Monash Planning Scheme Amendment C125

Benefits Derived from and the
Economic Value
of
Urban Trees

PREPARED FOR: Dr S Pfueller

PREPARED BY

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12 August, 2016

NAME AND ADDRESS OF THE EXPERT:

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QUALIFICATIONS AND EXPERIENCE:

BSc (Ed) B Sc (Hons) PhD (Botany) All from the University of Melbourne 1971-81
MBA Monash University, 1992

Greg Moore was Principal of Burnley College of the Institute of Land Food Resources at Melbourne University from 1988 to 2007. Prior to this he was a Senior Lecturer and Lecturer in Plant Science and Arboriculture at Burnley from 1979. He was Head of the School of Resource Management at the University from 2002 to 2007.

Apart from a general interest in horticultural plant science, revegetation and ecology, Greg has a specific interest in all aspects of arboriculture, which is the scientific study of the cultivation and management of trees. He has contributed to the development of Australian Standards in pruning and amenity tree evaluation and has been a major speaker at conferences in Australia, Israel, Hong Kong, USA and New Zealand in recent years. He was the inaugural president of the International Society of Arboriculture, Australian Chapter. He has been a regular on Melbourne radio, particularly with ABC 774 and 3AW.

He has been a member of the National Trust of Victoria's Register of Significant Trees since 1988 and has chaired the committee since 1996. Greg was on the Board of Greening Australia (Victoria) from 1989 until 2013 and was an active member of various sub-committees. He has chaired Treenet since 2005 and has been on the Board of SGA since 2002. He is a ministerial nomination as a Trustee for the Trust for Nature and the Yarra Park Advisory Committee. He has also served on a number of industry and TAFE sector committees, especially those that deal with curriculum and accreditation matters.

He is currently supervising post-graduate students and continues to pursue an active research profile in any matters that relate to trees in the urban environment and revegetation. He has written two books, contributed to four others and has had some 150 papers and articles relating to tree biology and management published.

AREA OF EXPERTISE

Greg is widely recognized for his expertise in arboriculture, plant biology and ecology and urban horticulture. He has published on urban tree management and the professional role of arboriculture in pre and post urban and peri-urban tree and vegetation fire ecology. His role of Chair of the National Trust Register of Significant Trees gives him twenty five years of experience in assessing the value and significance of trees.

EXPERTISE TO PREPARE THIS REPORT

Greg has taught the principles and techniques of managing urban trees for over thirty years and has delivered seminars and delivered papers on the topic in Australia, New Zealand and Hong Kong. He has prepared reports on individual; trees and groups of trees and appeared before VCAT and the heritage Council in matters related to trees on many occasions. For over nearly twenty years he managed the historic Burnley Gardens and was responsible for making decisions in relation to the value and safety of the trees within the grounds.

INSTRUCTIONS THAT DEFINE THE SCOPE OF THIS REPORT:

This report has been prepared following verbal instructions from Dr S Pfueller.

DOCUMENTS VIEWED IN PREPARING THIS REPORT:

In preparing this report the following documents were viewed and reviewed:

- Guide to expert evidence, Planning Panels Victoria.
- Monash Planning Scheme Amendemnt C125
- References as listed at the end of the report

IDENTITY OF THE PERSON WHO PREPARED THE REPORT:

The author of the report, Greg Moore.

A SUMMARY OF THE OPINIONS OF THE EXPERT:

Benefits Derived from Urban Trees and Greenspace: the Keys to Sustainable & Livable Cities

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INTRODUCTION

Trees are significant assets to our environment and our society regardless of where they occur or whether they are native or exotic. A great deal of effort has gone into establishing, managing, conserving and preserving them. Considerable human labour and time has been expended on the trees as well as real energy in the form of fossil fuel that has underpinned their maintenance. Significant quantities of water have been allocated to their growth and development.

There are also benefits that the urban forest provides for improving human heath, extending life spans, reducing violence and vandalism, lowering blood pressure and

providing economic savings on medical and social infrastructure costs (Tarran 2006; Tapper 2010). Tapper (2010) notes that use of water during heat waves could reduce ambient temperatures by both surface evaporation and transpirational cooling, and that such cooling could reduce the number of extra deaths that occur, particularly among elderly people. In its submission on water use, the Victorian Department of health noted that one of their objectives was promoting health and well being outcomes through promoting the use of alternative water resources such as stormwater to maintain green spaces, thereby enhancing physical activity and livability (Dedman 2010).

Cities are biodiversity hot spots due to the variety of habitats that are available in public and private open space. In the past decade tree populations in many Australian cities have declined, particularly with the loss of private open space. At a time of climate change, it is worrying that both private and public open spaces are threatened by urban renewal and development that puts at risk long term sustainability. This outcome raises questions about the economic viability of such developments, as well as their long term environmental sustainability.

Urban trees and landscapes are assets that require the expenditure of resources – labour, energy, and water - on their proper management. The questions that might be asked are: "What is the value of the benefits that are provided by mature urban trees?" or perhaps "What does society get in return?" This paper gives some examples of the benefits that urban vegetation provides, particularly large mature trees, and puts an economic value on shade, carbon sequestration, flood mitigation, land stabilization and human health benefits as well as savings in electricity and water use.

THE IMPACT OF CLIMATE CHANGE ON URBAN TREES

Many parts of south eastern Australia recorded below average rainfall for the fourteen years between 1997 and 2010. There have been major storm events (often described as one in a century or one in 50 year events) annually and sometimes two or three times annually in most States over the period 2005-2014. These events may be a part of natural cycles of perhaps five hundred years or more but current meteorological data are too recent to reveal such patterns. However, the dry period and recent storm events are consistent with climate change models and they are likely to become a permanent part of our environmental conditions (Table 1).

Regardless of how things eventuate the possibility of more permanent global climate change is changing the environments within which trees are growing. Such changes are also resulting in the rapid change of the political, economic and social environments within which tree managers operate, and the decision making processes that ensue. There will be more severe weather events more often in south eastern Australia, which will be associated with stronger winds and more intense rainfall (Table 2). Storm events that were once considered one in one hundred year or one in thirty year events are likely to occur every decade if not annually.

Table 1: Current data trends on global warming and predictions of the likely outcomes for climate and sea level related changes (Moore, 2012).

FACTOR	HOW WE ARE TRACKING	PREDICTION
Global temperature	The last 30 years have been the warmest of the past 200 years	Suggests that temperature rises will be at or above the worst case scenario of 6-8°C
Australia terrestrial temperatures	Have increased by 1°C in the past 50 years	Is in line with higher rather than lower temperature predictions and a rise of 4°C is likely
La Nina Events	The last two years 2010-11 and 2011-12 were La Nina years and wet	The 2011 was the warmest La Nina event of the past 150 years and rainfall is still trending down
Drought in Victoria	After 14 below average rainfall years the past two have been above average	There will be an increased drought frequency for the State – likely to be 3-4 more droughts than over the past century
Sea levels	Have risen by 3mm per annum for the past 15 years	Consistent with higher sea level predictions of greater than 60cm
Global Ocean Heat	The Heat content of global oceans is rising and it embodies massive extra energy	Consistent with temperature rises at or above the worst case scenario of 6-8°C
Atmospheric CO_2 levels	CO_2 levels for 2011 are at 390ppm, the highest level for the past 1000 years	These are above the predicted worst case scenario and could exceed 1000ppm
Safe Atmospheric CO_2 levels	The environmentally safe level seems to be about 350ppm, and for the past 200,000 years they have been at about 280ppm	Atmospheric CO_2 levels are likely to rise to between about 500 and 1000ppm, which could cause a major extinction event
Arctic Ice Cap	Melting more rapidly than expected. It seems the northern hemisphere is warming more rapidly than the south	Could melt as early as 2015 rather than 2040-2050 as was originally predicted
Melting Polar Ice Caps	Melting more rapidly	Only 3% of the extra energy absorbed in global warming has gone into heating the atmosphere. Most has gone in melting the ice caps
Reflection of radiation by ice caps	As they diminish in size, less radiation is reflected from earth	Heating of the planet will accelerate to or above the worst case scenario

Such changes will have profound impacts on urban tree managers. Increased storm events, could see higher rates of windthrow and major branch failure. In recent storm events there have been lengthy and widespread power outages, often caused by falling trees and branches. These events should have been used to inform management practices

that might be appropriate under a changed climate scenario, where the undergrounding of utility services, particularly in areas of high population density, should be adopted immediately (Moore 2009).

It has long been argued that undergrounding utility services is cost effective if installation and long term maintenance costs are considered. However, installation and maintenance are often done by different sectors. In some States, installation is by private energy providers and tree maintenance by private land owners and local government, but in other States installation is by State Governments and maintenance by local governments. Australian society cannot afford such a regime which is economically and environmentally unsustainable. The findings of the Victorian Royal Commission into the 2009 bushfires recommended the undergrounding of electricity services in fire prone regions (Anon 2010).

Table 2: Likely outcomes from climate related changes in south eastern Australia (Moore 2012)

Generally warmer winters and hotter summers
A more tropical climate extending southward
More easterly winds leading to summer storms
More frequent major storm events
More days of extreme fire risk weather
More bushfire prone regions, extending to peri-urban parts of major cities
Changed weather and fire patterns
Fewer frosts, and in some places elimination of frosts completely
Many more days above 30°C and double the number of days above 35°C
Higher summer rainfall with more intense rainfall events
Flooding of lowland coastal areas – probably minor
For every one degree that temperatures rise, the snowline rises 100m
Agricultural productivity will change, in some cases improving
Some crops will not be grown but others become viable
Housing and building construction processes will change
Energy demands and patterns of use will alter

The space required for the support of urban vegetation

A number of different research reports detail the below ground volumes of soil that are required to support trees of different sizes and species (Craul 1992, Perry 1994, Roberts et al 2006, Urban 2008) Depending on the depth the of soil available, the open area of soil that is required to support the water, aeration and nutrient requirements of tree varies. However, there is a remarkable consistency in the volumes that the different research of concluded are necessary for healthy tree growth (Perry 1994).

The variation in soil type and tree species characteristics makes it difficult to be accurate in the soil volumes required. However, for a medium sized tree that grows to a mature height of approximately 8-10m and with a diameter at breast height of 300mm, the

volume of soil required to maintain a healthy and attractive is approximately $30m^3$ (Perry 1994).

If the estimate of $30m^3$ is applied to the soils in parts of Melbourne, which vary in depth, but are often less than 0.5 m, the minimum open surface area required to support a medium sized tree would be approximately 60 m^2. Smaller trees would required a lesser volume and to some degree trees have the capacity for sharing root space and so two trees can often survive in a smaller volume than would be calculated for each alone. However, to do so, the rate of water infiltration into the soil must sufficient to meet the trees' requirements for water. Other factors such as soil type, soil aeration and drainage can all influence the volume of soil required by trees growing in urban areas.

A brief summary of the value of some of the services provided by urban trees and greenspace

In this paper the economic value provided by a population of an urban forest of 100,000 mature trees is calculated. The number of 100,000 was chosen as it is often about the number of mature trees managed by a single municipality. There are also some examples of economic value provided by trees in a typical; suburban garden

Shade

The shade provided by trees and the impact of evapotranspiration can lower temperatures by up to 8C, reducing air conditioner use and carbon emissions. Large mature trees are particularly effective because of the large area of shade that they provide. Estimates put the savings at between 12-15% per annum. One of the major economic benefits of shade in the context of the Australian climate is reduced air temperatures which then reduces the use of air conditioners. This not only saves on electricity use but since much of the power in Australia is generated by coal also reduces carbon emissions (Fisher, 2007).

Furthermore, in the generation of electricity from brown coal approximately 100L of water is used in the production of 1.0 KWh of electricity (Fisher, 2007). So the shade provided by trees can also generate a saving of water (Table 3). The shade from each tree saves 30kWh of electricity per annum so an urban forest of 100,000 trees saves some 3millionkWH per annum.

Carbon Sequestration

Mature trees are significant sinks of carbon sequestering atmospheric carbon dioxide for long periods of time. While young trees sequester carbon at a greater rate than older trees, it can take over twenty years before 10-20 younger trees planted as replacements for a mature tree sequester equivalent carbon. The amount of Carbon in a mature tree of 100t total fresh weight for foliage, trunk and root system is approximately 10t.assuming an 80% dry weight and carbon constituting some 50% of the dry matter (Table 4). Using estimates for 100,000 mature trees, there are about a million tonnes of carbon sequestered in the tree population alone, not to mention that sequestered by associated organisms such as mycorrhizae and microflora (Table 4). To calculate the amount of carbon dioxide sequestered simply multiply the weight of carbon by 3.67.

Table 3: Economic value of shade from an urban forest of 100,000 trees.

Approximations used	**Value**
Number of trees in the urban forest population	**100,000**
Electricity saving due to shade per tree per annum (kWh per annum)	**30**
Total electricity saving per annum (kWh)	**3 million**
Value of electricity per kWh AUD$	**0.17**
Total value of electricity saving per annum (AUD$)	**510,000**
Value of savings in electricity use per annum for one tree(AUD$)	**5.10**
Water saved by reduced electricity use at 100L per kWH (L)	**300 million**
Total value of water saved at $1.50 per kilolitre per annum (AUD$)	**450.000**
Value of savings in water use per annum for one tree(AUD$)	**4.50**
Total value of savings in electricity and water use per annum (AUD$)	**960.000**
Value of savings in electricity and water use per annum for one tree(AUD$)	**9.60**

Prolonging the useful life of pavements

Bitumen is a super cooled liquid, like glass. It is mixed with solvents which can evaporate under the hot and sunny conditions typical of south eastern Australia. This renders the surface of the tarmac crumbly as the asphalt degrades quite rapidly and reduces the useful life of the pavement. The presence of shade from large, older trees can increase the useful life of asphalt pavement by at least 50%. It is conceded that only when extensive contiguous shade occurs that the savings are realized in the prolongation of the useful life of the bitumen (Table 5).

Land stabilization

After the recent fires in the State of Victoria a large number of trees were cleared from building sites. On one site when it came to rebuilding after the fire, insurance companies would not insure the site because it was classed as unstable due to the risk of landslip. At least 5 large, mature trees had been removed from the site. Younger trees also stabilize soil, but you need many more of them and it still takes between 10 and 20 years to get the benefits provided by mature trees. To stabilize the site engineering techniques such as piling were used, costing between AUD$40-60,000. Given this scenario, each of the five large trees was providing a total value of $10.000 to the site.

Value of Shade in Schools and other Public Buildings

After the 2009 wild fires in Victoria, the government moved to take action in schools located in designated bush fire regions of the State to make them more fire safe. The guidelines required the removal of trees that were closer than 30m to school buildings. Consequently during the holiday period large trees were removed from a number of schools. One tree was removed from the middle of a large area of tarmac and several were removed from around sporting ovals and plays areas. In these cases the fire risks posed by the trees were minimal. On the first hot and sunny days of late October and November, it became obvious that there was a problem. Without the trees there was no

shade and under the Australian summer this posed serious health risks such as sunburn, heat stroke and skin cancer. The remedy was simple and expensive – the installation of shade sails. Some of the larger mature trees provide shade that was the equivalent to four or more shade sails.

The impact of Urban Tree on Property Value

It has been estimated that a good tree in a good front garden can add some $5,000 to domestic property values, and others put the value as high as $50,000 or 5% of the property value (Dwyer et al. 1992; Boyd 2010). Turf Australia after surveying 114 estate agents across the nation, estimated that people were prepared to pay an additional $75000 for a house with a green lawn (Williams 2014). There is also a strong likelihood of having a positive return if you spend wisely on landscaping (Anderson 2012). It is clear that the real estate industry does recognize the value that trees, both specifically and generally, add to properties (Anon 2010).

A Planet Ark (2014) survey, Valuing Trees: What is Nature Worth, reported that for a house valued at $500,000 Australians would be prepared to pay an extra $35,000 for a house in a green and leafy area and 34% would be prepared to pay an extra $100,000. Other survey results were that 73% of Australians want a backyard and that for 57% of respondents, having a park within a 5-10 minute walk of their home is important to them. Earlier work had estimated that a tree-lined nature strip added 30% to properties in streets that had trees compared to similar houses on treeless streets just two streets away (Gonzalez 2007).

In many of green and leafy suburbs, townhouses and multi-unit developments built on large blocks once full of mature trees ignore the community's valued, local character. Property prices have been affected by these tree removals and tree felling has an effect on the value of properties, particularly in areas known for their leafy character (Gonzalez 2007). There is also an indirect but significant financial benefit for a local council in increased house prices. Residents prefer leafy tree-lined streets with large specimens and the higher prices for these properties are reflected in the council property rates that are linked to the value of the property.

Figure 4. Estimates of various environmental economic values for 100,000 large mature urban trees growing in an Australian city (modified from Moore 2009b)

Parameter	Value per tree	Quantity	Unit Price AUD$	Value AUD$	Reference
Carbon sequestered in trees	12.5 tonne	1.25million tonne	$20 per t	$25 million	Moore 2009
Street Tree value	$ AUD 200per annum			$20million per annum	Killicoat et al 2002
Electricity	30KWh	3 million	$0.17 per	$510,000 per	Fisher 2007

saving		kWh	kWh	annum	
Carbon emissions saved	1.2Kg for each kWH	3,600 tonne	$20 per t	$72,000 per annum	Moore
Water saving from electricity generation	30 kWh per tree at 100L per kWh	300 mill L	$1.50 per kilolitre	$450000	Moore

Notes on estimations and calculations:

- the estimate of 12.5 tonne is for a large mature urban tree
- the price of AUD$20 per tonne is based on the Australian carbon market price
- the electricity saving is based on reduced energy use due to shade from trees
- the price used for electricity is based on a rounded Victorian rate per kWh
- value of prolonged bitumen is based on an extended life from 20 to 30 years
- 100L of water is used to generate each kWh by brown coal powered generators
- water valued at $1.50 per kilolitre
- assumes tree canopy of 75m^2 shading bitumen covering 30% of its canopy area

Table 5: Value of shade for an urban street lined by 100 trees prolonging the life of bitumen.

Approximations used	**Value**
Estimated length of street (m)	**500**
Width of road surface (m)	**7**
Area of Bitumen road surface (m^2)	**3500**
50 trees on each side of the street so total number of trees	**100**
Shade from an individual tree canopy (m^2)	**75**
Area of bitumen shaded by tree canopy, estimated at 33% of total (m^2)	**37.3**
Total area of bitumen shaded by tree population of 100 trees (m^2)	**3,730**
Cost of resurfacing bitumen per m^2 (AUD$)	**110.00**
Total value of extending the life of the shaded bitumen from 20 to 30 years due to the 33% shade from 100 trees (AUD$)	**410,300**

Extra deaths/Hospital costs

There are many studies that document the benefits that greenspace and trees in particular have in improving human heath, extending life spans, reducing violence and vandalism, lowering blood pressure and saving society a fortune on medical and social infrastructure costs. Recent studies (Tapper 2010) have suggested that the wise use of water and vegetated urban landscapes can reduce excess deaths during heat waves such as those experienced in Melbourne in the summer of 2008-9 (Table 6). Parts of cities such as the western suburbs of Melbourne are hotter as they are drier and less well vegetated, and it is in these suburbs that excess deaths of people over 65 years of age will be greatest. So how we use water within and manage urban landscapes really is a matter of life on death.

Table 6: Heat wave related deaths in urban climates (modified from Tapper, 2010).

Definition of heatwave (No formal definition)	BoM: "prolonged period of excessive heat"
	Largest cause of death from a natural event
Examples	Most famous large event – Europe 2003
	Up to 35000 excess deaths
	Indicative of what might happen with climate change
Where deaths occur	Natural & built landscapes affect heat loads
	Demographic, health and socio-economic status influence outcomes
	In Melbourne greatest number of deaths in the western and northern suburbs
	374 excess deaths (Jan26-Feb 1 2009)
	66% of such deaths in 75+ age group

Other benefits provided by trees

What is the value of reduced wind speeds of up to 10% due to the presence of trees under a climate change scenario when winds will be stronger? What role might this play in bushfire management, especially at a time when so few are considering the positive role that vegetation and especially larger trees can have in managing fire behaviour? These large trees can moderate the strength of the wind and also limit the swirling of the wind which can be of benefit to fire fighting.

There is also the role of trees and public open space under a changed climate in holding and absorbing water during intense rainfall events (Table 7). Such a role has profound implications for the behaviour of storm water systems in cities. Large trees are particularly effective in local flood mitigation due to their large roots systems their capacity to hold rainwater on their canopies, and through transpiration significantly reducing the amount of water entering drains. Furthermore, tree root systems act as effective biofilters of the stormwater before it enters watertables or river systems (Denman et al, 2006).

The benefits of urban trees and landscapes already mentioned have not included how gardens improve human heath, extend life spans, reduce violence and vandalism, lower blood pressure and save our society a fortune on medical and social infrastructure costs.

Table 7: Some of the many benefits that tree provide in your garden

Shade can reduce roof temperatures by up to 8C. This cools the house in summer and reduces air conditioner use and electricity consumption	Vegetation cools the area around your home. This reduces the urban heat island effect (UHI), cools cities and saves on water and electricity consumption
Trees can reduce storm wind speeds reducing the damage to roofs and other structures during storms	Absorption of water can reduce the risks of local flooding and removes the need for larger storm water gutters and pipes

Trees stabilise soil on steeply sloped blocks of land reducing building cost by thousands of dollars	Plants help off-set your carbon emissions and so reduce your contribution to the greenhouse effect and global warming
Trees remove airborne pollutants and humidify air, which can help reduce the effects of hayfever and asthma	Vegetation increases urban biodiversity so that there is more urban wildlife
Vegetation provides many human health benefits, such as reducing blood pressure, and improving the quality and longevity of life	Vegetation provides social benefits. Green and leafy suburbs tend to have lower rates of vandalism, violence and graffiti
Vegetation, especially trees, encourages both active a passive recreation by residents and so lower health costs	The shade provide by trees lowers water evaporation from the soil saving water and helping to further reduce the UHI

It is often forgotten that the major cities of Australia are biodiversity hot spots (Daniels and Tait 2005). The parks, gardens, streets and front and backyards provide a very diverse range of plant species that generate a myriad of habitats and niches for wildlife such as birds and mammals, reptiles, spiders and insects. There is also a diverse range of soil types that contribute to massive soil microflora and fauna. High density urban developments and inner city renewal make it virtually impossible to grow trees in places that were once green and leafy. The real and full costs of such developments are rarely ever calculated.

CONCLUSION

Mature trees will continue to have a significant place in urban landscapes and they must be managed to ensure that they remain healthy and fulfill the full potential of their lifespans. Governments at all levels and through their agencies are still major clearers of trees and ecosystems. In most States approaches to road side vegetation at a time of climate change are inappropriate. Trees in private gardens, parks and roadsides provide contiguous ecosystems that are assets that fix carbon, provide shade, filter air, protect from wind, and provide wildlife corridors and habitat. They must be protected by local government to maximize value, optimise their useful life and contribute to efficient and sustainable urban environs. What will happen in suburbs, which occur in all major cities, where housing development has been so intense that there is no capacity to plant trees on house blocks, and where streets are so narrow that street trees that have been planted will not be able to mature as they will inevitably restrict emergency vehicle access?

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INACCURACIES AND ADDITIONAL MATTERS.

To my knowledge, there are no inaccuracies in this report. I have made all the enquiries that I believe are desirable and appropriate and that no matters of significance, which I regard as relevant, have to my knowledge been withheld from the Panel.

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