TREE MANAGEMENT FOR CARBON, ENERGY AND DROUGHT EFFICIENCY

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INTRODUCTION

At the Treenet Symposium in 2006, the issue of the greenhouse effect and climate change were major topics of the opening session (Moore, 2006). However, it is unlikely that anyone attending the conference could have anticipated or predicted that the social, political and economic climates surrounding the issues would change so rapidly.

The rapidity of these changes has seen a focus on the greenhouse effect, climate change, carbon and the overall energy balances associated with urban living. Clearly, all of these matters have implications for urban tree management, and the place that trees have in streets, parks and gardens. This brief paper builds upon papers that have been presented at earlier Treenet Symposia, and addresses aspects of tree management that need serious consideration under the new decision making regimes that are rapidly emerging as a result of the general awareness of climate change and energy management.

MANAGING TREES UNDER THESE CHANGING CONDITIONS

The attitude of many Australian citizens to urban trees still seems to be that they are decorative items which are optional in the urban environment. This completely underestimates the many functional roles that mature trees play in created and natural landscapes. These functional roles have been underestimated in the past to the social, environmental and economic peril of those societies, which failed to appreciate that the trees are assets performing important functional roles, often over very long periods of time.

The costs associated with trees in urban landscapes are often well known but their real direct and indirect benefits are rarely fully valued. Economists, driven by the huge real costs of damage to the environment, and the costs of attempting environmental amelioration and rehabilitation, are only now starting to redress this problem and put balance back into the economic models. The impact of trees on the urban microclimate and city infrastructure are being recognized (Table 1). The role of trees as filters for pollutants, improving the quality of air, reducing wind speed and influencing water infiltration and absorption are the subject of research (Finnigan 1994). The presence of shady trees can increase the useful life of asphalt pavement by 30% (Killicoat, Puzio and Stringer, 2002).

While the Kyoto Protocol does not apply to urban vegetation, it has altered the political environment surrounding urban vegetation, and should see the value of urban vegetation increase. It is possible that the post-Kyoto protocol will include urban vegetation. It is also important to realize that there is a very strong relationship between vegetation and energy efficiency, so that trees will have a vital role in addressing issues related to energy balance. Thus there is an opportunity to increase the public awareness of trees in cities, an opportunity to have the real value of urban vegetation calculated and recognized, and the potential to significantly affect decision making processes.

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 the trees.

Table 1: Climate and environmental values associated with mature trees (After Grey and Deneke, 1978: Anon, 1989: Harris, 1992: Finnigan, 1994, Moore, 1997)

Climate related values:	**Environmental values:**
• Shade • Shelter from the wind • Thermal insulation • Temperature modification • Reduction in glare • Interception of rainfall • Humidification of the air • Filtration of polluted air • Reduced water runoff • Reduced stream turbidity • Altered effective precipitation	• Production of Oxygen • Fixing of Carbon Dioxide • Reduced soil erosion • Improved edaphic environment • Protecting watersheds • Ameliorating windflow • Improved air quality • Altering ambient temperature • Noise abatement • Wildlife habitat • Create ecosystems

In the urban context of this conference, considerable human effort and time has been expended on the trees as well as a great deal of real energy in the form of fossils fuels that has underpinned their maintenance. There have also been significant water resources 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.

TREES AND CARBON BALANCE

Mature trees are significant sinks of carbon and sequester atmospheric carbon dioxide for very long periods of time. Should the trees die, the carbon which is the major element of their structure would be released to the atmosphere making matters significantly worse (Table 2). Using rounded estimates for the City of Melbourne (Moore, 2007), the masses involved were calculated. There are at least 100,000 mature trees in the inner city area alone, and each weighs approximately 100t. Of this weight about 80% is water, leaving about 20t of structural mass, of which about 50% or 10t is carbon. Thus there are about a million tonnes of carbon sequestered in these inner city trees alone, not to mention that sequestered by associated organisms.

Table 2: Carbon fixed in Urban trees in inner Melbourne.

Approximations used	**Value**
Estimated number of trees in private and public open space in inner Melbourne	**100,000**
Average weight of whole tree, including above and below ground components (t)	**100**
Water content (%) of tree (approximation)	**80**
Dry matter mass of trees (%) (varies so conservative estimate)	**20**
Carbon content of dry matter (%) (varies so conservative estimate)	**50**
Amount of carbon sequestered in each tree (t)	**10**
Total carbon sequestered in urban trees of inner Melbourne (t)	**1,000,000**

If we take these calculations further, it can be calculated what effect pruning such mature trees for construction, or installation of utility services such as powerlines or communication cables, might have in terms of Carbon (Table 3). Different pruning regimes remove different proportions of the canopy, and so data for 30, 20 and 10% canopy reductions are shown.

Table 3: Carbon lost in pruning mature urban trees canopies.

Approximations used	**Value**
Average weight of whole tree, including above and below ground components (t)	**100**
Amount of carbon sequestered in each tree (t)	**10**
Amount of carbon sequestered in the canopy of each tree (t)	**5**
Amount of carbon lost if 30% of canopy pruned from each tree (t)	**1.5**
Amount of carbon lost if 20% of canopy pruned from each tree (t)	**1**
Amount of carbon lost if 10% of canopy pruned from each tree (t)	**0.5**

Given that pruning contracts and operations managed by local governments usually involve hundreds or perhaps even thousands of trees, it is worth estimating overall carbon losses for 100 trees (Table 4). Furthermore, if you value carbon at AUD$10.00 per tonne, the significance of the losses becomes clearer. When these values are considered it becomes apparent that they could affect the economic value of pruning as a management tool, and could see the rapid move to underground services. This is especially so when costs for 3 and 5 year pruning cycles are calculated.

Table 4: Carbon lost and its value for pruning 100 mature urban trees canopies.

Approximations used	**Value**
Amount of carbon lost if 30% of canopy pruned for 100 trees (t)	**150**
Amount of carbon lost if 20% of canopy pruned for 100 tree (t)	**100**
Amount of carbon lost if 10% of canopy pruned for 100 tree (t)	**50**
Value of 1tonne of carbon $AUD	**10**
Value of carbon pruned from 100 trees when 30% pruned (AUD$)	**1500.00**
Value of carbon pruned from 100 trees when 20% pruned (AUD$)	**1000.00**
Value of carbon pruned from 100 trees when 10% pruned (AUD$)	**500.00**

It should be noted that similar calculations can be applied to root damage and loss when roots are severed for construction and utility installation. Clearly, installation of underground services must be done in a way that does not damage or remove root mass. Similarly, research could reveal the extent of root loss due to compaction and waterlogging and the loss of carbon that results. Its economic impact could then be calculated.

The calculations above have involved the deliberate use of conservative estimates so that there can be no accusations of inflating values to serve the arguments in favour of urban trees. There are many algorithms that can be used for carbon calculations, including those available from the Australian Greenhouse Office, and most of these will give a higher carbon value than the calculations above. It should also be noted that there is growing evidence that there has been a general and significant undervaluation of carbon fixed below ground by mycorrhizae and the other microbes associated with plant root systems. In short, values for tree related carbon are likely to be considerably higher than any of the algorithms currently in use have so far revealed.

DROUGHT AND CHANGED WEATHER PATTERNS

The current drought that has affected the south eastern part of Australia is unprecedented over the period for which we have data. The current drought has not been of the type described as acute, like that of 1983, but has been a chronic drought with below average rainfall month after month, and year after year. It is not known whether this drought is a part of a regular natural pattern that occurs over a longer period of time. It might be the one in five hundred year or perhaps the once in a millennium drought for example, but current meteorological data are too recent to reveal such patterns.

There has been huge public interest in efficient and effective water use and conservation. 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 (Table 5).

Table 5: Tree management imperatives at times of drought and climate change

- Since absorbing roots are near the soil surface, use this in management
- Plant trees in large mulched beds
- Mulch of any type is beneficial, but organic mulches have much to offer
- Large old trees must use significant amounts of water
- A few irrigations over summer will see trees through the driest periods of the year
- Focus on younger trees so that there are new generations of trees for the future
- Select trees wisely for the particular landscape role that is intended
- Consider water efficiency as part of any urban tree management program

Mature trees will have a significant place in urban landscapes of the future and they must be managed to ensure that they remain healthy and fulfill the full potential of their lifespans. Through recognizing tree structure, appropriate space must be provided for their canopies and root systems. This will reduce human interference with root systems in particular, leading to healthier, longer lived trees and lowered maintenance costs. Larger spaces to accommodate trees must be a part of sustainable urban design. Use of mulch cannot be an afterthought, which often leads to an eyesore, but rather must be an integral part of proper design. The needs of trees will be provided for in a way which is incorporated into the design of urban landscapes, so that the right much will be used and it will be integral to the ambience of the landscape.

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 drains and alter the levels at which they enter waterways, but trees not only hold rainwater on their canopies, but through transpirational water use reduce water entering drains significantly. 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, the root systems may act as effective biofilters in improving the quality of the storm water before it enters watertables or river systems (Denman 2006).

CONCLUSION

By way of concluding this brief paper, a short hypothetical case study is presented. A local school has recently briefed a well-known firm of architects for the construction of its new school buildings. The school has a very strong environmental ethos, and employed the architects who are known for their environmental and energy expertise. The design has been presented and the architects have done a fine job in taking into account climate, energy use and recycling. The building and its landscape have been integrated, and the architects are relying on the proper choice of trees to shade buildings in Summer, but allow sunlight to warm the school in Winter. Their calculations show that this could save between 12-15% of the building's heating/cooling and lighting energy budget.

The architects have thus sought horticultural advice on which species of deciduous trees they can consider for planting to meet their design requirements, but at the same time meeting the school's policy of planting only indigenous trees. The school has planted Australian native plants in the past and may consider native plants, if appropriate local indigenous trees are not available, and so the architects have alerted horticulturists that this may be an acceptable option.

The architects have already had *Brachychiton* species, *Melia azedarach* and perhaps some *Nothofagus* species suggested as possibilities. However, they have considered the list to be too short; the *Nothofagus* seems inappropriate because of its slow growth rate, the *Melia* problematic because of its hard fruits in a school environment and they have heard reports that *Brachychiton* often has uneven canopy development. So they want a wider range from which to choose.

Here the issues of native versus exotic, efficient energy use in urban design and the role of trees in urban landscapes under changing climatic conditions collide.

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