URBAN FOREST STRATEGY
MAKING A GREAT CITY GREENER 2012–2032

CITY OF MELBOURNE

AN ECO CITY

We provide solid, sustainable foundations for the future communities of Melbourne. We are prepared to embrace the unfamiliar if it helps us achieve our lofty ambitions.

We will continue to encourage our community to take positive actions – to be part of the solution at a local, national and global level.

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how you can participate in the decision-making process for some of City of Melbourne's current and future initiatives.
(link: www.participate.melbourne.vic.gov.au)

VISION

The City of Melbourne's urban forest will be resilient, healthy and diverse and will contribute to the health and wellbeing of our community and to the creation of a liveable city.

A visualisation of the possible future 'greening' of Melbourne.

1. EXECUTIVE SUMMARY

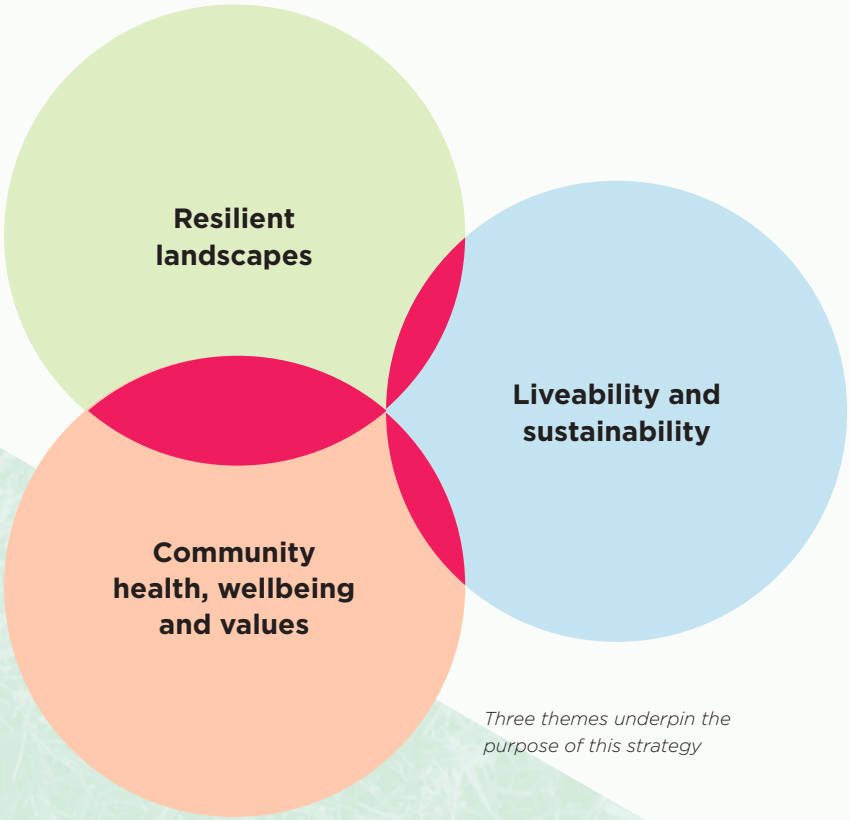
This is the City of Melbourne's first Urban Forest Strategy. It is the product of a collaborative process, developed over two years with a large number of stakeholders including local and international academics, interest groups and the broader community in Melbourne.

Goals

At the core of this strategy is a vision to create a **resilient, healthy and diverse forest** for the future. That creation begins by building upon the present and the past. The City of Melbourne is renowned for its historical parks, gardens and boulevards. These contribute greatly to the city's character and are integral to its social and cultural life. It is important that the forest of the future maintains the essential character of the urban forest that Melburnian's love.

In developing this strategy, the City of Melbourne recognises the importance of a holistic, 'whole-of-forest' approach to understanding and managing this invaluable resource. Many of Melbourne's landscapes were created well over 100 years ago in a different climatic and social environment. A significant number of our trees are nearing the end of their lives and landscapes are struggling to adapt to a changing climate. Now is the time to design and plant the forest of the future in a way that **respects Melbourne's unique character, responds to climate change and urban expansion, and underpins the health, liveability and wellbeing** of the city and its inhabitants.

The goal of this strategy is to guide the transition of our landscape to one that is resilient, healthy and diverse, and that meets the needs of the community. Its intended outcomes are to create **resilient landscapes, community health and wellbeing** and a **liveable, sustainable city**. Central to this is the vision to make our great city greener – to create a city within a forest rather than a forest within a city.



Three themes underpin the purpose of this strategy

1. EXECUTIVE SUMMARY

Key challenges

The City of Melbourne is currently facing three significant challenges: **climate change, population growth and urban heating**. These will place significant pressure on the built fabric, services and people of the city. A healthy urban forest will play a critical role in maintaining the health and liveability of Melbourne.

Over the next 20 years and beyond, Melbourne will experience a changing climate, becoming increasingly warm, dry, and liable to more frequent extremes of heat and inundation. We can also expect that Melbourne's urban heat island effect will intensify. One of the important functions of the urban forest is to provide shade and cooling. Increased canopy coverage throughout the city will minimise the urban heat island effect and improve thermal comfort at street level for pedestrians. Increased water sensitive urban design will play an important role in managing inundation and providing soil moisture for healthy vegetation growth, as well as enhancing the city's ecology.

Climate change science and international urban forestry research both indicate that a range of threats facing the urban forest will increase in the future, particularly vulnerability to pests, disease and extremes of weather. This requires a new approach in how the urban forest is managed, so that future vulnerability can be minimised and benefits maximised.

We expect to see growth in Melbourne's residential, worker and visitor populations and increasingly dense built form. An associated growth in the urban forest, 'green infrastructure' and 'ecosystem services' will respond to these pressures, reduce the cost of grey infrastructure and improve the quality of the urban environment. Urban forests and associated ecosystem services will also yield benefits by attracting more people to live, work and visit in our city.

Our urban forest is undergoing unprecedented change. The recent period of drought and water restrictions triggered irreversible decline for many trees. This exaggerated the age-related decline of many significant elms and other trees. Modelling shows that within the next ten years, 23% of our current tree population will be at the end of their useful lives and within twenty years this figure will have reached 39%. [1] The City of Melbourne is addressing these changes head on by looking at retention of existing trees and planning the urban forest of the future. To guide future planting, a series of tools and programs have been, and will continue to be, developed. Building the urban forest as a living ecosystem and ensuring that it provides the maximum benefits for our communities will rely on smart species selection, improving soil moisture retention, reducing stormwater flows, improving water quality and re-use, increasing shade and canopy cover, and reducing infrastructure conflicts.

Urban forestry is entering a new era in Australia and this strategy highlights how important it is, particularly in context of enhancing liveability and adapting to predicted climate change. An urban forest provides a multitude of benefits for ecosystems, the economy, and community health and wellbeing.

View of the city from Princes Park

The renowned avenue of Lemon Scented Gums along Fraser Avenue in Kings Park, Perth

It is essential that we acknowledge and build upon those benefits now to ensure the best future for our city – an urban forest loved and enjoyed by our children and their children. We now have a unique opportunity to create a healthy, resilient and diverse forest for the future.

Principles, strategies & targets

Our vision is of a healthy, resilient and diverse urban forest that contributes to the health and wellbeing of our communities, and to a liveable city that will create better urban environments for everyone. The principles outlined in this strategy will guide decision-making to create our future forest and achieve this vision. The strategy highlights proactive and adaptive management, and will transform an asset that has a current amenity value estimated at $700 million and a future value that is potentially priceless.[2]

In order to build a resilient, healthy and diverse urban forest that can thrive in the future, the strategy's guiding principles are to:

- mitigate and adapt to climate change
- reduce the urban heat island effect
- become a 'water sensitive' city
- design for health and wellbeing
- design for liveability and cultural integrity
- create healthier ecosystems
- position Melbourne as a leader in urban forestry

The strategies and targets proposed to achieve this vision are:

Strategy 1:
Increase canopy cover
Target: Increase public realm canopy cover from 22% at present to 40% by 2040.

Strategy 2:
Increase urban forest diversity
Target: The urban forest will be composed of no more than 5% of any tree species, no more than 10% of any genus and no more than 20% of any one family.

Strategy 3:
Improve vegetation health
Target: 90% of the City of Melbourne's tree population will be healthy by 2040.

Strategy 4:
Improve soil moisture and water quality
Target: Soil moisture levels will be maintained at levels to provide healthy growth of vegetation.

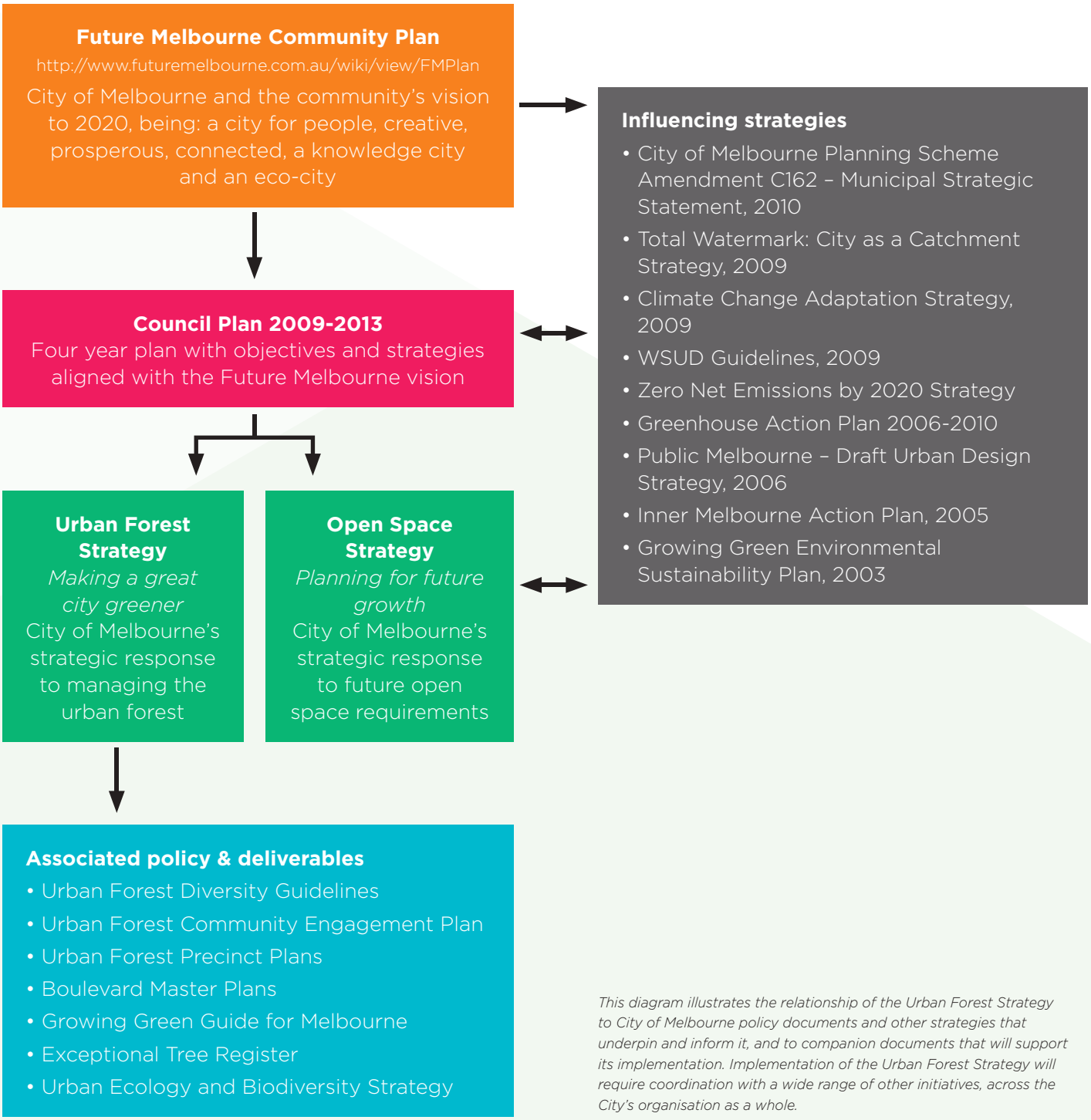
Strategy 5:
Improve urban ecology
Target: Protect and enhance a level of biodiversity that contributes to a healthy ecosystem.

Strategy 6:
Inform and consult the community
Target: The community will have a broader understanding of the importance of our urban forest, increase their connection to it and engage with its process of evolution.

Meeting these targets will provide many benefits. Most importantly they will ensure that we adapt for predicted climate change, manage the health of the urban forest, and provide the community with world class open spaces that provide benefits for public health and wellbeing and for the environment.

The City of Melbourne and its communities have a unique opportunity to work collaboratively to develop the future urban forest. The City of Melbourne has a leading role to play in urban forest advocacy. The principles and actions developed through this strategy can also be used and adapted across Melbourne, thereby reinforcing Greater Melbourne's urban forest.

> We often think of the trees as the lungs of our city, but they are also, in some ways, our heart and soul. The whole community owns our trees and our future trees... There are few political, budget or policy decisions that must deliver for people in 100 years. In politics, so much is driven by the artificial three- or four-year election cycle. Not this plan. Our trees are too important.
>
> **Robert Doyle, Herald Sun,**
> **9 January 2011**



This diagram illustrates the relationship of the Urban Forest Strategy to City of Melbourne policy documents and other strategies that underpin and inform it, and to companion documents that will support its implementation. Implementation of the Urban Forest Strategy will require coordination with a wide range of other initiatives, across the City's organisation as a whole.

2. BACKGROUND & CONTEXT

2.1 What is an urban forest?

The City of Melbourne's urban forest comprises all of the trees and other vegetation – and the soil and water that supports it – within the municipality. It incorporates vegetation in streets, parks, gardens, plazas, campuses, river and creek embankments, wetlands, railway corridors, community gardens, green walls, balconies and roofs.

Urban forests provide critical ecosystem services such as air and water filtration, shade, habitat, oxygen, carbon sequestration and nutrient cycling. The urban forest also provides a connection to nature that is often perceived to be missing in urban areas.

Urban forestry can be described as the science and art of managing trees, forests and natural ecosystems in and around urban communities to maximise the physiological, sociological, economic and aesthetic benefits that trees provide society.[3]

Urban forestry, as distinct from arboriculture and horticulture, considers the cumulative benefits of an entire tree population across a town or city. Looking holistically at the urban forest and its associated ecosystem services allows for consideration of the broader issues of climate change, urban heat island effects and population growth that can be influenced by, and that can affect, an urban forest.

The management of an urban forest is often considered a local government responsibility but frequently extends well beyond that; local communities, schools, community groups, developers, business, industry and State and Federal Government all have important roles to play. Every part of the city contributes in some way to the urban forest as a whole. None-the-less, the primary focus of this strategy and the actions recommended in it is the public realm for which the City of Melbourne is directly responsible.

A Docklands waterfront promenade. Local greening adds immeasurably to the quality of the city as a place to live.

Foresting the suburbs provides wider benefits for a healthy city.

Boston Ivy on the historic St Kilda Road Barracks.
All kinds of vegetation contribute to the urban forest.

2. BACKGROUND & CONTEXT

The discipline of urban forestry stemmed from research conducted by Erik Jorgensen at the University of Toronto, Canada in 1965. This was the first recognition that urban trees provide environmental benefits in addition to recreational and amenity value. With support from the International Society of Arboriculture and the US Department of Agriculture's Forestry Department, urban forestry gradually pervaded US urban policy. It reached the UK in the early 1980s – sparking the Forest of London project aimed at social, ecological and economic regeneration of UK cities – and flowed into the Netherlands in the mid 1980s. From there, Scandinavian, European and Asian cities have embraced the concept, broadening the depth of knowledge and research.[4]

A Model of Urban Forest Sustainability, by JR Clark et al. (1997), was one of the formative works applying principles of sustainability to urban trees. 'The most significant outcome of a sustainable urban forest is to maintain a maximum level of net environmental, ecological, social and economic benefits over time.' This paper:

- defined sustainable systems aligned with the (seminal) Brundtland Commission Report, 1987, and the characteristics of urban forest sustainability
- set criteria of urban forest sustainability for the vegetation resource, for the community framework and for resource management; and finally
- set criteria and performance indicators for the vegetation resource, for the community framework and for resource management

Urban forestry has yet to be well researched, implemented and evaluated in an Australian context. There is a reliance on research from the US, Europe, Scandinavia and Asia to supplement our thinking and programs. Whilst Australia is some way behind in providing robust research and literature on the topic, Australian cities are by no means behind in current management and planning of urban trees and vegetation. We have been practicing the art and science of urban forestry for years through tree and park planning, arboriculture, horticulture and urban design.

Defining what urban forestry means for Melbourne and Australia is important in determining visions for our future cities and how we will go about realising them. Essentially, urban forestry is the meeting of arboricultural and forestry with other disciplines such as urban planning, landscape architecture, architecture, engineering and economics. Ensuring these groups work collaboratively will be integral to a genuinely Australian concept of urban forestry.

> Urban and community forestry has transcended its original niche function in public policy as an aesthetic amenity to soften the urban landscape. It is increasingly perceived as a solution to many more pressing urban environmental problems and even as a tool for community and social development … Environmental benefits are also being quantified more accurately and more often in economic terms… Increasingly communities are realizing that green infrastructure is an economical long-term investment that reduces the need for much greater expenditures in gray infrastructure.
>
> **JC Schwab (Ed.), 2009.**
> **Planning the Urban Forest**

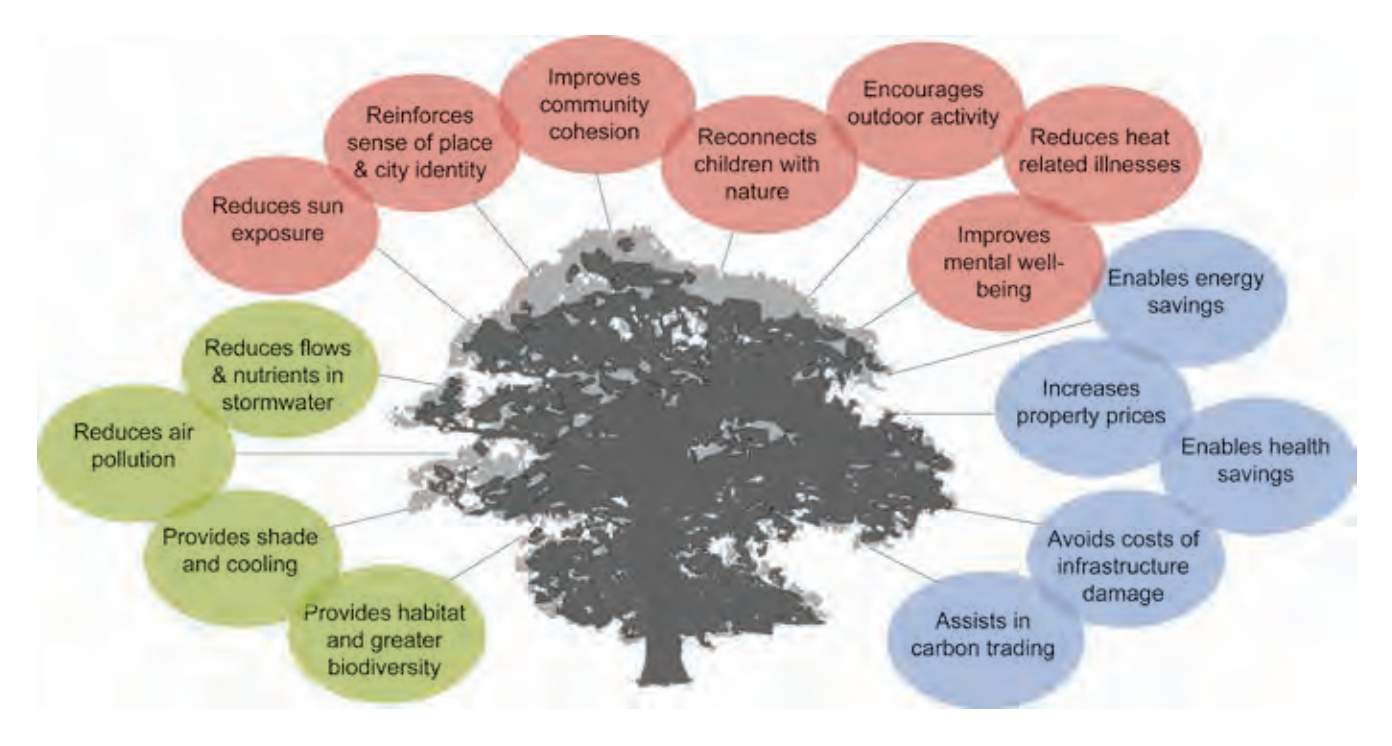
2.2 Benefits of the urban forest

Urban forests have been around for generations but only recently have they become valued for providing more than aesthetic and recreational values.

Cities around the world now regard trees and other vegetation as critical urban infrastructure – as important to how a city functions as roads or public transport and particularly vital to the health and wellbeing of communities.

The benefits of urban forests span **environmental, economic, cultural** and **political domains**. These benefits are interrelated, with each cumulatively feeding into the creation of resilient and sustainable urban landscapes.

Given the pressure on governments to plan for greater populations, increased urban density and climate change adaptation, there is a clear opportunity to communicate the importance and benefits of urban forests in creating resilient, sustainable cities that provide healthy and enjoyable places for people to live and work. Some of the major benefits of urban forests in supporting and providing essential services are explored in this section.



Summary of the broad array of benefits offered by urban trees [adapted from the Woodland Trust, UK]

2. BACKGROUND & CONTEXT

2.2.1 Environmental benefits

The urban forest is the 'engine room' for urban ecosystems. Trees take in water, nutrients and carbon dioxide and process them through photosynthesis and transpiration, transforming them into clean air, oxygen, shade and habitat.

Environmental benefits of the urban forest include:

- **Provide shade and cool our cities**
  The addition of trees and other vegetation to the built environment provides the greatest benefit in mitigating the urban heat island effect. Through the process of transpiration and the provision of shade, trees help reduce day and night-time temperatures, especially during summer. They shade streets and footpaths, and their leaves reflect more sunlight and absorb less heat than built materials, reducing the heat absorbed by the built environment. During transpiration, plants draw water from the soil and release moisture through their leaves into the air.
- **Reduce stormwater flows and nutrient loads** Tree canopies and root systems reduce stormwater flows and nutrient loads that end up in our waterways. Tree canopies intercept and mitigate the impact of heavy rainfalls. Healthy tree roots help reduce the nitrogen, phosphorus and heavy metal content in stormwater. Green roofs retain rainwater, filter the water that does run off, and delay the time at which runoff occurs, resulting in decreased stress on sewer systems at peak flow periods. Wetlands and raingardens also trap stormwater, improve water quality and reduce nutrient loads.
- **Reduce air pollution, air-borne particulates and greenhouse gas emissions** Vegetation ameliorates air pollution and reduces greenhouse gases. Through the process of photosynthesis trees remove carbon dioxide, nitrous oxides, sulphur dioxide, carbon monoxide and ozone from the atmosphere. As trees reduce temperatures, they help improve air quality through energy savings and reducing the emission of pollutants that are temperature dependant. A New York study found that its urban forest removed 1,821 metric tonnes of air pollution at an estimated value to society of $9.3 million annually. Carbon dioxide is a greenhouse gas associated with trapping heat in the atmosphere and driving climate change, and the effectiveness with which many trees sequester and store carbon is considered a key mitigation strategy for reducing levels of atmospheric carbon dioxide. Studies show a typical mature tree can store as much as 10 tonnes of carbon.[5]
- **Provide habitat and enhance levels of biodiversity** Although few Australian cities have preserved large areas of natural habitat, a healthy urban forest contributes to biodiversity and habitat provision. Urban forests around the world have been shown to support a wide range of species, even endangered animals and other species of high conservation value. By planting and managing different age strata, biodiversity and wildlife habitat values can be enhanced. Green roofs and walls can also provide habitat for wildlife.

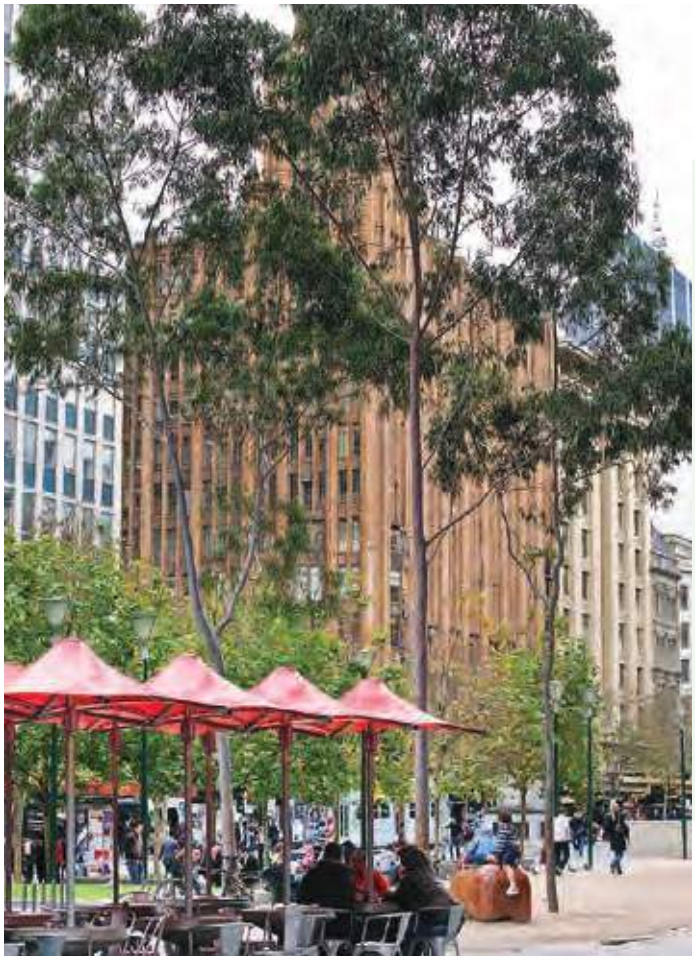
The Trin Warren Tamboore wetland in Royal Park provides habitat, a rich experience for visitors, and captures and cleans stormwater to use for irrigating parkland.

A green wall in Southbank. Despite the persuasive business case for green roofs, they have not been widely implemented in Melbourne, although cities across North America, Europe and Asia have embraced green roof technology.

2.2.2 Community benefits

Urban forests have many positive impacts for the community by forming shared points of reference within the urban environment and allowing daily interaction with nature. Specific benefits include:

- **Creation of local identity** A city's landscape helps define its character. Trees and vegetation can physically define a place. Landscapes are the setting for many everyday recreational opportunities such as organised sport, walking the dog or having a picnic and therefore help forge a sense of connection to place.
- **Improving community cohesion** Green open space provides places for events, festivals and celebrations throughout the city. These can bring diverse groups of people together within a public realm that is available for everyone to enjoy. Green spaces especially play an important role in the integration of minority groups and can assist in the adaptation of immigrants into their host country.
- **Encouraging outdoor activity** Well-vegetated parks, gardens and streets encourage the use of open spaces, with health benefits such as reduced obesity and improved general physical and mental wellbeing. This is important, as lifestyle-related illnesses are prevalent and 61% of Australian adults are overweight or obese (obesity costs Australia's health care industry $58 billion in 2008).[6]
- **Reconnecting children with nature** By enticing children into 'make believe worlds' of computer games, electronic technology is contributing to childhood obesity and inactivity. Studies have shown that green spaces provide therapy to children, allow creativity of mind, encourage exploration and adventure, promote physical activity, build resilience and enhance experiential learning.[7]
- **Reducing sun exposure** The prevalence of skin cancer and other illnesses due to sun exposure have shown that protection from sunlight's UV rays is vital. Shade alone can reduce overall exposure to UV radiation by up to 75%.[8] Trees provide the best form of natural shade, with broad canopied trees being the most effective.
- **Reducing heat related illnesses** The shade provided by trees on hot summer days helps to reduce localised temperatures by up to 2 degrees Celsius.[9] This is significant, as in Melbourne on days over 30 degrees Celsius, the risk of heat-related morbidity and mortality for people over 64 years of age increases significantly. Evidence suggests that people in buildings with little or no surrounding vegetation are at higher risk of heat related morbidity.[10]
- **Improving mental wellbeing**
  Access to, and views of, green spaces and trees have positive effects on people's wellbeing. Many studies have explored relationships between greenery in the landscape and levels of depression and wellbeing. In the Netherlands, disease rates, including mental disease, were shown to be less prevalent in areas with higher percentage of green space within a 1km radius than those with lower percentages.[11]



Paved surfaces are everywhere in the city, but trees in and around them transform some into special places. The tan track around the Domain and Botanic Gardens is one of Melbourne's premier green spaces for active recreation for people of all ages and abilities, while the City Square provides respite and a meeting space for shoppers and workers in the heart of the CBD. Jan Gehl (2007) refers to 'moving', 'meeting' and 'market' as pervasive elements of cities over time – reflecting the dimensions of city life that are particularly supported by green infrastructure.

2. BACKGROUND & CONTEXT

2.2.3 Economic benefits

Urban forest benefits that can be quantified in dollar terms span a range of industries and disciplines including health, engineering, planning, sustainability, geology and real estate industries. Bringing these together to form a solid economic business case for urban forests is a powerful tool for decision makers, as most infrastructure and design decisions are based on economic cost benefit analysis. Some of the economic benefits of an urban forest include:

- **Reducing energy costs** Restoring natural systems is often more cost-effective than technological substitutes or building new infrastructure. Major economic benefits come through shading buildings in summer, reducing the need for air conditioning, in turn cutting energy costs. Increasing tree cover by 10% – or strategically planting about three shade trees per building lot – saves annual heating and cooling costs by an estimated $50 to $90 per dwelling.[12]
- **Increasing property values** Trees in streets enhance neighbourhood aesthetics and consequently are proven to increase property values. It is estimated that properties in tree-lined streets are valued around 30% higher than those in streets without trees.[13]
- **Avoiding costs of infrastructure damage and renewal** Urban forests that provide significant canopy coverage improve the lifespan of certain assets such as asphalt by shading them from harmful UV rays – potentially by 30%.[14] Tree canopies and root systems also help to mitigate flood levels during extreme events and have the ability to lower stormwater flows into drainage infrastructure.
- **Decreasing health costs** Research suggests that a healthy green city helps alleviate the burden on national health systems. While it is difficult to create a direct link and quantify dollar savings, it is likely that urban forests reduce health costs associated with sedentary behaviour, obesity and mental illness. A view of green space, including trees, can also encourage hospital patient recoveries, reducing the amount of time spent in hospital.
- **Marketing the City** Green spaces play a role in defining the culture and image of a city. A better image makes a city more competitive, thus expanding its political and economic influence. Tourism is of increasing importance to many cities, and green space can help to promote tourism, as main attractions or – more commonly – as attractive 'settings' for various types of events and activities that boost the local economy.
- **Storing and sequestering carbon** During photosynthesis, trees convert carbon dioxide and water into sugar and oxygen and store carbon within their biomass. Urban trees therefore make an impact in absorbing carbon from the atmosphere.

[image: Michael Leunig]

The Chicago Trees Initiative, economic calculations indicated that a 17.2% canopy cover:

- Stores $14.8M carbon
- Sequesters carbon at a value of $521,000 per year
- Filters air pollution at $6M per year
- Has a structural value of $2.3 billion

Chicago's urban forest annually sequesters 318,800 tonnes of carbon from the atmosphere, equivalent to the annual greenhouse gas emissions from over 50,000 passenger vehicles.

Time and again, perceptions of the value of a local area and confidence in its future have been enhanced because of the physical improvements ... By contrast, under-investment in parks and green spaces has deterred investment in the area. Investment in green spaces reverses this spiral of decline, enhancing the well-being of out communities.

CABE Space, 2005.
Does Money Grow on Trees?

2.3 The evolution of Melbourne's urban forest

2.3.1 Historical development

It is hard to imagine exactly what Batman would have seen when he stepped off his boat in 1835. However, records suggest it was unlikely that he stepped into a dense forest. Instead, it was grasslands that caught his imagination, a landscape resulting from management by the Wurundjeri people. According to Batman there were not more 'than six [trees] to the acre', mostly sheoaks and wattle, in the region. Grasslands framed by lightly wooded hills stretched to the north of the river. To the south and west, swamps and lagoons dominated the landscape. The most forested land was significantly east of the place where Melbourne was first laid out, far enough away that Fawkner struggled to locate enough timber to build the permanent settlement.[15]

It is possible then, that today inner Melbourne's urban forest is as dense as it has ever been. However, it is an entirely different place than pre-colonisation. Today's trees are part of a conglomeration of processes, things and pressures that are unique to an urban world. The trees in Melbourne's parks, gardens and streets originated in forests from all corners of the world, or as is the case with the most common contemporary tree, the London Plane, the world's gardens. Other than some remnant river red gums the trees standing in central Melbourne today were planted with purpose by a person, and the story of Melbourne's urban forest is thus a tale of people and ideas. Today's landscape is the living result of a particular mix of human and plant migration with changing trends in science, morality, circumstance and aesthetics.[16]

Nineteenth century roots

In 1839, people were already concerned about the destruction of trees around the growing city. Surveyor Townsend wrote that people destroying Melbourne's trees must be hindered 'as the beauty of Melbourne will be destroyed if the land to the north of it is allowed to be cleared' and the trees growing on the city's boundaries were protected in one of Lonsdale's first pieces of legislation. Retaining unbuilt on land close to the city centre was part of a belief that these spaces were essential for people's health. 'It is of vital importance to the health of the inhabitants that there should be parks within a distance of the town' declared the Melbourne Town Council in the year it formed.[17]

Melbourne came to life at a time when cities were places to be feared by many people because they were thought to breed both disease and immorality. Preventing Melbourne from becoming too densely populated and an unhealthy place to live drove the desire to reserve land around the city from development. The parks and gardens in which Melbourne's urban forest grows today are the result of this nineteenth century fear and foresight.[18]

In 1846, the Botanic Gardens was reserved and laid out adjacent to the river where year-round water could be secured. The Carlton gardens were reserved in 1852, named by the Colonial Secretary as a 'recreation reserve'.[19]

River Red Gums near the Yarra River in Burnley. Very little of the vegetation pre-dating European colonisation of the Melbourne region remains today.

> As well as their aesthetic qualities, the trees [of Melbourne's urban forests and magnificent public gardens] reflect a history of thoughtful city planning by leaders who looked to the future and imagined how the landscape would appear decades later when the young trees they planted were fully formed. It is a much-cherished legacy. ... a new generation of leaders is working to ensure that trees remain a vital part of our landscape in the face of the ravages caused by time, disease and drought. ... [This] strategy acknowledges and responds to the pressure on the city from both population growth and climate change. The council's commitment to ensuring even greater biodiversity, shade and beauty than exists at present is an important step towards ensuring a vibrant and beautiful cityscape for future generations to enjoy.
>
> **'The trees that please' [editorial], The Age, 7 January 2012.**

2. BACKGROUND & CONTEXT

In 1854 the important Aboriginal camp, now Royal Park, was reserved, and also by 1856 the Fitzroy Gardens – around which Edward La Trobe Bateman planted a border of eucalypts and wattles.[20] Also popular during this first decade of park creation, were pines and other conifers. This was a legacy both of connections with Tasmania, where early settlement coincided with new species of conifers being celebrated Britain, and with a need to create a secure supply of timber.[21] Baron Ferdinand von Mueller, a key figure in the selection of tree species for in Melbourne, established a pinetum in his first year as director of the Botanic Gardens, with a goal of 'having these useful and noble pines planted copiously throughout the country'.[22] Often, popularity and availability of tree species in early Melbourne was connected to experiments for establishing larger rural industries, such as pines for timber. It also included a brief focus on mulberry trees for a proposed silk industry and various nut tree species.[23]

The trees grown in Melbourne's parks tended to be part of landscapes designed by a series of men, including Mueller, now famous in Melbourne's history. In 1860, Clement Hodgkinson began managing the city's reserves, including the Fitzroy Gardens. He designed the first major planting of these important spaces and used elms and other deciduous species to line various paths with shade trees. This brought relief from the hot summer and was also part of a desire to control the movement of people through these places, creating clear pathways to stroll through. Hodgkinson also believed that it was important to preserve as much remnant indigenous vegetation as possible in the city's reserves.[24] However, it is thought that by the time Hodgkinson started, this pre-settlement vegetation in and around the Hoddle Grid was already scarce.[25]

Melbourne's urban forest composition was not only driven by key designers and local leaders but also by citizens. Nineteenth century ideas of health drove individuals to request trees for their streets and in less formal spaces of the city. During the 1870s, almost one in three of the adult population in the city of Melbourne died of tuberculosis,[26] and more from other fever based disease. Prevailing medical science understood the source of such illness to arise from the landscape, from bad smells or miasmas that wafted from swamps, stagnant water and sewage. Particular trees were thought to absorb these odours and excess moisture. Leaving land poorly drained was considered irresponsible and dangerous, 'the existence of such a swamp on the margins of a populous city' wrote 'The Father of a Family' to the Argus newspaper, 'is a scandal and disgrace and must be remedied by creating a health-giving and life-sustaining garden'.[27]

Eucalyptus trees, promoted for their health-giving properties and quick timber growth by Mueller, were thought to be able to save the city from ill-health. Mueller led a cry of many voices recommending that Eucalyptus trees be planted on the streets.[28] Nurserymen agreed. William Adamson, one of the city's most prominent nurserymen, described the Blue Gum in his 1883/84 catalogue as being placed 'transcendentally above many other plants, if not ALL other plants in hygienic importance'.[29]

Recognition of the value of mature trees meant that this indigenous tree was preserved in the Fitzroy Gardens. [C. Nettleton, Latrobe Picture Collection, State Library of Victoria]

Conifers featured strongly in the early planting of Melbourne parks. [C. Rudd, as in Whitehead, From Acclimatisation towards Ecology]

Hodgkinson used two rows of deciduous trees to shade pathways, although he knew they were not fashionable in contemporary landscape design thinking.[Latrobe Picture Collection, State Library of Victoria]

In the early 1880s, the Melbourne City Council received letters from residents requesting the planting of Blue Gums along Flinders Street. One author argued that as the tree was 'well ascertained to provide in staying and absorbing bad gasses as that evil to manure depot, the polluting influences of the Yarra and the Swamps of west Melbourne may in great measure be stayed by such rows of Trees'.[30] Thus, contrary to current popular belief, many nineteenth century Melburnians wanted eucalyptus trees in their urban forest.

Mueller is important not only for his promotion of eucalyptus trees worldwide but also because his involvement in the colonial seed trade was often the entry point through which new trees reached Melbourne. This trade marked the beginning of a world in which city gardeners or landscape designers could easily open a catalogue and gain access to hundreds of choices of trees to plant. The seeds gathered by Mueller from his contacts at Kew Gardens in London and elsewhere were sometimes provided directly to the city's gardeners for planting. Because of his great knowledge of trees of the world, through books and letters and conversation he regularly advised which tree to plant in the city. Included in one piece of advice in 1861 were the British Elm and both the American and Oriental Plane tree, the beginnings of the trend towards varieties of these genera now so prominent in the city's urban forest.[31]

In the founding decades of Melbourne's urban forest, debates of whether to plant native or exotic trees were not important. Instead, discussion centred around which trees would best make the city healthy, or whether deciduous or evergreen were preferable. 'It becomes of primary importance' wrote von Mueller in 1861, 'whether evergreen or deciduous trees should receive preference for this purpose [street trees]'.[32]

Many people believed that deciduous trees were dull and lifeless when bare-branched in winter, and Mueller recommended avoiding this by interspersing his beloved blue gums with elms or oaks, both for shade and aesthetic purposes.[33] Pines were loved because they were green all year and were often also recommended alongside the eucalypt to mix with deciduous trees.[34] As the century progressed, deciduous trees – their colours, the way their changes marked seasons, and their architectural form – became more popular.[35]

Seeds and seedlings for the city did not always come through the botanic gardens. Nurserymen were vital, yet are often unmentioned in Melbourne's tree histories. There is evidence that nurserymen sometimes accessed their seeds from the botanical networks, but they also had their own connections. In the 1870s, Thomas Lang imported seeds from his own contacts in California, which he then passed onto the Botanic Gardens.[36] Each year the nurserymen produced catalogues describing trees they had available and each year they grew seedlings, often in land in nearby hills, such as Mt Macedon, nursing into life before making them ready for planting in the city's streets. The choices made about what to plant in Melbourne's urban forest have always been limited by access to seed and healthy seedlings.

On the Queen's Birthday in 1875 the Mayor of Melbourne planted the first elm in Collins Street. [Latrobe Picture Collection. State Library of Victoria]

*The grand avenue of London Planes (**Platanus x acerifolia**) in the Carlton Gardens dates from the redesign of the landscape for the 1880 Exhibition, when deciduous trees had become more popular in Melbourne.*

2. BACKGROUND & CONTEXT

Twentieth century changes

The turn of the twentieth century brought with it changes to the way trees in Melbourne were valued. The science of bacteriology slowly changed ideas of public health and trees were thought less valuable for ensuring human health. By the end of the nineteenth century issues of health were no longer present in public debates about urban trees and during the 1920s trees were removed from the Health Committee's portfolio and became instead the responsibility of the Parks and Gardens Committee.

Trees, however, were not less valued. They were just wanted for different purposes. Eucalyptus trees remained desired, but different species were planted. By the 1920s and 30s the red flowering gum from Western Australia had replaced the Tasmanian blue gum as one of the most highly requested urban trees. The Town Clerk received numerous letters requesting that the colourful Australian tree be planted. One writer wanted them along St Kilda road, to 'relieve the monotony' and address the 'want of colour'.[37] In the early 1930s, the curator of the city's Parks and Gardens tried to acquire 21 acres of land in the Government Domain for the purpose of planting Australian flowering gums. He believed that planting these trees would create 'a sanctuary for native birds and fauna' as well as creating a 'park of Flowering Gums which in due course will provide a very beautiful feature and be of considerable attraction to visitors and others'.[38]

The popularity of the flowering gums demonstrates two priorities and debates with implications for the city's urban forest during the 1910s, 20s and 30s. They had colourful flowers, a key characteristic of popular trees at this time, and they were native. As part of the furore surrounding Federation, Melbourne was keen to be seen by the world as both a modern and Australian city. The city thus required both the commonly planted deciduous trees that easily formed avenues and architectural shapes and colours popular in global urban landscaping trends as well as areas that show-cased the 'best' of Australian flora.

William Guilfoyle, who replaced Mueller as director of the Botanic Gardens in 1873, was renowned for bringing greater design flair to the Botanic Gardens. He was also important for Melbourne's urban forests due to his love for Australian plants, and his eye for design resulted in great changes to the city's landscape. His publication in 1912, Australian Plants suitable for Gardens, Parks, Timber Reserves, Etc. was highly influential and celebrated the 'splendour of the blossoms, the variety of forms and greenness of foliage, and their hardy nature' of the country's own flora. He argued in the introduction of his book that 'our Eucalypts, Acacias, Eugenias, Banksias, Hakeas, Grevilleas, Flindersias, Sterculias, Callistemoms, Melaleucas, Cupanias, Angophoras, and hundreds of other brilliant evergreen and gorgeous flowered trees and shrubs... are too often neglected, in the decoration of parks and gardens, in favour of exotic vegetation, which, in the majority of cases, is less hardy and not nearly so picturesque'.[39] This period of celebrating Australian trees, especially those with colourful and attractive flowers, was also the time when the golden wattle flower became the national floral emblem and this tree was also popular in the city's plantings.

MASTER BUILDERS WANT BLACK EMBARGO LIFTED.—Page 3

The Sun
NEWS—PICTORIAL
THE MORNING POST

WARNING!

Firewood Is Treasure Trove In These Gardens

A row of 'the despised ... Moreton Bay fig' was removed from along the Wellington Parade frontage of the Treasury Gardens in 1929, to be replaced by 'Australian flowering gums'.
[Sun, 20 May 1929, as reproduced in Whitehead, Civilising the City, 1997]

The Firewheel Tree ***(Stenocarpus sinuatus)****. William Guilfoyle admired 'brilliant evergreen and gorgeous flowered' Australian trees such as this, and they have been popular at various times in Melbourne's history.*

In addition to a love of Australian flowering trees, this was the time in which an organised town planning movement became important in Australia. The 1914 formation of the Victorian Town Planning and Parks Association brought with it goals to 'give the town a bit of the country and the country a bit of the town', 'to protect existing parks' and 'to safeguard native animals and plants'.[40] The first of these goals was the key to the Garden City movement and encouraged the creation of avenues, resulting, for example, in Royal Parade being planted with elms and a renewed sense of the need for urban citizens to access greenery.

The City Beautiful movement was also influential and 'beautification' efforts saw the reconsideration of trees involved in planting with an emphasis on shape and form as well as colour. Melburnians often reacted strongly to the heavy pruning of street trees, seeing it as vandalism rather than care.[41] For the urban forest the new formalised town planning movement was an important force protecting against tendencies to 'clip off little pieces' of the green spaces for development or sporting clubs. The post-war period, from 1945 to the early 1960s, was a time when Melbourne's inner city urban forest was regularly part of disputes. There was less discussion about which trees to plant during this period than there were fights over potential tree or park loss for building development. The shortage of quality housing for the post-war population boom placed great pressure on the ring of greenery surrounding the CBD. But Melburnians wanted their parks and trees, and regularly campaigned to keep the land as reserves.

The wave of energy in the early 1970s associated with the rise of both indigenous and environmental political movements brought with it new life for Melbourne's trees and parks. Rupert Hamer, the Victorian premier, revived the term 'Garden State' for Victoria and alongside this branding created new parks and public spaces throughout the state. In the centre of Melbourne trees also regained attention. The new political movements created a council in which green politics were at the centre, and key individuals such as Frank Keenan, horticulturalist and Director of the city's parks and gardens, fought for the council to think about the urban environment as an ecosystem. Trees were a key part of a vision the council held at this time, of restoring a balance between land and people, and Keenan was responsible for leading the planting of many trees during the 1970s and early 80s.

Importantly also to this time, was the rise of a different slant in debates of native versus exotic trees. The 'native' in discussions was more complicated than simply being any plant from the huge continent and nation of Australia, but for many was instead a plant that grew locally prior to colonisation. In conjunction with this the rise in the popularity of the science of ecology meant that more nuanced elements of a healthy landscape or environment were explored.

*Plants indigenous to Melbourne and the surrounding region, including Red Box (**Eucalyptus polyanthemos**, top) and Red Ironbark (**Eucalyptus sideroxylon**, centre), were added to the palette of cultivated species in the later 20th century.*

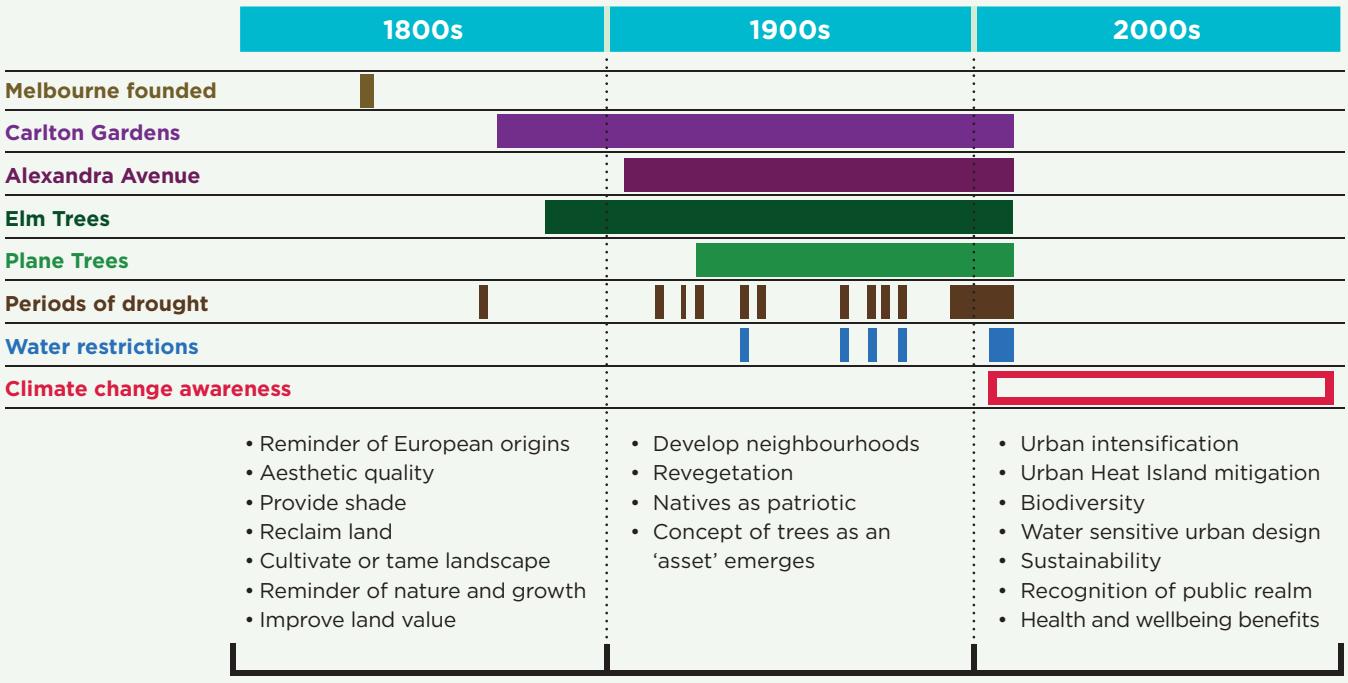
2. BACKGROUND & CONTEXT

The question of what constitutes a healthy urban landscape has changed throughout Melbourne's history and how trees have fitted into this has depended on the science and politics of the day. Since the 1890s, when Melbourne's first horticultural school was founded in Burnley, the city's planting policies have been heavily influenced by this school. This focus from such an early time in Melbourne's history on the science of horticulture, and then more specifically arboriculture, has given the city a high level of professionalism in its approach to the trees. A former principal of the school, Dr Greg Moore, has been a champion for Melbourne's trees this century and is at the forefront of ensuring their role in the city's future. He has been instrumental in promoting ways to value trees economically, ensuring that they are treated as key pieces of Melbourne's infrastructure.

Despite the impact of various debates and changing fashions on which trees were planted, a very small number of species dominate inner Melbourne's contemporary urban forest. This is partly because most of the city's mature trees today were planted in three periods: the latter half of the nineteenth century, the first decades of the twentieth century, and the late 1960s and 1970s. Certain species were more available or fashionable than others at those moments, so they dominated planting at these times. Once a park, garden or streetscape has a set of mature trees, it is rare to change or remove them unless they become ill, dangerous, or exceptionally offensive to new science or fashion. The removal of mature trees from a landscape is not only expensive but usually met with fierce opposition from people who have grown attached to the trees and the presence they bring to their place.

More fundamentally, trees require two types of characteristics to survive in the city. The first includes characteristics that make them attractive for us to use – for shade, ornament or other purposes. The second, although often less discussed, is hardiness and adaptability to urban conditions life. In streets especially, only certain species are able to cope. There is evidence that many of the early plantings of eucalypts did not survive in streets due to insect damage, and that oaks and elms died without constant watering in the black cracking soils in the west of Melbourne. The London Plane, currently dominating street plantings in the city, was never a wild tree. It is a cross between two species from different corners of the world, the American and Oriental Plane trees, occurring first in a garden in the UK. It exists only because of human involvement moving trees around the world and then of selectively gardening. One could thus say that this tree is 'native' to a city.

The history of Melbourne's urban forest is the story of such interdependence between people and trees. It is a story of people planting, transplanting and caring for trees in a very different landscape than pre-settlement, an environment where, without people, most of them would fail to grow.



Temporal evolution of Melbourne's urban forest

2.3.2 The urban forest today

The City of Melbourne's urban forest comprises around 70,000 trees in streets and parks as well as approximately 20,000 trees located in the private realm, in addition to a growing number of green roofs and walls across the municipality.

The trees managed by the City of Melbourne in the public realm contribute significantly to the character and identity of Melbourne. There are over 388 different species of trees in our municipality ranging from the iconic elms and planes to River Red Gums, Melaleucas, Lemon Scented Gums, Spotted Gums and significant stands of conifers in our gardens. The tree population is dominated by three species: elms, planes and River Red Gums. This dominance is part of what creates the respected and unique character of Melbourne's urban forest. Plane trees alone make up 75% of the trees within our central city.

The majestic, but ageing, elms that form magnificent avenues along many of our grand boulevards and through our historic parks are among the last remaining examples of mature elm avenues in the world. Dutch Elm Disease (DED) has killed 40 million elms in the Northern Hemisphere and more recently, in New Zealand and Japan. Worldwide, elm trees are an endangered species, which places an even greater importance on Melbourne's elms.

Our urban forest is home to diverse animal species including the Powerful Owl, Tawny Frogmouth, Kookaburra, Kingfisher, Possum, White's Skink, Grey-headed Flying Fox, Striped Legless Lizard and Blue-tongued Lizard, Eltham Copper butterfly, and a variety of frogs and micro bats. Waterways across the municipality are used by birds for nesting and habitat. The urban forest is vulnerable from a range of perspectives. The dominance of a small group of species and genera, and the ageing of many of our elms, combine to render it vulnerable to significant loss due to potential pest and disease attack, heat-waves and ageing.

Key urban forest indicators

We can examine our urban forest in a number of ways. In order to best manage existing vegetation and to guide the development of the forest of the future, we have undertaken extensive mapping of **tree health, species composition, canopy cover** and **useful life expectancy** for the trees now managed by the City of Melbourne. This mapping provides key indicators with which to benchmark the forest, set future targets and measure change over time.

The private realm requires a more collaborative approach with the community to gain a better understanding of vegetation health, diversity and distribution. The mapping of the private realm and landscapes managed by other agencies will be important for the on-going assessment and evaluation of the urban forest.

Plane Trees in Swanston Street, at the City Square. Planes make up 75% of total number of trees in Melbourne's CBD.

Moreton Bay Figs (Ficus macrophylla) in Princes Park

2. BACKGROUND & CONTEXT

Tree canopy cover

In the City of Melbourne we are seeking to increase summertime shade and biomass to combat the urban heat island effect, to adapt to climate change and to enhance our streetscapes for the comfort of people. Canopy cover is a measure of the physical coverage of the tree canopy over the land. It represents a way of expressing, as a percentage, how much of any given area is shaded by trees.

Canopy cover is an important way of measuring the character of any urban forest. Broad calculations suggest that large mature trees provide 75% more environmental benefits than smaller trees. As a single large tree can shade a larger area than several small trees, the measure of canopy cover is more valuable than simply counting the total number of trees. It is a repeatable benchmark that can be measured regularly and will guide future tree planting programs.

Across the City of Melbourne's public and private realm, canopy cover is estimated at 11%. This means 89% of the municipality is without natural shade. Tree canopy covers about 22% of Melbourne's public streets and park areas, while canopy cover in the private realm is only about 3%. There is also broad variability in canopy cover between suburbs, streets and parks.[42]

Environmental values

The City of Melbourne has prepared a scientifically-based formula for calculating the amenity value of our trees. The formula is based on factors including tree condition, species type and growth rate, aesthetics value and locality values. A rough estimate of the City of Melbourne's urban forest amenity value is around $700 million. We can also calculate the value of environmental benefits of trees through a tool called i-Tree Eco. Air pollution amelioration, carbon storage and sequestration, energy savings benefits of trees and structural values of the urban forest can be calculated using i-Tree.

Our initial results using i-Tree to assess trees in Royal Parade, Collins Street, Swanston Street, Lonsdale Street and Victoria Parade show that the 982 trees measured:

- remove 0.5 metric tonnes of air pollution per year at a dollar benefit of $3,820
- store 838 metric tonnes of carbon at a dollar value of $19,100
- sequester 24 metric tonnes of carbon each year at a value of $548 per year
- save $6,370 in energy costs each year through shading buildings in summer and providing solar access in winter
- avoid carbon emissions by reducing energy use by $114 per year
- have a structural value (replacement cost) of approximately $10.4 million.[43]

If we extrapolate these figures across the entire population of 70,000 trees, there is a clear indication that our urban forest is a very valuable environmental asset.

Canopy cover for major parks	
Carlton Gardens North	**62.3%**
Carlton Gardens South	**58.0%**
Kensington Reserves	**56.1%**
Fitzroy Gardens	**53.1%**
Kings Domain	**50.3%**
Treasury Gardens	**50.1%**
Alexandra Gardens	**48.0%**
Flagstaff Gardens	**45.0%**
Shrine Reserve	**42.5%**
Fawkner Park	**38.4%**
Birrarung Marr	**25.5%**
Princes Park	**21.9%**
Royal Park	**21.6%**
JJ Holland Park	**20.2%**
Docklands Park	**6.0%**

Public realm canopy cover by precinct	
South Yarra	**33.4%**
Carlton	**29.1%**
CBD	**21.2%**
East Melbourne & Jolimont	**20.7%**
North & West Melbourne	**19.9%**
Kensington	**19.7%**
Parkville	**19.4%**
Southbank	**14.2%**
Fishermans Bend	**6.4%**
Docklands	**4.7%**

Public realm canopy cover in the City of Melbourne	
Whole of Municipality	**22.2%**
Road Network	**10.2%**
All Parks and Gardens	**28.0%**

Tree diversity & vulnerability

The urban environment is highly modified, with harsher conditions for plant growth than in natural landscapes in similar climates and terrain. Urban soils are compacted, root volumes reduced, heating and shading more severe, and regular disruptions of roots and canopies occur. Not every tree species copes well with these conditions. Spatial constraints, particularly the need for street trees tall enough that their branches are clear of traffic, also limit what is planted. As a consequence, cities often contain few tree species.

Reliance on a few species is risky. A lack of **species diversity** leaves the urban forest more vulnerable to threats from pests, disease, and stress due to climate change. When managing financial assets, diversification is a basic rule for reducing risk. The same principle applies to urban forests, and tree managers around the world are investigating urban forest diversity. A greater range of species provides greater resilience and long-term stability for the forest as a whole.

A robust urban forest also features **age diversity**, with species of varying life spans and growth rates. A uniform age profile makes it likely that many trees will decline and senesce at the same time. Some areas in Melbourne are vulnerable due to a lack of diversity:

- Almost 43% of our trees come from one family, the *Myrtaceae*, which includes *Eucalyptus, Corymbia, Callistemon, Angophora* and *Melaleuca*. Our tree population features a high percentage of *Eucalyptus*, and *Eucalyptus camaldulensis* in particular dominates Royal Park. All members of this family are vulnerable to Myrtle Rust, which has been found in Melbourne. Myrtle Rust has caused the rapid decline and death of some species of *Syzygium* and *Agonis*, and is likely to have a negative impact on other species including *E. camaldulensis.*
- Elm avenues line many Melbourne boulevards and park paths. Dutch Elm Disease has wiped out most elms in the northern hemisphere and it has recently been found in New Zealand. Ever-growing global trade means it may reach Melbourne. Better understanding of the disease may help to mitigate its effects, but many important Melbourne landscapes are vulnerable to catastrophic failure if Dutch Elm Disease arrives.
- Melbourne's CBD is dominated by plane trees, which comprise over 75% of the central city's forest. Planes are vulnerable to extreme heat, pests such Sycamore Lace Bug which has recently become established in Australia, and diseases such as anthracnose, cinnamon fungus and plane tree canker stain. Large scale loss of planes due to a pest or pathogen would remove significant visual and environmental benefits, and exacerbate the urban heat island effect.

In addition to species and age diversity, a lack of **spatial diversity** contributes to vulnerability within the urban forest. Melbourne is widely recognised for its magnificent avenues formed of single species such as elms. While it is the uniformity of species, age and size that makes these avenues such a striking landscape element, this inherently contributes to their vulnerability. Elms also have the attribute of root grafting between trees, and this can spread pathogens such a Dutch Elm Disease rapidly along an avenue.

Most prominent trees in the City of Melbourne's streets	
Planes (Platanus x acerifolia, P. occidentalis, and P. orientalis 'digitata')	**24%**
European elms (Ulmus cornubiensis, U. glabra, U. minor and U. procera, but excluding U. parvifolia)	**11%**
Spotted Gum (Corymbia maculata)	**8%**
Angophora costata	**4%**
Lophostemon confertus	**3%**

Most prominent species within the City of Melbourne

Family	Common name	Total	%
Myrtaceae	Myrtle	29742	**42.3%**
Mimosaceae	Acacia	7920	**11.3%**
Ulmaceae	Elm	7245	**10.3%**
Platanaceae	Plane	6485	**9.2%**
Casuarinaceae	She-Oak	4750	**6.8%**
Fagaceae	Beech	1829	**2.6%**
Moraceae	Fig	1440	**2.0%**
Rosaceae	Rose	1164	**1.7%**
Meliaceae	Melia	916	**1.3%**
Pinaceae	Pines	832	**1.2%**
Oleaceae	Olives	829	**1.2%**
Araucariaceae	Araucaria	774	**1.1%**
Aceraceae	Maples	696	**1.0%**
Proteaceae	Grevillia	668	**1.0%**
Anacardiaceae	N/A	609	**0.9%**

2. BACKGROUND & CONTEXT

Furthermore, in the natural landscape, a diverse ecosystem inclusive of groundcovers, shrubs, tree roots, trunks, branches and canopies provides the best possible array of benefits. **Structural diversity** in the landscape includes these different vegetation strata, in urban settings as well as natural ones, with avenues in parks, street trees, green walls, and green roofs and balconies. Every plant has its own benefits: large deciduous trees provide summer shade and allow the winter sunlight to penetrate buildings and streets; native trees (including deadwood) promote biodiversity and habitat; smaller trees can be planted in areas that are not able to accommodate larger trees; shrubs and herbs in parks and riparian areas provide screening, visual amenity and habitat for fauna; climbers can cover walls for shading and protection; and green roofs reduce stormwater flows and improve insulation.

The interactions between these layers of the urban forest provide an opportunity for everyone to connect to nature, and for the different forms of green infrastructure to integrate and thereby increase the impact of their ecosystem services.

Useful life expectancy of Melbourne's trees

Useful life expectancy (ULE) is an estimate of how long a tree is likely to remain in the landscape based on health, amenity, environmental services contribution and risk to the community. It is not a measure of the biological life of the tree and it is not used as a timetable for scheduling tree removals. The primary benefit of a ULE assessment is that it facilitates strategic planning for the longevity of the urban forest. It allows for tree population decline to be identified and for long term responses to be developed.

A ULE assessment for the City of Melbourne's urban forest was undertaken between March 2011 and April 2012. 35,000 trees were assessed with results indicating that 23% of the tree population will be at the end of its useful life in the landscape within ten years and 39% within twenty years.

For heritage landscapes, excepting the Shrine of Remembrance Reserve, the findings are dramatic, with the ULE assessments indicating a likely 35% loss in ten years and a 58% loss in twenty years. The City of Melbourne's heritage landscapes include Kings Domain, Flagstaff Gardens, Speakers Corner, The Shrine of Remembrance, Royal Parade, Fitzroy Gardens, Carlton Gardens and Treasury Gardens. The reason why ULE assessments at the Shrine are not as alarming is due to the implementation of a five-year plan involving staged removal of dead and declining trees and a vigorous program of replanting. The approach was to plant en masse to allow for a natural reduction over time to ensure that landscape continues to be robust. The species selected for the Shrine Reserve are a diverse mix of native and exotic trees, with a focus on drought tolerance.

Most dramatically, ULE assessment of the City of Melbourne's elm trees indicated that 55% of Melbourne's elms are in a state of severe decline and will likely need to be removed from the landscape within the next ten years.

Many of the magnificent elm avenues in Melbourne's heritage landscapes are approaching the end of their life.

Useful life expectancy of Melbourne's elm trees	
<1 year to 10 years	**55%**
11-20 years	**21%**
21-30 years	**11%**
31-60 years	**9%**
61+ years	**4%**

Useful life expectancy tree survey
(February 2011 to September 2011)

- 1< year to 10 years
- 11-20 years
- 21-30 years
- 31-60 years
- 61+ years
- To be determined

Fitzroy Gardens modelling from aerial perspective, showing existing conditions (left) and potential effect if elm avenues were lost (right)

Fitzroy Gardens potential loss of avenues modelling at ground plane, showing existing conditions (left) and effect if elms were lost (right)

Royal Parade modelling of ground level view, showing existing conditions (left) and effect if elm avenues were lost (right)

3. ISSUES & CHALLENGES

In addition to the underlying vulnerability of our current urban forest resulting from a lack of diversity, the health of the tree population has been reduced by lack of rainfall, water restrictions, extreme heat, and development expansion and consolidation. We also have a tree population of which a very large proportion is reaching the end of its ULE at the same time.

Three species dominate our tree population: elms, plane trees and River Red Gums. This exposes the population to a higher risk of ill health and mortality through pests, pathogens, extreme heat events and low rainfall futures.

There is pressure on all levels of government to plan for greater population, economic growth, expanded urban boundaries and densification to ensure that our cities remain liveable. Urban forests play a critical role in responding to these future challenges. Sound adaptation solutions will require actions that yield multiple benefits. Effective adaptation in the built environment needs to account for the fact that green infrastructure solutions can be highly cost effective and may sometimes take precedence over 'grey infrastructure' solutions.

Green infrastructure, including open space, green environmental corridors, canopy cover and ecosystem services are the most efficient tools that cities can utilise to remain healthy, robust and liveable.

The key challenges for Melbourne's urban forest are:

- ageing tree population
- diminishing availability of water
- climate change
- urban heat island effect
- increase and urban intensification

Examples of life stages of tree decline, highlighting degree of vulnerability, in various locations in the city.

3. ISSUES & CHALLENGES

3.1 Ageing tree population

Many of Melbourne's trees, including those in our iconic boulevards and parks, are well over 100 years old and approaching the end of their useful life. Elms planted in the late 1800s such as those in Fitzroy Gardens, Royal Parade, Flemington Road, Fawkner Park, Alexandra Avenue and St Kilda Road were planted in socially, culturally and environmentally different times. They have performed remarkably well to date in faring against droughts, urbanisation and changing cultural trends. However the older a tree becomes, the less tolerant it is to change.

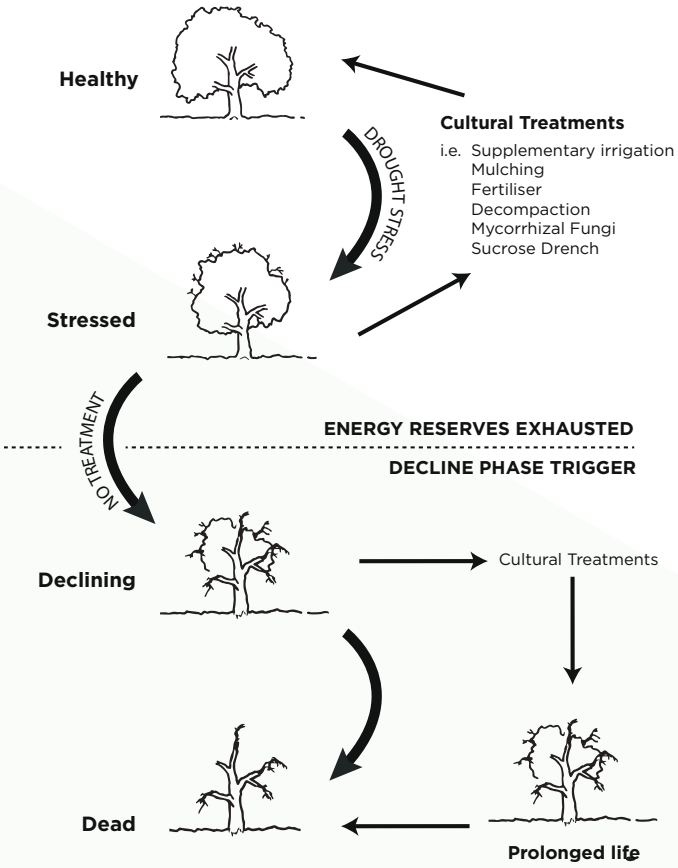
The City of Melbourne manages the population of ageing trees through regular assessments to determine which trees need to be treated or removed, and by planning when, how and with what trees they will be replaced. Managing ageing trees requires careful consideration. Urban tree renewal is not simply a question of replacing dying trees, but is also one of identifying the most resilient and appropriate replacement plan and engaging in a meaningful dialogue with a broad range of stakeholders and community members.

Melbourne's key challenges in terms of ageing trees are:

- An ageing tree population requires increasing resources to manage and sustain. Over time, the environmental value of urban trees diminishes and they become hazardous to people using the city's public spaces. A high proportion of over-mature trees carries an element of public risk (and cost) and must be managed accordingly.
- Uniform, symmetrical avenues create wonderful vistas along our boulevards and main streets, and in Melbourne these are largely synonymous with broad-canopied deciduous trees such as elms and planes. This raises an issue that needs to be carefully managed in consultation with the community. To achieve these aesthetics, it is desirable to plant identically aged trees that will maintain the visual consistency of the avenues. However, this can pose challenges for the community when confronted with large numbers of trees that require replacement at the same time.

St Kilda Road and Royal Parade are examples of the aforementioned problem. They require special care and extensive, thoughtful planning. The elms are ageing and the planes are declining as a result of past water restrictions and periods of extreme heat. Community and stakeholder collaboration will be crucial in determining how we manage the loss of these trees and plan for their replacement.

While the ageing population in some cases suggests subsequent landscape change, opportunities arise for us to now 'retrofit' these landscapes to ensure better conditions for our future trees. Conditions that require improvement include those below ground (soil structure, ground water, and conflict with underground services) and above ground (access to stormwater, conflict with infrastructure, mulching and potential compaction).



Tree mortality spiral: At some point, a tree in decline will pass the point of return back to good health

3.2 Water & soil moisture

Water is the primary element needed for vegetation growth. The recent extended drought and water restrictions severely damaged the health of Melbourne's urban forest, resulting in a steep increase in tree mortality. The useful life expectancy mapping that has been undertaken shows that about 23% of our trees will reach the end of their useful lives within a ten year period. Much of this is due to long term effects of low water availability.

Mature trees help to ameliorate the urban heat island effect both through shading of urban surfaces and atmospheric cooling through evapotranspiration. Access to ample soil moisture enables trees to actively transpire and assist in atmospheric cooling. Maximising the potential for vegetation to cool the city through evapotranspiration is another important reason to maintain soil moisture.

Adequate available soil moisture is critical for healthy vegetation. Thirteen years of drought have left soil moisture levels morbidly low, affecting tree health throughout the municipality. In particular, trees in traditionally irrigated landscapes were affected by a combination of low rainfall and decreased irrigation due to watering restrictions.

While 2010/2011 and 2011/2012 summer rains have been valuable, soil moisture remains depleted and this poses an on-going threat to tree health. A number of active and passive approaches are currently undertaken to replenish soil moisture and ensure it is maintained at levels to provide healthy growth. Changes to irrigation practices, mulching, soil injection, water barrier and tanker watering have preserved the health of many trees. Tree health monitoring and measurement of soil moisture provide strategic guidance to direct resources and will be vital in ensuring the health of the future forest.

Fundamentally, the city has low levels of water permeability. Hard surfaces on roads and roofs shed stormwater rapidly into an extensive drainage system and direct it into Port Phillip Bay and the Yarra River. While this ensures the functionality of the city to some extent, it means that rain has little opportunity to infiltrate the soil. Ground surfaces need to allow rainfall to enter the soil, a huge reservoir that is ready made to provide for a healthy forest. Using soil as a reservoir has benefits in addition to vegetation health, including improved stream health, reduced damage to infrastructure from soil movement, and decreased flood damage.

Permeation of water through the entire soil profile is also critical. Surface irrigation exacerbates trees' vulnerability by encouraging shallow root systems. Deep watering encourages deep root growth better able to access soil moisture during low rainfall periods.

Alexandra Avenue and riverfront with a healthy tree canopy in February 2004

The same area with the tree canopy in a severe state of decline due to several years of drought-related stress, in February 2010

Ensuring that trees are not reliant on potable water – which runs the risk of being restricted when running at low levels – and yet still have access to adequate soil moisture, particularly during periods of low rainfall, is crucial. We can learn from past practices in irrigation, particularly in parks, where supplemental irrigation via surface watering resulted in the development of shallow rooted, unstable trees wholly reliant on continued superficial irrigation.

With expected long-term low water futures and a desired move away from reliance on costly potable water, alternative water sources are needed to ensure healthy vegetation growth. The capture and reuse of stormwater is an important way to decrease reliance on potable water, particularly given the great quantity of stormwater flowing into the river and bay. The city that has traditionally shed water needs to capture, store and reuse it. However, this presents challenges as well as opportunities. In particular, storing stormwater for reuse in dry periods is challenging in densely-built urban areas, but can be supported by wetlands, underground tanks and water sensitive urban design.

3. ISSUES & CHALLENGES

3.3 Climate change

The Australian Government's most recent report on climate change, the Critical Decade, states unequivocally that it is 'beyond doubt' that climate change is occurring.[44] The primary cause of the observed warming and associated changes since the mid-20th century – human emissions of greenhouse gases – is also known with a high level of confidence.

The most widely used indicator of climate change is the global mean, annual average, near-surface air temperature – commonly referred to as the global average temperature. This has risen by about 0.17°C over the last three decades. More notably, the global average temperature from 2001-2010 was 0.46°C above the 1961–1990 average, making it the warmest decade on record.

Whilst the effects of climate change are just becoming discernible, they will become increasingly prominent. The effects over coming decades will include warmer average temperatures, heat waves, more extreme storm events and lower average annual rainfall. We have already observed the damage caused by extreme heat and floods in Australia in recent years, and it is likely that these events will become more prevalent.

The risks to cities of more severe weather conditions will increase, bringing with them high economic, social and environmental costs. For the urban forest, the impacts of climate change will include:

- The susceptibility of vegetation to **increasing and emerging pests and diseases** will challenge the urban forest's ability to withstand and recover from these outbreaks. Recent observations in NSW pine plantations have found that drought-stressed trees are suffering increased incidence of attack from insect stem borers, bark beetles and fungi. Changes in climate can affect pests' life cycles. Warmer summers can increase insects' development rate and reproductive potential, while warmer winters can increase over-winter survival. Many pests and diseases may have extended geographical ranges as warmer temperatures affect flight behaviour and vector spread. Introduced pests may also find conditions more favourable for population growth. Forests not previously at risk could become vulnerable as pests and disease ranges change.
- Extreme weather events directly affect vegetation health, generally leading to a reduction in canopy cover and overall decline. Heat extremes can lead to foliage and trunk scorch and canopy desiccation. Storms can shred foliage, break branches and uproot trees.
- Lower rainfall will result in increasing frequency of tree death in many species and overall forest health decline in response to frequent and severe drought.
- Inundation can lead to soil erosion, salinity, tree instability, tree mortality and damage to infrastructure. In southern Australia, more frequent extremes of wet and dry periods may increase the incidence of the root rot pathogen Phytophthora cinnamomi. Trees weakened by this disease have a reduced capacity to survive drought.

Climate changes predicted in Australia by 2070			
Climate Variable		**Now**	**Predicted by 2070**
IPPCC (2007) Predictions for Melbourne			**Estimate of Change**
Temperature	Annual average temperature	Max 18.7°C Min 8.3°C	+2.6°C (1.8 to 3.7°C)
Extreme Temperature	Annual av. no. of hot days (over 35°C)	9 days	20 days (15 to 26 days)
Rainfall	Annual average rainfall	864mm	-11% (-24% to no change)
	Summer	166mm	-7% (-31 to +21%)
	Autumn	213mm	-5% (-24 to +16%)
	Winter	245mm	-11% (-26 to +4%)
	Spring	152mm	-21% (-41 to -1%)
Extreme Rainfall	Heavy rainfall intensity (99th percentile)	Not avail.	=5.9% (-24.9 to +48.9%)
Sea Level Rise	Average sea level rise	3.2mm per year	+110cm (CSIRO)

The Bureau of Meteorology and CSIRO climate change modelling predicts that Melbourne is likely to experience an increase in more days of extreme heat. The city already experiences on average nine days per annum over 35°C but by 2030 it is predicted this will increase to 11 days, and then increase again to 20 days by 2070. Projections for future changes in rainfall patterns are uncertain. It is likely that Melbourne will experience increasing extremes of lower average annual rainfall as well as extreme rainfall events. Rainfall patterns are likely to be more unpredictable, increasing risks of low for water availability during certain periods. The high end CSIRO scenario predicts that current sea levels will increase by 1.1 metres at the end of the century. Inundation modelling hows that while few areas of the city will be vulnerable to permanent inundation at this level of increase, many areas in the municipality will be prone to inundation with the combination of extreme high tides, storm surges and a 1.1 metre rise in current sea levels.

3.4 Urban heat island & extreme heat

The urban heat island effect is common worldwide, as cities become warmer than nearby suburban and regional areas, particularly at night. After a hot day parts of the city can be four to seven degrees hotter than surrounding rural areas. This phenomenon occurs all year round, but it becomes a problem during hot weather.

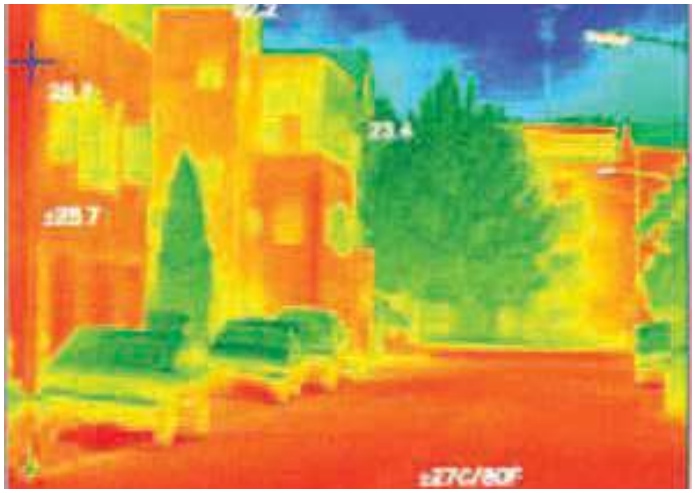
In periods of prolonged heat, the urban heat island effect increases pressure on the city. It exacerbates heat stress, particularly for vulnerable people such as the elderly, the very young, and those with pre-existing medical conditions. Heat waves already kill more Australians than any other natural disasters, and have led to many deaths in Melbourne, Adelaide, Brisbane, Sydney and Perth over the past 50 years. Victoria's Chief Health Officer found that the heat wave preceding the 2009 Black Saturday fires contributed to an increase above normal of 374 deaths in inner Melbourne – almost double those who died as a result of the fires.[45] People living in high-density areas are at greater risk during heat events as a result of the urban heat island effect.

This heat also contributes to the decline of certain tree species. Extreme heat, particularly if combined with low soil moisture, causes the foliage and even the bark of some trees to scorch, which can lead to decline as happened with many of the City of Melbourne's plane trees during the extreme heat event in 2009. The urban heat island effect has three main causes:

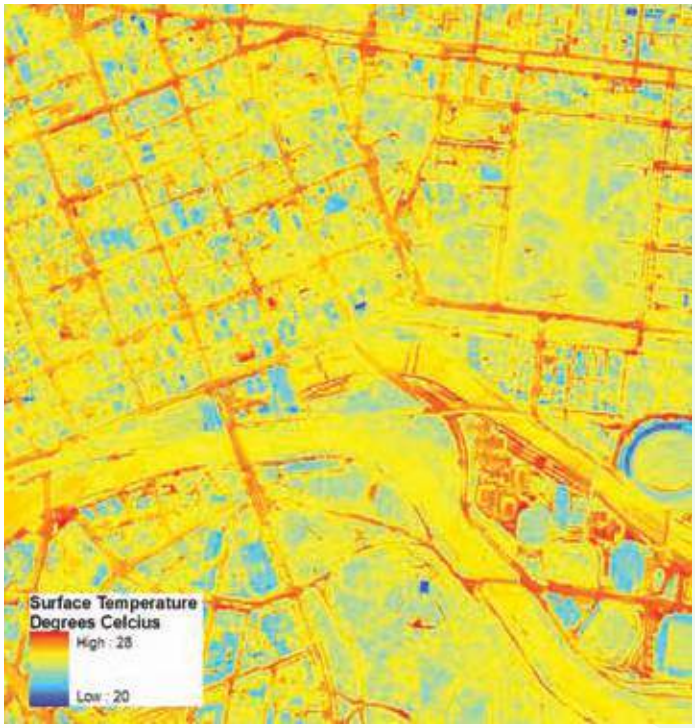
- **Impervious hard surfaces**: Buildings and pavements are typically impervious and have high heat absorption capabilities. Asphalt and concrete trap and store heat from the sun, while solar radiation is reflected off building surfaces along street canyons, causing greater absorption of solar energy and a reduction in the reflective power of these surfaces.
- **Human activity**: Motorised transport is a major contributor to increased greenhouse gas emissions. In hot weather, the use of air conditioners increases, generating more waste heat.
- **Low vegetation coverage**: With less vegetation, cities receive less natural cooling from shade and evapotranspiration.

Urban forests have proven to be one of the most effective methods for mitigating heat retention in urban areas, particularly central business districts. However, there are several challenges we face in tackling the urban heat island, including:

- The current urban heat island effect will be exacerbated by predicted climate changes.
- The existing tree canopy cumulatively covers 22% of public streets and park areas. This means 78% of Melbourne's streets and parks are without natural shade.
- It can take 20 years for a tree to grow to a size that will assist effectively in mitigating the urban heat island effect.
- Vegetation cover must be primarily composed of species that are able to survive and remain healthy under hotter conditions.
- Mitigating the urban heat island effect may require increased water use during dry periods to maintain tree health and maximise evapotranspiration.



Example of thermal imaging at streetscape level

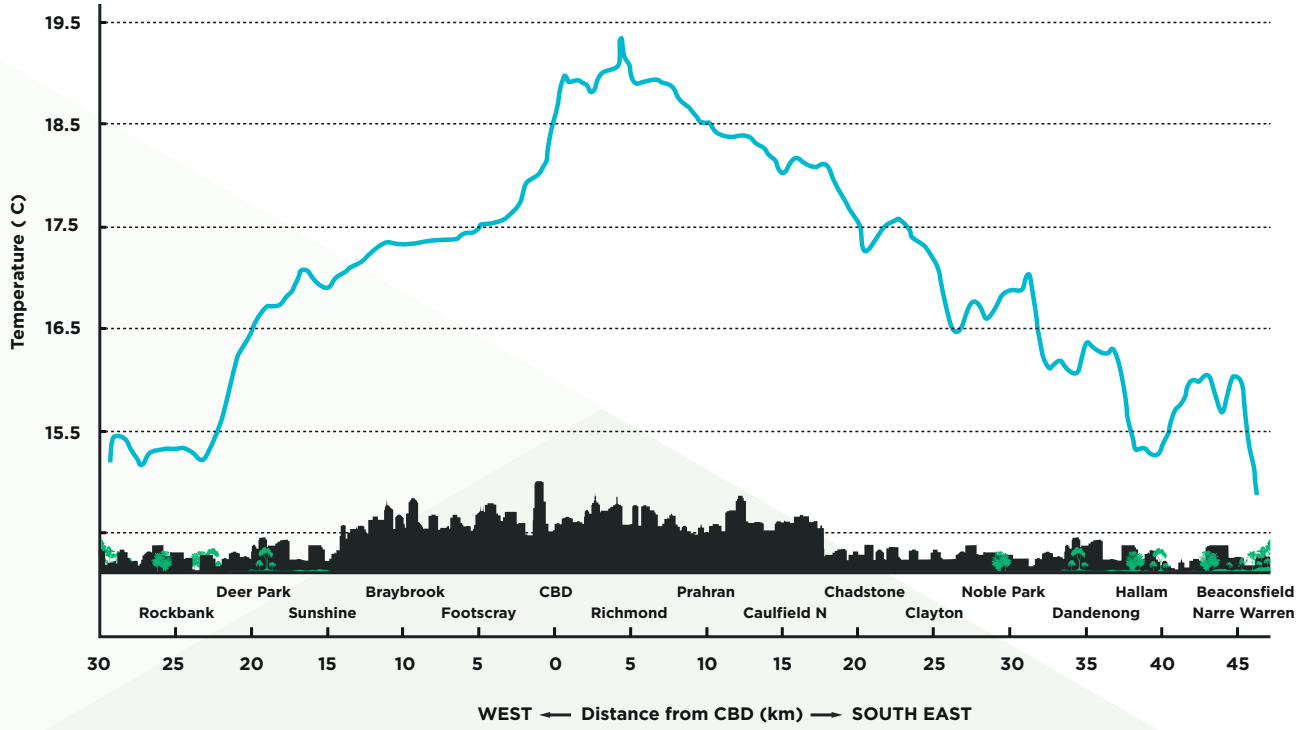


Thermal imaging of central Melbourne, taken late at night, which shows how paved unshaded surfaces store heat from solar radiation and retain it long into the night, contributing to increased temperatures in urban areas.

Currently, heat related deaths in Victoria exceed the average annual road toll. Projections indicate that by 2050 an extreme heat event in Melbourne alone could kill over one thousand people in a few days if we don't improve the way we forecast, prepare for and manage these events.

Protecting Human Health & Safety During Extreme Heat Events, Commonwealth Government & PWC, 2011

3. ISSUES & CHALLENGES



The aerial photo below, from about 2005, shows Melbourne's CBD and its hinterland. Docklands is in the foreground; the intensive redevelopment of such areas will exacerbate the urban heat island effect unless significantly increased greening occurs as part of the redevelopment process.

3.5 Population increase & urban intensification

In 2011, the City of Melbourne's residential population was 93,000. By 2030, the population may be 150,000, possibly even 208,000. The city's daytime population is also growing. There are now about 790,000 daily workers and visitors to the central city, and this figure is expected to exceed one million by 2030. In 2006 there were about 74,000 daily tourist visitors to the municipality, and by 2020 this is expected to increase to around 250,000 visitors daily.[46]

While metropolitan Melbourne has one of the largest per capita ecological footprints in the world – reflecting unsustainable trends of resource consumption, waste generation and greenhouse gas emission – the City of Melbourne is one of the most compact, dense and mixed use parts of the metropolitan area, with the best network of public transport services and generous public open spaces. These characteristics offer the potential to drive down per capita energy use for building and transport, and to make the city more robust against the predicted impacts of climate change, particularly water scarcity and heat waves.

In meeting the challenge of population increase and urban intensification, we need to acknowledge the following:[47]

- Transforming the urban area will not only involve rebuilding roads, transport networks and services, but will also require rationalisation and better use of existing infrastructure, and a strong focus on expanding green infrastructure.
- This will need to be integrated with the application of good urban design principles, such as high quality public realm, clear definition between public and private space, active street frontages, sun and weather protection.
- Trees and other green infrastructure are important integrative elements, not just potential buffers between established and developing areas. The urban forest will be central to delivering amenity and ecosystem services, and ensuring that the new growth and development of the city is functionally and visually integrated with existing neighbouring urban fabric.
- As urban areas are also generally expanding, the carbon stock of urban vegetation will become more relevant, although vegetation cleared during urban expansion will determine whether there is a net gain or loss in carbon stocks per hectare of urban land.[48]

While urban intensification makes the urban forest more important, it also adds significant challenges to the forest's future health and development. Increased development densities often result in greater site coverage by buildings and pavements, resulting in:

- Reductions in the extent of vegetation on private land, especially large canopy trees.
- Reduction of permeable ground surfaces that allow for the infiltration of rainwater into the soil.
- Increased shading of streets by buildings, potentially to the extent that tree growth suffers due to a lack of sunlight.

Visualisation showing the integrative role of landscape and the built environment in denser urban corridors - existing and future [Transforming Australian Cities]

Flagstaff Gardens. With increasing development density, the importance of parks and other public spaces as settings for active use will increase.

- Increased pressures on public spaces to accommodate more uses – whether for recreation in parks or for traffic and parking in streets – which can result in direct competition with plantings for space as well as making more demanding growth conditions due to more extensive hard or compacted surfaces.

3. ISSUES & CHALLENGES

Existing conditions at Birrarung Marr and Yarra River southern bank with the trees colour coded to show existing ULE. (Colours indicate: Red 0-5 years ULE; Orange 5-10 years ULE; Blue 10-20 years ULE; Green 20+ years ULE).

Modelling of Birrarung Marr and river bank in next 11-20+ years without replacement planting.

Modelling of Birrarung Marr where successional planting has been undertaking over the next 11-20+ years. The series of images above illustrates the importance of successional planning to compensate for the future loss of trees.

3.6 Towards our future forest

How do we set out to achieve our vision of a healthy, diverse and resilient urban forest that contributes to the health and wellbeing of our community and to the creation of a liveable city?

This strategy sets out the priorities to guide future decisions whilst responding to the three overarching themes of resilient landscapes, community health and wellbeing, and liveability and sustainability. The issues and challenges facing Melbourne that directly affect the urban forest have been outlined in tandem with a set of pragmatic solutions.

To achieve the forest of the future and leave a legacy for future generations requires a long term vision and a commitment to work in tree life cycles, not electoral cycles. Developing the urban forest requires expert input from multiple disciplines including planning, engineering, urban design, landscape architecture, economics, sustainability and most importantly from the general community.

The community's sense of place and capacity for change needs to be captured and nurtured to ensure a dynamic approach in managing Melbourne's urban forest.

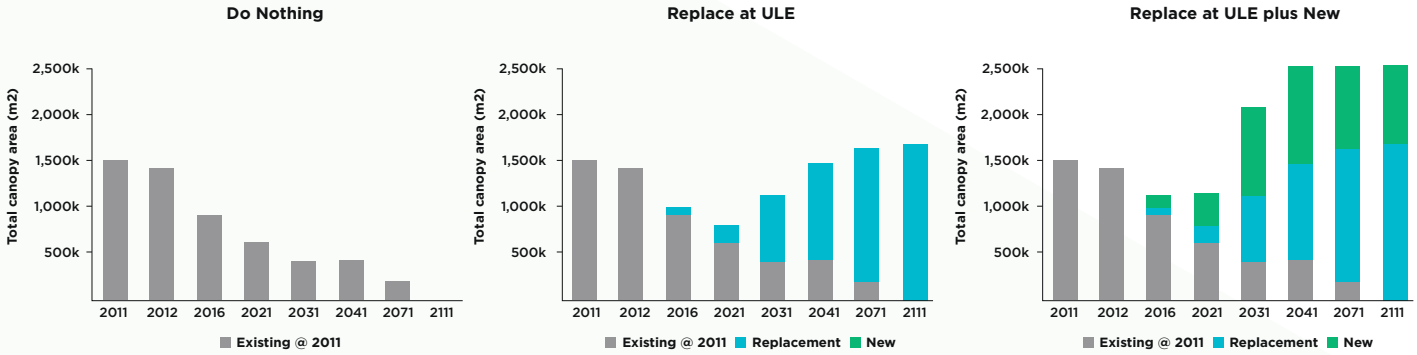
Tools & research guide development of the urban forest

Taking the current (2012) composition of Melbourne's urban forest as a baseline we have established a series of processes and tools for measuring and modelling the future potential of our urban forest:

- On ground field data collections have provided a rich source of data relating to our trees and their environment.
- Spatial and temporal mapping using ArcGIS allows us to determine which trees we will lose, where, when and how much tree canopy will diminish.
- Geospatial tools such as Lidar, Quickbird, and High Resolution Aerial Photography enable analysis of spatial heterogeneity, the structure and composition of vegetation, vegetation health and carbon storage.
- Thermal imaging highlights the hot and cool areas of our city which guides our tree planting decision making.
- A detailed urban heat island study has recommended canopy cover levels to mitigate heat retention in the City of Melbourne.
- US-based valuation model, i-Tree Eco provides a means to attribute dollar values to the environmental benefits of our trees.
- Weather stations installed around the city allow for monitoring the effects of tree canopy on streetscape thermal comfort levels.
- Tabling of ULE results and canopy cover has provided the opportunity to determine when and where we can start to plant trees to overcome the inevitable tree loss of canopy cover.

Using this knowledge we can benchmark key urban forest attributes to ensure we are on track to achieve our vision.

Future canopy projection (scenarios x2)



Analysis of the likely loss and replacement of canopy cover over time, under three alternative scenarios within Fawkner Park.

The first graph (at left) assumes that no new tree planting or replanting occurs, and illustrates the loss of canopy cover due to the decline and death of existing trees. A dramatic, rapid and long-lasting loss of canopy cover would occur with this 'do nothing' approach.

The second graph shows the impact of replacing existing trees as they reach the end of their useful life expectancy and are removed, without planting new trees in other locations. In this example, there will be an interim loss of canopy cover when large existing trees are replaced with small young trees, which will be recovered slowly as the new trees mature.

The third case (at right) assumes that some additional tree planting occurs, beyond replacing existing trees as they die. With this approach the interim reduction of canopy cover is reduced (but not eliminated) and the long term canopy cover is increased as there will be more mature trees in the park.

In many places where there is no space for additional planting, as in streets where there are existing trees, the centre option is the only feasible course of action. This makes it even more vital to pursue additional tree planting where space is available, if we are to meet our target of significantly increasing canopy cover across the city as a whole.

4. PRINCIPLES & STRATEGIES

The City of Melbourne's urban forest will be resilient, healthy and diverse. It will contribute to the health and wellbeing of our community and to the creation of a liveable city.

4.1 Priorities

The challenges facing Melbourne's urban forest provide the City of Melbourne and its diverse communities with a unique opportunity to genuinely connect with our urban forest.

The City of Melbourne has a leading role to play in encouraging other councils, development agencies and landholders to enhance the city's urban forest. The principles and actions developed through this strategy have the capacity to be used and adapted across Melbourne, thereby reinforcing Greater Melbourne's urban forest.

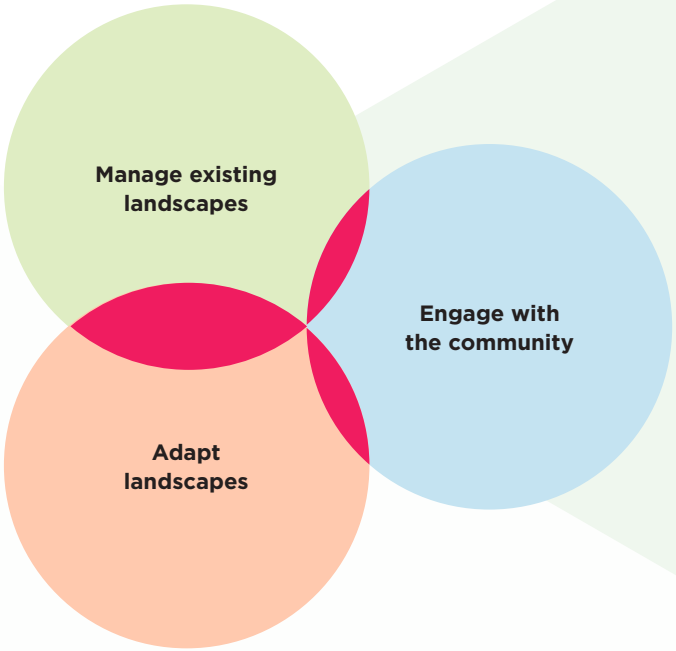
Our community also has an important role to play in building a more resilient urban landscape through their actions and decisions at home, in their own gardens. Private green spaces are an important component of our urban ecology that contribute to neighbourhood wellbeing, connectedness to nature and biodiversity, and help our city adapt to changing climates. These also need nurturing and growth.

Given the impact of the diminishing water supply for Melbourne's urban forest and the fact that many of the city's mature trees are ageing or in decline, the next ten years will be critical for how we adapt the landscape to make it more suited to Melbourne's future needs and more resilient to the anticipated impacts of climate change and population and urban growth generally.

Vegetation is a key component of urban ecosystems. Various indicators highlight the relative health of cities such as biodiversity levels, vegetation species diversity, age diversity, soil moisture levels, and air and water pollution levels. Setting achievable benchmarks for these indicators will ensure we stay on track to achieve our vision.

Before we quantify these benchmarks, we need to establish principles that will guide our decisions. These principles respond directly to the challenges and opportunities that face our urban forest when we consider to the need to **manage our existing landscapes, adapt new landscapes** and involve and **engage with the community**.

> Design is an important part of the growth of our urban forest, in fact as development pressures use up more and more available soil, innovative design that is integral to the development process is increasingly essential. ... It is not enough to plant trees at every opportunity. Without careful consideration of the many influences on tree selection and placement we risk an outcome that is not sustainable. Horticultural, functional, wider environmental, local ecological, cultural, social, spatial, economic and aesthetic factors [collectively need to] be considered in order to achieve a mosaic of plantings which respond to the needs of each particular community and place.
> In an increasingly dense urban environment innovative design solutions are necessary to ensure that trees remain a significant part of the fabric of the city and contribute to the daily experience of city dwellers.
>
> **Kevin Taylor, 2006. Improving the Urban Forest by Design**



4. PRINCIPLES & STRATEGIES

4.2 Principles

Mitigate and adapt to climate change

- Build a resilient urban forest that can tolerate and continue to thrive in future climatic extremes
- Ensure a diversity of tree species and ages to maximise resilience against pests and diseases
- Increase overall vegetation biomass to assist in storage and sequestration of carbon

Reduce the urban heat island effect

- Build a functioning healthy urban forest canopy to provide shade and cooling to reduce heat absorption and emission by the built environment
- Develop public spaces to improve human thermal comfort and maximise health benefits
- Capture more stormwater to increase infiltration into the soil and enable maximum evapotranspiration

Design for health and wellbeing

- Provide cool shaded spaces in summer; sunlight access in winter
- Plan and manage the urban forest to ensure longevity of green spaces for future generations
- Create well-designed public spaces to encourage outdoor activity, social connectedness, respite, exercise and general sense of wellbeing

Create healthier ecosystems

- Support healthy ecosystems in order to provide maximum benefits in terms of clean air, water and soils
- Expand and improve biological and structural diversity

Design for liveability and cultural integrity

- Design landscapes to reflect the cultural integrity, identity and character of Melbourne and its neighbourhoods
- Create world class open spaces, parks and streetscapes
- Design spaces for people to reconnect with nature, that create a sense of place and enable reflection and tranquillity

Become a water sensitive city

- Promote the use of innovative techniques for water sensitive urban design, such as rain gardens, bioswales, underground storage reservoirs and biofilters
- Use alternative water sources for irrigation to reduce potable water use
- Ease stormwater flows and peaks by replacing impervious surfaces with porous materials to reduce heat absorption and encourage soil moisture retention

Position Melbourne as a leader in urban forestry

- Increase Australian-based urban forestry research
- Inform and involve the community in decision-making for landscape adaptation and change
- Increase the public profile and understanding of the attributes, role and benefits of the urban forest

4.3 Strategies

To achieve our vision of a healthy and resilient urban forest that contributes to the health and wellbeing of our communities and to a liveable city, we need to create better urban environments for everyone. The principles defined above highlight the importance of a well-designed city, and the following strategies list how we go about creating these 'living spaces':

- increase canopy cover
- increase urban forest diversity
- improve vegetation health
- improve soil moisture and water quality
- improve urban ecology
- inform and consult with the community

Each of these strategies have priority actions for implementation in order to achieve specific targets.

Increasing the effective canopy cover above paved surfaces is an important strategy to mitigate the impacts of the urban heat island effect. These mature elms shading George Street, East Melbourne make a healthier place to live, not just a more attractive one.

*Greater diversity can be achieved through the use of a variety of species, genera and families. For example, although rarely seen in Melbourne, the Dawn Redwood (**Metasequoia glyptostroboides**) has proven to be tolerant of quite hostile street conditions near the South Melbourne Town Hall, and may be suitable for more widespread use.*

4. PRINCIPLES & STRATEGIES

4.3.1 Increase canopy cover

Canopy cover is a key criterion by which we measure the urban forest's ability to produce benefits for the community and the environment. Large canopied trees provide greater environmental and health benefits than smaller canopies – depending on the scale, up to 75% more benefit per tree.

Increasing the number of trees within our municipality is important, but we must plan properly to achieve the greatest environmental and health benefits. It is more important to improve the extent of canopy cover across the municipality than to simply increase the number of trees. Analysis of aerial imagery combined with canopy cover modelling suggests that the municipality can accommodate a significant increase in canopy cover.

Identification of new opportunities for tree plantings is central to increasing canopy cover throughout the municipality. A great proportion of the City of Melbourne's public space – and by far the most intensively used space – is in streets, providing the most important targets for increasing canopy cover. In precincts such as North and West Melbourne with only a 20% canopy cover, streets are an obvious priority for tree planting.

A recent study on the urban heat island effect in Melbourne recommends that one of the most cost efficient and effective mitigation strategies is to ensure a minimum canopy cover of 30% with a leaf area index (a measure of shade density) of 5.3 within the municipality. Thermal images taken of the city identify particular areas that absorb more heat than others and highlight the cooling effect of canopy cover and green spaces. This mapping also locates areas that are a high priority for increasing canopy cover.[49]

The City of Melbourne in partnership with Monash University is monitoring microclimate conditions at streetscape level beneath different tree canopy configurations. Weather stations have been installed in Bourke Street in the CBD, and Gipps and George Streets in East Melbourne. Data from these stations highlights temperature differentials between shaded and open streets. When used in conjunction with thermal imagery, this helps to identify opportunities to increase canopy cover where it will provide thermal comfort benefits to people during periods of heat. This data also provides guidance around spatial patterns of canopy distribution.[50]

The private realm occupies 68% of the area of the municipality and can therefore contribute significantly to the urban forest. However, a study conducted by three Melbourne councils suggests that private realm trees have reduced in number considerably since the 1970s. This is due largely to infill development, competing land uses and increasing land prices. Protection and enhancement of private realm vegetation is therefore an important component of the urban forest strategy.[51]

Modelling for the development of linear transport routes into medium-rise high density corridors demonstrates that development pressure on the surrounding suburbs can be alleviated. These lower-density suburbs can act as the 'green wedges' for increased green infrastructure, both in streetscapes and in private gardens.[52]

TARGET: The City of Melbourne's canopy cover will be 40% by 2040.

Actions:

- Conduct a thorough spatial analysis to identify areas of low canopy and include selected areas in planting programs for the next 20 years.
- Provide the best planting conditions possible for new trees to ensure maximum canopy potential, including below ground spaces and water.
- Select the most appropriate vegetation type and species for each location given spatial and climatic constraints and neighbourhood character.
- Ensure that the overall urban design for places ensures that spaces and streets are best designed for our urban forest and for people.
- Review and update Council's Tree Precinct Plans which detail the locations and species for increasing canopy cover.
- Encourage increased canopy cover where possible in the private realm.
- Promote the retention of open space on private land, especially in areas and in configurations that allow for the planting of canopy trees.
- Ensure that management regimes over the urban forest are adaptive to reflect its dynamic nature.

Case study:

Prioritising the greening of streets - City Road, Southbank

The 2010 Southbank Structure Plan recommends the upgrade of City Road into an active pedestrian and cycling spine while maintaining its important traffic functions. Although the riverside promenade now has a higher profile as Southbank's key 'public space', City Road is actually a much larger space and the opportunity it presents for additional tree planting is significant.

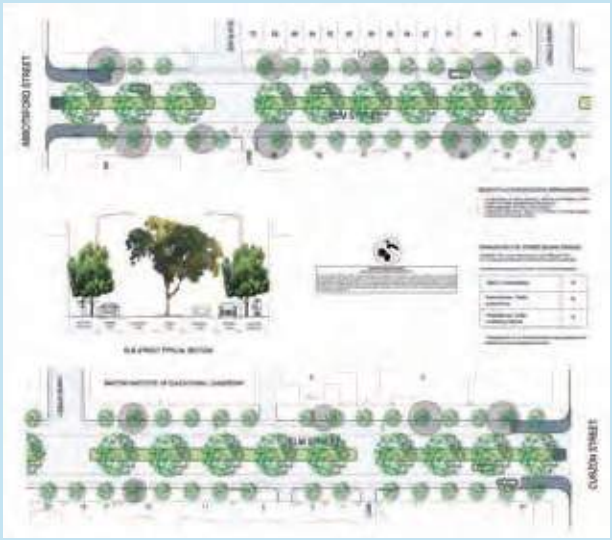
The visualisations below show existing conditions in City Road and the potential impact of increasing tree canopy cover.

Case study:

Increasing canopy cover, North Melbourne

A project in Elm Street, a residential street in North Melbourne, completed in 2011, will increase canopy cover from 18 to 65%. This has been achieved through the creation of a new central median, providing an opportunity for 13 large canopy trees to be planted. This, combined with 26 smaller trees in the footpath, will within 20 years decrease summer temperatures in the streetscape by 3-4 degrees Celsius, compared to a non-treed street.

Extensive community consultation with residents and residents' association contributed to a successful outcome, and notably there was majority support for this project by demonstrating that increased tree planting would not impair the integrity or functionality of the street.



4. PRINCIPLES & STRATEGIES

4.3.2 Increase urban forest diversity

Our urban forest faces potential threats from Dutch Elm Disease, Myrtle Rust, plane tree canker stain, fireblight, elm leaf beetle, sycamore lace bug, emerald ash borer and fig psyllid. Diversifying the urban forest lowers the risk of significant loss in any individual or group of species due to these pests and diseases. What we choose to plant now must also have the resilience to tolerate hotter, drier conditions, and potentially also cope with major storm events.

Over the past few decades, various models for the composition of the urban forest have been proposed. The City of Melbourne intends that the urban forest population will be composed of no more than 5% of one tree species, no more than 10% of one genus and no more than 20% of any one family.[53]

While vulnerability can be reduced by planting a more diverse range of tree species, a number of Melbourne's vulnerable landscapes are affected by other concerns and policies that may not allow simple species substitutions. Heritage policies protect many Melbourne streetscapes and parks, in particular a number of elm avenues. The devastation caused by Dutch Elm Disease has left Melbourne's elm population as one of the most significant in the world, and our community is protective of this legacy. Changing demographic and cultural factors over the last fifty years have also increased pressure to preserve, restore and cultivate native vegetation in public landscapes. Native vegetation policies protect the tree communities in Royal Park, which is dominated by two genera (*Eucalyptus* and *Acacia*) and two families (*Myrtaceae* and *Fabaceae*).

Both of these factors require careful consideration, and consultation with authorities such as Heritage Victoria, community groups such as the Friends of the elms, and others. Melbourne's historic landscapes are particularly vulnerable due to the combination of the uniform old age of many trees, climate change, and the threat of Dutch Elm Disease. Like-for-like replacement of trees based on species is often insisted upon for many heritage landscapes, and obviously new plantings should respect the heritage values and character of any area, but appropriate responses may not be so obvious. For example, if elms are wiped out by Dutch Elm Disease, it would become evident that the heritage values of Melbourne's parks and boulevards had been poorly served by maintaining the current dominance of elms in the landscape.

Similarly, native trees will continue to play a critical role in broader biodiversity outcomes, and Melbourne will undoubtedly have a significant population of native trees into the future. However, where species choices are informed by indigenous vegetation policies, the species, genetic and spatial diversity should be maximised where possible. New plantings should also include trees from families other than the *Myrtaceae* (e.g. *Casuarinaceae* and *Proteaceae*). These guidelines may be revised as more information on the impact of Myrtle Rust on different species and genera becomes available and in respect of the development of knowledge of other pests and pathogens.

It is planned that character will be determined through the design of tree precinct plans and master plans to be developed through a collaborative and consultative process with the community.

TARGET: The City of Melbourne's urban forest population will be composed of no more than 5% of one tree species, no more than 10% of one genus and no more than 20% of any one family.

Actions:

- Follow planting targets set out in the Urban Forest Diversity Guidelines.
- Undertake regular plantings across the municipality to reduce the risk of similar aged trees dying at the same time.
- Review and update Council's Tree Precinct Plans to achieve age, species and spatial diversity.
- Consistently monitor, treat and evaluate threats and attack from pest and pathogen as part of the tree maintenance program.
- Utilise a scientifically-based tree selection matrix when planting in different street and park typologies.
- Enhance the structural diversity in the urban forest through green walls, green roofs and green laneways, encourage design, funding and implementation where possible.
- Enhance vegetation strata diversity through the planting of shrubs, ground covers and grasses where appropriate.

*A newly planted Agathis robusta (**Queensland Kauri**) avenue in Fitzroy Gardens. This species is proven to grow well in Melbourne but relatively little used.*

Case study:

Vulnerability & species diversity, New York

New York's Urban Forest consists of 5.2 million trees, including 592,000 street trees. The street trees alone have an asset value of $2.3 billion and an average replacement value of $3,938 per tree. In 1995 New York recognised that limited species diversity exposed the urban forest to catastrophic loss from extreme weather events, pests and diseases. London Plane, Norway Maple and Callery Pear comprised nearly 39% of the street tree population with, for example, 44% of all trees vulnerable to the Asian Long-Horned Beetle. Active diversification over the past 16 years through the Million Trees NYC program has seen an increased range of species planted in place of the dominant species. This has been successful in decreasing Norway Maples comprising 23% of street trees to 13%.[54]

Case Study:

Shrine Reserve landscape management plan

The landscape management plan for the Shrine of Remembrance Reserve in Melbourne, prepared by Rush/Wright Associates for the Shrine Trustees, deals with one of Melbourne's most important designed landscapes. This is a place of extraordinary significance for many people. In any parkland trees play an important role, but here many have added meaning as commemorative plantings and as part of a setting for deeply emotional ceremonies.

It is in this context that the Landscape Management Plan was prepared. Building on a detailed inventory and study of the site, and extensive consultation with user groups and stakeholders, the Plan proposed a long tern vision that involves considerable, but gradual changes through selective removal of dead and declining trees, and replanting with a variety of drought tolerant species.

Even after a few years of implementation its effectiveness has been proven. Recent ULE assessments show a far healthier average condition for trees in the Shrine Reserve than in comparable areas of other heritage landscapes in the City of Melbourne.[55]

The Shrine of Remembrance Photo by Gryffindor used under Creative Commons License CC BY-SA 3.0

4. PRINCIPLES & STRATEGIES

4.3.3 Improve vegetation health

To maximise the ecosystem services, community health, and financial benefits that the urban forest provides it is imperative to ensure our trees and vegetation are healthy. Safeguarding the urban forest against extreme weather events such as drought, heat and flooding is vital to long term health. Integral to tree planning is ensuring that the most appropriate species is selected for each location, stock quality is assured, and best practice planting procedures are in place.

The City of Melbourne conducts a two year maintenance program for all newly planted trees. During this period it is vital to monitor any stress, pest and disease attacks. Throughout the lifecycle of each tree, annual analyses are carried out to ensure that data collection supports their on-going health and longevity.

Maintenance of our tree database regarding tree health, dieback, symptoms of stress, and pest and disease movements will highlight vulnerabilities and help to refine management programs. Given the current vulnerability of the urban forest and the relatively poor health of many trees, significant challenges are associated with canopy replacement and expansion.

Growing conditions in the urban environment are relatively harsher than those found in a natural landscape. It is therefore necessary that species selected for planting throughout the municipality are adaptable to current urban conditions as well as future conditions, which are likely to be even harsher in a changed climate. An improved irrigation regime, more frequent health assessments, removal of dying and dead trees, and continuous replacement with healthy stock is already being implemented.

TARGET: 90% of the City of Melbourne's tree population will be healthy by 2040.

Actions:

- Undertake annual health checks for every tree in the municipality.
- Reduce the number of stressed trees through regular watering, mulching and other cultural treatments, particularly over summer periods.
- Select species that are robust and resilient to the potential effects of climate changes and urbanisation.
- Implement best practice soil preparation before planting.
- Ensure the water needs of all vegetation are met, particularly during summer.
- Minimise conflict with above and below ground infrastructure.
- Create enhanced planting opportunities in streets, where possible, to allow for space for larger, healthier trees to grow.
- Remove asphalt and concrete where possible and replace with pervious surfaces to encourage healthy root growth for larger trees.
- Develop a forest health management plan to provide direction for managing diversity and forest health risks

Healthy figs provide shade and wind protection in exposed areas near the waterfront in Docklands.

A well-placed tree with suitable below ground growing conditions maximises the benefits of trees in a city street

Case study:

Street tree evaluation project, Ohio

In 1971, the Ohio Department of Natural Resources initiated a project that assessed the long term performance of 53 tree species in five Ohio cities. The comprehensive study, entitled 'Street Tree Evaluation Project' or STEP, was developed as a tool to assist in the planning and management of appropriate tree species in the varied urban environmental conditions found across the state. At its onset, the trees were assessed for health and growth characteristics and the locations and photographs of each tree were documented.

In 1997, the potential values of the STEP project, established more than two decades before, were realised. Now, every ten years, survival data, tree measurements, and specific information on tree height, girth, and spread, along with a current photograph are collected. The information gathered has been used to inform urban forest planning and management by identifying optimal species to achieve various goals in various locations. Additionally, the four decades of documented change illustrate how different species have, over time, affected the character of the individual streets.

The knowledge gained by such long term studies, and the on-going attention and care given to the established and mature trees in these cities mean that the appearance, resilience and other important ecosystem services of the urban forest can be optimised.

Case study:

Street tree census & tree mortality, New York

The City of New York completes a street tree census every ten years. The census data is collected by volunteers, staff and urban forestry consultants and was most recently completed in 2006. Information recorded for each tree includes location, species, diameter at breast height, condition, tree pit type, soil level, foopath condition, presence of overhead wires and infrastructure conflicts. Results were reported through an interactive website application or submitted on paper.

The data highlighted a need for greater species diversification across the city and identified some of the trees' key conflicts with other infrastructure. Because property owners in NYC are responsible for maintaining footpaths adjoining their land, many removal requests or objections to new plantings reflect the potential for trees to cause utility service disturbance or pavement damage. Additionally, 15% of the tree population had trunk wounds. This data was useful for informing future tree planning to reduce the incidence of conflicts with property owners and to improve overall tree health. Data collection by survey area enabled consideration of disparities between boroughs in terms of canopy cover, tree health and species diversity. Because of the data, urban forest planning could target work to address these disparities directly.

The Young Tree Mortality Study was a separate study conducted in 2006 by NYC staff and interns. A random sample of street trees planted three to nine years previously was surveyed to examine how biological, social and urban design factors affected mortality. Findings indicated that survival was about 75% and identified factors influencing survival. This research provided valuable insight into how tree survival rates may be improved in the city and has provided a methodology that other cities can follow to assess their own performance.

4. PRINCIPLES & STRATEGIES

4.3.4 Improve soil moisture & water quality

We have become experts in managing stormwater to prevent flooding. In Melbourne, we have paved over creeks and streams, diverted rivers, and installed millions of kilometres of pipes to ensure that rainfall is moved speedily into Port Phillip Bay. The increase in impervious surfaces across the city has consequences for depleting soil moisture, irrespective of the amount of current or past rainfall levels, simply due to the inability of water to reach and permeate the soil.

Trees will seek out water wherever possible, some of them being able to penetrate deep into the groundwater if they need to, thereby also slowly reducing groundwater levels.

While traditional engineering solutions for water capture and discharge are efficient, extreme weather events have proven that certain areas throughout the city, including the central city, are still prone to heavy inundation during major storm events.

Introducing measures to capture and retain stormwater in the soil, and to increase water availability for tree roots, will allow water to filter naturally into the soil in readiness for periods of low rainfall. As long as soil does not become waterlogged and deprived of oxygen, the higher the level of moisture in the soil, the more trees are able to transpire at maximum efficiency, allowing for cooling of the urban environment and combating the urban heat island effect.

Trees have the added benefit of collecting phosphorus, nitrogen and heavy metals from our stormwater through their root systems, lowering the levels of stormwater pollution.

Traditionally, surface irrigation has been employed in most of our parks and gardens and has been regarded as a temporary response to keep lawns green and to minimise tree mortality during summer. However this has encouraged trees to develop superficial root systems close to the surface and does little to recharge soil moisture reserves. If such irrigation has to cease, as it did during the recent water restrictions, the impact on these shallow-rooted trees can be catastrophic.

A range of innovative tools is required to increase permeability of our urban soil structure: to recharge groundwater; to reduce the amount of stormwater flowing into waterways; and to improve water quality. This will directly contribute to tree health, ensuring that trees provide the maximum benefits to support healthy landscapes and communities.

A range of water sensitive urban design measures are being implemented throughout Australian cities and towns. These include roadside tree pits and bioswales, stormwater capture systems and storage tanks beneath parks and streets, rain gardens and permeable paving. Implementation of these measures is generally adaptable to different locations and budgets. However it is fair to say that most landscape typologies, whether streets, laneways, parks, median strips, boulevards or individual trees, provide an opportunity for water sensitive design.

TARGET: Soil moisture levels will be maintained at levels to provide healthy growth of vegetation.

Actions:

- Action the works detailed in *Total Watermark, City as a Catchment* encouraging Melbourne to become a water sensitive city.
- Incorporate and expand water sensitive urban design measures wherever possible.
- Ensure that available water content of soils in irrigated landscapes does not fall below 50% during vegetation growing seasons.
- Improve soil structures to allow for oxygenation and water movement for the benefit of tree roots.
- Replace asphalt and concrete with porous surfaces such as porous asphalt, turf, garden beds and rain gardens to reduce heat retention and encourage soil moisture retention.
- Seek alternative water sources for all major parks and gardens and treed boulevards, avenues, roads and streets.

Examples of WSUD tree pits allowing rainwater runoff to increase soil moisture in tree root zones

Rain gardens outside the Dame Elisabeth Murdoch Building at the Victorian College of the Arts on St Kilda Rd

Case study:

Darling Street stormwater harvesting

The stormwater harvesting project in Darling Street East Melbourne is a prototype for in-road stormwater capture and re-use. Completed in 2011 this system has been designed to capture and treat stormwater from surrounding streets to irrigate Darling Square, Powlett Reserve and median strips with trees in Grey, Simpson, Powlett and Albert Streets.

This system has the potential to harvest an estimated 24 million litres of stormwater each year, which is the equivalent of saving more than 18 Olympic swimming pools worth of water annually. As well as capturing water for irrigation, this system prevents gross pollutants such as soil, silt. clay and litter, and can aid in reduction of local flooding.

With funding from the Victorian Government and Melbourne Water, the system is being monitored to measure its on-going success.

Darling Street stormwater harvesting project

Case study:

Stormwater capture, Eades Place, West Melbourne

The Eades Place stormwater capture project uses porous asphalt and structural soil to capture roadway stormwater runoff. Moisture is retained in the structural soil to provide an optimal growing environment for new trees. The project involved reconstruction of a roadside parking area with a porous asphalt surface laid over a structural soil base, and the construction of ten new tree islands with parking spaces in between. The total surface area of porous paving and structural soil is 482 square metres, and the structural soil has a minimum depth of 600mm.

In drought years this area will capture 591,000 litres of stormwater annually, providing 162 litres of water per day to each tree. In average rainfall years 790,000 litres of stormwater will be captured, providing 217 litres per day to each tree. Pollution loads in the stormwater will be reduced by 90% and peak stormwater flows will be reduced by 90%, resulting in a reduction in local flooding.

A monitoring regime will be established to measure the project's success.

4. PRINCIPLES & STRATEGIES

4.3.5 Improve urban ecology

Over 40% of nationally listed threatened ecological communities in Australia occur in urban areas. Loss of natural habitat, urbanisation, and air and water pollution have all threatened the survival of many plant and animal species.[56]

A 2009 study by the Victorian Environmental Assessment Council identified ten major threats to biodiversity in Melbourne including fragmented landscapes, connectivity loss due to major roads, pollution, human impacts (e.g. rubbish and trampling), predation from cats and dogs, and competition from introduced species. With potential urban growth into brown- and greenfield sites, the likely loss of biodiversity from these threats becomes even greater, highlighting the need to seriously regard biodiversity in our city.

Urban landscapes and biodiversity have often been seen to be mutually exclusive. However, research continues to demonstrate that urban areas can provide opportunities for protecting and enhancing vulnerable species. Urban ecosystems give rise to new habitat types which include green roofs and walls, gardens, reserves and parks.

The urban forest plays a crucial role in providing habitat, food and protection for wildlife in addition to providing a diversity of plant species. Healthy trees supported by adequate soil moisture and structural and biological diversity collectively contribute to healthy ecosystems. Public parks and gardens, golf courses, remnant vegetation and private gardens are all capable of providing habitat for a variety of species.

This is not to underestimate urbanisation's impact on biodiversity. Our imperative is to ensure protection and enhancement of vulnerable species. Biodiversity in the City of Melbourne includes a wide range of wildlife species. Whilst certain species (e.g. Eastern Quoll) face severe loss or even extinction due to loss of habitat, others (e.g. Brush Tail Possum) have adapted all too well to urbanisation, to the extent that many inner area parks are overpopulated.

TARGET: Protect and enhance urban ecology and biodiversity to contribute to the delivery of healthy ecosystem services.

Actions:

- Develop an urban ecology and biodiversity strategy in collaboration with Australian Research Centre for Urban Ecology (ARCUE, University of Melbourne)
- Consult the community and stakeholders to inform measures regarding the enhancement of biodiversity in the municipality
- Further integrate biodiversity and urban ecology values into the planning of parks, green spaces, precincts and waterways through master plans, structure plans, precinct plans and Total Watermark – City as a Catchment
- Increase the diversity of trees and other plants to provide food sources, to protect habitat and to promote healthy ecosystems
- Use water sensitive urban design to improve groundwater levels and encourage biodiversity in our soils
- Maintain on-going relationships with key research organisations such as ARCUE and CSIRO Ecosystem Sciences.
- Develop programs to encourage the interaction between people and nature and to raise awareness
- Enhance ecological connectivity through urban forest corridors along streets and bio-links between larger green spaces.
- Develop productive urban landscapes, where possible in public spaces but mainly through encouragement for private gardens.
- Provide habitat through dead trees where possible, while ensuring health and safety for everyone

Providing a diverse range of species and combining all vegetation strata (trees, shrubs and groundcovers) improves habitat value.

Case study:

Mainstreaming Biodiversity through Urban Design and Community Engagement, Edmonton, AB

Edmonton is a large urban centre in western Canada. The city has prioritised biodiversity protection by integrating biodiversity into urban planning and community engagement.

Edmonton has focused on land acquisition and strategies that move neighbourhood development towards design that is sensitive to biodiversity values while reducing community conflicts. The city has also created the largest municipally owned park system in Canada.

Community engagement is used to promote biodiversity management and awareness. The city has introduced the Master Naturalists Program, which offers 35 hours of training and field trips in exchange for 35 hours of stewardship volunteer-service. Participants become ambassadors, working with city staff and experts to build community learning capacity.

The Biokit for New Canadian Immigrants is a pilot initiative which educates immigrant families on local natural areas and biodiversity. Participants are offered training delivered by leaders in the Master Naturalists Program.

The lessons learned from these initiatives to date were:

1. Integrate biodiversity conservation into the city's vision, policies, and high level plans;
2. Use strategic partnerships to work around limited staff and resources;
3. Engage citizens and create opportunities for them to demonstrate their interests;
4. Measure and report on progress to help develop a system of effective environmental management;
5. Build momentum through implementation plans;
6. Participate in biodiversity networks to avoid working in isolation; and
7. Allow for biodiversity management to become a priority through cross-department initiatives.

Case study:

Conserving biodiversity, Adelaide

Adelaide's Urban Forest Biodiversity Program attempts to redress the loss of biodiversity across Adelaide. It has been delivered alongside two other programs: the Million Trees program - dedicated to planting three million local native trees and associated understorey species across the Adelaide metropolitan area by 2014 - and Backyards 4 Wildlife. Each program is aimed at improving the amount and type of vegetation across the city in both the public and private realms to provide more habitat, food and protection for Adelaide's native wildlife.

A study of Adelaide's biodiversity has found that only 12% of the area's original vegetation remains, and this is recognised as a contributor to the severe decline in native fauna and flora. The South Australian Government along with the Federal Government has responded to improve the biological diversity of the city, recognising that biodiversity conservation is crucial in ensuring a healthy and sustainable local environment for future generations.

Four key actions were taken to kick-start this initiative:

- A spatial analysis identified areas of high conservation significance.
- Implementation of on ground restoration projects. With support of local government, industry and the community, the aim is to restore approximately 2,000 hectares of native vegetation using suitable areas of public open space, including parks, reserves, transport corridors, water courses, coastline and council land.
- Provision of education, training and resources for everyone to improve biodiversity. Innovative resourcing, accredited training and support to schools are planned to maximise involvement in local projects and activities across the curriculum and to foster 'ecoliteracy'.
- Facilitating greater participation, raising greater awareness, and increasing skills and knowledge in the wider community through coordinated communication, education and involvement strategies.

There are currently fourteen projects taking place throughout Adelaide enhancing parks, waterways and corridors for biodiversity.

4. PRINCIPLES & STRATEGIES

4.3.6 Engage with the community

The urban forest influences everyone in the community. Engaging the wider community involves not only informing them about the importance and benefits of green infrastructure, but also highlighting the role it plays in ensuring Melbourne's liveability, sustainability and support of cultural identity.

The success of an urban forestry program relies on the commitment of citizens and local businesses to support and enhance work done in the public realm, and to translate the benefits of urban forestry and increased tree canopy into action in the private realm.

Community support for the urban forest in the public realm can include: tree-related advocacy groups and trusts; associations that lobby for more street trees and greenery in their neighbourhoods; and others who demand open space and tree protection through better planning, new regulations, and public acquisition. Community groups and dedicated individuals can provide the 'glue' to link open space networks within larger metropolitan areas, and can provide the political backbone to sustain public investment in green infrastructure.[57]

On a larger scale, business-driven civic leadership can incorporate urban forestry visibly into much broader planning initiatives and thus build its legitimacy as a public policy issue. Similarly, educational institutions at all levels should be involved in any long-term communications strategy for urban forestry.[58]

Our aim is to have the urban forest included in a broader conversation about how Melbourne's cultural identity can be enhanced through revisioning, redesign and ultimately replanting. For example: Can Melbourne's increasing diversification of its landscapes reflect its multicultural plurality? This should open the space for the community to connect with the urban forest, to establish how it contributes to their sense of place, and to allow the community a role in growing and sustaining our urban forest.

The City of Melbourne will be a strong advocate for the benefits of a healthy urban forest and will continue, through various media, to seek the views of the wider community about how to protect, manage and enhance our urban forest asset for future generations. We will work with partners to build the profile of urban forestry in greater Melbourne and Australia, and to support action on canopy enhancement in the private realm. We will continue to build on-going research and measurement into management innovations and, above all, allow the local community to have their say in the way our landscapes are planned, designed and managed into the future.

TARGET: The community will have a broader understanding of the importance of our urban forest, increase their connection to it and engage with its process of evolution.

Actions:

- Enable the community to 'have a say' in the design of landscapes of the future.
- Use innovative tools to engage and involve with the Urban Forest Strategy.
- Encourage 'diverse conversations' about the urban forest through a range of fora.
- Foster the emergence of urban forestry as an essential planning discipline in Australia.
- Align with other local municipalities to enhance the whole Melbourne urban forest.
- Encourage and support further research into Australian urban forestry.
- Create opportunities and co-benefits of producing this strategy: align with other strategies to ensure greater impact, increase fields of research, and develop relationships with private landholders.
- Work with traditional owners to develop community programs that increase knowledge of the cultural significance of landscapes in our environment.
- Develop health and wellbeing indicators to benchmark the role of our urban forests in contributing to human health.

Planting days, such as this at Royal Park, provide an opportunity for our community to be directly involved in the establishment and on-going management of the urban forest

Case study:

The Urban Forest Project, New York

In 2006, Times Square in New York City was brought to life by banners inspired by the form or metaphor of the tree, compiled by 185 acclaimed artists from around the globe. Entitled 'The Urban Forest Project', this was a visually stimulating, powerful community engagement event that both celebrated the urban forest, and stimulated discussions around sustainability and the environment.

Since its New York germination, The Urban Forest Project has spread to other US cities of Albuquerque, Baltimore, Denver, Portland, Toledo, San Francisco, Tacoma and Washington DC. In each city, local artists, designers and students have contributed their personal reflections on the tree to the outdoor exhibitions. The banners, inspired by and displayed in a unique local context of each city have proved a positive way to promote eco-city events and programs that exist in the local area, while opening up the community's imagination and motivation to stimulate new ones.

The Urban Forest Project and similar initiatives sprouting up alongside innovative approaches to the management of urban forests provide a platform from which to engage the public in urban forest planning and management strategies, to share narratives, and to celebrate art, community, and the environment.

Case study:

Engaging the community in Melbourne

Melbourne's Urban Forest Strategy was developed in consultation with the community between November 2011 and April 2012. An extensive community engagement process was undertaken to provide an opportunity for all members of the community to provide feedback through a variety of convenient channels. Publicity was sought across a broad range of media channels, including social media, to generate widespread community awareness of the strategy and the associated consultation period.

Activities during the consultation period included:

- An Urban Forest – Eco City Forum in the Town Hall in November 2011 with 135 participants.
- Nine precinct based community consultation meetings held between January and March 2012.
- A bespoke website was developed to provide a fulltime 'online forum' for the duration of the project, which generated 4249 individual visitors, a combined total of 11,991 site visits, 20,316 page views, and 818 downloads of the Strategy.
- Over 19,000 words in submissions and commentary were received from 177 commentators.
- A corporate website page for the strategy that received 5,034 unique views.
- A short video conveying key messages about on the Strategy viewed more than 2,500 times.
- More than 30 media articles, letters and editorials informing the community about the strategy on TV and radio and in the newspapers.
- Distribution of 10,000 copies of a specially designed Avant postcard by Michael Leunig to promote the consultation period throughout inner Melbourne.
- 419 entrants for the Urban Forest Art and Design Competition from 71 Melbourne suburbs and Victorian regional areas.
- Winning entries from the Urban Forest Art and Design Competition displayed throughout city in November to promote the consultation period and the strategy.

Design from the City of Melbourne's 2011 Urban Forest Art and Design Competition

5. IMPLEMENTATION FRAMEWORK

This strategy puts forward principles and strategies that will guide the long-term planning, development and management of the City of Melbourne's urban forest. It also outlines a set of targets to evaluate the success of implementation.

Evolution in urban forest planning will need to be based on solid research, well-informed options and best practice implementation tools and processes. With these foundations, the City of Melbourne will advocate for the practice of urban forestry in Australia.

Creating a resilient and robust urban forest requires forward planning in a similar manner to municipal strategic planning. The management and development of our urban forest needs to undertaken with a long-term vision.

Planning, development and implementation of urban tree policy takes place at two levels: long term (strategic and spatial planning) and shorter-term (project-focused planning). The success of the Urban Forest Strategy will rely on effective 'green governance' by the City of Melbourne, clear communications, and a widely understood implementation strategy that comprises programs that meet both short and long-term goals.

5.1 Green governance

Green governance shapes the plans and decisions that influence the development of urban forestry. A multitude of institutions, organisations and stakeholders are involved in shaping and making policy and management decisions that affect our urban forests

Successful urban forestry requires creative and effective design at all levels, from metropolitan areas and regional ecosystems down to neighbourhoods and individual development sites.[59] Integrated planning, knowledge sharing and communication are critical components for successful green governance. They need to occur on a range of levels and work across administrative boundaries and disciplines within the municipality and beyond.

- **Intra-Council integration** involves internal stakeholder and interdepartmental cooperation. At a city scale, planners work directly with urban foresters to integrate policy, practices and analytical tools, coordinating input from many other departments related to managing growth.
- **Community and inter-professional integration** means the role of non-public proponents becomes more influential by raising public and bi-partisan political awareness. We recognise the impact that changes in the urban forest have on the values of communities and individual, and must therefore maintain and enhance interaction with the community to ensure these values are considered during planning and decision making.
- **Inter-municipal integration** involves the need for policy makers to link together with other local municipalities. At this scale, this calls for more systematic assessments of the urban forest across a larger bio-geographical area, beyond arbitrary political boundaries.
- Locally-led action on the urban forest potentially influences **national action**. The learning acquired from small scale autonomous urban forest projects can aid in steering policy-making and the quality and quantity of research across the country. The importance of comparable data would allow urban forests to be managed and have collective benchmarks established to ensure that national climate adaptation targets can be met.
- **International cooperation**. There is a need to network globally to drive uptake of the principles of contemporary urban forestry, to share research and technical knowledge, and to achieve better outcomes for our cities as our urban environment continues to expand.

5.2 Priority implementation actions

Priority implementation actions that have been identified include:

- Review and update tree precinct plans
- Develop boulevard master plans
- Implement urban forest diversity guidelines
- Valuing the urban forest
- Develop growing green guide for Melbourne
- Develop community engagement programs
- Maintain and develop exceptional tree register

A wide range of other initiatives may also be identified in the future.

5. IMPLEMENTATION FRAMEWORK

Review & update tree precinct plans

The City of Melbourne has a set of street tree precinct plans dating from 2002 that were developed through extensive community consultation. The plans have three primary aims:

- Protect and develop neighbourhood character
- Assist in prioritising works and budgets
- Support proactive and well planned planting to ensure a healthy stock of trees over the long term

A new set of precinct tree plans will build upon the aims above and respond to objectives of the Urban Forest Strategy.

The plans will assess and define the character of each precinct in collaboration with the community. They will identify opportunities to guide future street tree planting programs and provide an overarching framework to reference future tree species selections.

The plans can also incorporate a green infrastructure approach. GIS mapping and analysis can be used to consider the coordination of all green elements in a precinct, including:

- Urban character and heritage
- Street and open space trees
- Open space
- Water sensitive urban design
- Soil, topography, hydrology, stormwater, and permeability
- Street design
- Path networks
- Strategic integration with other council plans (i.e. built form, path networks, major infrastructure developments)
- Specific outputs should include:
- Demonstrate where to plant (spatial distribution), how to plant (design guidelines) and when to plant.
- Communicate how this transition will occur over the suburb and by each street.
- Provide an implementation plan for priority of works over the next ten years.
- Provide design guidelines for integrated tree planning, WSUD and streetscape design.
- Provide recommended street tree species lists for each street.
- Provide a recommendation for the appropriate level of diversity of age and diversity.

Royal Parade

These plans will be designed and developed through an extensive community engagement program, with a focus on collaboration.

Proposed timeframes for precinct plan implementation are:

Year 1: July 2012 – June 2013
Carlton, East Melbourne & Jolimont,
South Yarra, CBD

Year 2: July 2013 – June 2014
North & West Melbourne, Kensington, Docklands

Year 3: July 2013 – June 2015
Parkville, Southbank, Fishermans Bend

Develop boulevard master plans

In addition to the development of a new set of precinct plans, several master plans need to be developed to guide high profile sites including St Kilda Road, Flemington Road and Elizabeth Street.

Proposed timeframes for Boulevard Master Plan implementation are:

Year 1: July 2012 – June 2013
St Kilda Rd Master Plan – commence

Year 2: July 2013 – June 2014
Flemington Rd Master Plan – commence
St Kilda Rd Master Plan – complete

Year 3: July 2014 – June 2015
Elizabeth St (Haymarket – Victoria St) Master Plan
Flemington Rd Master Plan – complete

Longer term
Royal Parade, Victoria Parade

Implement urban forest diversity guidelines

Implement urban forest diversity guidelines Urban Forest Diversity Guidelines have been developed to accompany this document. These set out a basis for selecting the right trees and other vegetation for our future urban forest. A scientifically-based matrix has been created to support the selection of appropriate trees for each street typology within the municipality.

The guidelines also stipulate diversity targets to be set across the total urban forest in terms of vegetation form, species, age and health. These guidelines should be used to inform capital works programming and the development of the tree precinct plans. The selection matrix and list should be reviewed and updated by 2015.

In order to ensure species diversification, tree planning will be implemented both at precinct and city-wide scales in parallel. Annually, the species list may be altered and a planting maximum may be established for each species to ensure that age diversity is achieved across the population.

Develop a forest health management plan

Declining forest health in Melbourne is of concern due to the expected increase in the frequency of extreme weather events, limited diversity within the current urban forest population and the threat of emerging pests and diseases. Additionally, Melbourne's elm population, which contributes significantly to the character of avenues and boulevards within the city, is in decline with 76% expected to reach the end of their useful life expectancy in the next 20 years. An integrated forest health management plan will improve long-term vegetation health across the city by providing strategies to:

- Manage diversity (genetic, species and age).
- Assess the risk to Melbourne's urban forest from known and potential forest health threats.
- Ensure the on-going viability of the elm population.
- Manage pathogens, insects and abiotic factors known to impact urban tree health in Victoria.
- Manage for pathogens and insects that could impact Melbourne's urban tree health in the future
- Outline best management practices for maintaining urban forest health
- Define indicators for success to be measured through forest health monitoring

Valuing the urban forest

The City of Melbourne adopted the Mauer-Hoffman formula for assessing the monetary value of amenity trees in 1970. In 1990, Peter Yau developed the City of Melbourne amenity value formula, which council adopted for calculating the monetary value of urban trees. This has since been used successfully to acquire compensation for trees lost due to development, and has been adopted by other local government authorities in Australia for appraising values of Urban Trees (Adelaide City Council).

Amenity valuations establish City of Melbourne's urban forest as having an approximate worth of $700 million. Valuing the urban forest solely on the basis of an amenity formula does not account for the environmental benefits provided by the urban forest.

The i-Tree Eco tool is a free, peer-reviewed software suite from the United States Department of Agriculture's Forest Service, which provides an urban and community forestry analysis and benefits assessment tool (www.itreetools.org/about.php). It provides a broad picture of the entire urban forest and is designed to use field data along with local hourly air pollution and meteorological data to quantify urban forest structure, environmental effects, and value to communities.

i-Tree Eco will provide us with a more holistic dollar value for our urban forest. New York has used i-tree to evaluate that for every dollar they spend on trees, they receive a return of $5.60.

In 2010, the Victorian Local Sustainability Accord provided funding to the Cities of Melbourne, Port Phillip and Moonee Valley to develop and contextualise the i-tree Eco tool for Australian use. The National Urban Forest Alliance (NUFA) and Arboriculture Australia have partnered as joint custodians of the i-Tree Eco Australia to promote and develop tool's future use in Australia.

City of Melbourne has currently assessed over one thousand trees using i-Tree Eco. Continued use and development of the i-Tree Eco tool will be critical to evaluating and measuring the benefits of our urban forest.

Spotted Gums in Erskine Street, North Melbourne

5. IMPLEMENTATION FRAMEWORK

Develop 'Growing Green' guide for Melbourne

Green roofs, walls and facades have not yet been widely implemented in Melbourne, or indeed Australia. By contrast, cities across North America, Europe and Asia have widely embraced green roof technology and are encouraging and/or enforcing their installation through incentives and regulation.

In Australia we do not have policies or formal guidance requiring the installation of green roofs or walls. Standards for best practice in green roof, wall and facade design for the Australian climate have not been developed and there is a strong demand for such standards.

A project has recently commenced to respond to this demand and its delivery will be a critical element in bolstering the further development and expanding the benefits of the urban forest. Growing Green Guide for Melbourne: A how-to guide for green roofs, walls and facades will be developed collaboratively through representatives from the Inner Melbourne Action Plan partner councils (Cities of Melbourne, Port Phillip, Yarra and Stonnington), as well as The University of Melbourne and the Department of Sustainability and Environment and other stakeholders.

The Growing Green Guide for Melbourne project will develop a practical tool (best practice guidelines) that will increase the knowledge and reduce the technical barriers of green roof wall and facade construction. The project will also include a policy options paper that can be readily utilised by councils, building developers and planners across Victoria. An opportunities assessment will be carried out to identify potential sites to develop green roofs, walls or facades across the four council partner localities.

Green roof on The Venny communal backyard, JJ Holland Park, Kensington

Develop community engagement programs

Community engagement programming will aim to include the broadest possible cross-section of the community, including federal, state and local governments, leaseholders, champions and environmental sector leaders, research and educational institutions, artists, industry forums, businesses, schools and developers.

The term 'urban forest' does not just encompass those green aspects of our city that are managed by City of Melbourne. In an ecological sense, all living components within the municipality, and spanning out to wider Melbourne, contribute to the function and benefits of the collective urban forest.

Unlike some forest systems in rural contexts, the attributes of our urban forest require coordination of many public and private land managers. In the City of Melbourne, a large percentage of land is under the management of independent organisations and private land owners. We need to better understand the current composition of the private realm, as future changes will significantly affect our functional, ecological and visual landscape, which will in turn influence the social and environmental benefits afforded by the urban forest.

Within our municipality, we have diverse property types ranging from tiny apartments to large house and garden plots. We also have a community with diverse cultural, socio-economic, and education backgrounds. As Melbourne continues to increase in density the private realm to the urban forest will need to be fostered and promoted.

Opportunities exist to partner with numerous stakeholders including other Councils, businesses, community groups, not for profit organisations and institutions to develop programs that will:

- Educate and support private land owners to plant and care for suitable trees on their property
- Celebrate events such as National Tree Day to raise the profile of urban forestry
- Develop self-guided walking tours for exceptional trees
- Market the benefits of trees to landowners, developers and businesses
- Educate the greater Melbourne community about the importance of managing and enhancing urban ecology across our city

Maintain & develop exceptional tree register

One component of the long term planning for the urban forest and liveability of Melbourne is the protection of trees on private property. A study undertaken by Treelogic has found that tree protection in the private realm is most effective via significant tree registers.

As a result of this study, the City of Melbourne has undertaken an exceptional tree survey in the municipality and produced a register of exceptional trees that will be nominated for protection through an amendment to the Melbourne Planning Scheme in mid to late 2012. Protection of exceptional trees in the private realm will mean that to significantly prune, lop or destroy a tree listed on the Exceptional Tree Register will require a planning permit.

The aim of the register is to recognise, celebrate and protect the exceptional trees that exist in the municipality in the private realm, which contribute to the urban forest and city character as a whole.

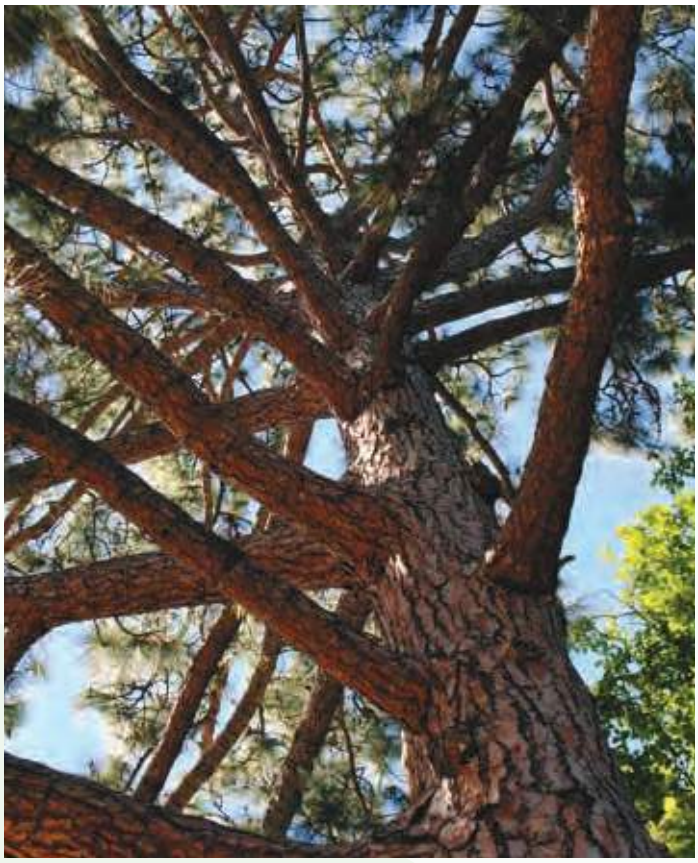
5.3 Measurement, monitoring & review

The development and efficient management of a resilient and robust urban forest requires on-going evaluation and assessment of the physical resources, the benefits they provide and their values – economic and non-economic.

At present the primary data collected includes species, life expectancy and infrastructure constraints for tree establishment and growth. Additional data needs are being identified to improve our ability to quantify the value of environmental services provided by the urban forest, assess tree survival, forest health and measure structural diversity, habitat characteristics and landscape connectivity. Ultimately, the data we collect will be focused on measuring the success of the urban forest strategy and improving urban forest practices at the local, regional and national level. Monitoring and research outcomes facilitate continual improvement in our management practices through an adaptive management approach.

Key areas for Information development include:

- **Total area of the urban forest** including canopy cover, density and vegetation per inhabitant in the public and private realm.
- **Urban forest composition, structure and age class** including species, diameter at breast height, height and age classes.
- **Urban forest landscape mapping** including recognition of corridors linking open spaces and contributing to connectivity at a metropolitan scale.
- **Urban forest effects on climate amelioration** including the effect of the right tree in the right place on reducing thermal discomfort, sun exposure and energy savings.
- **Urban forest habitat values** including tree traits and species that could provide habitat for fauna.
- **Urban forest productivity, health and vitality** including estimates of species growth and biomass, canopy growth over time and impacts of biotic and abiotic forest health factors.
- **Urban forest contribution to the carbon cycl**e including carbon storage and sequestration rates with consideration of the effect of events such as drought on tree productivity and health.
- **Contributions to air quality** including pollution removal, noise reduction, energy savings and cooling.
- **Contribution to conserving and maintaining soil and water resources**, by estimating values for infiltration and draining while considering soil properties such as pH, bulk density, water content and soil carbon.
- **Socioeconomic benefits** including outdoor activities, property values, wellbeing, sense of place, and cultural heritage.
- **Establish community connection** including the perceived benefits and nuisances.
- **Urban forest disservices** including species that have a high allergenicity index, are highly prone to pest and diseases, have low ULE, and are higher emitters of volatile organic compounds.
- **Economic value of the urban forest** in terms of property values, carbon stored, energy savings, health benefits etc.
- **Spatial distribution of urban forest ecosystem services**.
- **Spatial analysis of the urban heat island** using thermal, road density and population density mapping (or building density map) and normalized difference vegetation (NDVI) mapping.
- **Establish a thermal map relationship** between urbanization, UHI and canopy cover for the City of Melbourne.



*An exceptional Canary Island Pine (**Pinus canariensis**) at the Melbourne Zoological Gardens. Pines and other conifers were among the most popular trees for planting in Melbourne's parks in the 1860s and 1870s, but very few remain today.*

5.4 Funding resources

True success in maintaining our urban forest depends on continuing support from the **public sector, developers, businesses** and **wider community**. The City of Melbourne recognises that effective implementation of green infrastructure throughout our urban environment depends on a coherent public policy supporting it – financially, administratively and legally – and that a long term funding commitment is required over the next two decades.

Development of the urban forest is also an area of public planning that government does not need to tackle alone. Developers have always looked for a marketing edge for their properties. The best developers understand that building green means not just structural design, but the entire development site and its relationship to its surroundings. Developer open space contributions are also an important means of supporting and advancing tree programs and other green infrastructure initiatives in newly developing areas.

Business partners can be powerful contributors to the expansion and success of urban forestry through financial support, planting and maintenance of trees on commercial property, and support of civic organizations involved in forestry. Some businesses have a direct stake in urban forestry as a function of their own enterprises. Others may be interested in offsetting environmental impacts, an area that is likely to grow as carbon credits become commoditised as a result of climate change policy.

Achieving funding stability ultimately depends on on-going support by the public such that the City of Melbourne remains committed to the program. Much of this hinges on communicating and disseminating information about benefits of Melbourne's urban forest in terms of reduced stormwater pollution, electricity saved, carbon and water savings from lower energy use in buildings, lower demands on power plants, biodiversity benefits, and temperature reductions in city as a whole – not to mention the city's aesthetic enhancement and wide-ranging social and economic advantages.

Project costs can be more easily justified when they can be linked to benefits derived from specific green infrastructure implementation strategies, and the provision of a robust cost benefit analysis for the urban forest will help ensure that it remains competitive as a high value land use amongst hard infrastructure and transport. In other words, stable support from the community is generated by a long-term track record of documenting and disseminating those benefits.

> Trees are not merely amenities; they are assets that pay regular dividends when well managed. As such, the urban forest should become a magnet for public investment.
>
> **JC Schwab (Ed.), 2009. Planning the Urban Forest**

GLOSSARY

Adaptive management is an interdisciplinary process that refers to the application of new knowledge in updates and changes to a program. In this approach, 'the best science, albeit incomplete, is brought to bear on an ecosystem, management is implemented under rigorously monitored conditions, and adaptations in management are made as the feedback from monitoring teaches us ore about the way the ecosystem behaves.' (Rowntree, 1995) The process of management yields new lessons as an urban forestry program moves forward, (e.g. the ways in which trees respond to new stresses as well as new treatments for those stresses). Applying the new knowledge helps improve the accuracy in predicting how an ecosystem will respond to new managerial approaches. Adaptive management is also a very interdisciplinary process. (Schwab, 2009)

Biodiversity refers to the wide variety of ecosystems and living organisms from all sources including terrestrial, marine and other aquatic ecosystems, their habitats and their genes, and the ecological complexes of which they are part. Biodiversity also refers to the degree of variation of life forms within a given species or ecosystem, and is a measure of the health of ecosystems.

Biomass, in ecology, is the mass of living biological organisms in a given area or ecosystem at a given time. As a renewable energy source, biomass refers to biological material from living, or recently living organisms. As an energy source, biomass can either be used directly, or converted into other energy products.

Botanical family (pl. families). A taxonomic group composed of one or more genera. The names of most botanical families end in '-aceae' (e.g., Myrtaceae, Ulmaceae, Plantanaceae etc.), however, there are some exceptions. Groups of similar families are placed in orders.

Botanical genus (pl. genera). A taxonomic group consisting of related species that resemble each other more closely than they resemble other groups. Genus is subordinate to family and ranked above species. The genus name forms the first part of a scientific name (e.g., Eucalyptus leucoxylon) and is written in Latin with the first letter capitalized. Collections of similar genera are grouped into families.

Botanical species. A taxonomic group that unites like individuals within the same genus that breed among themselves, produce fertile offspring and are distinguishable from other closely related groups. Species is the basic unit of classification. The scientific name is formed by the genus name followed by the species name (e.g., Eucalyptus leucoxylon) and is always written in lower case. Collections of similar species are grouped into genera.

Brownfield sites generally refer to previously developed land that has the potential for being redeveloped – often in terms of redevelopment for housing and commercial buildings, but also as open spaces for recreation, conservation, woodland and other community areas. Specifically, it is often (but not always) land that has been used for industrial and/or commercial purposes that has been abandoned, derelict and possibly contaminated.

A carbon sink is a natural or artificial reservoir process that accumulates and stores any carbon-containing chemical compound for an indefinite period, thus lowering the amount of carbon dioxide in the atmosphere. Photosynthesis by terrestrial plants is a major natural carbon sink.

Climate change adaptation refers to the ability of natural or human systems (i.e. ecosystems or communities) to adjust in response to actual or expected climate change, including climate variability and extremes. It involves a process (or outcome of processes) of anticipating or monitoring change and undertaking actions to address the consequences of that change – such as moderating potential damage, reducing harm or risk of harm, coping with the consequences, and taking advantage of beneficial opportunities (evident or unforeseen) of climate events, variability and climate change.

Climate change mitigation refers to human intervention to reduce or ultimately permanently eliminate or reduce the long-term risk and hazards of climate change to life and property. Most often, climate change mitigation scenarios involve reductions in the concentrations of greenhouse gases, either by reducing their sources or by increasing their sinks. While adaptation tackles the effects of climate change, mitigation tackles its causes.

Ecosystem resilience is a measure of how much disturbance (such as from storms, fire or pollutants) an ecosystem can handle without shifting into a qualitatively different state. It refers to the capacity of a system to both withstand shocks and to rebuild itself if damaged. In a resilient ecosystem, the process of rebuilding after disturbance promotes renewal and innovation; without resilience, ecosystems become vulnerable to adverse effects and may not only be biologically and economically impoverished, but also irreversible

Ecosystem services refer to transformation of natural assets (soil, plants and animals, air and water) into things that we value through natural or enhanced ecological processes; i.e. those organisms and processes which clean our air and water, pollinate plants, filter and recycle nutrients, modify our climate, control floods and improve soil fertility, and enhance the aesthetic and cultural benefits that derive from nature.

Environmental justice seeks to protect disadvantaged (e.g. socially and economically) people from unfair environmental impacts. Often closely correlated with community development, participatory environmental projects can help to increase community capacity and build social structure.

Green infrastructure describes the network of natural landscape assets which underpin the economic, socio-cultural and environmental functionality of our cities and towns; i.e. the green spaces, water systems and built environment landscapes which intersperse and increase connectivity, multi-functionality and landscape performance in urban environments. Individual components of this network can be referred to as 'green infrastructure assets', and these occur across a range of landscape scales from residential gardens to local parks and housing estates, streetscapes and highway verges, services and communications corridors, waterways and regional recreation areas. Green infrastructure comprises an important innovation in the integrative planning of forests and other green space, and has become frequently used in reference to urban renaissance and green space regeneration. It can be defined as creating networks of multifunctional green spaces that are carefully planned to meet the environmental, social and economic needs of a community.

Green governance involves the development of robust processes directed towards achieving the transformation of cities to sustainability through continual improvement, ethical urban responsibility, and strategically planning and working across administrative boundaries and disciplines. It broadly includes visionary leadership, developing innovative strategies, programs and technologies, advocacy for sustainable production and consumption, and balancing local and strategic initiatives. Green governance is committed to participatory leadership and open source management.

Green wedges are generally non-urban or peri-urban areas of environmental or scenic sensitivity and strategic locations for uses that require separation from residential, industrial or commercial uses. They may include public land, catchments or agricultural areas that support biodiversity, farming, open space, attractive landscapes, tourism and recreation, and cultural heritage.

Greenfield sites are areas of land, often in rural or countryside areas in proximity to towns and cities, that have not been built on before but are being considered for urban development. While these areas usually support agricultural or environmental amenity, as development potential they offer better access, have less congestion, a more pleasant environment, and have more space to expand.

GLOSSARY

Grey infrastructure refers to man-made, constructed assets such as transport infrastructure (e.g. motorways, roads, car parks, railways, bridges, ports/freight terminals, canals, airports, dams), utilities and services distribution (e.g. conventional piped drainage, cables, water and waste management systems, energy generation networks) and commercial infrastructure (e.g. factories and industrial offices).

Natural capital is an extension of the traditional economic notion of capital, but represents natural assets such as non-renewable resources (e.g. fossil fuels and mineral deposits), renewable resources (e.g. fish or timber) or ecosystem services (e.g. the generation of fertile soils, pollination, or purification of air and water).

Nutrient cycling (or ecological recycling) is the movement and exchange of organic and inorganic matter back into the production of living matter within ecosystems. Ecosystems recycle locally, converting mineral nutrients into the production of biomass, and globally where matter is exchanged and transported through a larger system of inputs and outputs (biogeochemical cycles).

Productive urban landscapes make use of urban and peri-urban spaces – including residential properties, green roofs, 'food forests' and community gardens – to provide sustainable, food-producing cityscapes, where food is grown locally and organically within communities and suburbs. 'Food-sensitive urban design' can contribute to resilient, sustainable communities by diversifying food sources and making use of local resources. To make it ultimately viable, the same level of investment put into broadacre agriculture needs to be put into urban production systems.

Resilience is the capacity to deal with change and continue to develop. Ecological resilience refers to the capacity of an ecosystem or natural population to resist or recover from major changes in structure and function following natural or human-caused disturbances, without undergoing a shift to a vastly different regime but remain within its natural variability and viability. Social resilience is the ability of human communities to withstand and recover from stresses, such as environmental change or social, economic or political upheaval. Resilience in societies and their life-supporting ecosystems is the key to sustainable development and is crucial in maintaining options for future human development.

Sequestration describes the removal of greenhouse gases from the atmosphere, and absorption and long-term storage of carbon dioxide or other forms of carbon, usually by biomass such as trees, soils and crops, or technological measures over a period of time. It has been proposed as a way to slow the atmospheric and marine accumulation of greenhouse gases, which are released by burning fossil fuels, to either mitigate or defer global warming and avoid dangerous climate change.

Social Capital is a concept used in various fields, from economics and political science to sociology and natural resources management. Broadly, it refers to social relations and among individuals and the norms and social trust which they generate and which facilitate coordination and cooperation for mutual benefit.

Social resilience is the ability of human communities to withstand and recover from stresses, such as environmental change or social, economic or political upheaval. Resilience in societies and their life-supporting ecosystems is crucial in maintaining options for future human development.

Social-ecological systems are linked systems of people and nature. The term emphasises that humans must be seen as a part of, not apart from, nature, and has been supported by concepts such as 'human-environment systems','ecosocial systems' and 'socio-ecological systems' to illustrate the interplay between them.

Sustainable urban development focuses on creating urban communities where both the current and the needs of future generations are met. It is a pattern of economic growth in which resource use aims to meet human needs while preserving the environment. There are two important principles – resilience and connectivity – that underpin sustainable urban development. There is an additional focus on the responsibility of the present to improve the life of future generations by restoring the previous ecosystem damage and resisting to contribute to further ecosystem damage. In recent times, sustainable development principles have been developed through concepts such as new urbanism, smart growth, low impact development, walkable neighbourhoods, multimodal transport systems, and transport oriented development.

Urban ecology describes how ecological models from natural environments are applied to urban areas, including the interactions between organisms and environments, energy and food sources.

Urban ecosystems are the product of multidisciplinary development incorporating the natural, physical and social sciences, and consist of various components including: the physical environment (both natural features and built infrastructure), the spatial and social context of urban people, and the biotic community. It is a human-based ecology that recognises the critical aspects of urban systems of governance in sustaining urban quality of life.

Urban forest (in addition to definition in Section 2.1). 'The art, science and technology of managing trees and forest resources in and around urban community ecosystems for the physiological, sociological, economic and aesthetic benefits trees provide society'. (Helms, 1998) 'The art, science and technology of managing trees, forests and natural systems in and around cities, suburbs and towns for the health and wellbeing of all people'. (USDA Forest Service). 'The aggregate of all community vegetation and green spaces that provide benefits vital to enriching the quality of life.' (Sustainable Urban Forests Coalition)

Urban forestry is a planned and programmatic approach to the development and maintenance of an urban forest, including all elements of green infrastructure within the community, especially when resulting from a community visioning and goal-setting process. (Schwab, 2009). In its broadest sense, it is a multidisciplinary process that takes account of water municipal water catchments, wildlife habitats, outdoor recreation opportunities, design, and care of trees and cultivated landscapes.

Urban greening refers to the process of establishing the components of green infrastructure in the urban landscape. From a design perspective it principally refers to plants growing in creative adaptations with built infrastructure.

Urban sprawl is a phenomenon that plagues cities in both developing and industrial countries. It is an uncontrolled or unplanned extension of urban areas into the countryside that tends to result in an inefficient and wasteful use of land and its associated natural resources.

Vulnerability refers to the propensity and degree of sensitivity of social and ecological systems to suffer from exposure to external stresses and shocks. It is generally regarded as the antithesis of resilience.

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