Authority%20Regulation%202015.pdf

[139] Anning, D. (2012), *Estimation of the economic importance of beaches in Sydney, Australia, and implications for management*, PhD Thesis UNSW, March, http://unsworks.unsw.edu.au/fapi/datastream/unsworks:10467/SOURCE02?view=true.

[140] Pascoe, S. (2019), 'Recreational beach use values with multiple activities' Vol. 160 *Ecological Economics*, pp. 137-144, https://doi.org/10.1016/j.ecolecon.2019.02.018.

[141] Mahmoudi, P., Hatton MacDonald, D., Crossman, N.D., Summers, D.M. and van der Hoek, J. (2013), 'Space matters: the importance of amenity in planning metropolitan growth', *The Australian Journal of Agricultural and Resource Economics*, Vol. 57, pp. 1-22, https://doi.org/10.1111/j.1467-8489.2012.00608.x.

[142] The CIE 2020, Western Sydney Place Based Infrastructure Compact. Prepared for Greater Sydney Commission, Appendix A, https://gsc-public-1.s3-ap-southeast-2.amazonaws.com/s3fs-public/appendix_6_-_economic_evaluation_pic_2.pdf?YI2OKoda1ZmXFIXYZH3cXVDJurKoxcM.

| Study | Approach | Type of space | Factors accounted for and metric |
|---|---|---|---|
| Ambrey and Fleming (2014)143 – Australia | Subjective wellbeing | Any public green space, but not including street trees | $1,355 per household per year within a collection district for a 1 per cent increase (on average 143 sqm) in green space in a collection district (average of 1.85 square km) (adjusted to 2020$).<br>Higher effects are found at higher density levels. |
| Rossetti (2013), 144Australia | Hedonic | Enhanced vegetation index | A one standard deviation increase in the EVI (0.074) increases house prices by 8.6 to 15.6 per cent. EVI covers all forms of greenery. |
| van Bueren et al (2019)145, Perth | Stated preference | Characteristics of green open space | Households were willing to pay $1 per year to avoid 1 per cent of parks going brown (i.e. watering of parks) and $4 per year for each additional park upgraded (2020$). |
| Brander and Koetse (2011),146 Australia and other countries | Meta-analysis of hedonic and contingent valuation studies | Urban and peri-urban open space | Found that values are higher where population density is higher, and is higher for recreational space than other forms of urban open space. The authors also conclude that there are substantial regional differences in open space preferences making benefit transfer difficult. |
| Bennett et al (2015)147, NSW | Stated preference | Swimming in Hawkesbury-Nepean river | Willingness to pay of $3.11 for moving from 50 km to 70 km and $2.38 for moving from 70 to 100 km (2020$) per household per year for ten years per additional km of river suitable for swimming up to having access to 100 km of swimmable rivers. The catchment to which this was applied was the Sydney metropolitan area. |
| Morrison and Bennett 2004,148 NSW | Stated preference | Swimming in NSW rivers | $78 per household one off payment to make a river swimmable for those in catchment, and $43 for those out of catchment (2020$). This study also reports values for making the water quality fishable. |
| Selected international studies | | | |
| GLA Economics (2003)149, London | Hedonic | Green space | A 1 percentage point increase in the amount of green space in a London neighbourhood increases house values by between 0.3 and 0.5 per cent. |
| GLA Economics (2010)150, London | Hedonic | Green space | Each hectare of park space within 1 km of housing increases house prices by 0.08%. Plus, |

[143] Ambrey, C. & C. Fleming (2012), 'Public Greenspace and Life Satisfaction in Urban Australia', *Urban Studies*, Vol. 51, pp. 1290-1321, https://doi.org/10.1177/0042098013494417.

[144] Rossetti, J. (2013), Valuation of Australia's green infrastructure: Hedonic pricing model using the enhanced vegetation index, Thesis Monash University, October, https://datainspace.org/wp-content/uploads/2017/04/Joe-Rossetti-2013-Thesis-1.pdf.

[145] van Bueren and Blamey (2019), Community values for green public open space, A choice modelling analysis in Perth, Western Australia, https://watersource.awa.asn.au/publications/technical-papers/community-values-for-green-public-open-space/.

[146] Brander, L. M. & Koetse, M. J. (2011), 'The value of urban open space: Meta-analyses of contingent valuation and hedonic pricing results', *Journal of Environmental Management*, Vol. 92, pp. 2763-2773, https://doi.org/10.1016/j.jenvman.2011.06.019.

[147] Bennett, J., Cheesman, J., Blamey, R., and Kragt, M. (2015), 'Estimating the non-market benefits of environmental flows in the Hawkesbury-Nepean River', *Journal of Environmental Economics and Policy*, Vol. 5(2), pp. 236-248, https://doi.org/10.1080/21606544.2015.1083484.

[148] Morrison, M., and Bennett, J.,(2004), 'Valuing New South Wales rivers for use in benefit transfer', *The Australian Journal of Agricultural and Resource Economics*, Vol. 48(4), pp. 591-611, https://onlinelibrary.wiley.com/doi/10.1111/j.1467-8489.2004.00263.x.

[149] Greater London Authority Economics (2003), 'Valuing Greenness: Green spaces, house prices and Londoner's priorities', https://www.london.gov.uk/sites/default/files/valuing_greenness_report.pdf and technical paper at https://www.london.gov.uk/sites/default/files/valuing_greenness_paper.pdf.

[150] Greater London Authority Economics (2010), Valuing housing and green spaces: Understanding local amenities, the built environment and house prices in London, Working paper 42, https://www.london.gov.uk/sites/default/files/gla_migrate_files_destination/GLAE-wp-42.pdf.

| Study | Approach | Type of space | Factors accounted for and metric |
|---|---|---|---|
| | | | the presence of a regional or metropolitan park within 600 metres was found to add between 1.9% and 2.9% to total house value. |
| Lutzenhiser and Netusil (2001)151 – US | Hedonic | Specialty and urban parks | 8.5 per cent of property value for properties within 500m of a specialty park or 1.8 per cent for urban parks. |
| Acharya and Bennet (2001)152 – US | Hedonic | Public open space | 0.06 per cent increase in house price from a 1 per cent increase in open space within 1 mile of a dwelling. |

[151] Lutzenhiser, M. and Netusil, N. N. (2001), 'The effect of open spaces on a home's sale price', Contemporary Economic Policy, Vol. 19(3), pp. 291-298, https://doi.org/10.1093/cep/19.3.291

[152] Acharya, G., Bennett, L.L. (2001), Valuing Open Space and Land-Use Patterns in Urban Watersheds. The Journal of Real Estate Finance and Economics 22, 221–237, https://doi.org/10.1023/A:1007843514233.

# 12 Annexure B: Review of studies related to use value of public facilities

A range of studies have sought to estimate the value of public facilities. The literature has largely focused on estimating values for libraries and museums using stated preference techniques.

The set of studies related to public facilities which were available for this study are shown in Table 12.1.

**Table 12.1 Summary of studies on public facilities**

| Study | Approach | Type of space | Factors accounted for and metric |
|---|---|---|---|
| CIE (2022),[153] NSW | Discrete choice experience (new public facilities)<br>Continent valuation (improved public facilities) | New or upgraded library, museum, gallery, civic/community centre, showground, indoor sports facilities | New facility<br>Average WTP per household per year declines with travel time (see Table 9.1). WTP estimates also need to be adjusted for size and surrounds (Table 9.2).<br>Upgraded facility<br>Average WTP per household per year for 10 years (central analysis) was:<br>$11.43 for indoor sports facility<br>$13.66 for showground<br>$14.66 for gallery<br>$10.01 for library<br>$13.05 for museum<br>$10.59 for community centre<br>$12.23 for all facilities |
| Queensland Museum (2009)[154], Queensland | Contingent Valuation | existing museums<br>investment in existing museums | On average adults in Queensland are:<br>WTP $19.15 per year (in 2009) for the existing Queensland Museum facilities.<br>WTP $16.43 once off payment (in 2009) to fund developments planned over a 5-7 year period. |
| Library Council of New South Wales (2008)[155], NSW | Contingent Valuation | existing libraries | Library user WTP $58.20 per year in 2008 for existing libraries for NSW, $61 per year in metropolitan areas and $54 for regional areas, and $19 per year for non-users. |

153 CIE, 2022, Willingness to pay for new and improved public facilities: Stated preference research. Prepared for Department of Planning and Environment.

154 Queensland Museum 2009. Valuing the Queensland Museum, http://www.qm.qld.gov.au/~/media/Documents/QM/Policies%20and%20Forms/final_valuing_qm_report_20090706.pdf.

155 Library Council of New South Wales 2008. Enriching communities: the value of public libraries in New South Wales, https://www.sl.nsw.gov.au/sites/default/files/Enriching%20Communities%20-%20the%20value%20of%20public%20libraries%20in%20New%20South%20Wales%20Full%20Report.pdf.

| Study | Approach | Type of space | Factors accounted for and metric |
|---|---|---|---|
| SGS Economics and Planning (2011)[156], Victoria | Contingent valuation method | existing libraries | Library users WTP $72 per year in 2009 and $65 per year in 2009 for non-users to maintain community access to existing library services. |
| Museums & Galleries NSW (2010)[157], NSW | Contingent valuation method | existing cultural facilities and activities | WTP of $57 per year per household in Central NSW in 2010 to maintain the current level of service and access to the existing facilities. |
| Fujiwara et al (2018)[158], United Kingdom | Contingent valuation method | existing museums | User WTP between £6.01 and £7.79 per visit, depending on museum, in 2018.<br>Non-user WTP between £2.79 and £4.06 per year, depending on museum, in 2018 to support maintenance and conservation of the museum's collection. |
| Bakshi et al (2015)[159], United Kingdom | Contingent valuation method | existing museums | User WTP of £6.65 (National History Museum) and £10.83 (Tate Museum) per visit in 2015.<br>Non-user WTP of £2.78 and £8.00 per year in 2015, to support maintenance and conservation of the museum's collection. |

Most studies identified measure the value of existing facilities available. Facility specific estimates reflect the available substitutes and quality for the facility of interest and do not easily allow the impact of quality and substitute availability to be separately identified. For example, the Library Council of New South Wales (2008) reports a single WTP parameter and does not indicate how this value may change depending on the quality of a library's collections, programs and services and physical infrastructure. Over time visits to libraries have decreased, while visits to their websites and usage of their online collection has increased. As a result, the expected average willingness to pay per user is now lower. Assuming the change in values are proportional to the usage rates and fitting a linear trend to usage, implies that benefits in 2021 would be around 24 per cent lower than in 2008.

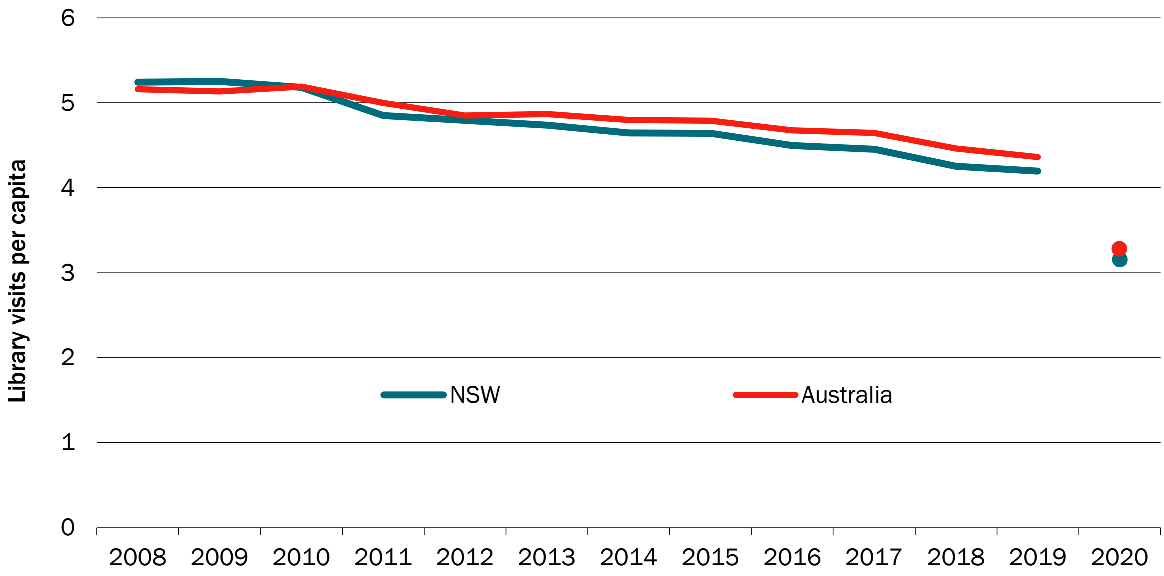
156 SGS Economics and Planning 2011. Dollars, Sense and Public Libraries: Technical Report. https://www.slv.vic.gov.au/sites/default/files/Dollars-sense-public-libraries-technical-report.pdf.

157 Museums & Galleries NSW 2010. Value Added! Value Added! The economic and social contribution of cultural facilities and activities in Central NSW, https://mgnsw.org.au/wp-content/uploads/2019/01/Value_Added_V8_for_Web__131126.pdf.

158 Fujiwara, D., Bakhshi, H., Mourato, S., Hotopp, U., Lawton, R., Lagarde, A., Davies, J. 2018. The economic value of culture: A benefit transfer study, prepared for the Department for Digital, Culture, Media and Sport, https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/963226/The_Economic_Value_of_Culture_-_A_Benefit_Transfer_Study_-_Final_report_V2.pdf.

159 Bakhshi, H., Fujiwara, D., Lawton, R., Mourato, S. & Dolan, P. 2015. Measuring economic value in cultural institutions, prepared for the Arts and Humanities Research Council, https://ahrc.ukri.org/documents/project-reports-and-reviews/measuringeconomicvalue/.

Figure 12.1 Library visitation rates in NSW and Australia over time




Note: 2019/20 visitor rates were affected by COVID-19. Source: National and State Libraries Australia, State Library NSW.

Some of the studies report both user and non-user valuation parameters. The non-use parameters may capture option, existence, and legacy value, urban amenity and cultural value of protecting artefacts. Generally, these values will also be reflected in the user valuations.

There is limited information available for major projects as few studies have been published or were available for this analysis.[160] Business cases for cultural infrastructure have in the past been informed by a choice modelling exercises, presenting participants with different infrastructure options, and using a one-off funding levy as the payment instrument. Parameter estimates tend to be very specific to proposed options, such as location, size, quality, and type of facility of the options presented to participants.

Across the studies, parameter values are reported per visit or per person in a relevant community (such as NSW). The latter are sometimes reported as an annual payment and sometimes as a once-off upfront payment (which can be interpreted as the present value of user value). This reflects the payment instrument, with entry fees providing values per visit, annual funding providing annual values and prospective investments providing once off upfront payments.

This analysis did not identify any public studies which have used the travel cost method to measure use value of public facilities. Some studies use travel costs as a direct measure of user value[161] [162], however this is not a measure of consumer surplus. To measure consumer surplus requires using travel cost information to construct a demand curve, from which consumer surplus can be measured

160 In addition to the projects identified in the table, there was an identified WTP of a once off payment of $29.40 per household in 2012 for the Walsh Bay Arts Precinct redevelopment from a presentation. The actual report was not available so was excluded from the table.

161 BIS Oxford Economics 2019. Newcastle Art Gallery Strategic Cost Benefit Analysis, https://newcastle.nsw.gov.au/getattachment/af7630c4-96cf-4e5c-8bf8-5918d349d056/Item-5-LMM-Newcastle-Art-Gallery-Redevelopment-Update#:~:text=Notes%20that%20in%202019%2C%20City,that%20the%20benefits%20of%20the, and

162 SGS Economics and Planning 2019. Cowes Community and Cultural Centre – Cost Benefit Analysis and Economic Impact Assessment, https://d2n3eh1td3vwdm.cloudfront.net/general-images/Strategy-and-Growth/COWES-COMMUNITY-AND-CULTURAL-CENTRE-%E2%80%93-COST-BENEFIT-ANALYSIS-AND-ECONOMIC-IMPACT-ASSESSMENT.pdf?mtime=20200717130135&focal=none.

(Figure 12.1). The travel costs incurred in accessing a facility are a resource cost to a user rather than a measure of benefit.

# 13 Annexure C: Review of studies related to biodiversity values

## 13.1 Review of values for terrestrial biodiversity

Estimated community values for native vegetation and habitat area were reviewed for suitability as a parameter value for terrestrial biodiversity. Table 13.1 outlines estimated values from primary studies which undertook surveys to elicit household's WTP for native vegetation, habitat types and other iconic species (e.g. Endangered Ecological Communities and River Red Gums). These attributes are considered suitable proxies to reflect values of terrestrial biodiversity for use as a generic parameter value.

In terms of native vegetation, there is a very wide range of WTP estimates, ranging from a present value of $0.003 per hectare to $0.38 per hectare.[163] Interestingly the WTP values for iconic species valued in Bennett et al. (2007) do not differ substantially from WTP values for the more generic native vegetation attribute.

Hatton MacDonald and Morrison (2010) used choice modelling to estimate monetary values for three types of habitat types -scrublands, grassy woodlands and wetlands. The study's focus was habitat areas because pre qualitative testing conducted found that 'biodiversity' was a difficult concept for respondents to understand whereas 'habitat' conveyed important information to potential survey respondents.[164] The estimated values for the two terrestrial habitats, $0.004 per hectare per household (present value) for scrublands and $0.005 per hectare per household (present value) for grassy woodlands, do not differ substantially from estimates of $0.007 per hectare per household (present value) in Hatton et.al. (2011) and $0.003 per hectare per household (present value) in Mazur and Bennett (2009).

Native vegetation is an extremely broad term and encompasses a range of different types and quality of biodiversity. It would be useful to be able to adjust values for some sort of relative biodiversity value, but the guidance is not able to do this currently based on available literature.

[163] Values from original studies are adjusted for inflation to 2021 dollars.

[164] D. Hatton MacDonald and M.D. Morrison (2010), Valuing biodiversity using habitat type, Australasian Journal of Environmental Management, 17:4, 235-243.

Table 13.1 Estimated values for native vegetation from literature

| Study | Attribute valued | Original WTP value ($ per household per unit) | WTP value in 2021 dollars ($ per household per unit) | Payment frequency | Present value ($2021 per household) | Suitable for application in other CBAs in NSW |
|---|---|---|---|---|---|---|
| Native vegetation | | | | | | |
| Hatton et. al. (2011)[a] | Healthy vegetation (ha) | 0.0008 | 0.00096 | Annual payment per household for 10 years | 0.007 | Yes. Comparability of context, attributes and scale between study and project case should be assessed. |
| Mazur & Bennett (2009)[b] | Native vegetation in good condition (ha) | 0.0006 | 0.0008 | Annual payment per household for 5 years | 0.003 | Yes. Comparability of context, attributes and scale between study and project case should be assessed. |
| Gillespie Economics (2009a)[c] | Native vegetation protected (ha) | 0.3 | 0.38 | Once-off payment | 0.38 | Yes. However, applicability is limited because the study was conducted in specific context of mining. |
| Endangered Ecological Communities | | | | | | |
| Gillespie Economics (2009b)[d] | Avoid EECs from being cleared (ha) | 0.41 | 0.52 | Once-off payment | 0.52 | Yes. However, applicability is limited because the attribute is unique and iconic, and the study was conducted in specific context of mining. |
| | EEC planted in the region (ha) | 0.10 | 0.13 | Once-off payment | 0.13 | |
| | Protect existing EEC in the region (ha) | 0.28 | 0.35 | Once-off payment | 0.35 | |
| Iconic native species | | | | | | |
| Bennett, et al (2007)[e] | Healthy River Red Gums (per 1,000 ha) | 1.45* | 1.95 | Annual payment per household for 20 years | $0.02 per hectare<br>($20.68 per 1,000 hectares) | Yes. However, noting the attribute is unique and iconic and not |

| Study | Attribute valued | Original WTP value ($ per household per unit) | WTP value in 2021 dollars ($ per household per unit) | Payment frequency | Present value ($2021 per household) | Suitable for application in other CBAs in NSW |
|---|---|---|---|---|---|---|
| | Rainforest (per 1,000 ha) | 11.16* | 15.02 | Annual payment per household for 20 years | $0.16 per hectare<br>($159.14 per 1,000 hectares) | broadly applicable. |
| | Old growth forest (per 1,000 ha) | 0.65* | 0.87 | Annual payment per household for 20 years | $0.01 per hectare<br>($9.27 per 1,000 hectares) | |
| Recommended value in this framework | | | | | | |
| MacDonald and Morrison (2010) | Scrubland (per 1,000 ha) | 0.72 | 0.88 | Annual payment per household for 5 years | $0.004 per hectare<br>($3.61 per 1,000 hectares) | |
| | Grassy woodland (per 1,000 ha) | 1.06 | 1.30 | Annual payment per household for 5 years | $0.005 per hectare<br>($5.32 per 1,000 hectares) | |
| | Wetlands (per 1,000 ha) | 1.36 | 1.66 | Annual payment per household for 5 years | $0.007 per hectare<br>($6.82 per 1,000 hectares) | |

* Value for the Melbourne sub-sample

Note: EECs stands for Endangered Ecological Communities.

a Hatton MacDonald, D., Morrison, M., Rose, J., and Boyle, K., 2011, Valuing a multistate river: the case of the River Murray, The Australian Journal of Agricultural and Resources Economics, 55, pp. 374 – 392

b Mazur and Bennett 2009, Location differences in communities' preferences for environmental improvements in selected NSW catchments: A Choice Modelling approach

c Gillespie Economics 2009a, Bulli Seam Operations Socio-Economic Assessment, prepared for Illawarra Coal Holdings.

d Gillespie Economics 2009b, Mount Thorley Warkworth Operations Choice Modelling Study of Environmental and Social Impacts, prepared for Coal & Allied Pty Ltd.

e Bennett, J., Dumsday, R., Lloyd, C., Kragt, M., (2007) Non-use values of Victorian Public Land: Case Studies of River Red Gum and East Gippsland Forests.

## 13.2 Review of values for aquatic biodiversity

Estimated community values for healthy riverside vegetation and healthy waterways were reviewed for suitability as a parameter value for aquatic biodiversity.

Table 13.2 outlines estimated values from primary studies which undertook surveys to elicit household's WTP for healthy riverside vegetation and healthy waterways. These two attributes are considered suitable proxies to reflect values of aquatic biodiversity for use as a generic parameter value.

As is the case with native vegetation, there is a very wide range of WTP estimates for:

- Healthy riverside vegetation —ranging between $0.13 per km per household (present value) to $17.50 per km per household (present value.
- Healthy waterways — ranging between $0.63 per km per household (present value) to $51.11 per km per household.

### Table 13.2 Estimated values for healthy riverside vegetation and healthy waterways from literature

| Study | Attribute valued | Original WTP value ($ per household per km) | Payment frequency | WTP in current dollars ($2021 per household per km) | Present value ($2021 per household per km) | Suitable for application in other CBAs in NSW |
|---|---|---|---|---|---|---|
| Bennett et al. (2015) | Riverside vegetation (50 to 85 km) | $0.67 | Annual payment per household per year for 10 years | $0.74 | $5.17 | Recommended value in this framework |
| | Riverside vegetation (85 to 100 km) | $2.28 | Annual payment per household per year for 10 years | $2.51 | $17.50 | |
| | Riverside vegetation (100 to 120 km) | Not significant | Annual payment per household per year for 10 years | $0 | $0 | |
| Kragt & Bennett (2011)[b] | Native riverside vegetation | $2.07 | Once-off payment | $2.47 | $2.47 | Yes, however comparability of context, attributes and scale between study and project case should be assessed. Study was completed in Tasmania. |
| Mazur & Bennett (2009)[c] | Healthy waterways (km) | $0.11 to $1.29 | Annual payment per household for 5 years | $1.64 | $6.70 | Yes, however comparability of context, attributes and scale between study and project case should be assessed. |

| Study | Attribute valued | Original WTP value ($ per household per km) | Payment frequency | WTP in current dollars ($2021 per household per km) | Present value ($2021 per household per km) | Suitable for application in other CBAs in NSW |
|---|---|---|---|---|---|---|
| Gillespie and Kragt (2010)[d] | Length of stream affected (km) | $3.74 | Annual payment per household for 20 years | $4.82 | $51.11 | Yes. However, applicability is limited because the study was conducted in specific context of mining. |
| Gillespie Economics (2009)[e] | Length of stream affected (km) | $5.9 | Once-off payment per household | $7.48 | $7.48 | Yes. However, applicability is limited because the study was conducted in specific context of mining. |
| Morrison & Bennett (2004)[f] | Healthy riverside vegetation and wetlands | Between $0.10 and $4.66 | Once-off payment | Between $0.13 and $6.83 | Between $0.13 and $6.83 | Yes. However, age of study reduces applicability |
| Rolfe & Windle (2003)[g] | Waterways in good health (km) | $0.06 | Assumed to be annual payment for 10 years. Not specified in study. | $0.09 | $0.63 | Yes. However, age of study reduces applicability |

a Bennet, J., Cheesman, J., Blamey, R., and Kragt, M., 2015, Estimating the non-market benefits of environmental flows in the Hawkesbury-Nepean River, Journal of Environmental Economics and Policy.

b Kragt, M. E. & Bennett, J. W. 2011. Using choice experiments to value catchment and estuary health in Tasmania with individual preference heterogeneity. Australian Journal of Agricultural and Resource Economics, 55, 159-179

c Mazur and Bennett 2009, Location differences in communities' preferences for environmental improvements in selected NSW catchments: A Choice Modelling approach.

d Gillespie, R. and Kragt, M.E. (2010) Valuing the non-market impacts of underground coal mining, Working Paper 1007, School of Agricultural and Resource Economics, University of Western Australia, Crawley, Australia.

e Gillespie Economics 2009a, Bulli Seam Operations Socio-Economic Assessment, prepared for Illawarra Coal Holdings.

f Morrison, M., and Bennett, J.,2004, Valuing New South Wales rivers for use in benefit transfer. The Australian Journal of Agricultural and Resource Economics, 48:4, pp. 591-611.

g Rolfe, J. and Windle, J., (2003), Valuing the Protection of Aboriginal Cultural Heritage Sites, The Economic Record, Vol. 79, Special Issues, June, 2003, S85-S95.

## Table 13.3 Summary of non-market studies related to biodiversity and ecosystem services

| Study | Study year | Location | Attributes |
|---|---|---|---|
| New South Wales | | | |
| Estimating the non-market benefits of environmental flows in the Hawkesbury-Nepean River<br>(J. Bennett, J. Cheesman, R. Blamey, Kragt. M) | 2015 | New South Wales, Hawkesbury Nepean | length of river suitable for swimming (per km)<br>improved condition of riverside vegetation (per km)<br>length of river clear of non-native water weeds (per km)<br>time to catch one Bass fish (per min) |

| Study | Study year | Location | Attributes |
|---|---|---|---|
| Valuing a multistate river: the case of the River Murray<br>(D. Hatton MacDonald, M. Morrison, J. Rose, K. Boyle) | 2011 | River Murray<br>(SA, VIC, NSW) | waterbird breeding (every 10 years)<br>native fish (%)<br>healthy vegetation (%)<br>waterbird habitat in the Coorong (poor or good quality) |
| Valuing the non-market impacts of underground coal mining<br>(Gillespie and Kragt) | 2010 | South Coalfield<br>New South Wales | length of stream affected (km)<br>area of upland swamp affected (ha)<br>number of Aboriginal sites affected (no.)<br>period of time that the mine will provide 320 jobs (years) |
| Location differences in communities' preferences for environmental improvements in selected NSW catchments: A Choice Modelling approach<br>(K. Mazur, J. Bennett) | 2009 | New South Wales | native vegetation in good quality ($km^2$)<br>native species (number)<br>healthy waterways (km) |
| Bulli Seam Operations: Choice Modelling Study of Environmental and Social Impacts<br>(Gillespie Economics) | 2009 | New South Wales | length of stream affected (km)<br>area of native vegetation cleared (hectares)<br>total number of Aboriginal sites affected (number)<br>period of time that mine would provide 1170 jobs |
| Valuing New South Wales rivers for use in benefit transfer<br>(M. Morrison, J. Bennett) | 2004 | New South Wales | vegetation (per % of area)<br>fish species (per species)<br>fauna species (per species)<br>swimmable water quality (across river)<br>fishable water quality (across river) |

| **Study** | **Study year** | **Location** | **Attributes** |
|---|---|---|---|
| Other Australian states/territories | | | |
| Mainstreaming of ecosystem services as a rational for ecological restoration in Australia<br>(V. Matzek, K. Wilson, M. Kragt) | 2019 | Australia | Two scenarios:<br>• ecological restoration with benefits from biodiversity only (BO)<br>• ecological restoration with benefits from biodiversity and ecosystem services (BES) |

| Study | Study year | Location | Attributes |
|---|---|---|---|
| Willingness to Pay for Revegetating the City of Subiaco's Railway Reserve: A Choice Experiment to Determine Public Preferences<br>(G. De Vos, M. Kragt, R. Pandit) | 2016 | City of Subiaco, Western Australia | • proportion of the length of railway reserve revegetated<br>• management for wildlife habitat |
| Using choice experiments to value catchment and estuary health in Tasmania with individual preference heterogeneity.<br>(M. Kragt, J., Bennett) | 2011 | Tasmania, George catchment | • length of native riverside vegetation<br>• number of rare native animal and plant species in the George catchment<br>• area of healthy seagrass beds in the Georges Bay (used as a measure of estuary condition). |
| Valuing biodiversity using habitat types<br>(D. Hatton MacDonald, M. Morrison) | 2010 | South Australia, Adelaide | • scrublands<br>• grassy woodlands<br>• wetlands |
| The economic value of improved environmental health in Victorian Rivers<br>(J. Bennett, R. Dumsday, G. Howell, C. Lloyd, N. Sturgess, L. Van Raalte) | 2008 | Three Victorian Rivers:<br>• Gellibrand<br>• Moorabool<br>• Goulburn | • native fish (%)<br>• riverside vegetation (%)<br>• native waterbirds and other animals (number)<br>• water quality/recreation opportunities (%) |

| Study | Study year | Location | Attributes |
| --- | --- | --- | --- |
| Non-use values of Victorian Public Land: Case Studies of River Red Gum and East Gippsland Forests<br><br>(Bennett, J., Dumsday, R., Lloyd, C., Kragt, M.) | 2007 | Victoria | River Red Gum forest:<br>• healthy River Red Gums (per 1,000 hectares)<br>• parrots (per 100 pairs)<br>• cod (per 1 per cent increase)<br>• recreation (per campsite)<br><br>East Gippsland Forests:<br>• owls (per pair)<br>• potoroos (per 100 individuals)<br>• rainforest (per 1000 hectares)<br>• old growth forest (per 1000 hectares) |
| Towards the development of a transferable set of value estimates for environmental attributes<br><br>(M. Van Bueren, J. Bennett) | 2004 | • Australia<br>• Great Southern Region of Western Australia<br>• Fitzroy Basin of Central Queensland | • endangered native species (number of species protected from extinction)<br>• countryside aesthetics (area of farmland repaired and bush protected (ha))<br>• waterway health (length of waterways restored for fishing or swimming (km))<br>• country communities (net loss of people from country towns each year) |
| Valuing the Protection of Aboriginal Cultural Heritage Sites<br><br>(J. Rolfe, J. Windle) | 2003 | | • healthy vegetation in the floodplain (per cent)<br>• kilometres of waterways in good health<br>• protection of Aboriginal cultural sites<br>• unallocated water (per cent) |

| Study | Study year | Location | Attributes |
|---|---|---|---|
| Valuing remnant vegetation in Central Queensland using choice modelling<br>(R. Blamey, J. Rolfe, J. Bennett, M. Morrison) | 2000 | • Central Queensland | • income lost to the region<br>• jobs lost in region<br>• number of endangered species lost to region<br>• reduction in population size of non-threatened species (%)<br>• loss in area of unique ecosystems (%) |

# 14 Annexure D: Non-market valuation studies — NSW based studies

## 14.1 Review of values for aquatic biodiversity

Bennett et al. (2015) used choice modelling to estimate the benefits of environmental flow for the management of the Hawkesbury-Nepean River. The study explored where there are non-linearities in WTP response and thresholds in community's preferences for specific environmental attributes.

### 14.1.1 Attributes and levels

The four attributes used to characterise the condition of the river environment were:

- Suitability for swimming — length of the river (km) which has water quality meeting minimum quality standards for direct contact recreation such as swimming
- Time taken to catch a Bass fish — used as an indicator of the total number of native fish in the river
- Riverside vegetation — length of the river (km) with native vegetation growing on both banks. An indicator of native plants and animal diversity, including birds dependent on the river.
- Clear of non-native water weeds — length of the river (km) that is not infested with invasive water weeds. Weeds can be unsightly, a nuisance to recreational swimming and boating and also one of the reasons for reduced native plant and animal life in the river.

The cost attribute was specified as an increase in water bills over a 10-year period.

**Table 14.1 The environmental condition of the Hawkesbury-Nepean River**

| Environmental attribute | Current level (2012) | Future level (2024) with no new government actions |
|---|---|---|
| Suitable for swimming | 70 km (40%) | 50 km (30%) |
| Time to catch a Bass fish | 90 mins | 180 mins |
| Riverside vegetation | 85 km (50%) | 50 km (30%) |
| Weed-free river | 90 km (55%) | 70 km (40%) |

Source: Bennet, J., Cheesman, J., Blamey, R., and Kragt, M., 2015, Estimating the non-market benefits of environmental flows in the Hawkesbury-Nepean River, Journal of Environmental Economics and Policy.

### 14.1.2 Estimated values and key findings

outlines the estimated WTP for each attribute and attribute level change. The results suggest diminishing marginal utility for two attributes, suitability for swimming and river clean of non-native water weeds. However, the trend is not clear for riverside vegetation with a value of $0.67 per kilometre for improvements between 50 to 85 kilometres, increasing to $2.28 per kilometre for improvements between 85 to 100 kilometres and then falling to being not significantly different from zero for improvements greater than 100 kilometres.

The presence of WTP thresholds was another key finding from the study. Households are willing to pay for river improvements up to 100 kilometres of river suitable for swimming and 100 kilometres of riverside vegetation, but not for river improvements beyond these threshold levels.[165]

Table 14.2 Willingness to pay for attribute improvements in the Hawkesbury-Nepean River

| Attribute | Attribute change | Average WTP per year for 10 years |
|---|---|---|
| Suitability for swimming | 50 to 70 km | $2.92/km |
| | 70 to 100 km | $2.24/km |
| | 100 to 150 km | Not significant |
| Time to catch one Bass fish | 180 to 90 min | Not significant |
| | 90 to 60 min | $0.70/min |
| | 60 to 30 min | $0.98/min |
| Riverside vegetation | 50 to 85 km | $0.67/km |
| | 85 to 100 km | $2.28/km |
| | 100 to 120km | Not significant |
| Clear of non-native water weeds | 70 to 90 km | $2.19/km |
| | 90 to 120 km | $0.77/km |
| | 120 to 150 km | Not significant |

Source: Bennet, J., Cheesman, J., Blamey, R., and Kragt, M., 2015, Estimating the non-market benefits of environmental flows in the Hawkesbury-Nepean River, Journal of Environmental Economics and Policy

## 14.2 Valuing a multistate river: the case of the River Murray

Hatton MacDonald et al. (2011) conducted a choice modelling survey to elicit willingness to pay for improvements in environmental quality for the River Murray and the Coorong.

### 14.2.1 Attributes

The attributes were selected based on their relevance for policy analysis and environmental managers in the design and implementation of water buy-back programs, investments in infrastructure and habitat restoration:

- frequency of waterbird breeding along the River Murray
- increasing native fish populations in the River Murray
- increasing the area of healthy vegetation along the River Murray
- restoring water bird habitat in the Coorong.

The cost attribute was specified as an annual household cost that will be paid each year for 10 years through increased taxes and higher prices for food.

The study sample was initially 6000 households across NSW, Murray Darling Basin, Victoria, South Australia, Rest of Australia. The overall response rate was 54.2 per cent.

165 Bennet, J., Cheesman, J., Blamey, R., and Kragt, M., 2015, *Estimating the non-market benefits of environmental flows in the Hawkesbury-Nepean River,* Journal of Environmental Economics and Policy.

Table 14.3 Attribute levels used in choice sets

| Attributes | Current situation | Levels in options B and C |
|---|---|---|
| Waterbird breeding along the River Murray | Every 10 years | 10, 7, 4, 1 |
| Native fish in the River Murray | 30% of original population | 30%, 40%, 50%, 60% |
| Healthy vegetation along the River Murray | 50% of original area | 50%, 60%, 70%, 80% |
| Waterbird habitat in the Coorong | Poor quality | Poor quality, good quality |
| Household cost per year for 10 years | $0 | $20, $50, $75, $100, $125, $150, $200, $250 |

Source: Hatton MacDonald, D., Morrison, M., Rose, J., and Boyle, K., 2011, Valuing a multistate river: the case of the River Murray, The Australian Journal of Agricultural and Resources Economics, 55, pp. 374 – 392

## 14.2.2 Results

Table 14.4 outlines the implicit prices for each attribute and region, payable each year per household for 10 years. The authors note some spatial heterogeneity in WTP, with respondents from ACT having the highest willingness to pay across the choice attributes, with the exception of waterbird breeding.

The WTP estimate for healthy vegetation is per 1 per cent increase in healthy vegetation. Based on a total area of 356 000 hectares, a 1 per cent increase is equivalent to 3560 hectares. This is converted into a WTP of $0.0008 per household per hectare of healthy vegetation per year for 10 years.

Table 14.4 Implicit prices - household willingness to pay each year for 10 years (dollars)

| Attribute | NSW | ACT | Victoria | South Australia | Rest of Australia |
|---|---|---|---|---|---|
| Waterbird breeding (increase by 1 year) | 13.64 | 15.99 | 12.00 | 15.96 | 18.64 |
| Native fish (1% increase) | 2.50 | 3.58 | 2.28 | 2.15 | 1.71 |
| Healthy vegetation (1% increase) | 2.88 | 4.42 | 2.87 | 3.88 | 3.31 |
| Waterbird habitat in Coorong | 146.48 | 198.15 | 126.63 | 169.18 | 187.09 |

Source: Hatton MacDonald, D., Morrison, M., Rose, J., and Boyle, K., 2011, Valuing a multistate river: the case of the River Murray, The Australian Journal of Agricultural and Resources Economics, 55, pp. 374 – 392.

## 14.2.3 Key findings

The WTP estimates from this study were higher than previous studies. The authors outlined three reasons for the higher implicit prices

- The unique ecological, historical and cultural importance of the River Murray and the Coorong for Australians.
- Earlier choice modelling studies use one-off payment scenarios, which have been recognised in the literature as being a very conservative design feature (Whitehead and Blomquist 2006).

- There has been a growing public awareness of the severe environmental degradation of the River Murray and Coorong.

It was noted that the study was conducted towards the end of a period of prolonged drought, and also during the global financial crisis. Both of these events may have influenced the choices made by respondents and therefore the results.

## 14.3 Valuing the non-market impacts of underground coal mining

Gillespie and Kragt (2010) undertook a choice modelling study based on an underground mine in the South Coalfield of NSW. The results were included a benefit cost analysis of continued mining at the Colliery.

### 14.3.1 Attributes

The specified attributes were designed to reflect the environmental, cultural and social attributes impacted by underground coal mining in Australia. Table 14.5 lists the attributes and levels for the project. The cost attribute was an annual payment for 20 years.

**Table 14.5 Attributes, their measurement units and levels**

| Attribute | Unit of measurement | Levels |
|---|---|---|
| Cost | Annual payment ($) for 20 years | 0; 10; 20; 50 |
| Total length of stream affected | Length in kilometres (km) | 15; 12; 8; 4 |
| Total area of upland swamp affected | Area in hectares (Ha) | 200; 140; 80; 20 |
| Total number of Aboriginal sites affected | Number of Aboriginal sites (No.) | 270; 220; 160; 100 |
| Period of time that the mine will provide 320 jobs | Number of years (Years) | 25; 18; 10; 2 |

Note: Attribute levels for the status quo of mining continues as currently planned in bold.

Source: Gillespie, R. and Kragt, M.E. (2010) Valuing the non-market impacts of underground coal mining, Working Paper 1007, School of Agricultural and Resource Economics, University of Western Australia, Crawley, Australia.

### 14.3.2 Results and key findings

Respondents were, on average, willing to pay $3.74 per kilometre of stream protected, $0.34 per hectare of swamp protected, $0.27 per Aboriginal site protected and $5.94 per year that the mine provides 320 jobs (Table 14.6).

The authors note the results indicate that community wellbeing declines with increase in kilometres of stream affected, hectares of swamp affected and the number of Aboriginal sites affected. Conversely, the results indicated that community wellbeing increases with the length of time that the mine provides 320 jobs.[166]

166 Gillespie, R. and Kragt, M.E. (2010) Valuing the non-market impacts of underground coal mining, Working Paper 1007, School of Agricultural and Resource Economics, University of Western Australia, Crawley, Australia.

The study had a response rate of 13.6 per cent.[167] The results were used in a benefit cost analysis aggregated up to 50 per cent of NSW households.[168]

Table 14.6 Willingness to pay estimates

| Attribute | Original WTP per household (per annum for 20 years) $2008 | WTP per household (per annum for 20 years) $2021 | WTP per household (PV of once off payment)[a] $2021 |
|---|---|---|---|
| Total length of stream affected (km) | 3.74 | 4.82 | 60.07 |
| Total area of upland swamp affected (ha) | 0.34 | 0.44 | 5.48 |
| Total number of Aboriginal sites affected (no.) | 0.27 | 0.35 | 4.36 |
| Period of time that the mine will provide 320 jobs (years) | 5.94 | 7.66 | 95.46 |

a Calculated over 20 years applying 5 per cent discount rate as per NSW Treasury guidelines. Noted that the author applies 15 per cent discount rate to convert per annum payments into present value lump sum.

Note: Original study presented implicit prices in 2008 dollars. Estimates in table have been converted into 2021 dollars.

Source: Gillespie, R. and Kragt, M.E. (2010) Valuing the non-market impacts of underground coal mining, Working Paper 1007, School of Agricultural and Resource Economics, University of Western Australia, Crawley, Australia.

## 14.4 Bulli Seam Operations: Choice Modelling Study of Environmental and Social Impacts

Gillespie Economics (2009) estimated the community's values for key potential environmental and social impacts of the Bulli Seam longwall mining operations, including impacts to stream, native vegetation/upland swamps, Aboriginal heritage sites, and the number of jobs. The wiliness to pay estimates were incorporated into a benefit cost analysis of continued mining at the Southern Coalfield mine.

### 14.4.1 Attributes

The attributes and levels for the study are outlined in Table 14.7. The following descriptions of each variable was provided to respondents:

- Length of stream affected — impacts included cracking of the stream bed, water flow under the bed of the stream, reduction in surface flow in the stream, reduction in water levels in pools, staining of the water and stream bed downstream of where the water resurfaces and localised changes to the stream environment
- Native vegetation — impacts included clearing of vegetation and associated threatened plant species and habitat for a range of non-threatened and threatened animal species.

167 A total of 7,553 questionnaires were distributed, of which 1, 028 completed questionnaires were returned.

168 Aggregation of 50 per cent was based on a response rate of 13.6 per cent plus one-third of non-response rate, equivalent to 42 per cent and rounded up to 50 per cent.

- Aboriginal heritage — impacts included cracking and collapse of rock features containing grinding grooves, engraving sites, rock art and artefacts.

Table 14.7 Attributes, descriptions and levels

| Attribute | Unit of measurement | Levels |
|---|---|---|
| Cost | Compulsory once-off payment ($) | 0; 125; 300; 625 |
| Total length of stream affected | Length in kilometres | 40; 60; 80; 100 |
| Total area of native vegetation cleared | Area in hectares | 240; 290; 330; 380 |
| Total number of Aboriginal sites affected | Number of Aboriginal sites | 20; 30; 40; 50 |
| Period of time that the mine would provide 1,170 jobs | Number of years | 1; 11; 21; 31 |

Source: Gillespie Economics, 2009, Bulli Seam Operations: Choice modelling study of environmental and social impacts. Prepared for Illawarra Coal Holdings Pty Ltd.

### 14.4.2 Results

The study results showed the community value reducing impacts of mining on environmental attributes such as streams, vegetation and Aboriginal heritage sites, and also the employment that mining provides to the Illawarra Region.

The survey had a response rate of 18.7 per cent.[169]

Table 14.8 Willingness to pay estimates

| Attribute | Original WTP per household $2009 | WTP per household $2021 |
|---|---|---|
| Total length of stream affected (km) | 4.73 | 6.00 |
| Total area of native vegetation cleared (ha) | 0.90 | 1.14 |
| Total number of Aboriginal sites affected (no.)[a] | 5.15 | 6.53 |
| Period of time that the mine would provide 1,170 jobs (years)[a] | 26.90 | 34.09 |

a Calculated at the average per year.

Source: Gillespie Economics, 2009, Bulli Seam Operations: Choice modelling study of environmental and social impacts. Prepared for Illawarra Coal Holdings Pty Ltd.

## 14.5 Proposed Warkworth Extension: Choice Modelling Study of Environmental, Cultural and Social Impacts

Gillespie (2009) conducted a choice modelling study to estimate environmental, cultural and social values to inform decision-making on the future management of the Warkworth open cut mine.

### 14.5.1 Attributes

The environmental and social attributes included in the survey are outlined in Table 14.9.

[169] A total 24,966 questionnaires were distributed, of which 2,917 completed responses and 1,771 screened responses.

Table 14.9 Attributes and their description and levels

| Attribute | Description | Levels[a] |
|---|---|---|
| Cost | Compulsory once-off payment ($) | 0; +125; +300; +625 |
| Impact on mine site EEC vegetation | Hectares | -900; -700; -500; -300 |
| Area of EEC planted in the region | Hectares | 0; +200; +400; +600 |
| Area of existing EEC protected in the region | Hectares | 0; +200; +400; +600 |
| Impact on highly significant Aboriginal sites | Number of Aboriginal sites | -12; -8; -4; 0 |
| Impact on rural families in the small rural community | Number of rural families | -15; -10; -5; 0 |
| No. of years that the mine will provide 975 jobs | Number of years | +22; +19; _16; +12 |

Gillespie Economics 2009b, Mount Thorley Warkworth Operations Choice Modelling Study of Environmental and Social Impacts, prepared for Coal & Allied Pty Ltd.

## 14.5.2 Results

The study found that the community values reductions in negative environmental, social and cultural impacts of the proposed mining activities, but also values increases in the length of time that the mine provides employment as well as planting and protection of EEC.

The estimated response rate for the study was 17 per cent. Gillespie (2009) applied the Morrison (2000)[170] approach to the minimum estimate of a response rate from the online survey for an adjusted response rate of 45 per cent.

Table 14.10 Estimated implicit prices (A$/household)

| Attribute 1 | Implicit prices for preferred model |
|---|---|
| Impact on mine site EEC vegetation | -$0.41 |
| Area of EEC planted in the region | $0.10 |
| Area of existing EEC protected in the region | $0.28 |
| Impact on highly significant Aboriginal sites | -$29.71 |
| Impact on rural families in the small rural community | -$33.88 |
| No. of years that the mine will provide 975 jobs | $27.13[a] |

a Average

Note: The study included 6 models. The model identified as the preferred model by the author is listed above.

Source: Gillespie Economics 2009b, Mount Thorley Warkworth Operations Choice Modelling Study of Environmental and Social Impacts, prepared for Coal & Allied Pty Ltd.

[170] Morrison, M. (2000), *Aggregation Biases in States Preferences Studies,* Australian Economic Papers, 39(2), pp 21-230.

## 14.6 Location differences in communities' preferences for environmental improvements in selected NSW catchments: A Choice Modelling approach

Mazur and Bennett (2009) used choice modelling to estimate household willingness to pay (WTP) for improvements in environmental quality in the Hawkesbury Nepean catchment as well as the Namoi and Lachlan catchments in NSW.

### 14.6.1 Attributes

The study estimated WTP for three environmental attributes:

- square kilometres of native vegetation in good condition
- number of native species
- kilometres of healthy waterways (where healthy means suitable for drinking and recreational use (swimming and boating).

The cost attribute was described as a mixture of increased taxes, council rates, prices and recreational charges. The annual payment to be made by respondents for new NRM actions was specified to continue for five years.

**Table 14.11 Attributes, descriptions and levels**

| Attribute | Unit of measurement | Levels |
|---|---|---|
| Cost | Annual payment for five years | 0; 50; 200 |
| Native vegetation in good condition | Square kilometres | 10500; 11000; 12000 |
| Native species | Number of species | 2970; 2980; 2990; 3000 |
| Healthy waterways | Kilometres | 600; 630; 650; 750 |
| People working in agriculture | Number | 7000; 7200; 8000 |

Source: Mazur, K. and Bennett, J., 2009, Location differences in communities' preference for environmental improvements in selected NSW catchments: A Choice Modelling approach. Environmental Economics Research Hub Research Reports.

### 14.6.2 Results

The aim of the study was to investigate variations in WTP across different communities. Economic values in the three catchments are in Table 14.12. The highlighted values are relevant for the Hawkesbury Nepean catchment.

Key results relating to the Hawkesbury Nepean catchment include:

- Respondents in all three surveyed catchments (Sydney, Hawkesbury Nepean and Namoi) were willing to pay for maintaining/increasing both the number of native species and the kilometres of healthy waterways.
- Only Sydney catchment respondents were willing to pay for maintaining/increasing the area of native vegetation in good quality in the Hawkesbury Nepean catchment.
- Therefore, respondents in the Hawkesbury Nepean catchment were not willing to pay for maintaining/increasing the area of native vegetation in good quality.

**Table 14.12 Economic values ($ per household per year for 5 years)**

| Catchment | Respondent location (sub-sample) | Native vegetation in good quality<br>$ per km$^2$ | Native species<br>$ per number of species | Healthy waterways<br>$ per km |
|---|---|---|---|---|
| Hawkesbury Nepean | Sydney (distant/urban) | 0.06 | 5.25 | 1.10 |
| | Hawkesbury Nepean (local/rural) | .... | 6.97 | 0.90 |
| | Namoi (distant/rural) | .... | 4.97 | 0.84 |
| Lachlan | Sydney (distant/urban) | 0.02 | 8.11 | 0.35 |
| | Lachlan (local/rural) | 0.01 | 4.51 | 0.83 |
| | Hawkesbury Nepean (distant/rural) | .... | 7.45 | 1.29 |
| Namoi | Sydney (distant/urban) | 0.02 | 2.43 | .... |
| | Namoi (local/rural) | .... | 2.50 | 0.11 |
| | Lachlan (distant/rural) | 0.02 | .... | .... |

Note: '.....' indicates that values were not significant and 'HN' represents Hawkesbury Nepean. 'Distant' refers to catchment outside the study catchment.

Source: Mazur, K. and Bennett, J., 2009, Location differences in communities' preference for environmental improvements in selected NSW catchments: A Choice Modelling approach. Environmental Economics Research Hub Research Reports.

## 14.7 Valuing New South Wales rivers for use in benefit transfer

Morrison and Bennett (2004) estimated environmental values for river health in five catchments across NSW using choice modelling.

**Table 14.13 Key characteristics of the five rivers**

| Area | Catchment area<br>km$^2$ | Length of river<br>Km | Current proportion of healthy vegetation and wetlands<br>Per cent |
|---|---|---|---|
| Bega | 2 000 | 50 | 30 |
| Clarence | 23 000 | 390 | 40 |
| Georges | 960 | 96 | 20 |
| Gwydir | 26 000 | 330 | 10 |
| Murrumbidgee | 84 000 | 1 690 | 10 |

### 14.7.1 Attributes

Four environmental attributes (use and non-use attributes) were valued:

- recreational use (swimming and fishing)

- fish species
- healthy vegetation and wetlands
- waterbirds and other fauna.

## 14.7.2 Results

The study found significant differences between the majority of environmental values for the comparisons between the within-catchment samples (Table 14.14). This result emphasises the importance, at least in some catchments, of sampling populations within the catchment in which an environmental impact will occur. Given the values estimated are catchment specific, it is important to conduct valuation studies in multiple catchments if environmental values are intended for use in benefit transfer (for example, to estimate the total value to the NSW community). To remedy these limitations, the authors estimated a pooled model of the samples from the five catchments to improve the adaptability of the environmental values for benefit transfer studies (Table 14.15).

### Table 14.14 Implicit prices for environmental attributes - one-off payment per household

| Catchment | Vegetation<br><br>Per percentage of river covered with healthy native vegetation | Fish species<br><br>Per species | Fauna species<br><br>Per species | Swimmable water quality<br><br>Across river | Fishable water quality<br><br>Across river |
|---|---|---|---|---|---|
| Within-catchment | | | | | |
| Bega | 2.33 | 7.23 | 0.88 | 100.98 | 51.33 |
| Clarence | 2.07 | -0.05* | 1.92 | 72.77 | 46.63 |
| Georges | 1.51 | 1.77* | 0.59* | 73.88 | 45.26 |
| Gwydir | 1.46 | 2.12 | 1.76 | 104.07 | 48.94 |
| Murrumbidgee | 1.46 | 2.77 | 1.73 | 75.24 | 54.16 |
| Outside Catchment | | | | | |
| Gwydir | 1.98 | 3.51 | 0.55* | 59.98 | 29.93 |
| Murrumbidgee | 2.15 | 4.05 | 1.79 | 86.46 | 28.75 |

Note: * represents insignificant coefficients in model.

Source: Morrison, M., and Bennett, J.,2004, Valuing New South Wales rivers for use in benefit transfer. The Australian Journal of Agricultural and Resource Economics, 48:4, pp. 591-611.

### Table 14.15 Pooled model of implicit prices for environmental attributes ($A)

| | Vegetation (A$) | Fish species (A$) | Fauna species (A$) | Swimmable water quality (A$) | Fishable water quality (A$) |
|---|---|---|---|---|---|
| Southern, coastal, within-catchment | 1.96 | 6.27 | 0.87 | 55.55 | 29.00 |
| Southern, coastal, out-of-catchment | 2.61 | 6.27 | 0.87 | 30.10 | 38.74 |
| Northern, coastal, within-catchment | 1.96 | 2.02 | 0.87 | 55.55 | 29 |
| Northern, coastal, out-of-catchment | 2.61 | 2.02 | 0.87 | 30.10 | 38.74 |
| Southern, inland, within-catchment | 1.25 | 3.25 | 0.87 | 55.55 | 29.00 |
| Southern, inland, out-of-catchment | 1.90 | 3.25 | 0.87 | 30.10 | 38.74 |
| Northern, inland, within-catchment | 1.25 | 3.25 | 0.87 | 55.55 | 29.00 |
| Northern, inland, out-of-catchment | 1.90 | 3.25 | 0.87 | 30.10 | 38.74 |

Source: Morrison, M., and Bennett, J.,2004, Valuing New South Wales rivers for use in benefit transfer. The Australian Journal of Agricultural and Resource Economics, 48:4, pp. 591-611.

### 14.7.3 Key findings

Key results from the pooled model, as identified by the authors, are:

- non-use values for vegetation are higher in coastal catchments – implies non-use values for vegetation in the Hawkesbury-Nepean catchment, which is one of the largest coastal basins in NSW, are relatively higher than in a non-coastal catchment.
- non-use values for vegetation are lower for respondents living within a catchment – implies that residents in Sydney, for example, may place a higher value on vegetation in the Hawkesbury-Nepean catchment relative to residents of the Hawkesbury-Nepean catchment. Mazur and Bennett (2009) found that residents within the Hawkesbury-Nepean catchment were not willing to pay for maintaining/increasing the area of native vegetation in good quality.
- non-use values for fauna species are not systematically affected by catchment characteristics (inland/coastal or north/south) – implies that this value for fauna species could be transferred to the Hawkesbury-Nepean catchment relatively seamlessly.
- willingness to pay is a function of respondent's environmental orientation (i.e. pro-green or predevelopment) and socio-demographic characteristics (income and age) – therefore transferring environmental values from this study to a study in the Hawkesbury-Nepean catchment must take into account significant differences between respondent's preferences and socio-demographic characteristics.

# 15 Annexure E: Non-market valuation studies — Other Australian states/territories

## 15.1 Mainstreaming of ecosystem services as a rational for ecological restoration in Australia

Matzek, et al. (2019) conducted a survey to assess the public's priorities for biodiversity and ecosystem services.

### 15.1.1 Attributes

The four attributes used to characterise the condition of the river environment were:

Two restoration scenarios were presented to respondents:

- biodiversity only
- biodiversity plus ecosystem services.

The payment mechanism was framed as a donation of funds to a non-profit agency that would undertake restoration projects.

### 15.1.2 Results

The mean WTP for restoration with biodiversity plus ecosystem services of $23.62 was higher than the mean WTP for with biodiversity only of $21.72 (Table 15.1).

The study also examined WTP for different types of ecosystem services:

- regulating services had a mean WTP of $20.80
- provisioning services had a mean WTP of $23.20
- cultural services had a mean WTP of $23.15.

The study found the public was more willing to donate to a restoration scenario that included ecosystem services, demonstrated that ecosystem services are an important rationale for restoration funding and implementation.

**Table 15.1 Willingness to pay for restoration**

| Attribute | Mean WTP |
|---|---|
| Restoration of biodiversity only | $21.72 |
| Restoration of biodiversity plus ecosystem services | $23.62 |

Note: The final sample size was 897.

Source: Matzek, V., Wilson, K., and Kragt, M., 2019, Mainstreaming of ecosystem services as a rational for ecological restoration in Australia, Ecosystem Services 35 (2019) 79-86.

## 15.2 Willingness to Pay for Revegetating the City of Subiaco's Railway Reserve: A Choice Experiment to Determine Public Preferences

De Vos et. al. (2016) conducted a choice experiment to estimate willingness to pay for different ways to manage the Railway Reserve in the City of Subiaco (Western Australia).

### 15.2.1 Attributes

**Table 15.2 Willingness to pay for managing the Railway Reserve in the City of Subiaco**

| Attribute | Description | Level |
|---|---|---|
| Annual contribution | An annual contribution per household in the City of Subiaco | $10; $20; $50; $100 |
| Proportion of the length of railway reserve revegetated | Percentage of the available land along the railway line in the City of Subiaco that will be revegetated | 25%; 50%; 75%; 100% |
| Interpretative signs | Provide information to the general public about the revegetation process and plants that are used | None; Yes overview of project near train stations or points of interest; Yes individual signs at regular intervals. |
| Management for wildlife habitat | Management practices could enhance the creation of habitat for native wildlife such as birds, microbats and lizards. | Yes; No |
| Type of vegetation used | Three types of plants can be used for the revegetation project: ground-covering plants, shrubs, trees | Ground-covering only; Ground-covering and shrubs; Ground-covering and trees; Ground-covering, shrubs and trees |

Source: de Vos, G., Kragt, M., and Pandit, R., 2016, Willingness to Pay for Revegetating the City of Subiaco's Railway Reserve: A Choice Experiment to Determine Public Preferences.

### 15.2.2 Results

The conditional logit model with interactions estimated the part-worth of the different attributes. The part-worth is the marginal WTP for a unit change in an attribute when all other attribute levels remain the same.

The marginal WTP for revegetation of the reserve was $0.27 per year per household per additional percentage of area revegetated. The marginal WTP was $24.63 per year when trees where included, $16.29 for shrubs and trees and $9.80 for only shrubs. Respondents were willing to pay an average $14.15 per year for the inclusion of management for wildlife habitat.

The survey was started by 188 respondents, with 151 completed surveys.

A finding of the study was heterogeneity in the preference and WTP among different types of residents, a higher WTP for females and regular users of the walking and bicycle path along the railway line.

The authors noted the following limitations of the study:

- the status quo scenario did not reflect the current state of the Railway Reserve
- there may have been participation bias due to respondents taking time to complete the survey were residents who showed an interest in the topic of the survey
- a small sample size
- a more representative sample on key characteristics (including education and interest in urban greenery) was not possible for this study which was undertaken as part of a Master's project.

**Table 15.3 Part-worth estimated from CL model with interactions**

| Variable name | Part-worth (A$/year) |
|---|---|
| Proportion of the length of railway reserve revegetated (per 1%) | $0.27 |
| Vegetation shrubs (Yes/No) | $9.80 |
| Vegetation trees (Yes/No) | $24.63 |
| Vegetation shrubs and trees (Yes/No) | $16.29 |
| Management of wildlife habitat (Yes/No) | $14.15 |

Source: de Vos, G., Kragt, M., and Pandit, R., 2016, Willingness to Pay for Revegetating the City of Subiaco's Railway Reserve: A Choice Experiment to Determine Public Preferences.

## 15.3 Using choice experiments to value catchment and estuary health in Tasmania with individual preference heterogeneity

Kragt and Bennett (2011) conducted a choice modelling study to analyse community preferences for natural resource management options in the George catchment, Tasmania.[171]

### 15.3.1 Attributes

Catchment health attributes included were:

- length of native riverside vegetation
- number of rare native animal and plant species in the George catchment
- area of healthy seagrass beds in the Georges Bay (used as a measure of estuary condition).

Table 15.4 outlines the attributes, their description and levels constructed for the survey. The payment attribute was included as a one-off levy on rates to be paid by all Tasmanian households during the year 2009.

The levels of the attributes included in the choice sets reflected the different situations that could occur in the George catchment under alternative catchment management strategies.

171 KRAGT, M. E. & BENNETT, J. W. 2011. Using choice experiments to value catchment and estuary health in Tasmania with individual preference heterogeneity. Australian Journal of Agricultural and Resource Economics, 55, 159-179.

**Table 15.4 Attributes, description and levels included in the George catchment choice experiments**

| Attribute | Description | Levels |
|---|---|---|
| Native riverside vegetation[a] | Native riverside vegetation is mostly native species, not weeds and is important for many native animal and plant species, and can reduce the risk of erosion and provides shelter for livestock. | 40, 56, 74, 84 (km) |
| Rare native animal and plant species | Several of the species living in the George catchment are listed as vulnerable or (critically) endangered and rely on good water quality and health native vegetation | 35, 50, 65, 80 (number of species present) |
| Seagrass area | Seagrass grows best in clean, clear, sunlit waters and provides habitat for many species of fish | 420, 560, 690, 815 (hectares) |
| Payment | One-off levy on rates collected during 2009 | 0, 30, 60, 200, 400 ($)<br>Or<br>0, 50, 100, 300, 600 ($) |

a The total length of rivers in the George catchment is approximately 113 kilometres.

Note: The currently observed attribute levels in the George catchment are in bold.

Source: KRAGT, M. E. & BENNETT, J. W. 2011. Using choice experiments to value catchment and estuary health in Tasmania with individual preference heterogeneity. Australian Journal of Agricultural and Resource Economics, 55, 159-179

## 15.3.2 Results

Table 15.5 outlines the WTP estimates for environmental attributes for the two models, attributes only and attributes with interaction effects. The WTP estimates are lower for all attributes when interaction effects are modelled.

**Table 15.5 Median marginal WTP estimates for environmental attributes - one-off levy on rate**

| Attribute | ML Model – attributes only<br>Sample average | ML Model – interaction effects<br>Sample average |
|---|---|---|
| Seagrass (ha) | $0.11 | $0.06 |
| Riverside vegetation (km) | $3.91 | $2.07 |
| Rare species (no.) | $8.62 | $5.26 |

# 15.4 Valuing biodiversity using habitat types

Hatton MacDonald and Morrison (2010) used choice modelling to estimate monetary values for three types of habitat types - wetlands, scrublands and grassy woodlands. The study's focus was habitat areas because pre-qualitative testing conducted found that 'biodiversity' was a difficult concept for respondents to understand whereas 'habitat' conveyed important information to potential survey respondents.

## 15.4.1 Attributes

Respondents were provided information on the three habitats, including the different communities of flora and fauna supported and the ecosystem service provided (see Table 15.6). Surveys were conducted in three sample areas, residents from the Upper South East region of South Australia, Adelaide and the rest of the state.

**Table 15.6 Information provided to respondents regarding habitat types**

| Description | Scrublands | Grassy woodlands | Wetlands |
| --- | --- | --- | --- |
| Description and habitat value | Low, thick vegetation such as shrubs and mallee<br>Limited potential for agriculture<br>Provide habitat for a wide variety of birds and animal species<br>A number of different wrens can be found in scrublands | Open areas with larger trees<br>Often cleared because the land is good for agriculture<br>Provide habitat for nesting for bird species such as Red-tailed Black Cockatoos<br>Provide habitat for a variety of other animals such as possums and kangaroos | Areas where water accumulates for short or long periods during the year<br>Contain open water, rushes and sedges and may have shrubs and trees around their edges<br>Provide habitat for fish, frogs, snakes, migratory waterbirds such as ducks and wading birds such as the Red-capped Plover |
| Rare, vulnerable or endangered species present | Animals such as:<br>Red-Necked Wallabies<br>Pygmy Possums<br>Birds such as:<br>Malleefowl<br>Yellow-tailed Black Cockatoos<br>Heathwrens<br>Plants such as:<br>Spiral Sun-orchid and Monarto mintbush | Animals such as:<br>Wombats<br>Sugar Gliders<br>Birds such as:<br>Red-tailed Black Cockatoos<br>Little Lorikeets<br>Diamond Firetails<br>Black-chinned Honeyeaters<br>Stone Curlews<br>Shrubs and plants including:<br>Jumping Jack Wattles<br>Orchids | Animals such as:<br>Tortoises<br>Goannas<br>Birds such as:<br>Freckled Ducks<br>Latham's Snipe<br>Freshwater fish such as:<br>Pygmy Perch |
| Ecosystem functions | Prevention of water logging and control of salinity<br>Windbreaks<br>Pollination | Prevention of water logging and control of salinity<br>Shelter for stock and native species<br>Pollination | Water purification<br>Flood mitigation<br>Fish breeding<br>Bird breeding<br>Recharge of groundwater |
| Area in 1980 | 250,000 hectares | 75,000 hectares | 187,000 hectares |
| Current area | 77,000 hectares | 54,000 hectares | 86,000 hectares |
| Expected area in 10 years' time | 66,000 hectares | 46,000 hectares | 73,000 hectares |
| Expected change in 10 years | Loss of 11,000 hectares | Loss of 8,000 hectares | Loss of 13,000 hectares |

Source: D. Hatton MacDonald and M.D. Morrison (2010), Valuing biodiversity using habitat type, Australasian Journal of Environmental Management, 17:4, 235-243.

Table 15.7 outlines the attributes used in the choice sets including the payment vehicle of levy from all households in South Australia.

**Table 15.7 Attributes used in choice sets**

| Levy | Status Quo<br>$0 | Attribute levels in other alternatives<br>$10, $20, $40, $60, $80 and $100 |
|---|---|---|
| Scrublands | 66,000 | 73,000, 80,000 and 90,000 hectares |
| Grassy woodlands | 46,000 | 51,000, 56,000 and 63,000 hectares |
| Wetlands | 73,000 | 81,000, 88,000 and 99,000 hectares |
| Levy | $0 | $10; $20; $40; $60; $80 and $100 |

Source: D. Hatton MacDonald and M.D. Morrison (2010), Valuing biodiversity using habitat type, Australasian Journal of Environmental Management, 17:4, 235-243.

## 15.4.2 Results

For the entire sample, respondents valued, on a per hectare basis, wetland habitats most highly, followed by grassy woodlands and scrublands. However, significant differences across sub-samples were identified (Table 15.8). The authors noted:

- the lower values for preserving additional grassy woodlands and wetlands among households in the Upper South East reflected the importance of these area for agricultural uses.[172]
- wetlands have recreational values associated within hunting, birdwatching, walking and hiking. They are valued by landholders as a water supply, and as high-quality grazing areas in dry periods.

The response rate was 38.2 per cent (of those who were initially called). A total of 731 usable surveys from Adelaide, the Upper SE and the rest of the state were received. It was assumed that 58 per cent of households in South Australia had the same preferences as the sample in this study.

Table 15.8 outlines the recommended values for scrublands and grassy woodlands. It is not recommended the value for wetlands be applied because the study suggested recreational and agricultural values may be included in the value for wetlands.

172 https://www.mdba.gov.au/sites/default/files/archived/basinplan/1282-MDBA-NMV-Report-Morrison-and-Hatton-MacDonald-20Sep2010.pdf

**Table 15.8 Implicit prices for habitat ($ per household), per 1000 hectares, each year for five years**

| Area | Scrublands | Grassy woodlands | Wetlands |
|---|---|---|---|
| Whole state | 0.72 | 1.06 | 1.36 |
| Adelaide | 0.73 | 1.04 | 1.41 |
| Upper SE | 0.97 | 0.06* | 0.45 |
| Rest of the state | 0.70 | 1.17 | 1.22 |

*Statistically insignificant from zero

Source: D. Hatton MacDonald and M.D. Morrison (2010), Valuing biodiversity using habitat type, Australasian Journal of Environmental Management, 17:4, 235-243.

## 15.5 The economic value of improved environmental health in Victorian Rivers

Bennett, et al. (2008) estimated the value of improvements to river health to sub-samples of the Victorian population for three representative rivers:

- Goulburn River —large lowland regulated river, irrigation
- Moorabool River —large peri-urban regulated river
- Gellibrand River — large unregulated coastal river.

### 15.5.1 Attributes

The four river health attributes included in the survey were:

- native fish — a health river will have an abundant and self-sustaining population of native fish. Attribute was measured as percentage of pre-settlement species and population levels
- riverside vegetation — a healthy river-side zone has more than 60 per cent of the ground cover as native species, and eh vegetation belt on each side of the river is more than about 1.5 times as wide as the channel. Attribute was measured as percentage of river's length with healthy vegetation on both banks.
- native waterbirds and other animals — observed populations of native birds and animals are sustainable. Attribute was measured as number of native waterbirds and other animal species with sustainable populations.
- water quality/recreation opportunities — recreational opportunities that can be undertaken is an indicator of the water quality. This attribute was measured as percent of the river suitable for primary contact recreation without threat to public health.

The payment vehicle for the study was a one-off compulsory payment by Victorian households into a Trust Fund to be used to pay for river health improvements. The total sample size across six sub-samples was 4 656 respondents with an average response rate of 17 per cent (total of 806 respondents).

### 15.5.2 Results

Table 15.9 outlines the implicit prices by attribute and region.

**Table 15.9 Implicit prices**

| Attribute | Moorabool/ in-catchment | Moorabool/ Melbourne | Gellibrand/ in-catchment | Goulburn/ Gellibrand | Goulburn/in-catchment | Goulburn/ Melbourne |
|---|---|---|---|---|---|---|
| Fish | 4.95* | 5.34* | 2.19* | 5.56* | 4.39* | 4.47* |
| Vegetation | 5.56* | 5.33* | 2.91* | 4.65* | 3.56* | 5.53* |
| Birds | 22.07* | 18.19* | 17.33* | 3.04* | 3.90* | 3.35* |
| Water quality | 0.09 | 0.34 | -0.05 | -0.59 | 2.12* | 1.64* |

Note: * Significant at the 5 per cent level. Confidence intervals of 95 per cent were presented in original study.

Source: Bennet, J., Dumsday, R., Howell, G., Lloyd, C., Sturgess. N., and Van Raalte, L., 2008, The economic value of improved environmental health in Victorian rivers.

## 15.6 Non-use values of Victorian Public Land: Case Studies of River Red Gum and East Gippsland Forests

Bennett et. al. (2007) used choice modelling to estimate the values of key environmental attributes of two forest areas, River Red Gum and East Gippsland Forests.

### 15.6.1 Attributes

**Table 15.10 Attributes and their levels for River Red Gum forests**

| Attribute | Description | Levels |
|---|---|---|
| Cost | Compulsory annual payment ($) | 0; 20; 50; 100 |
| Healthy RRGs | Area in hectares | 54,000; 67,000; 74,000; 80,000 |
| Threatened Parrots | Number of breeding pairs | 900; 1,200; 1,500; 1,800 |
| Murray Cod and other threatened native fish | Percentage of pre-European numbers | 10; 20; 40; 60 |
| Recreation facilities | Number of campsites with facilities | 6; 9; 12; 18 |

Source: Bennett, J., Dumsday, R., Lloyd, C., Kragt, M., (2007) Non-use values of Victorian Public Land: Case Studies of River Red Gum and East Gippsland Forests.

**Table 15.11 Attributes and their levels for East Gippsland forests**

| Attribute | Description | Levels |
|---|---|---|
| Cost | Compulsory annual payment ($) | 0; 20; 50; 100 |
| Threatened Own Species | Number of breeding pairs | 400; 440; 460; 500 |
| Threatened Long-footed Potoroos | Number of individuals | 2,000; 2,500; 3,000; 4,000 |
| Significant Rainforest Sites | Number of hectares protected | 3,350; 4,000; 4,500; 5,000 |
| Old Growth Forest | Number of hectares protected | 172,000; 190,000; 215,000; 240,000 |

Source: Bennett, J., Dumsday, R., Lloyd, C., Kragt, M., (2007) Non-use values of Victorian Public Land: Case Studies of River Red Gum and East Gippsland Forests

## 15.6.2 Results

With respect to Healthy River Red Gums, the study found Melbourne households (urban sub-sample) were willing to pay $1.45 per year for 20 years for a 1 000 hectare increase in the area of healthy River Red Gum forest and Bairnsdale households (outside-region sub-sample) were willing to pay $3.29 per year for 20 years. The results for households within the region were not significantly different from zero (Table 15.12).

**Table 15.12 Implicit price estimates for River Red Gums**

| Attribute | Melbourne ($/yr/hh) | Bairnsdale ($/yr/hh) | Within region ($/yr/hh) |
|---|---|---|---|
| Healthy RRGs (per 1,000 ha) | 1.45*** | 3.29** | 0.0677 |
| Parrots (per 100 pairs) | 4.39*** | 8.39*** | 3.96*** |
| Cod (per 1 per cent increase) | 1.02*** | 1.37*** | 1.09*** |
| Recreation (per campsite) | -0.11 | -0.85 | -0.24 |

Note: Significance levels indicated by: *0.1, **0.05, ***0.01.

Source: Bennett, J., Dumsday, R., Lloyd, C., Kragt, M., (2007) Non-use values of Victorian Public Land: Case Studies of River Red Gum and East Gippsland Forests.

Community's value of rainforest and old growth forest were also estimated in the Melbourne, Bairnsdale and East Gippsland sub-samples. The study found households in Melbourne and East Gippsland were willing to pay in the order of $11 and $53, respectively, per 1000 hectares of rainforest site protected. Community's willingness to pay for a 1000 hectare increase in the area of protected old growth forest ranged between $0.33 and $2.05 across the three sub-samples (Table 15.12).

# 15.7 Towards the development of a transferable set of value estimates for environmental attributes

Van Bueren and Bennett (2004) conducted a choice modelling study to estimate values for the impacts of land and water degradation in Australia. The study tested the validity of transferring value estimates derived in a national context to different regional contexts.

The authors note choice modelling is suited to the role of benefit transfer as value estimates can be disassembled into component values. Also, that benefit transfer requires the physical impacts in the source study to be similar in type to those at the target site.

### 15.7.1 Attributes

Table 15.13 outlines the attributes used.

**Table 15.13 Attributes selected for the choice modelling questionnaire**

| Attribute | Unit of measurement |
|---|---|
| Endangered native species | The number of species protected from extinction |
| Countryside aesthetics | The area of farmland repaired and bush protected (ha) |
| Waterway health | The length of waterways restored for fishing or swimming (km) |
| Country communities | The net loss of people from country towns each year |
| Environmental levy | Annual household levy ($) |

Source: VAN BUEREN, M. & BENNETT, J. 2004. Towards the development of a transferable set of value estimates for environmental attributes. Paper presented at the 45th Annual Conference of the Australian Agricultural and Resource Economics Society, January 23 to 25, 2001, Adelaide, South Australia.

### 15.7.2 Results and key findings

Table 15.14 outlines the implicit prices estimated for the National model. Key findings from the study are:

- Community values for environmental and social attributes are dependent on the context in which changes are made and the population for whom the impacts are relevant.
- Values are dependent on the population sampled for at least some attributes. Value estimates obtained in one region do not necessarily reflect community values in a different region for all attributes. Hence it is important to take account of framing and population characteristics when transferring value estimates.
- Implicit price estimates sourced from the national study are lower than those derived from the regional case studies. Conversely, respondents have significant higher values when attributes are framed in a regional context.

**Table 15.14 Attribute implicit prices derived from the National model (NF NP), expressed in terms of annual household values**

| Attribute | Units | Mean | 95% confidence interval |
|---|---|---|---|
| Endangered species | $ per species protected | 0.67 | 0.47 – 0.88 |
| Look of the land | $ per 10,000 ha restored | 0.07 | 0.02 – 0.14 |
| Waterway health | $ per 10 km restored | 0.08 | 0.04 – 0.16 |
| Country communities | $ per 10 persons leaving | -0.09 | (-0.11) – (-0.07) |

Source: VAN BUEREN, M. & BENNETT, J. 2004. Towards the development of a transferable set of value estimates for environmental attributes. Paper presented at the 45th Annual Conference of the Australian Agricultural and Resource Economics Society, January 23 to 25, 2001, Adelaide, South Australia.

The overall response rate was 16 per cent, or 1569 completed questionnaires. A follow-up telephone survey of 340 non-respondents was undertaken to explore reasons for the low response rate:

- 55 per cent of respondents did not recall receiving the questionnaire, which was interpreted as a zero level of interest (zero WTP)
- 20 per cent of respondents recalled receiving the questionnaire but did not complete it because they were not interested in the subject matter
- the remaining 25 per cent said they received the questionnaire and were interested in the subject matter but did not complete the survey because they were either too busy or thought the survey did not ask the right questions. Approximately half (47 per cent) of this group said 'yes or maybe' to the idea of supporting an environmental levy.[173]

The authors concluded that:

- approximately 75 per cent hold zero values
- 25 per cent implicitly place some value on protecting the environment. The authors assumed these non-respondents held the same values as the respondents.

Extrapolation was applied to 37 per cent of the population.[174]

## 15.8 Valuing the Protection of Aboriginal Cultural Heritage Sites

Rolfe and Windle (2003) used choice modelling to estimate non-use values for protection cultural heritage sites in the context of further water resource allocation and irrigation development.

### 15.8.1 Attributes

The attributes included in the survey were:

- healthy vegetation left in the floodplain

[173] VAN BUEREN, M. & BENNETT, J. 2004. Towards the development of a transferable set of value estimates for environmental attributes. Paper presented at the 45th Annual Conference of the Australian Agricultural and Resource Economics Society, January 23 to 25, 2001, Adelaide, South Australia.

[174] The total number of non-respondents was 8152. Of this group, the follow up survey suggests that 25 per cent (or 2038) have non-zero values. This proportion, when expressed as a percentage of the total number of delivered questionnaires (9721) is 21 per cent. When this is added to the 16 per cent of people who responded to the survey, the total proportion of the population to which the results can be safely extrapolated is 37 per cent.

- kilometres of waterways in good health
- protection of Aboriginal cultural sites
- unallocated water

The cost attribute was specified as an increase in local rates (or rent) each year to fund improvements.

**Table 15.15 Base and attribute levels**

| Attribute | Base levels | Choice set levels |
|---|---|---|
| Payment ($) | 0 | 10, 20, 50, 100 |
| Healthy vegetation in the floodplain (per cent) | 20 | 20, 30, 40, 50 |
| Kilometres of waterways in good health (km) | 1500 | 1500, 1800, 2100, 2400 |
| Protection of Aboriginal cultural sites (per cent) | 25 | 25, 35, 45, 55 |
| Unallocated water (per cent) | 0 | -15, -10, -5, 0, 5, 10, 15, 20 |

Source: Rolfe, J. and Windle, J., (2003), Valuing the Protection of Aboriginal Cultural Heritage Sites, The Economic Record, Vol. 79, Special Issues, June, 2003, S85-S95.

## 15.8.2 Results

Table 15.16 outlines the part-worth estimates by attribute and community. There was no significant difference found Rockhampton and Brisbane general communities for any of the part-worths. A significant difference was found for the cultural heritage attribute in the general community samples compared to the Indigenous sample.

Response rates:

- 112 surveys were hand delivered to an Indigenous sample of the Rockhampton area, 65 collected (response rate of 56 per cent)
- 120 surveys hand delivered in Rockhampton, 100 collected (response rate of 83 per cent)
- 58 collected from Brisbane (response rate of 70 per cent).

**Table 15.16 Part Worth estimates**

| Community | Vegetation | Water | Cultural Heritage | Reserve | Asc1 |
|---|---|---|---|---|---|
| Rockhampton Indigenous community | Not sig | 0.05 | 3.22 | 3.62 | 28.38 |
| Rockhampton general community | 2.45 | 0.06 | -2.08 | 3.12 | Not sig |
| Brisbane general community | 2.68 | 0.06 | -1.78 | 3.33 | Not sig |

Note: Lower and upper confidence intervals reported in original study.

Source: Rolfe, J. and Windle, J., (2003), Valuing the Protection of Aboriginal Cultural Heritage Sites, The Economic Record, Vol. 79, Special Issues, June, 2003, S85-S95.

## 15.9 The Private and Social Values of Wetlands: an Overview

Bennett and Whitten (2002) studied values associated the management of wetlands located on private property. In particular the study explored the imbalance of incentives that private wetland owners receive from either exploiting or protecting their wetlands. And whether the incentives private owners face align with the community's broader values.

Two case study areas were included in the study, each representing widely different biophysical and socio-economic characteristics:

- Wetlands located in the Upper South East of South Australia (USESA) between Bool Lagoon and The Coorong.
- Wetlands located on the Murrumbidgee River Floodplain (MRF) between Wagga Wagga and Hay.

### 15.9.1 Attributes and results

**Table 15.17 Attribute value estimates**

| Attribute | Value estimate ($ per unit) |
|---|---|
| Upper South East of South Australia | |
| Area of healthy wetlands (pro-conservation respondents per '000 ha)[a] | 1.51 |
| Area of healthy wetlands (other respondents per '000 ha) [a] | -1.22 |
| Area of healthy remnant vegetation ('000 ha) | 1.51 |
| Number of threatened species that benefit | 4.81 |
| Number of ducks hunted (non-hunters per '000) | -4.35 |
| Number of ducks hunted (hunters per '000) | 3.01[b] |
| Murrumbidgee River Floodplain | |
| Area of healthy wetland ('000 ha) | 11.39 |
| Number of native birds (percentage of 1800 population) | 0.55 |
| Number of native fish (percentage of 1880 population) | 0.34 |
| Number of farmers leaving | -5.73 |

a Pro-conservation respondents reported favouring conservation over development, other respondents either favoured conservation and development equally or favoured development.

b The value of ducks hunted to duck hunters is not significantly different from zero at the 95 percent level of confidence due to the relatively small number of respondents who had hunted ducks.

Source: Bennett, J. W and Whitten S.M. (2002), The private and social values of wetlands: an overview, Land and Water Australia.

## 15.10 Valuing remnant vegetation in Central Queensland using choice modelling

Blamey et al. (2000) used a choice modelling study to estimate the benefits of retaining remnant vegetation in the Desert Uplands of Queensland.

Table 15.18 outlines the attributes and estimates values for a one unit of improvement.

### Table 15.18 Implicit prices for the attributes

| Variable | Value of a one unit improvement (A$) |
|---|---|
| Jobs lost in local region | 3.04 |
| Loss in regional income (A$m) | 5.60 |
| Number of endangered species lost | 11.39 |
| Percentage reduction in population of non-threatened species | 1.69 |
| Percentage loss in area of unique ecosystems | 3.68 |

Source: Blamey, R., Rolfe, J., Bennett, J., and Morrison, M., 2000, Valuing remnant vegetation in Central Queensland using choice modelling, The Australian Journal of Agricultural and Resources Economics, 44:3, pp. 439 – 456.

# 16 Annexure F: Response rates for a selection of studies of biodiversity value

In aggregating per household values up to a total population value, a conservation approach is to apply the response rate achieved in the primary study. Alternatively, based on results in Morrison (2000)175, aggregation is the survey's response rate plus 30% of non-respondents who are likely to have the same values as respondents, and that the remainder most likely had a zero value. This approach has been followed in various studies (e.g., Hatton MacDonald and Morrison 2005, Bennett et al., 2008b). The response rates for a range of studies including environmental attributes is shown in the second column of Table 16.1. Assuming that 30% of non-respondents have equivalent values to respondents, the extrapolation percentage can be calculated for each study, and is shown in the final column of Table 16.1.

**Table 16.1 Response rates from a selection of non-market valuation studies with environmental attributes**

| Study | Response rate | Percentage of non-respondents likely to have values | Extrapolation percentage |
|---|---|---|---|
| Bennett et al., (2008a) | 17.0% | 24.9% | 41.9% |
| Whitten and Bennett (2001) | 32.3% | 20.3% | 52.6% |
| Morrison, Bennett and Blamey (1999) | 49.4% | 15.2% | 64.6% |
| Morrison (2002) | 49.0% | 15.3% | 64.3% |
| Morrison, Bennett, Blamey and Louviere (2002) | 49.4% | 15.2% | 64.6% |
| Morrison and Bennett (2004) | 39.6% | 18.1% | 57.7% |
| Morrison, Hatton MacDonald, Boyle and Rose (2010) | 54.2% | 13.7% | 67.9% |
| Rolfe and Windle (2006) | 50.0% | 15.0% | 65.0% |
| Average across studies | 42.6% | 17.2% | 59.8% |

Source: Morrison, M. and Hatton MacDonald, D., 2010, Economic Valuation of Environmental Benefits in the Murray-Darling Basin, Report prepared for the Murray-Darling Basing Authority.

[175] Morrison, M., (2000), *Aggregation Biases in Stated Preference Studies,* Australian Economic Papers, Volume 39, Issue 2, June 2000, Pages 215-230.