# Urban Trees: Worth More Than They Cost

G M Moore

Research Associate, Burnley College, University of Melbourne, 500 Yarra Boulevard, Richmond Victoria 3021

**ABSTRACT**:

Trees are major urban infrastructure assets. While costs, and the damage and nuisance values attributed to trees are widely known, the benefits they provide are often subtle and under-appreciated. Cities are biodiversity hot spots due to the variety of habitats 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. In many of these situations there is insufficient open space - public or private - for the planting of large trees and so the opportunities for the role of vegetation in ameliorating the heat island effect, reducing wind speed, providing shade and reducing energy use are reduced. This outcome raises questions about the economic viability of such developments, as well as their long term environmental sustainability.

Trees provide economic and ecological services benefits to society. They are assets which warrant the expenditure of resources such as labour, energy and water. Such expenditure is not wasted as trees and urban landscapes provide more economically and ecologically than they use. In any comprehensive and fair calculation urban trees and landscapes are worth more than they cost.

**INTRODUCTION:**

Mature 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 managing, conserving and preserving these trees. 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. There has also been significant water allocated to their growth and development. They are community assets in every sense of the word – society has invested resources in their establishment and management, and they have matured as assets and are now returning great and diverse benefits (Moore 1997) to society in return.

For trees growing in parks and gardens there must be proper inventories that are computer-based, providing full and comprehensive information on the specimen, including its identity, location, age, condition and monetary value amongst other important details. A monetary value must be assigned to a tree using an acceptable amenity tree valuation program. This value raises the status of the tree to that of an asset, and allows for the proper recognition of trees in the decision making processes by those who may fail to recognize the inherent value of the tree.

In an analysis of Urban Tree Cover in Melbourne, Mullaly (2000) used aerial photographs to estimate changes in the cover of an inner suburb - a part of Richmond, now in the City of Yarra-and an eastern suburb – a part of Balwyn, now in the City of Boroondara. Aerial photographs from 1993 were compared with those from the year 2000 (Table 1). There was a reduction in overall canopy cover of 2% in Richmond and 7% in Balwyn. While the reduction in cover was anticipated it was not expected that the reduction would be greater in the outer compared with the inner suburb. These results suggest that whilst there is recognition of loss of cover in inner city urban renewal, changes in the vegetation cover of other suburbs should not be underestimated.

**Table 1: Changes in tree cover for developed and undeveloped land in Richmond and Balwyn between 1993 and 2000 (Modified from Mullaly 2000)**

| LAND TYPE | OWNERSHIP OF LAND | BALWYN | | | RICHMOND | | |
|---|---|---|---|---|---|---|---|
| **Developed Land** | | **1993** | **2000** | **CHANGE** | **1993** | **2000** | **CHANGE** |
| | PRIVATE | 19.23 | 10.49 | -8.24 | 7.01 | 5.17 | -1.84 |
| | PUBLIC | 3.45 | 4.65 | 1.20 | 2.65 | 2.12 | -0.43 |
| | **TOTAL** | 22.68 | 15.64 | **-7.04** | 9.66 | 7.39 | **-2.27** |
| **Undeveloped Land** | | | | | | | |
| | PRIVATE | 20.00 | 17.47 | -2.53 | 5.89 | 5.78 | -0.11 |
| | PUBLIC | 6.25 | 7.81 | 1.56 | 2.84 | 5.45 | 2.61 |
| | **TOTAL** | 26.25 | 25.28 | **-0.97** | 8.73 | 11.23 | **2.50** |

Upon further analysis (Table 1) it was noted that Balwyn had approximately 2.5 times more foliage cover per unit area in developed open space than Richmond in 1993. This would suggest that there has been a significant loss of tree cover in Balwyn and that a 7% loss represents a substantial change in this part of Melbourne. This loss of trees, however, is not as noticeable as in many parts of cities as there are still many substantial trees remaining. A 2% loss in the City of Richmond may seem almost insignificant. However, given the relatively low levels of cover, even 2% can make a substantial difference.

The initial assumption that little had changed in Richmond was proved to be further unjustified when the percentage of cover was related to land ownership. The analysis showed that there had been a considerable loss of cover in Richmond on privately owned property, but that this had been compensated for by significant tree planting in the public open space (Mullaly 2000). Significant losses of trees on private property due to intense high-density housing development had been compensated for, to some degree, by the planting of trees in local streets and parks. However many of the spaces suitable for planting larger specimen trees on public land had already been utilized, and as further high density inner city development proceeds, the loss of trees on private open space is unlikely to be compensated for by public planting.

The significance of these changes in a mere seven years should not be underestimated. These trends will have a profound influence in inner and outer city suburbs, and similar trends are likely in other Australian cities. It is ironic that at a time when the environment and climate change are major matters of public concern, in cities public and private open spaces are reducing and vegetation cover is depleted.

**CLIMATE CHANGE, TREES and LANDSCAPES**

The current drought affecting south eastern Australia is into its thirteenth year, and there have been major storm events in most States in each of the past three years. In parts of southern Australia, there has not been a dry period like it in recorded history. 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 current dry period and recent storm events are likely to indicate the climate changes that are to come, and which will be a permanent part of our environmental conditions (Table 2).

**Table 2: Current data trends on global warming and predictions of the likely outcomes for climate and sea level related changes (Moore 2009a).**

| FACTOR | HOW ARE WE 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 |
| Sea levels | Have risen by 3mm per annum for the past 15 years | Consistent with higher sea level predictions |
| Atmospheric $CO_2$ levels | These are above the predicted worst case scenario and could exceed 1000ppm | This suggests atmospheric temperature rises of 6-8°C |
| 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 2013 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 |

Regardless of how things eventually pan out, chronic drought and the possibility of more permanent global climate change are 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 (Moore 2006). 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 3). Storm events that were once considered one in one hundred year or one in thirty year events are likely to occur perhaps every decade or even annually.

**Table 3: Likely outcomes from climate related changes in south eastern Australia.**

| |
|---|
| 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 30C and double the number of days above 35c |
| Higher summer rainfall with more intense rainfall events |
| Flooding of lowland coastal areas – probably minor |
| For every one degree 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 |

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 due to falling trees and branches. Such incidents have attracted major media coverage, and the events are often described as an *Act of God* or perhaps an example of the *Fury of Mother Nature*. Such descriptions allow authorities to dodge the responsibility of managing the consequences of such events, and minimize the opportunities for learning from extreme weather events. There is also the common and predictable public demand for urban tree removal.

However these events should have been used to inform management practices that might be appropriate under a changed climate scenario, where the undergrounding of services, particularly in areas of high population density should be adopted immediately. It is curious that undergrounding of services is often opposed on the grounds of its high installation cost. However, not undergrounding is simply too costly to society to be maintained for much longer into the future under a changed climate.

It has long been argued that if installation and long term maintenance costs are considered then, undergrounding is cost effective. 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, in others States installation is by State Governments and maintenance by local governments and in yet other States there are even greater numbers of entities involved. Such an arrangement is simply untenable, because Australian society cannot afford such a regime which is economically and environmentally unsustainable. Perhaps it is also time to note that costs to government and costs to society are not necessarily the same thing.

Recent and tragic bushfires in New South Wales, Canberra and Victoria have raised many concerns about tree management and infrastructure. While the findings of the Victorian Royal Commission into the 2009 bushfires are yet to be finalized or released, there would be few who could argue that undergrounding of electricity services would not have been an advantage during these terrible fires. Sadly it would seem that yet another opportunity to manage the vegetation/infrastructure interface in a way that is appropriate to a future and changed climate is to be lost. The above ground cabling has been replaced, just as it was, and the chance for a modern, safer, underground system appears to have been lost.

**CITIES AND TREE VALUE:**

Urban trees and landscapes are assets that require the expenditure of resources – labour, energy, and even water - on their proper management. The question that might be asked: “What is the value of the benefits that are provided by trees? Or perhaps what does society get in return?” (Table 4). What is the value of shade provided by trees that drop temperatures by up to 8C, reduce air conditioner use and reduce carbon emissions? Estimates put the savings at between 12-15% per annum. Manchester University’s Adaptation Strategies for Climate Change in the Urban Environment Project has found increasing green space in cities by 10% reduces surface temperatures by 4°C due to water evaporating into the air from trees and other vegetation (Fisher 2007).

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 can have in managing fire behaviour? The presence of shady trees can increase the useful life of asphalt pavement by at least 30%, which can be of considerable value in the hot climate of Australia, where asphalt degrades quite rapidly. Little scientific research work has been done in Australia on these benefits from vegetation and there is even less economic data to inform decisions.

What is the value of the pollutants removed from the air of Australian cities? In New York in 1994 the value of the city’s trees in removing pollutants was estimated at US$10 million per annum. Planting 11 million trees in the Los Angeles basin saves US$50 million per annum on air conditioning bills. Still the only Australian study of its kind by economists notes that an Adelaide street tree provides a minimum annual benefit of about $200 per year, noting that it is an under-estimate of real value (Killicoat, Puzio and Stringer, 2002). The value returned to the City of Melbourne by its approximately 70 thousand public trees alone it would be more than $14 million per annum. Other studies show a cost/benefit ratio of 1 to 6 in favour of urban trees and landscapes.

There is also the role of trees and public open space under a changed climate in holding and absorbing water during intense rainfall events. Such a role has profound implications for the behaviour of storm water systems in cities. What is their value in reducing localized flooding?  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.

**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 saving | 30KWh | 3 million kWh | $0.17 per kWh | $510,000 per annum | Fisher 2007 |
| 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 | $45000 | Moore |
| Prolonged life of bitumen footpaths | $450 per $m^2$ for life of 20 years | | $225 per $m^2$ for an extended life of 50% (10 years) | $47,250,000 | 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 $1.50 per kilolitre
- assumes tree canopy of 75$m^2$ shading bitumen covering 30% of its canopy area

A recent Australian National University study found that suburban street trees were more effective than native forests at capturing carbon because of their relative youth. The study was commissioned by the Australian Capitol Territory Government as part of refining its climate change strategy and was the first time carbon stocks and carbon storage rates have been measured for an entire state or territory (ABC News 2009).

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. So if urban trees and landscapes are lost because politicians don’t think they are worthy of some of our resources society could pay a very high price indeed. It is lucky that as we let the turf in our parks and ovals die that we don't have a problem with children lacking exercise and becoming obese. If we did, we might be paying a far higher price than was ever dreamed possible – society won't know what it's got till it's gone!

As the populations of Australia and its major cities continue to grow, by the year 2050, the pressure on public open space will be enormous. There will be a tendency for politicians and bureaucrats to see any open space whether public or private as ornamental and therefore ripe for development. However, these cities will only be sustainable if the open space is sufficient to balance the resource demands of a modern society.

It is often forgotten that the major cities of Australia are biodiversity hot spots (Roetman and Daniels 2008). 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.

## ARBORICULTURE AND URBAN FORESTRY: A MATTER OF SEMANTICS?

It is interesting that at present the phrase *urban forestry* is often used as a synonym for *arboriculture*. However, the terms do have different meanings and while the semantics may not be of interest to urban tree managers, the consequences for tree management and urban tree populations might be. It should be remembered that in Australia arboriculture and urban forestry come from different traditions that are underpinned by different, and sometimes conflicting, philosophies. Urban forestry comes from a forestry tradition of managing groups of trees for their production values, while arboriculture comes from a horticultural tradition that focuses on tree as a specimen.

Both approaches have value and application in the management of urban trees, as the discussion of the loss of urban tree cover in Balwyn and Richmond illustrates. This study used an urban forestry paradigm as well as a classic aerial forestry analytical technique. However, there is a need for a word of caution about the use of the term "urban forestry" in relation to urban trees. In focusing on the urban forest it is easy for the importance of the individual specimen to be minimized and undervalued, which could see the removal of individual trees as long as the forest is maintained. Clearly neglecting the removal of single trees could see the forest as a whole reduced as a consequence, but the arboricultural focus on the specimen ensures that the forest is undiminished.

While this paper is not the place for a lengthy discussion of the differences in the philosophies supporting *arboriculture* and *urban forestry*, it is worth remembering that they can lead to quite different outcomes in urban tree management. Both have their place and application, and at present they often aspire to the same goals in the face of climate change and urban development. However, the terms should be applied knowledgeably and in the appropriate environmental context.

**WATER, DROUGHT AND CHANGED WEATHER PATTERNS**

There has been huge public interest in efficient and effective water use and conservation. In many parts of south eastern Australia, restrictions to water use have been applied to urban gardens, parks and streetscapes and these have placed the vegetation under considerable stress. There have been debates about whether trees –native or exotic- should be irrigated over the summer, and suggestions that perhaps the drought should take its course and consequently trees could be left to die. This is neither asset nor environmental management! Our knowledge of trees and particularly their root biology can be applied to effective and efficient management practices.

Effective and efficient use of water is both wise and sustainable. Subsurface irrigation under mulch early in the morning provides water at a time when it is most needed by trees. They photosynthesise most in the morning and in many species stomata are often closed by about 2.00 pm especially if soil water is limiting. Furthermore for many species evapotranspiration cools them reducing the risks of heat damage especially on hot windy days, the frequency of which is likely to increase under climate change.

In most States, however, water restrictions seem to assign a low or zero value to potable water released to the environment (Fisher 2007). This ignores the economic value of the ecological services that urban vegetation provides and which can lessen the carbon footprint of cities (Fisher 2007). The water used to maintain trees and urban landscapes during drought and summer is neither wasted nor lost. It returns real economic and sustainable value in the years ahead.

Despite the current, popular view that turf and lawns are profligate water users and are unsustainable in the Australian environment, natural turf is usually a more sustainable option than sealed surfaces or artificial turf if you consider the latter’s fossil fuel chemical base and imbedded energy. Turf is quite a complex ecosystem that has a significant effect on temperature and the heat island effect, and if properly managed also sequesters a considerable amount of carbon. Perhaps it is not the villain that many think it is when they consider only the water component of a more complex equation.

Consider the following scenario. In a small backyard the lawn (8 x 4m) has been replaced with artificial turf at a cost of $6000. The owner has done so because they have heard that lawn is not good for water use or the environment. The artificial turf is made from fossil fuel, imported from overseas and has high embedded energy. The purchase and installation of a locally made 5000L tank would cost $1200 and provide enough water for such a small lawn year round. Already the owner misses the birds that used to come fossicking in the lawn. Her local council is also replacing a turf oval, which they cannot irrigate due to local water authority restrictions, with artificial turf. They are doing so as part of their water policy. However, the product is imported with high embedded energy and carbon, and the council is not harvesting the water that runs off or passes through the new artificial turf surface. Efficient irrigation and water recycling and a water efficient native grass would be a far more sustainable option for a low use oval. The council has also used couch grass on many of its other sporting ovals, unaware that its high binding strength could cause serious knee injuries to teenage football, hockey or cricket players.

Trees and urban landscapes are assets in every sense of the word and resources for allocated for their proper and sustained management. Amongst these resources may be the need for an allocation of water, used wisely and sustainably. If the focus is solely on water such that trees and other vegetation are left to die, then consequently the carbon that they sequester would be released into the atmosphere. It has been estimated that some 10% of the inner city of Melbourne trees are drought stressed and at risk of death, and that for the city more broadly 15% of trees are at risk. Should these trees die it would represent a massive loss of sequestered carbon. Such an outcome would be environmentally irresponsible, and highlights the need for those managing urban vegetation to appreciate the larger environmental picture.

## 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. As climate changes, the impact of vegetation on stormwater runoff could save billions of dollars in infrastructure costs to Australia's cities. It is not economically possible to retrofit larger stormwater drains and alter the levels at which they enter waterways. However, trees hold rainwater on their canopies, and through transpiration significantly reduce the amount of water entering drains. Estimates suggest that trees may hold up to 40% of the rain water that impacts on them and that as little as 40% of water striking trees may enter drains. Furthermore, tree root systems may act as effective biofilters of the storm water before it enters watertables or river systems (Denman 2006).

Given that carbon dioxide is the most significant of the greenhouse gases, especially for the states of South Eastern Australia, and considerable electricity is derived from coal powered generators. The public is becoming increasingly aware that power generation is producing large volumes of greenhouse emissions and that the clearing of trees for powerlines and general tree pruning is reducing the level of carbon sequestered in the canopy structures of urban trees. Thus the power generating and distribution companies and authorities are compounding their contributions to the greenhouse effect and global warming. On the one hand they are major greenhouse gas emitters, and on the other they are causing significant carbon losses by their line clearing activities. Line clearing compounds the negative effects of power generation on greenhouse gas production.

Governments through their agencies are still major clearers of trees, forests and ecosystems. In most States approaches to road side vegetation at a time of climate change are inappropriate. Trees and roadside ecosystems are assets that fix carbon, provide shade, filter air and protect from wind, and provide wildlife corridors and habitat just to mention a few of the obvious benefits. Are these benefits properly costed for road related projects where a balance of safety, cost and the environment has to be achieved? It is to be hoped that an old-fashioned engineering philosophy to trees and the environment that is as inflexible as concrete is no longer the reigning paradigm at a time of climate change. However, roadside vegetation is still being cleared right across the country, despite the fact that it sequesters massive amounts of carbon that could be used to partially offset the carbon produced by the vehicles that use the roads. Once again it is clear that the real and full economics of the situation have not been properly considered.

It is highly likely that the Australian Government will become a signatory to the post-Kyoto successor. Consequently, it would seem that the present situation, which often substantially undervalues trees and urban vegetation, will change once the impact of the protocols on greenhouse gas emissions are recognized. The economic algorithms and paradigms that have applied to the management of trees and public open space in urban environments are changing rapidly. As a consequence the economic imperatives that apply to managing trees will change under a thorough cost/benefit analysis.

The future role of trees in the urban landscape, and indeed of public and private open space are being redefined by those who have little interest or expertise in urban vegetation management and are driven by other imperatives. It is time to address some of these issues before changes are made that degrade the landscape, and which could take decades to remedy. This is the century of the environment and the value of urban trees and vegetation will rise, simply because they provide more than they cost. As a truly Australian urban landscape, which values trees and recognizes aridity and changed climate, emerges, it will be understood that urban trees and landscapes are worth much more than they cost and that they are the keys to urban sustainability.

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