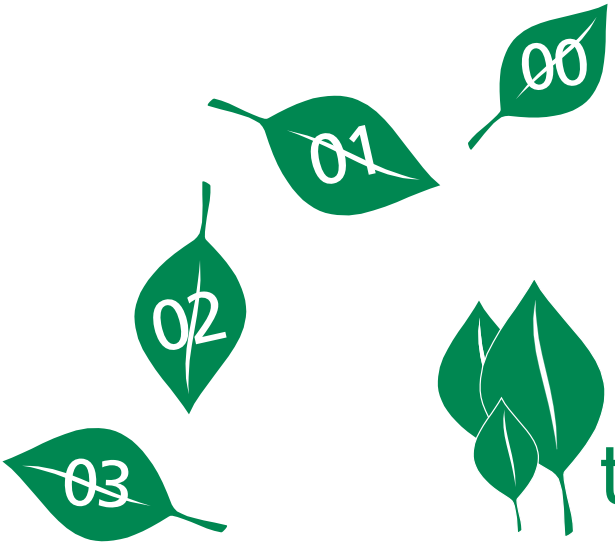

treenet

Proceedings of the

10th National Street Tree Symposium 2009

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JUDY FAKES

Judy Fakes (HRH arb)
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Judy was crowned Queen of TREENET at an official ceremony held in the National Wine Centre during the 6th National Street Tree Symposium in 2005. She has been teaching the practical and theoretical aspects of soils and arboriculture at Ryde for many years. She occasionally consults on tree related matters to councils to and government organisations. It has become very obvious to her that many tree problems are below ground so a good working knowledge of soils is indispensable to the arborist. Since her coronation, 'Queen Judy' regularly holds audience as Acting Commissioner in the Land and Environment Court of NSW. She is a member of the Management Committee of TREENET and much loved by her many loyal subjects. Long may She reign!

DR GREG MOORE

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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 had been 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 October 2002 to April 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 is recognised internationally as one of the founders of the modern arboricultural movement and is widely sought after as a speaker, advisor, advocate and mentor. His keynote papers at past Treenet Symposia have been a major catalyst for the recent changes in attitudes and practices relating to Australia's urban trees. His presentations are founded on his exceptional ability to pass onto his audience his thorough understanding of the subject at hand.

As Chair since 2005, Greg's other major contribution is the orderly and efficient governance he brings to TREENET. His ability to think strategically and his wide experience in the management of not for profit organisations has been called upon to the benefit of many environmental and educational causes over the past 30 years.

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 has been on the Board of Greening Australia (Victoria) since 1989 and has been an active member of various sub-committees of that organisation. He was involved with the Agriculture and Horticulture subject at VCE level setting several of the examinations. 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 eleven 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 one book, contributed to another and has had some 80 papers and articles relating to tree biology and management published.

TIM JOHNSON

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Tim Johnson has over 25 years experience in horticulture and arboriculture in both the private sector and local government. His interests include all aspects of urban forestry, particularly its integration into sustainable urban design and the interactions of trees, urban hydrology and built infrastructure. His current research project, titled *Trees, Stormwater, Soil and Civil Infrastructure, Synergies Towards Sustainable Urban Design for a Changing Climate*, investigates the relationships between tree and root growth, tree and soil moisture interaction, and permeable pavements.

PROFESSOR RANDY STRINGER

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Randy Stringer is Professor, School of Agriculture, Food and Wine at the University of Adelaide University where he teaches and conducts research on food, agriculture and natural resource policy. From 2002 to 2006, Randy was the Director of the Comparative Studies Service, Agricultural and Development Economics Division, United Nations Food and Agricultural Organization. He was the Deputy Director of the Centre for International Economic Studies from 1996 to 2001, where he managed research programs and lectured in the School of Economics, University of Adelaide. Over the past thirty years, he has taught, published and conducted research on agricultural development, food security, water resource use, climate change, poverty and environmental services in Australia, the Asia/Pacific, Africa, Europe, the Near East and Latin America.

MARK BRINDAL

In 2009, Mark Brindal commenced his PhD studies at Adelaide University, under Professors Randy Stringer and Mike Young, into economic questions relating to property rights and ownership aspects of water. Mark began his working life as a Cadet journalist with Advertiser newspapers. However, he gave this away in favour of pursuing a tertiary education. He became a primary school teacher and taught at Cockburn Primary School and Northfield Primary School, before being appointed Principal of Cook Primary School in 1975. He was seconded to a professional consultancy in educational disadvantage accruing form isolation in 1979. He rose in this position to Sate Co-ordinator of the Country Areas.

In 1989 was elected to the seat of Hayward in the Parliament of South Australia. In 1993 he was elected as Member for Unley, a position he held until his retirement in 2006. In Parliament he served on the Economic and Finance Committee and the Public Works Committee. He was a member of numerous Select Committees including 'Organ Transplantation', 'Disposal of Human Remains and the River Murray'. From 1999 – 2002 he served as a Minister; holding the portfolios of Youth, Employment, Education and Training, and Local Government. He was South Australia's first, and only, Minister for Water Resources.

In the community his current duties include, Justice of the Peace, Trustee of the Unley RSL, Board Member of Goodwood Financial Services and President of Adelaide Tech Old Scholars Association. His hobbies include reading and writing. He enjoys travelling and has recently returned from Alaska. More practically, he turns his hand to home renovation and is a passionate gardener. Mark and his wife Pam have been together for 28 years. He has 4 stepchildren and 13 grandchildren.

PHILIP HEWETT

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Phil Hewett began studies in horticulture at Ryde in 1979 and has extensive experience in many facets of arboriculture and tree management, including four years as a tree planning consultant, four years as full time teacher of horticulture, and twenty one years in local government. Phil's local government experience has covered tree preservation order administration, tree asset management planning and operational work involving tree planting and pruning. During a seminar in 1985 Phil was exposed to the 'urban forest virus' and subsequently set out to infect not only arboriculturists but also town planners, engineers and myriad others he came in contact with.

DAVID LAWRY OAM

Director TREENET
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David Lawry is the Director of TREENET based at the Adelaide University's Waite Campus. He also graduated from there in 1972 with a degree in Agricultural Science majoring in Horticulture. After a 3 year teaching stint he established his family nursery and commercial landscaping business specialising in Australian natives. Having been involved in many tree planting projects which he believed were ultimately unsustainable, David became interested in the science of establishing trees in urban settings, particularly street trees. This led to the co-founding of TREENET (Tree and Roadway Experimental and Educational Network) in 1997 with Dr Jennifer Gardner, curator of the Waite Arboretum. In 2002 an illness rescued him from his attempts to make money in business and he applied his management skills in not for profit organisations to the running of TREENET.

He also heads up his own company 'Space Down Under' which specialises in the development of root friendly environments for trees, based on the beneficial reuse of colloidal residues filtered from Adelaide's reservoirs. His invention of the TREENET inlet has been greatly facilitated by the practical application of his PhD.

He was awarded an Order of Australia Medal in the 2008 Queens Birthday Honours list. The citation reads: '*For service to arboriculture and the environment, particularly through research and support for sustainable plantings in the urban landscape, and to the community through the Avenues of Honour project.'* OAM also stands for Only A Mug.

IAN SHEARS

Team Leader Tree Planning,
City of Melbourne

Ian Shears has been Team Leader Tree Planning at the City of Melbourne for the past 10 years. Ian completed a Masters in Applied Science (Horticulture) in 1996 at the University of Melbourne, and has also been involved in teaching and private practice consulting. He is currently Chair of the Committee for Amenity Tree Health and is involved in a range of industry organisations and forums, and retains strong research links with the University of Melbourne.

Dr JANE TARRAN
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Until recently, Jane Tarran was a Senior Lecturer in the Department of Environmental Sciences (Faculty of Science) at the University of Technology Sydney (UTS) where she developed the interdisciplinary course of Bachelor of Science in Urban Ecology. Jane has over 20 years experience in university teaching and research in a range of areas, including urban vegetation management, plant pathology, landscape design history, open space management and horticulture. Recently, she has been promoting, to various audiences, the concept of urban forestry and urban greening and the benefits that flow to people and their cities from well-managed urban vegetation. Increasingly, these talks on Green Infrastructure have focussed on issues of biodiversity and climate change, in addition to the provision of sustainable and life-enhancing urban environments for people. When not working, Jane prefers to spend time in green environments, whether in the bushland or parks of Australia or the gardens of Japan.

LYNDAL PLANT
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Lyndal describes her current role in Brisbane City Council's City Assets area as, an urban forester, ensuring that the forest of amenity trees on public and private land is recognised as some of Brisbane's most important assets, and managed to optimise their values and minimise their risks. Lyndal graduated from James Cook University (B.Sc Hons) in 1981 and worked with Queensland Forestry Department for seven years. Lyndal's passion for urban trees includes a long and successful career in local government, leading significant change in urban tree policy and programs using cutting edge research and strategy development. Awarded a Churchill Fellowship in 1995, Lyndal visited nine cities in South East Asia, North and South America investigating best practices in growing and managing trees in cities.

MARTIN ELY
PhD candidate
School of Architecture, Landscape Architecture and Urban Design
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Martin Ely is a landscape architect and urban designer with extensive experience in the design of urban streetscapes and public spaces. For the past three years he has been undertaking a PhD at the School of Architecture, Landscape Architecture and Urban Design, researching better ways of integrating street trees into the design of urban streetscapes. In this paper he will present some of his research findings relating to the planning and design of urban areas to grow healthier, longer lived street trees, while reducing conflicts with surrounding infrastructure.

KAREN SWEENEY

Arboricultural Services Manager
City of Sydney

Karen Sweeney is currently the City Arborist for the City of Sydney Council and the President of the Local Government Tree Resources Association. Karen has worked in local government for the last twelve years, in all aspects of tree management from the operational side, tree assessments through to contract management and policy development. Karen is responsible for the direction of Sydney's urban forest in a physically and politically challenging environment…. and loves it!

DR PETER MAY

May Horticulture Services,
Associate: Graduate School of Land and Environment,
The University of Melbourne

Dr.Peter May taught at the Burnley Campus of The University of Melbourne for 30 years, developing expertise in soil science, urban soils and urban and landscape horticulture. After retiring in 2005 he established a consulting business that provides specialist advice in a range of areas including urban and landscape soils, landscape plant establishment, landscape plant selection and the management and maintenance of landscape plants, primarily to local government and landscape architecture firms.

DR JENNIFER GARDNER

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Jennifer has been the Director of Waite Arboretum since 1987. She has collaborated with David Lawry on the Treenet project since its foundation in 1997 and is on the Treenet Management Committee and Advisory Board. Jennifer is committed to the long term protection and on-going development of the Arboretum as a valuable experimental collection for research and education. She aims to promote its use to the widest community as well as a resource for landscape architects, planners, arboriculturalists, the nursery and allied industries.

ROSS CLARK

Ross Clark BSc (Forestry)
Managing Director - Trees Impact Pty Limited

Ross has a degree in Forestry from ANU and began growing good trees in the early 1980's when, while working as a landscape contractor, he was appalled by the standard of trees then offered by the nursery industry. Over he past 25 years Ross has continued his involvement with the advanced tree industry and his push for improved standards. He wrote *Purchasing Landscape Trees (NATSPEC//Construction Information)* in 1996 which contained the first NATSPEC specification for trees and his later book *Specifying Trees (*also *NATSPEC//Construction Information)* was published in 2003. Ross is an industry spokesperson on the subject of tree quality and is currently the Managing Director of Trees Impact Pty Limited, one of Australia's most respected tree growers.

DAVID GALWEY

David Galwey is the Manager and Principal Consulting Arborist at Tree Dimensions, a Melbourne-based arboricultural consultancy. He grew up in Brisbane, where he fell out of a She-oak at the age of 10. His father preferred power lines to trees and spread them across Queensland. His mother taught him how to cook.

After running away to join a symphony orchestra at 16, David worked as a musician for several years, first playing the French horn in orchestras and later playing trumpet in bands. He was rescued from this gypsy lifestyle by Judy Fakes, Ted Hoare, Bruce Macleod and John Douglas, who told him it was time to grow up and learn how to use a chainsaw. They forced him back to school and wouldn't release him until he had completed a Certificate of Arboriculture (Ryde). They then packed him off to Melbourne where he completed an Associate Diploma of Applied Science (Arboriculture) and Bachelor of Applied Science (Horticulture) at The University of Melbourne (Burnley Campus). He liked Melbourne and stayed.

Since establishing Tree Dimensions in 1996, David has completed extensive work concerning trees on development sites for local councils, developers, architects and town planners, along with all other aspects of arboricultural consultancy. David also lectures occasionally at The University of Melbourne.

A director of the International Society of Arboriculture–Australia Chapter (ISAAC) from 2001 to 2005, David was nominated as the ISAAC representative to the Standards Australia Arboriculture Committee in early 2005. He has been involved in ongoing development and review of several standards needed by the arboricultural profession, including AS4970 Protection of trees on development sites.

In 2008, David cycled to the ISAAC conference in Brisbane. He looks forward to you all joining him for the Tour des Trees in 2011.

JAMES SMITH

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Honours degree in zoology. Career started working for the Qld Museum in education and fisheries research for CSIRO. An extended stay overseas led to a directional change into sales and marketing. On returning to Australia, James' collective skills were combined to established ***fauNa***ture, a company which aims to "bring people and wildlife together". James' principle focus is in urban and peri-urban environments.

TREENET: 2000-2009

Judy Fakes
Head Teacher – Parks, Gardens & Arboriculture
Ryde College of TAFE, NSW

TREENET stands for Tree and Roadway Experimental and Educational Network.

It is an independent not-for-profit organisation dedicated to improving the urban forest. It is funded by grants and voluntary contributions from participating councils, nurseries and other groups[1].

In 2000 at the inaugural TREENET symposium, David Lawry gave the introductory address where he outlined TREENET's origins and its visions. It is my mission, at the tenth annual symposium, to reflect on David's paper and consider TREENET's achievements and perhaps its direction for the next 10 years.

Its spiritual home is in Adelaide at the University of Adelaide's Waite Arboretum. The arboretum is on land gifted to the University of Adelaide by Peter Waite 'to be held upon trust and in perpetuity as a park or garden for the enjoyment of the public'. It covers approximately 30 hectares and contains about 2,200 specimens representing 800 species from about 200 genera from around the world[2].

TREENET was co-founded by Dr Jennifer Gardner, Director of the Arboretum and David Lawry who for 20 years had been a producer and installer of urban trees. He had enjoyed the Arboretum as a student at Waite in the early 70s. Together they recognised the unique opportunity the Arboretum provided as a focus for research and education in urban arboriculture.

The first meeting of The Urban Tree Cooperative Research Group in February 1997 brought together four representatives from State Government, the nursery industry and education. Its aims were 'to improve the streetscapes of South Australia through a co-ordinated assessment of existing and potential client needs, species, production methods, establishment practices and information sharing[3]'. Transport SA was happy to finance research and Urrbrae Agricultural High School, located across the road from the Arboretum, was keen to involve students in projects.

The initial meeting envisaged three main areas of activity: street tree trials (to broaden the palette of species for street plantings and to focus on species that required less intervention), production of *Pyrus* 'Lynington' to generate income and kudos for the Waite Arboretum (this is a splendid selection of *Pyrus calleryana* made by Dr David Symon, former Curator of the Arboretum), and to test new technology in irrigation and research soil and water properties in relation to dryland and wetland plants. Future projects that were envisaged included storm water harvesting, incorporation of green waste into tree planting, running a two day conference in 1999/2000 and conveying information on all projects via the internet.

One week after the first meeting, the group had grown to seven and the name TREENET was adopted. In his 2000 introductory address, David stated that by that stage the group had achieved most of its original aims including the establishment of street tree trials, the production of *Pyrus* 'Lynington', and the expansion of the TREENET network to include many individuals, organisations and professions who influence the condition of the urban forest.

This progress was made possible by a Local Government grant of $30,000 to survey SA Councils regarding tree policies and practice[4], to set up a website and run a two day conference. That Conference was the Inaugural Street Tree Symposium in the first week of September 2000.

In this paper I'd like to reflect on the meaning of TREENET and in doing so, highlight some of its achievements and the highpoints of previous symposia from the past 10 years.

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[1] http//: www.treenet.com.au accessed 16.08.09
[2] http//:www.waite.adelaide.edu.au/arboretum accessed 16.08.09
[3] Lawry, D. 2000 "Introductory address', *Treenet Proceedings of the Inaugural Street Tree Symposium*, Treenet Inc. Adelaide
4 Hodges, G "TREENET Local Government Survey South Australia" *Treenet Proceedings of the Inaugural Street Tree Symposium*, Treenet Inc

TREE

TREENET is all about trees. However, trees in our urban landscapes are also about interactions with people, other assets, infrastructure and other organisms. The fact that TREENET's home is the Waite Arboretum reminds us that there are thousands of species of trees in the world, but very few of them see the light of day in our streets. Over the years various papers have highlighted the potential of many of the species planted in the Arboretum as possible street trees, especially as the trees in the Arboretum receive almost no supplementary irrigation.

The street tree trials continue to be a resource for tree managers; however, the full potential of this approach has yet to be seen. Sadly, conservatism still rules in most local government areas throughout Australia.

Trees provide a significant number of environmental services. They do this 24 hours a day with no sick pay, no holidays and no overtime, and they manage to do this in very challenging growing environments. The benefits of trees to human health are becoming clearer, not only in providing shade and reducing UV radiation; but in less tangible ways through their effects on attitudes, behaviour and general human well-being. Research from around the world confirms that the benefits derived from urban trees far outweigh the costs associated with their planting and management.

The importance of trees to individuals and communities is illustrated in another of TREENET's achievements, the Avenues of Honour 1915-2015 Project. David Lawry founded the project based on a challenge arising from Dr Greg Moore's paper at the 2000 Symposium to create more tree lined avenues and boulevards in Australia.[5] It was officially launched with great fanfare at the 2004 Symposium, the only time TREENET held the Symposium in a tent in the Arboretum. The aim of the project is to commemorate every individual who has fallen in the service of Australia with a tree. The sale of Gallipoli Rosemary partly funds this project.[4]

The role of trees in a rapidly changing world of increasing urbanisation, increasing population density and global warming presents trees and their managers with significant challenges. This symposium highlights how the capital cities of Brisbane, Melbourne and Sydney are meeting those challenges.

ROADWAY

Roadways are an integral and inescapable part of our lives. We live, work, and commute in and along streets. They contain the 'grey' services necessary to our daily lives and should contain the 'green' services. Unfortunately, trees are still seen by many as simply ornaments or embellishments and not as essential infrastructure.

Streets are challenging environments in which to grow trees. Streetscapes are dynamic and as urban environments become more densely populated and more complex, the challenges for tree managers will increase. Some tree managers are embracing these challenges and are working with other professionals to engineer planting spaces that meet the needs of the tree and minimise negative interactions with other infrastructure.

Whilst there are some wins, there continue to be too many losses. Many councils, utilities and government departments are still risk averse and removing trees seems to be the easiest solution. It is incumbent on everyone in the TREENET family to promote the benefits and values of trees in our streets and along our highways.

EXPERIMENTAL

One of the first initiatives of TREENET was to establish street tree trial sites to test species for their suitability as street trees in the conditions that they would have to endure during their lives. One of the earliest councils to take this up was the City of West Torrens under the leadership of Tim Johnson and his enthusiastic team[5]. The success and challenges of that project will be revisited during this symposium.

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[4] http//:www.avenuesofhonour.org accessed 11.08.09

5 Moore, G "TREENET: A Management System and Choices for Australia" *Treenet Proceedings of the Inaugural Street Tree Symposium*, Treenet Inc

[5] Johnson, T. 2000 "Greening the City of West Torrens" *Treenet Proceedings of the Inaugural Street Tree Symposium*, Treenet Inc. Adelaide

Over the past 10 years, the TREENET symposia have highlighted a number of experimental approaches to tree planting and establishment. Storm water harvesting has featured in many symposia as have structural soils and other initiatives and innovations. In 2003 a number of trials were established in Claremont Avenue which bounds the Arboretum.

The key to many of the successes reported in those presentations was the engagement with other professionals. Arborists and tree managers are regularly offended by the perceived ignorance of others when it comes to trees. This is probably true for engineers and others who are probably equally annoyed when an arborist or tree manager fails to understand the ins and outs of providing their particular services. Successful experiments are generally collaborative efforts. It is essential that we engage with other professionals to help develop sustainable and green streets. Whether the experiment is intentional or accidental, we always need to learn from both the successes and the failures.

EDUCATIONAL

Underpinning all of TREENET's goals is the need to spread the word. We are all on a learning curve. In achieving the experimental successes we need to educate other professions in the ways of trees. However, we must also inform ourselves of the challenges faced by those professionals.

TREENET has always been linked to educational institutions: formally with the University of Adelaide and less formally but very closely with the University of Melbourne, other universities and Technical and Further Education colleges such as Ryde, Urrbrae and others. Various symposia have featured presentations by research students from the Universities of Adelaide and Melbourne.

Learning should be everyone's lifelong goal. Keeping our eyes open, our brains engaged and sharing the knowledge is essential if we want to make a difference.

NETWORK

Apart from the formal aspects of the symposia, such as the papers and the workshops, much of the 'education' and information gathering comes from the informal gatherings over a cup of tea or a beer. I know that I really look forward to catching up with people from other States that I generally only see at TREENET.

One of the original aims of TREENET was to set up a website so that everyone who had access to the Internet could share information and get the latest on the trial sites. This aim has certainly been achieved through the hard work, persistence and talent of people behind the scenes such as Sean Donaghy who created and maintained the original TREENET and Avenues of Honour websites and Andrea Lawry who manages the new site that went online on July 1, 2009.

One of the excellent features of the TREENET website is the publication of the proceedings of all of the symposia to date. This is an invaluable resource for anyone interested in the amazing breadth of material that has been covered since 2000.

TREENET actively encourages links with other arboricultural associations and is grateful for the support of its many sponsors and its institutional members. It is also dependent on the support of everyone who attends the symposia.

CONCLUSION

In 2000 there were 130 attendees and we comfortably fitted into the largest auditorium that the University of Adelaide could provide at its Waite campus. After the rather risky 2004 venture in the marquee we moved to the National Wine Centre which had recently been acquired by the University of Adelaide.

It has been a very successful move as proximity to accommodation and restaurants has encouraged networking amongst delegates, particularly for the hundreds that now fly in each year. The facilities and experienced staff provide a first class venue for up to 400 delegates. This year we have planned for 300 so we can still have room to grow. In 2008 we ran our first field day at the Waite Arboretum on day two, and it is wonderful to make contact once again with our spiritual home and to touch the trees that touch our hearts.

Behind the scenes TREENET has a Management Committee chaired by Dr Greg Moore, Dr Jennifer Gardner, Curator of the Waite Arboretum is Secretary and Brian Measday retired accountant and "Greenwell" inventor is Treasurer. The other members are Dr Bob Such, Independent Member for Fisher in the Parliament of South Australia, Professor Chris Daniels, University of SA, Tim Johnson, City of Mitcham, Judy Fakes, Ryde College of TAFE, John Zwar, Urrbrae College of TAFE and ex officio David Lawry as TREENET Director. Apart from that team, TREENET has an Advisory Board of 50 members from all over Australia representing local government, nurseries, utilities, government departments and arboricultural industry associations. It is truly a TREE-NETWORK.

Over the past 10 years TREENET has grown and matured. It is still driven by an enthusiasm and commitment to improve the urban forest. It is incredibly proud to be a voice for home-grown achievements. It has been policy to date that all papers are about local issues as we have very much to be proud of.

There are many challenges ahead including the big one of climate change and the likelihood of drier times and more storms. We have seen more information on the benefits of trees to human health but the message still needs to get to the policy makers. Financial pressures on utilities and increased foreign ownership don't bode well for trees. We are still to see a more diverse palette of species in our streets. Incursions of exotic pests and diseases are real threats to seemingly bullet-proof species like *Platanus*. TREENET will continue to highlight these challenges and, more importantly, continue to showcase and disseminate solutions.

Delegates to the Inaugural TREENET Symposium 2000

Dr David Symon with Burnley Students 2001 and Pyrus calleyreana

Delegates plant Gallipoli Rosemary at launch of Avenues of Honour project 2004

URBAN TREES: WORTH MORE THAN THEY COST

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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 service 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 recognise 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 suburb 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 utilised, 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 is 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 2009).

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 CO2 levels	These are above the predicted worst case scenario and could exceed 1000ppm	This suggests atmospheric temperature rises of 6-8°C

Safe Atmospheric CO2 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 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 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 minimise 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 is by private land owners and Local Government, while in other States installation is by State Governments and maintenance is by Local Government, 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 finalised 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 8°C, 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 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 localised flooding? It is important to consider what is happening in the suburbs of all the major cities around the country. Intense housing development has resulted in house blocks with little, or no, capacity to plant trees and narrow streets that restrict the planting and maturation of trees.

Figure 4. Estimates of various environmental economic values for 100,000 large ature urban trees growing in an Australian city

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	$200 per 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 2009
Water saving from electricity generation	30 kWh per tree at 100L per kWh	300 million L	$1.50 per kilolitre	$45,000	Moore 2009
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)	Moore 2009

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
- about 100L of water is used to generate each kWh by coal powered generators
- water valued at $1.50 per kilolitre

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 minimised 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 2.00pm especially if soil water is limited. 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 should be 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's 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 fulfil the full potential of their lifespan. 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).

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 roadside 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 is recognised. The economic algorithms and paradigms that have been 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 recognises 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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TREENET TRIALS 2009: A SPECIES ODYSSEY

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Introduction

Street tree trials have been a fundamental part of TREENET since its inception in 1997.
Ten years since it was discussed at TREENET's first symposium, the focus on tree species selection remains, and other factors which impact on the effective functioning of urban trees are also receiving considerable attention. Growing healthy trees in urban streets where conflicts involving space, soil and water are usual is as much about planning for, building and managing urban spaces, as it is about selecting tree species.

Much has been written on tree species selection and these related issues in papers presented at past symposia. Their full content can be viewed or downloaded at www.treenet.org. In recognition and celebration of the Tenth National Street Tree Symposium this paper reviews some of TREENET's past works, introduces some current projects, and reports on some of the outstanding works of the last decade which provide a firm foundation for the next.

As TREENET was formed at the Waite Arboretum, it was inevitable that many of the original street tree trials focused on species which had proved themselves there. At TREENET's Inaugural National Street Tree Symposium, Gardner (2000) introduced a range of the Arboretum's trees as having potential for use in streets. These included the Wilga (*Geijera parviflora*) and Chinese pistachio (*Pistachia chinensis*).

Success Story #1: The Wilga (*Geijera parviflora*)

My research into the Wilga as a potential street tree species began in 1997 when considering species for use in the City of West Torrens. In reviewing the list of species which the Electricity (Principles of Vegetation Clearance) Regulations 1996 exempt from restrictions with regard to planting in proximity of overhead powerlines, I discounted the shrub species, noted some of the few tree species as having limited application in urban streets, and listed some species with which I was unfamiliar as needing further investigation. The Wilga was one of these species.

Examination of the specimens at the Waite Arboretum showed the species' potential for street use, its structure appearing suited to appropriate formative pruning. A single specimen at the Adelaide Zoo showed the species had the capacity to reach a large enough size to be reasonably effective in residential streets and with appropriate maintenance could provide the necessary clearances. Several texts presented the Wilga as a hardy but slow growing species. But would they grow in streets?

A search for examples of the Wilga growing in streets in Adelaide during early 1997 proved futile. Colleagues in local government across South Australia were unfamiliar with the species; none could direct me to examples in streets or to a nursery where they were propagated. The substantial number of commercial nurseries which I contacted regarding the species were not familiar with it.

A few months after putting the quest for the Wilga on hold I happened to pass a display at a local government expo and noticed the species' now familiar narrow foliage amongst some small nursery stock. The stall holder introduced himself as David Lawry. He seemed surprised that I knew the species, and more surprised that I wanted to buy his total stock. He agreed to sell me some trees, although he wanted to keep the majority to distribute to other councils. He wanted to do this to gain an understanding of how the species would performed under varying conditions.

The success of the Wilga under street conditions resulted in regular enquiries and requests for the species. Over time it has been more widely planted across South Australia, New South Wales, Victoria, and possibly even further afield. The fact that the Wilga is now propagated commercially and planted in streets across several states is testament to David Lawry's vision and his networking abilities which have been instrumental to the success of TREENET.

Success Story #2: Chinese pistachio (*Pistachia chinensis*)

Following Dr Gardner's suggestion that the Chinese pistachio may be a suitable species for planting as a street tree, a small number of isolated individual specimens were identified in streets and gardens around Adelaide. Few local government horticulturists were familiar with the species in cultivation at the time but interest in its potential was considerable. Though it was not widely available, small numbers were available as it was occasionally sought by enthusiastic gardeners looking for autumnal colour.

The first trial plantings of Chinese pistachio showed the species could thrive in Adelaide's street environments. Obtaining stock in quantities remained difficult in the late 1990's and into the new millennium, with local nurseries reporting difficulties in reliably sourcing or producing quality trees. As with the Wilga and a range of other species to date, TREENET's initiation and reporting of street trials of Chinese pistachio resulted in increased interest and demand. As a result quality stock is now readily available. Chinese pistachio is proving itself as a reliable street tree across several councils in Adelaide and surrounding regions.

Dwarf apple-myrtle (*Angophora hispida*) and Japanese Zelkova (*Zelkova serrata*)

It is likely that production and use of other species which have been established as trials will also increase in coming years. It has been difficult to source stock of Dwarf apple-myrtle (*Angophora hispida*) in recent years, possibly due to the species' propensity to shed seed over a very brief period whilst the fruits still hang on the tree. Or it could be due to local production difficulties associated with cold weather and frost. Trial stock at the time of planting has sometimes appeared less than promising, but within a few years the trees planted have developed into attractive specimens.

The current local status of the Dwarf apple-myrtle is reminiscent of the Wilga in 2000. It has the potential to become a staple of semi-arid streetscapes. Discussions with commercial producers suggest that while propagation of *Angophora hispida* is still relatively low it is beginning to increase, with some minor plantings in recent years in South Australia and Victoria.

The excellent examples of Japanese zelkova (*Zelkova serrata*) in the Waite Arboretum suggested from the outset that the species had great potential for street planting, but stock quality and the progress of initial trials varied. The structure of Japanese zelkova both above and below the ground appears well suited to streetscape management regimes. Early trials of advanced trees performed poorly while small bare-root stock grew rapidly.

Recent Japanese zelkova trials in the City of Mitcham using 300mm container stock achieved acceptable growth rates. Several examples have survived extreme vandalism. Early maintenance requirements of Japanese zelkova are high, being similar to *Celtis* and *Sophora.* Ideally the trial planting of Dwarf apple-myrtle and Japanese zelkova will increase in the next few years so that the value of these species can be more widely assessed and reported.

Information on other tree species trials is reported in the proceedings of earlier symposia; see Watt (2005), Plant and See (2002), See (2003), Hay, Johnson & Kirwan (2002) and Johnson (2000, 2001, 2007). Beyond the snapshot information provided in these reports, information on the majority of established street tree trials is limited. Website "hits" and enquiries reflect the need for relevant information, and the number of trials planted by local councils has expanded over the last decade, but the rate at which information about street tree trials has been uploaded onto TREENET's website is disappointing.

Some immediate benefits of the initial TREENET street tree trials are apparent:

- commercial production of a greater diversity of tree species
- greater diversity of species and an associated reduction in risk to the urban forest
- increased choices with regard to streetscaping resulting in greater diversity
- greater climate change adaptation potential

Expanding TREENET street tree trials in the future will sustain these community and commercial benefits. TREENET's major challenges for the next decade include establishing systems to encourage and support more species trials and ensuring they are documented on the website and that their progress is reported.

Establishing and Monitoring TREENET Street Tree Trials

The rationale regarding establishing street tree trials has been detailed at previous symposia; see Watt (2005) and Hay, Johnson and Kirwan (2002), which includes the following practical suggestions with regard to establishing trials:

- Trials should utilise a small number of trees so that if issues or problems arise they will remain manageable. An ideal trial size is between five and ten trees.
- Locate trials such that if issues arise they will have little impact on neighbouring properties. Reserve frontages make ideal trial sites for larger species. Avoid high profile sites.
- Species should not be excluded from trial for fear of potential problems, as problems may not eventuate under local conditions.
- Knowledge of species gained through experience with the seedling varieties or one selected form cannot be applied to other forms. One selection may thrive where other selections have failed. Ideally all selections should be tested.
- Trees are typically selected for a given location whereas the reverse may be more appropriate for tree trials. Identify the species to be tested first, and then select an appropriate site where success is most likely.
- Learn about the species from all available sources including colleagues and nursery personnel.

The methodology described in Plant and See (2002) expands on the practical approach needed to integrate trials into local government planting programs. The involvement of community volunteers in planning and implementing tree trials in Brisbane has considerable potential to benefit trials in other areas.

Monitoring and documenting TREENET trials requires resources. When TREENET began Internet speeds were slow, data storage was expensive, computer access and familiarity with the "information superhighway" was limited. It was anticipated that personnel involved in street tree trials might have difficulty uploading images and other data. Over the past decade technology has improved considerably and has become more affordable, but this increased access and familiarity with information systems has not increased the rate of information upload.

The value of street tree trials is substantially diminished if their progress cannot be readily documented and shared. TREENET must improve the effectiveness of data capture and sharing in relation to street tree trials. Opportunities to improve in this area are currently being investigated. A grant application has recently been lodged with the Local Government of South Australia's Research and Development Scheme which, if successful, will enable a review of local government's requirements with regard to tree trials, upgrading of species trial components of the website, and the collection of data on some established trials which are currently not documented. Similar funding opportunities may be available to assist with data collection in other states and territories.

The City of Brisbane's initiative to involve volunteers in establishing street tree trials may be a key to long term monitoring and provision of data and images. Many Councils own and manage land which is leased to community groups such as Scouts and Guides, Kindergartens and sporting groups. These tenants often request tree planting on or near their facilities. Trees planted could include species trials, which the groups might then monitor on behalf of the council. Establishing and monitoring TREENET trials might also be integrated into school lessons, which could provide additional long-term benefits. For instance a teacher may champion a project and then go on to establish trials at other sites during their career.

Street Tree Trials for the Next Decade

Gardner (2000) introduced over 30 species with potential as street trees. Of these, not less than 12 have so far been included in street tree trials. Over the next decade TREENET plans to further investigate some of those which have not yet been established in trials, including:

- Rough-barked broad-leaved apple-myrtle (*Angophora subvelutina*)
- Whitewood (*Atalaya hemiglauca*)
- Large-fruited yellow jacket (*Corymbia watsoniana*)
- Caley's ironbark (*Eucalyptus caleyi*)
- Forest elder (*Nuxia floribunda*)
- Mt Atlas pistachio (*Pistachia atlantica*)
- Field oak (*Quercus agrifolia*)

- Blue oak (*Quercus douglasii*)
- Englemann oak (*Quercus englemannii*)
- Vallonea oak (*Quercus ithaburensis*)
- Valley oak (*Quercus lobata*)
- Interior live oak (*Quercus wislizenii*)
- White ironwood (*Vepris lanceolata*)
- Puriri (*Vitex lucens*)

Nicolle (2002) listed some recently discovered species with potential for street planting as well as some relatively unknown ones with desirable characteristics. They included:

- Bandalup silver mallet (*Eucalyptus purpurata*)
- Newdegate mallett (*Eucalyptus mimica*)
- Cup gum (*Eucalyptus cosmophylla,* pink-flowering form)
- Quoin Head marlock (*Eucalyptus mcquoidii*)
- Apricot-flowered mallee *Eucalyptus x stoaptera*
- Merrit (*Eucalyptus urna*)
- Victoria Range stringybark (*Eucalyptus victoriana*)
- Smooth-barked apple (*Angophora leiocarpa*)
- Coastal brown mallet (*Eucalyptus astringens* subsp. *redacta*)
- Wing-fruited mallee (*Eucalyptus kingsmillii* subsp. *alatissima*)

It is anticipated that trial plantings of these species will be established in the next decade, though it is acknowledged that some of these species may provide particular challenges in propagation, production and establishment. Anyone with knowledge of the existence of any of these species in streetscapes is encouraged to contact TREENET with this information.

Street Tree Trials Go Underground

Issues with tree root systems, and particularly misconceptions about tree root growth, were instrumental in the formation of TREENET. A species' suitability for planting in urban streets, in terms of both tree health and impacts on infrastructure and underground utilities, is dependent on its root system. Moore (2002) introduced TREENET to tree root management through soil management. The title of his presentation, 'Tree Root Networks – A Vital Ingredient of TREENET*'* remains as valid today.

Early collaboration between TREENET and the civil engineering profession provided infrastructure to irrigate street trees with stormwater: see Porch, Zanker and Pezzaniti (2003). This preliminary work suggested that street trees might benefit through irrigation with stormwater without compromising infrastructure integrity. Ongoing collaboration with the engineering profession has increased opportunities to improve the sustainability of the urban forest and to avoid or minimise conflicts with infrastructure: see Wettenhall (2006), Argue (2006), Denman (2006), Plant (2002), O'Malley and Cameron (2001).

Prolonged drought, climate change and pollution issues have provided additional incentives to advance this work. A prototype 'TREENET Inlet' was demonstrated at the TREENET Symposium in 2008. Over the past year the 'TREENET Inlet' has developed into a device to extract stormwater from the street, to detain it temporarily until it can infiltrate soils beneath the road verges. An application for a provisional patent has been lodged to protect the current design and so enable field testing over the coming year.

Civil Engineering and the Urban Forest

The City of Mitcham's initial investigations of stormwater infiltration infrastructure in 2003 were followed by construction of soakage trenches in association with planting of river red gum (*Eucalyptus camaldulensis*) saplings in Doncaster Avenue at Colonel Light Gardens: see Johnson (2007). This project continues to function as planned, with no issues or problems observed in the two years since construction. The health and vigour of the young trees is excellent. Surface porosity appears to have remained high, with surface flows visibly diminishing while traversing the infiltration trench sites.

The success of the Doncaster Avenue project has resulted in several new trials involving infiltration trenches and, more recently, permeable brick paving. Council's support for these works is indicated by the inclusion of a new budget item in the City's 2009/2010 budget for investigation and construction of water sensitive urban design projects (WSUD) in streets and on reserves. The funding provides for

a cautious approach to WSUD, enabling investigation of issues surrounding soil stability and contamination as well as management of stormwater quantity and quality.

Risks associated with working with the limited information available are managed by selecting suitable locations and incorporating 'fail-safes' into designs to ensure that stormwater can be diverted to bypass the interception system, or to allow the quantity of stormwater harvested to be reduced if problems arise. Some of Mitcham's trials have been established on reserve areas and, in the case of street infrastructure, in areas of Colonel Light Gardens where nature strips are relatively broad. Level sites are favoured for stormwater interception trials.

As Doncaster Avenue does not have kerbs and water tables, infiltration was achieved at the road shoulder through the porous soil surface. Achieving a similar result in an urban street with existing stormwater management infrastructure including kerbs and water tables required a different approach. A side entry pit was designed to feed a soakage trench in Dorset Avenue in Colonel Light Gardens, at a site where a single tree had to be removed from a mature avenue of white cedar (*Melia azedarach*): see Figures 1 and 2.

Voids between the crushed rock in the soakage trench provide storage for approximately two kilolitres of stormwater which quickly infiltrates surrounding soils. When the system's capacity is reached the pit simply fills to the top and all subsequent flow bypasses it and continues downstream through the pre-existing stormwater system.

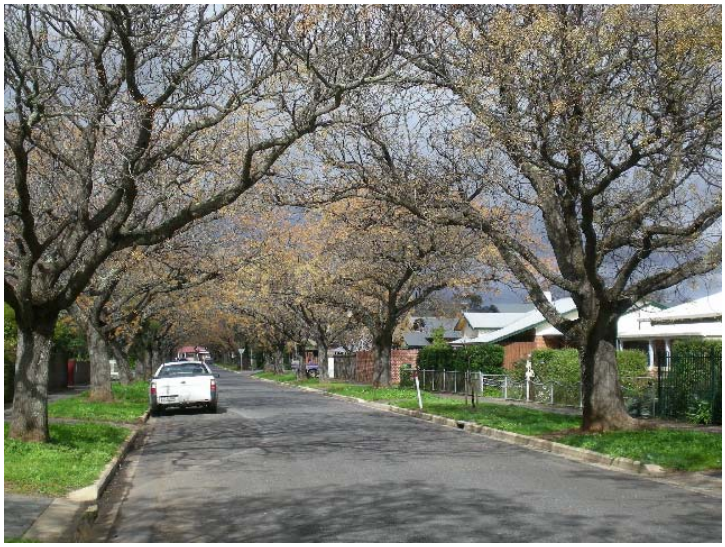

Figure 1 (left) showing the infiltration trench in Dorset Avenue Colonel Light Gardens during construction and
Figure 2 (right) showing the streetscape view containing only an additional side entry pit (centre right)

The capacity of soil to absorb and store water is a limiting factor in the design of infiltration systems. Trees and other vegetation have the potential to enhance the capacity of such systems with soil stabilisation being a secondary benefit. Eamus (2007) describes soil stabilisation as just one of a range of poorly understood and poorly acknowledged economic benefits of the ecosystem services provided by vegetation. Eamus, Hatton, Cook and Colvin (2006) provide further detail of the relationship between soil, plant and atmosphere, stating:

> "*Generally, as the availability of water at a site increases, the leaf area index and rate of water use by vegetation increases, and the vegetation will use almost all of the water that arrives as rainfall*".

Incorporating well vegetated stormwater infiltration infrastructure into streetscape design may therefore be an effective means of managing a considerable portion of all stormwater.

The Potential of Permeable Pavements

With financial support from the Adelaide and Mount Lofty Ranges Natural Resource Management Board and academic supervision by Dr Don Cameron (University of SA) and Dr Greg Moore (University of Melbourne), the City of Mitcham has begun an investigation of the interrelationships

between permeable brick paving, soil moisture levels, soil oxygen levels and the resulting growth of street trees including root system development.

Six field trials of two permeable footpath designs were constructed in July and August 2009. They will be monitored and analysed against a control of non-permeable concrete block paving to determine the influence of pavement construction on the establishment and growth of *Pyrus calleryana* 'Glen's form' Chanticleer. Bores to three metres deep were installed across the field trials to allow regular soil moisture and oxygen monitoring.

It is anticipated that increased rainfall infiltration and higher oxygen levels in the soil beneath permeable pavements may provide for more rapid tree growth and development. The porosity of the base material beneath permeable paving is also expected to desiccate rapidly following rainfall events, thus limiting root development near the paved surface which might result in pavement damage (Randrup et. al 2001). Root growth and development will be assessed following the three year monitoring period through non-injurious excavation of root zones.

The Future: Increased Integration of Urban Forestry, Civil Engineering and Water Sensitive Urban Design.

Evapotranspiration of moisture by trees has the potential to significantly enhance the stormwater management capacity of permeable paving and other water-sensitive design features. 'Hydraulic lift' described in Eamus et. al. (2006) may also work in reverse, allowing increased infiltration rates at depth and increasing the speed and volume of soil moisture recharge in areas surrounding water sensitive design features.

Deep rooted perennial native grasses may also be adept at 'hydraulic shift'; redistributing moisture during the night when evapotranspiration is minimal to equalise water potential throughout the organism. If moisture is in abundance at a point of root contact, given adequate moisture and time, this high moisture potential might by osmosis and entropy be distributed throughout the plant. In situations where time and moisture permit, this moisture might also recharge the soils around drier roots, as described by Eamus et. al. (2006).

In addition to the potential soil moisture benefits of native grasses some species may provide valuable pollution remediation services. Research conducted at Flinders University suggests that the roots of several species of native grasses support bacteria which can contribute to the rhizoremediation of soil-borne hydrocarbons. We await the publication of this research by Prof. Richard Bentham and Sharyn Gaskin with interest, as it may have application in the design of sustainable stormwater management devices which directly support improved urban forestry.

In conclusion, climate change and the predicted progressive drying of southeast Australia present serious challenges and corresponding opportunities for urban forestry. As communities focus more clearly on these challenges we will be presented with opportunities to highlight the benefits of urban trees and the services they deliver. Urban trees will in the future contribute more to reducing greenhouse gas emissions, managing urban climates, purifying and recycling stormwater, managing groundwater and bioremediating pollution. By working closely with research institutions and related professions in delivering these services, TREENET is continuing to help build a sustainable urban forest and a sustainable future. TREENET's work over the past decade has given it the credibility and respect through which it will influence urban forest development in the years to come. TREENET's results have been achieved largely by its volunteers. The challenges and results of the past decade were many; those of the next will be greater.

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THE VALUE OF URBAN TREES: ENVIRONMENTAL FACTORS and ECONOMIC EFFICIENCY

Mark Brindal[6], Professor Randy Stringer[7]

It can be argued that trees occupy the same zone in the emotional intelligence of our species as do Pandas: there are many species of animals which are far more threatened than the Panda but there is something about its size, general appearance and the way in which it lives its life that strikes such particular resonance with humanity as to make it a suitable symbol of all endangered species. In the Kingdom of flora, trees occupy that same niche[8].This view has, and is likely to continue to be re-enforced by the Kyoto Protocol and its successors.

For a decade, the National Street Tree Symposium has played an important role in the education and development of the Australian community. Any cursory glance at the quality of its presenters and the range of their papers leaves no doubt as to the efficacy and significance of these proceedings.

Though 'time and tide wait for no man'[9], symposium papers have kept pace with the ebb and flow of ideas, prejudice and public policy. However, as Shakespeare said:

> 'There is a tide in the affairs of men,
> Which, taken at the flood, leads on to fortune'[10]

In their contributions to this forum, Dr G M Moore (Moore 2006)[11], Hon Dr Bob Such MP (Such 2007)[12], though balanced by the observations of Jeff Angel (Angel 2007) provide pointers to new possibilities. This paper argues for the exploitation of those opportunities.

The 2002 presentation 'The Economic Value of Trees in Urban Areas: Estimating the Benefits of Adelaide's Street Trees' (Killicoat, Puzio et al. 2002) (revisited by Stringer in 2007 (Stringer 2007)), develops an argument which goes beyond environment for the environment's sake and triple bottom line accounting. The authors reason that urban trees have a quantifiable economic value[13]. Extensive studies both before (Simpson and McPherson 1996; McPherson 1998; Simpson and McPherson 1998; McPherson, Simpson et al. 1999) and since (Geof Donovan 2008); (Connellan 2005); (Lohr, Pearson - Mims et al. 2004) have put this hypothesis beyond dispute.

It is equally beyond dispute that the world in which we live has been indelibly marked, during the past 500 years, by the inexorable development of the market economy. Trying to understand its forces led to the evolution of the study of economics and, in turn, to the domination of the thinking of Neo classical Economists.

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[8] Kim D Coder *Identified Benefits of Community Trees and Forests*, The University of Georgia Cooperative Extension Service forest Resources Unit Publication, For 96-39, University of Georgia, 1996
Robertson, M. and R. Walford (2000). "Views and Visions of Land Use in the United Kingdom." The Geographical Journal **166**(3): 239-254.

[9] The origin is uncertain, although it's clear that the phrase is ancient and that it predates modern English. The earliest known record is from *St. Marher*, 1225:"And te tide and te time þat tu iboren were, schal beon iblescet."

[10] Brutus in **William Shakespeare's** Julius Caesar Act 4, Scene 3,218-224

[11] "Such opportunities come but rarely and they must be seized upon if public open space and urban trees are to be professionally managed; Moore, G. M. (2006). Urban Trees and the Global Greenhouse. 7th National Street Tree Conference, Treenet Inc**:** 6. ,p5

[12] This is the age of the managed tree and the managed urban forest, based on science and on accumulated experience and skills; Such, B. (2007). Setting a New policy Agenda for the Urban Forest. 8th National Street Tree Symposium**:** 6. ,p5

[13] A conservative estimate of $171AUD (in 2002 dollars);Killicoat, P., E. Puzio, et al. (2002). The Economic Value of Trees in Urban Areas: Estimating the Benefits of Adelaide's Street trees. 3rd National Street Tree Symposium**:** 12.

To the chagrin of environmentalists and others seeking alternate paradigms, their theories[14] have become so pervasive as to colour opinion, shape policy and influence legislation. Killicoat, Puzio and Stringer (Killicoat, Puzio et al. 2002) highlight a future in which environmentalists are no longer relegated to the contemporary equivalence of Old Testament prophets but have an indisputable seat at the table of mainstream economic thought.

Urban green space should no longer be considered and managed as a liability or 'cost centre'. It is an 'asset', whose value increases with time and whose beneficial outputs should be accounted. Fixing an accurate value is one of the challenges we face.

Accountants like nothing better than a neat ledger. They claim that economic efficiency is enhanced when 'cost centres' can be clearly defined. Such unbundling, however, may be to the detriment of efficient resource management. Those concerned with street trees or urban green spaces should not fall into the same trap.

While street trees are an important component of the urban landscape, many contemporary thinkers conceive the totality of urban green spaces as constituting the urban ecological system (Miller and Hobbs 2002; Roetman and Daniels 2008). Whether a tree is planted in the street, in a park, car park or backyard, or simply some neglected remnant of the indigenous vegetation, its contribution to the environment is related to species, health, age and its relationship to understory plantings (if any), rather than where or why it was planted.

Apart from their intrinsic worth, street trees have an almost unique capacity to provide those linkages without which the urban landscape might fragment into isolated green islands set in a sea of concrete, steel and bitumen. By broadening its vision to include the cities' flora (no matter where it is situated), we not only educate and champion eco-friendly cities, we elevate street trees to an unassailable position within that construct. The components are already understood. The challenge is to synthesise them into an integrated whole.

Efficiency

Efficiency is the linchpin of economic profitability. If urban green space can be conceived and safeguarded because of its economic profitability, then those responsible for its planning and management should be mindful of increasing that profitability through efficiency.

For trees, and especially for urban street trees, efficiency gains can be made through increasing their longevity, reducing maintenance costs and reducing damage to infrastructure.

Matching species to location is of prime importance. While the debate will continue on the relative merits of indigenous, native and exotic species, it is the suitability of species to modified locations (likely to become more hostile with global warming) which should form the paramount concern of urban planners.

Increasing Genetic Efficiency

An argument can be mounted that we should draw on the expertise of arborists, botanists and geneticists in institutions such as the CSRIO and the Waite to develop new varieties and even new species which, while serving existing ecosystem needs, are capable of providing additional environmental services [15]in the urban setting[16].

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[14] Some of which, it can be argued, are tragically flawed and may well be responsible for creating many of our problems (eg (a) the notion that for every depletable resource, a substitute will arise and (b) the notion that the economy is infinitely expandable)

[15] Least-Cost Input Mixtures of Water and Nitrogen for Photosynthesis Author(s): Ian J. Wright, Peter B. Reich, Mark Westoby

[1616] Ms Helen Leicht, working with a grower, trialled a range of power line friendly street trees. This culminated in the release of a new tree (Noel Surprise) in January 2006; hleicht@bigpond.net.au Leadbeater, S. (2006). A Community in Conflict- Discussion Paper. 7th National Street Tree Symposium**:** 9.

Research has shown, for instance, that the tree roots of certain species are capable of assimilating toxic pollutants from the urban environment: organic compounds are often broken down by the tree. In the case of inorganic pollutants, such as heavy metals, evidence suggests that these are accumulated and stored benignly in the tree's root structures and not transmitted to the trunk, branches or leaves (Seuntjens, Nowack et al. 2005). This capacity creates the potential for urban street trees to play an even greater role in bio-remediation than was previously conceived.

Some, remembering the paper 'A Community in Conflict - Discussion Paper' (Leadbeater 2006) which was presented at the 2006 symposium, might consider that this implies the development of cultivars whose trunk reaches 2.5m above the ground before its lowest branch is extended and whose maximum canopy height is less than 4.5m. Such trees would obviate the need for the pruning and maintenance. Indeed, there may be some locations in which such trees would offer the most efficient solution. However, given that many studies suggest that the economic benefit of trees increases directly with their longevity and size, the most economically efficient solution may well lie in alternate strategies for service provision[17].

Matching the most suitable species to its ideal location enhances the likelihood of producing the most economically efficient tree.

Environmental Efficiency

Like all species, the genetic potential of street trees is limited by their environment.

Soil

A suitable and adequate milieu for root development is essential so that the tree might reach its full potential. It also promotes greater efficiency by lessening the maintenance required because of root damage to road surfaces and pavements (Leadbeater 2006). While the efficacy of 'structural soil' has been well tested (Grabosky et al. & Couenberg from (Plant 2002)) and its success when used in trenching documented (Plant 2002)[18], the technique has been limited to green-field sites or to sites requiring major remedial works. To date, because of cost and potential root disturbance, trenching has not been considered a viable means of environmental improvement for existing urban street trees. Notwithstanding this, the technique is now so extensively accepted that a range of premixed structural soils are among the products available from at least one Australian firm[19]. Providing a suitable environment for root growth promotes longevity and increases the economic efficiency of trees.

Sharing Water Efficiently

The most important factor in tree development and longevity is water. While provision may be made for trees to access adequate water supplies through trenching or the provision of an adequate permeable zone beneath their canopy, water supply is generally determined by weather patterns.
Street trees, in particular, are forced to extract water from soil which has a continuous and impermeable barrier on both sides beneath the tree's canopy. A permeable zone may either not exist[20] or be as narrow as 40cm. Yet this zone is expected to supply the water needs of mature trees growing 6 apart, with transverse intercepts (driveways) every 8 metres. Such trees survive because their root systems manage to access neighbouring gardens, or sources of supply including underground streams and leakage from both the potable water supply and sewerage systems.

The Costs of Efficiency Gains in the Water Delivery System

In South Australia that regime is changing. Water scarcity is increasing its resource value. However, the debate about what constitutes 'best practise' in water resource management 'continues to be hampered by a sort of water blindness favouring a basically technical conceptualisation of water. In line with such a view, water resources management is taken as various ways of controlling and governing direct water use and related waste flows, not as managing water's various functions in the landscape' (Falkenmark 2003, p237).

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[17] The undergrounding of power cables being the most obvious example

[18]" Sydney, Melbourne and Hobart have incorporated "tree trenches" into major streetscape improvement projects where large growing tree species were an important part of the desired outcome"(Plant 2002)

[19] Benedict Soil and Gravel Pty Ltd. (Sydney) www.**benedict**.com.au *The products are marketed as Benedict Smartmix2 & 3*

[20] As in many urban car parks

SA Water estimate system losses at about 10%. Water use in Adelaide is approximately 300,000ML pa. This equates to the system providing 30,000MLs of water to the urban environment through leakage (South Australia 2004, p11). The sewerage system accounts for an estimated annual flow of 100,000ML (60% of residential + 100% return of commercial and industrial). If we assume a similar leakage rate, this source provides another 10,000MLs of environmental water (i*bid.* p11). Efficiency gains will come at a cost to the urban environment and, in particular, to street trees.

The Cost of Drought and Water Price Rises

The years of drought in south-eastern Australia resulted in water restrictions for household gardens. As a consequence many street trees, relying on water from adjacent properties, became stressed. This could be considered a normal part of the Australian climatic cycle and one could contemplate that the ecosystem should return to its general equilibrium. However, with watering restrictions in place, the South Australian Government used the crisis to announce steep increases in the price of water.

Previous studies (2000) have shown that, while the price of water used internally is relatively elastic (Thomas and Syme,1979, Perth Aus., -0.04, Veck & Bill, Alberton & Thokaza, South Africa, -0.13), the price of water used outdoors is inelastic (Thomas and Syme,1979, Perth Aus., -0.31, Veck & Bill, Alberton & Thokaza, South Africa, -0.38). It would appear that with a price rise in the region of 10%, the volume of water used externally will drop 3.1% (or 1674 ML/annum using Water Proofing Adelaide figures).

The suburbs of Adelaide already exhibit many examples of abandoned gardens. Other householders have installed water wise plantings or subsurface irrigation. Some have installed synthetic lawns. Others have dramatically increased the areas of impermeable paved surfaces. Each of these actions deprives deep rooted plants of moisture.

The Cost of Urban Infill

Traditionally the suburbs of Adelaide have reflected the Australian dream: the modest house on the quarter acre block, 'the home among the gum trees, with lots of plum trees'. The city epitomised the 'garden city' as conceived by Ebenezer Howard in his 1898 book, 'Tomorrow: a peaceful path to real reform'. In reality, it is increasingly accepted that the concept is wasteful and inefficient in its use of land and infrastructure resources. Increased urban density has become a policy goal.

However, rather than pursue the vision of the Swiss-French architect Le Corbusier, who envisaged dense concentrations of people in high-rise condominiums, with 95% of the plot ratio being devoted to green spaces and urban forest, the South Australian Government has sought increased density through the subdivision of suburban blocks.

Where once one dwelling existed on a 600m² allotment, with a roof area occupying about a quarter of the area, there are now two and sometimes three homes. The roof area of each is generally larger than that of the original dwelling. The necessity of three driveways, patio areas etc results in an increase of impervious surfaces from about 30% to between 80 and 90% of the allotment. The consequences for subsurface moisture are as obvious as are the consequences for increased run off.

Higher urban densities remained elusive. Twenty years ago the original house would have provided a home for five or six people. Census data reveals that the occupancy rate of dwellings in Adelaide is around two. No more people are housed on the allotment, but a lot more resources have been used to house them.

Again this has a water consequence: single person households use more water per person than do multi person households. As the occupancy rate decreases, the demand for water will increase, price will increase and the elasticity of outdoor water use will again come into play.

The Cost of Capturing Stormwater Run-Off

The South Australian Government has recently committed to a storage and recovery program harvesting 80 gigalitres of potable water per annum. As total run-off is calculated to be in the order of 160 gigalitres (South Australia 2004), and as this run-off is not available to street trees, there would appear to be little problem.

If the previously mentioned policies deprive urban ecosystems of significant quantities of water, we may well reach a point which is catastrophic for street trees. The most logical solution, therefore, is to develop a management regime which assigns an adequate share of rainwater run-off to urban green spaces and, in particular, street trees.

David Lawry has been working on an innovative and cost effective solution for in situ tree plantings. It has the potential, not only to water the trees, but, because it this changes root patterns, to diminish the damage and consequently the costs associated with pavement and road paving repairs. It therefore increases the economic efficiency of the tree

He hopes to achieve this through a design which utilises two waste products; water treatment solids and old tyres. The water treatment solids exhibit compaction characteristics and free draining structures similar to structural soils. Additionally, the cation fixing properties of the medium will facilitate the removal of nutrients and heavy metals from roadway run-off, while its carbon component will contribute positively to the soil profile.

The proposed system can be engineered to collect given volumes of water during any rainfall event. It has the advantage of capturing, at least theoretically, first flush run-off. Importantly, this water contains all of the environmental "nasties". Because these can be captured by the medium and captured or processed in the root zone of trees, the ecosystem advantages and the smaller amount of remediation required to purify the remaining water in Wetlands is obvious.

Carbon Sequestration and its Economic Possibilities

Dispelling Some Myths

In 2007 Jeff Angel delivered a paper, 'Trees and Carbon Trading'. He acknowledged that 'the tree has been an enduring feature in the policy, rhetoric and symbolism of the environmental fight' (Angel 2007, p.1). He posits that the champions of carbon trading are 'leveraging off the last 30 years of environmental campaigning that made the trees so popular with the community' (*ibid.* p1).

He goes on to assert however that 'tree plantations are the least credible carbon offset' (*ibid.* p2) and quotes Cambridge University botanist Oliver Rackham as saying 'telling people to plant trees (to address climate change) is like telling them to drink more water to keep down rising sea levels' (Ibid,p.3). Indeed, studies reveal that over their lifecycle, all vegetation, including trees, are carbon neutral: while vegetation extracts carbon and synthesises it into organic compounds, when that vegetation dies, aerobic decomposition releases the sequestered carbon.

Kyoto and the Future

Under the Kyoto protocols, urban vegetation cannot be included in the calculations of greenhouse gas emissions, as either sinks or for the purposes of sequestration. Nor is it intended that urban vegetation can be used in carbon credit calculations or carbon trading. This is primarily because of difficulties that relate to verification of data and the relatively small scale of urban plantings in relation to the large scale of forests or plantations. Moore (2006) argues that 'this does not seem logical and it is difficult to imagine that under the more stringent post-Kyoto protocols, urban woody vegetation will not have some value after 2012. Again this should translate into an added recognition of the increased value of urban woody vegetation in real terms'. (*ibid.* p.5). This contention receives qualified support in a paper by McHalea (McHalea, McPhersonb et al. 2007).

From its genesis, policymakers have targeted major point sources of polluting products (e.g. oil refineries are held responsible, not only for the emissions of the refining process, but for the carbon emissions produced by consumers). Logic and equity[21] would suggest that either future protocols or the governments responsible for their management and implementation will hold urban centres[22] accountable for their emissions in a similar manner[23].

[21] Taxing urban populations in respect to their "carbon footprint" is one methodology by which the developing world can be relieved of some of the burden of the first world's profligacy

[22] " With over 60% of world' population (nearly 5 billion people) expected to be living in urban areas by 2030 (compared with less than 15% in 1990 and 48% in 2002), cities are rising to the top of the policy agenda" Additionally, by " 2000 there were 388 cities with a million or more inhabitants(UN2002)….with 16 cities

Indeed, the work of Rees and others (Rees 1992) (Rees 1995; Rees 1996) could lead policymakers in the direction of an even more focused 'user pays' system: vis taxing urban centres for their carbon footprint.

While the way forward is uncertain, all signposts indicate that the urban forest will play an integral role in future plans for the bio sequestration of carbon.

Present Opportunities

In concentrating on the future, it is easy to ignore immediate opportunities. As has been mentioned, scientifically, trees represent an efficient means of bio sequestration in the short and medium term. The world must find long-term solutions. To do this we can have no better teacher than nature[24].

Vast reserves of coal, oil and natural gas, having locked carbonaceous material beneath the earth's crust for aeons, have given this planet its current climatology. Their release is universally attributed as the prime cause of global warming. These reserves were created by the anaerobic decomposition of carbonaceous material Vast quantities of green organics found their way into aqueous environments and, protected from the atmosphere, formed those reserves which, with heat, pressure and time would provide the fuel sources of the modern epoch. On its journey the detritus was critical in providing nutrients to estuarine ecosystems[25].

Why then, in a world which is desperately attempting to sequester carbon, are we lectured by Catchment Management Boards (behind whom stand water engineers) to sweep our gutters clean of leaves and never to dispose of green waste in our watercourses? I refer you back to Falkenmark's comment 'water resources management is taken as various ways of controlling and governing direct water use and related waste flows, not as managing water's various functions in the landscape' (Falkenmark 2003, p237). The purpose of stormwater drainage systems is to avoid flooding. Economic efficiency in such systems is measured by getting the maximum amount of water through the least amount of infrastructure in the shortest possible time. Leaves and other vegetable matter, block outlets and slow flow, creating inefficiency. In a world where the efficiency of a part is often regarded as more important than the well-being of the whole, leaves are to be avoided.

Unfortunately for us and for our environment, we are trapped by this error. Since most of the urban world is 'stuck' with stormwater systems engineered on the principles outlined, to ignore the engineer's advice is to court flooding and, at worst, systems failure. Nevertheless as old systems are replaced or new systems constructed, a holistic approach to urban ecological management which mimics natural systems should be developed. The efficiency of these new systems should be estimated by their lack of disruption to the ecosystem.

Possible Solutions

In the short term then, does this consign leaf litter to the debit column when measuring the economic value of street trees? The answer, according to Dr. Tim Flannery (Flannery 2008) and other distinguished academics, is no.

Urban leaf litter, and most particularly that of large deciduous trees, is a valuable fuel source for pyrolysis (often referred to as char burning). This process generates excess methane that can be used as a fuel. The waste product is carbon. Such carbon, unlike a growing forest, is tangible. It does not need to be estimated. It contains neither risk nor uncertainty. It can be weighed and

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becoming "megacities" in 2000 (a "megacity" has a population of 10 million or more)(2003). Water for People, Water for Life. The United Nations World Water Development Report. Barcelona, UNESCO: 575.
,p160.

[23] if petroleum product emissions are accounted at refineries and double dipping is to be avoided, the emissions for which the urban centre would be held responsible are "total emissions minus petroleum product emissions"

[24] George Santayana: "Those who cannot learn from history are doomed to repeat it". H.G. Wells: "History is the race between education and catastrophe"

[25] the same process remains a primary part of a modified estuarine ecosystems and can be seen in such places as the Kimberley region of Australia and the Amazon river basin

measured, its credits sold. It has a stability which is measured in centuries. It has been demonstrated to enhance soil structure, fertility and water retention rates, especially in fragile soils (Lal 2004).

If we consider that a mature plane tree can sequester about 70kg of atmospheric carbon per annum and that a large amount of this carbon is used to form the leaves, the potential of urban forest as a major source of fuel for the bio charter industry is enormous. The economic value of each street tree would increase accordingly.

Further Possibilities

We cannot do justice to all the possibilities for enhancing the economic value of our urban forest within the limited confines of this paper. However, I would like to canvass one more.

In a recent address at the University of Adelaide, Associate Professor David Paton spoke of the loss of habitat for the birds of the Mount Lofty region and the consequent endangerment of a number of species. Properly planned, suitable plantings in urban green spaces could remediate this problem. Executed as a contractual arrangement between local government authorities, government or wildlife conservation trusts such plantings could generate revenue for their owners. The provision and management of urban habitat could prove a profitable business venture.

Summary

In concluding, we seek to avoid the pitfalls of oversimplification. We see the future of the management of urban green space as a myriad of possibilities. We see the work Stringer and others as establishing, beyond doubt, the rightful place of environmental managers in economic fora. We have not attempted to place a value on urban trees, for not only do these vary with species, site and size, but, as new uses are found for them and as the measures by which their values are assessed change[26] their economic value will increase. Rather we have attempted to argue a case for increasing the economic value of street trees through efficiency and through canvassing alternative possibilities for their use.

While environmental economics must grapple with the constructs of efficiency it should never succumb to the pitfall of 'one size fits all' solutions. Environmental efficiency is achieved holistically but is dependent on optimum solutions within the complexities of species, place and time. Changing any of the variables will result in different solutions for each place and each species at any particular time.

Though the solutions will be complex, we remain confident that they are achievable. A decade ago you came together because you believed that you have a part to play in saving street trees. I think that you should go from here believing that you have a part to play in saving our world. For as Robert Kennedy once said: 'Few will have the greatness to bend history itself; but each of us can work to change a small portion of events, and in the total of all those acts will be written in the history of this generation'.

[26] When Killicoat et al calculated their original values, the median house value was hundred and $174,000. It is currently $360,000 (Anthony Toop, 12/08/09). If street trees add, as asserted, 1% to house value the median value of those trees is $3600. Toop estimates the value of a garden to be 10% of the sale value of the property i.e. $36,000. Trees on properties could therefore be worth considerably more than $3600.

Reprinted from: Killicoat, P., E. Puzio et al. (2002) **"The Economic Value of Trees in Urban Areas: estimating the Benefits of Adelaide's Street Trees"**
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Table 1 summarises many tree benefits, including various estimates of the values associated with those benefits. *Table 1 An overview of tree benefits: selected studies.*

Temperature and Energy Use
a) Community heat islands (3o to 10°F warmer than surrounding countryside) exist because of decreased wind, increased high density surfaces, and heat generated from human associated activities, all of which requires addition energy expenditures to off-set. Trees can be successfully used to mitigate heat islands.
b) Trees reduce temperatures by shading surfaces, dissipating heat through evaporation, and controlling air movement responsible for advected heat.

Shade
a) 20°F lower temperature on a site from trees.
b) 35°F lower hard surface temperature under tree shade than in full summer sun.
c) 27% decrease in summer cooling costs with trees.
d) 75% cooling savings under deciduous trees.
e) 50% cooling energy savings with trees. (1980) 20°F lower room temperatures in uninsulated house during summer from tree shade.
f) $242 savings per home per year in cooling costs with trees.
g) West wall shading is the best cooling cost savings component.
h) South side shade trees saved $38 per home per year.
i) 10% energy savings when cooling equipment shaded (no air flow reduction).
j) 12% increase in heating costs under evergreen canopy
k) 15% heating energy savings with trees (1980).
l) 5% higher winter energy use under tree shade.
m) $122 increase in annual heating costs with south and east wall shading off-set by $155 annual savings in cooling costs.
n) Crown form and amount of light passing through a tree can be adjusted by crown reduction and thinning.
o) Shade areas generated by trees are equivalent to $2.75 per square foot of value (1975 dollars).

Wind Control
a) 50% wind speed reduction by shade trees yielded 7% reduction in heating energy in winter.
b) 8% reduction in heating energy in home from deciduous trees although solar gain was reduced.
c) $50 per year decrease in heating costs from tree control of wind.
d) Trees block winter winds and reduces 'chill factor'.
e) Trees can reduce cold air infiltration and exchange in a house by maintaining a reduced wind or still area.
f) Trees can be planted to funnel or baffle wind away from areas - both vertical and horizontal concentrations of foliage can modify air movement patterns.
g) Blockage of cooling breezes by trees increased by $75 per year cooling energy use.

Active Evaporation
a) 65% of heat generated in full sunlight on a tree is dissipated by active evaporation from leaf surfaces. (Source: Kim D. Coder *Identified Benefits of Community Trees and Forests*, The University Of Georgia Cooperative Extension Service Forest Resources Unit Publication, For96-39, University of Georgia, 1996).
b) 17% reduction in building cooling by active evaporation by trees.
c) One acre of vegetation transpires as much as 1600 gallons of water on sunny summer days.
d) 30% vegetation coverage will provide 66% as much cooling to a site as full vegetation coverage.
e) A one-fifth acre house lot with 30% vegetation cover dissipates as much heat as running two central air conditioners.

Pollution Reduction
a) Community forests cleanse the air by intercepting and slowing particulate materials causing them to fall out, and by absorbing pollutant gases on surfaces and through uptake onto inner leaf surfaces.

b) Pollutants partially controlled by trees include nitrogen oxides, sulfur dioxides, carbon monoxide, carbon dioxide (required for normal tree function), ozone, and small particulates less than 10 microns in size.
c) Removal of particulates amounts to 9% across deciduous trees and 13% across evergreen trees.
d) Pollen and mould spore, are part of a living system and produced in tree areas, but trees also sweep out of the air large amounts of these particulates.
e) In one urban park (212 ha), tree cover was found to remove daily 48lbs particulates, 9lbs nitrogen dioxide, 6 lbs sulfur dioxide, and frac12; lbs carbon monoxide. ($136 per day value based upon pollution control technology).
f) 60% reduction in street level particulates with trees.
g) One sugar maple (one foot in diameter) along a roadway removes in one growing season 60mg cadmium, 140 mg chromium, 820 mg nickel and 5200mg lead from the environment.
h) Interior scape trees can remove organic pollutants from indoor air.

Carbon Dioxide Reduction
a) Approximately 800 million tons of carbon are currently stored in US community forests with 6.5 million tons per year increase in storage ($22 billion equivalent in control costs).
b) A single tree stores on average 13 pounds of carbon annually.
c) A community forest can store 2.6 tons of carbon per acre per year.

Hydrology
a) Development increases hard, non-evaporative surfaces and decreases soil infiltration – increases water volume, velocity and pollution load of run-off -- increases water quality
losses, erosion, and flooding.
b) Community tree and forest cover intercepts, slows, evaporates, and stores water through normal tree functions, soil surface protection, and soil area of biologically active surfaces.

Water Run-Off
a) 7% of winter precipitation intercepted and evaporated by deciduous trees.
b) 22% of winter precipitation intercepted and evaporated by evergreen trees.
c) 18% of growing season precipitation intercepted and evaporated by all trees.
d) For every 5% of tree cover area added to a community, run-off is reduced by approximately 2%
e) 7% volume reduction in six-hour storm flow by community tree canopies.
f) 17% (11.3 million gallons) run-off reduction from a twelve-hour storm with tree canopies in a medium-sized city ($226,000 avoided run-off water control costs).

Water Quality / Erosion
a) Community trees and forests act as filters removing nutrients and sediments while increasing ground water recharge.
b) 37,500 tons of sediment per square mile per year comes off of developing and developed landscapes - trees could reduce this value by 95% ($336,000 annual control cost savings with trees).
c) 47% of surface pollutants are removed in first 15 minutes of storm. This includes pesticides, fertilizers, and biologically derived materials and litter.
d) 10,886 tons of soil saved annually with tree cover in a medium-sized city.

Glare Reduction
a) Trees help control light scattering, light intensity, and modifies predominant wavelengths on a site.
b) Trees block and reflect sunlight and artificial lights to minimize eye strain and frame lighted areas where needed for architectural emphasis, safety, and visibility.

Property Values -- Real Estate Comparisons
a) Community trees and forests provide a business generating, and a positive real estate transaction appearance and atmosphere.
b) Increased property values, increased tax revenues, increased income levels, faster real estate sales turn-over rates, shorter unoccupied periods, increased recruitment of buyers, increased jobs, increased worker productivity, and increased number of customers have all been linked to tree and landscape presence.
c) Tree amenity values are a part of real estate prices.
d) Clearing unimproved lots is costlier than properly preserving trees.
e) 6% ($2,686) total property value in tree cover.
f) $9,500 higher sale values due to tree cover.

g) 4% higher sale value with five trees in the front yard -- $257 per pine, $333 per hardwood, $336 per large tree, and $0 per small tree.
h) $2,675 increase in sale price when adjacent to tree green space as compared to similar houses 200 feet away from green space.
i) $4.20 decrease in residential sales price for every foot away from green space.
j) 27% increase in development land values with trees present.
k) 19% increase in property values with trees. (1971 & 1983)
l) 27% increase in appraised land values with trees. (1973)
m) 9% increase in property value for a single tree. (1981)
n) Values of single trees in perfect conditions and locations in the Southeast range up to $100,000.
o) $100 million is the value of community trees and forests in Savannah, GA.
p) $386 million is the value of community trees and forests in Oakland, CA (59% of this value is in residential trees).

Animal Habitats
a) Wildlife values are derived from aesthetic, recreation, and educational uses.
b) Lowest bird diversity is in areas of mowed lawn - highest in area of large trees, greatest tree diversity, and brushy areas.
c) Highest native bird populations in areas of highest native plant populations.
d) Highly variable species attributes and needs must be identified to clearly determine tree and community tree and forest influences.
e) Trees are living systems that interact with other living things in sharing and recycling resources -- as such, trees are living centres where living thing congregate and are concentrated.
f) The annual ecological contribution of an average community tree is estimated at $270.

Aesthetic Preferences
a) Conifers, large trees, low tree densities, closed tree canopies, distant views, and native species all had positive values in scenic quality.
b) Large old street trees were found to be the most important indicator of attractiveness in a community.
c) Increasing tree density (optimal 53 trees per acre) and decreasing understory density are associated with positive perceptions.
d) Increasing levels of tree density can initiate feelings of fear and endangerment – an optimum number of trees allows for visual distances and openness while blocking or screening developed areas.
e) Species diversity as a distinct quantity was not important to scenic quality.

Visual Screening
a) The most common use of trees for utilitarian purposes is screening undesirable and disturbing sight lines.
b) Tree crown management and tree species selection can help completely or partially block vision lines that show human density problems, development activities, or commercial / residential interfaces.

Health
a) Stressed individuals looking at slides of nature had reduced negative emotions and greater positive feelings than when looking at urban scenes without trees and other plants.
b) Stressed individuals recuperate faster when viewing tree filled images.
c) Hospital patients with natural views from their rooms had significantly shorter stays, less pain medicine required, and fewer post-operative complications.
d) Psychiatric patients are more sociable and less stressed when green things are visible and immediately present.

Human Social Interactions
a) People feel more comfortable and at ease when in shaded, open areas of trees as compared to areas of hardscapes and non-living things.
b) People's preferences for locating areas of social interactions in calming, beautiful, and nature-dominated areas revolve around the presence of community trees and forests.
c) Trees and people are psychologically linked by culture, socialization, and coadaptive history.

Recreation
a) Contact with nature in many communities may be limited to local trees and green areas (for noticing natural cycles, seasons, sounds, animals, plants, etc.) Trees are critical in this context.
b) $1.60 is the willing additional payment per visit for use of a tree covered park compared with a maintained lawn area.

Noise Abatement
a) 7db noise reduction per 100 feet of forest due to trees by reflecting and absorbing sound energy (solid walls decrease sound by 15 db)
b) Trees provide 'white noise', the noise of the leaves and branches in the wind and associated natural sounds that mask other man-caused sounds.
(Source: Kim D. Coder *Identified Benefits of Community Trees and Forests*, The University Of Georgia Cooperative Extension Service, Forest Resources Unit Publication, For96-39,University of Georgia, 1996.)

Calculating the gross benefits of Adelaide's street trees
Quantifying the exact net value of Adelaide's street trees is beyond the scope of this paper. Instead the aim here to provide an overview of the kinds of benefits and costs that should be considered and estimates, especially for some of the benefits. The costs of street tree management will vary by council, so the responsible officials are best placed to quantify the costs per tree.

The core benefits street trees provide can be captured as follows:
B = E+A+C+H+P+F
Where:
B = street tree annual benefits
E = annual price of energy savings (cooling and heating);
Q = annual price of air quality improvement(pollutant uptake and avoided power plant emissions);
C = annual price of carbon dioxide reductions;
H = annual price of stormwater runoff reductions;
P = annual price of property value and related benefits;
F = annual savings for reductions in repaving streets.

A suggested formula for estimating annual costs is:
C = M+T+R+D+I+S+L+A
Where:
C = annual costs of street trees;
M = annual price of tree planting;
T = annual price for pruning;
R = annual price of tree removal;
D = annual price for pest and disease control;
I = annual price for repairing tree-damaged infrastructure;
S= annual price of litter and storm clean up;
L = annual insurance costs for street tree liability;
A = annual price for program administration.

Our assumptions include the following:

- The estimated number of street trees in Adelaide is 128,000 (based on 1927km of roadsides;
- If all Adelaide's street trees were removed summer temperatures would be from .5^{o}C to 2^{o}C warmer due to the heat island impact, lack of evapotranspiration and, most importantly, shade on paved streets and side walks;
- The average Adelaide household spends $193 on air conditioning due to heat (more than $80 million per year);
- Spending on air conditioning energy consumption would increase by $20 per household per year if street trees were removed or an increase in 57 million kWh power consumption;
- Difference in street tree growth rates, size, leaf area, and canopy are ignored and a typical medium sized tree is used for a typical tree;
- Street tree CO_2 sequestration is offset by CO_2 released but CO_2 is reduced due to reduced power consumption;
- Air Pollution (Ozone, NO_2, SO_2,PM_{10},VOCs, and BVOCs) are based on California data (city of Buena Vista);

- Power supply in Adelaide is 50 -50 gas and petroleum with .2299 grams carbon per kWh for petroleum and .1562 grams carbon per kWh for gas;
- Street trees contribute 1 percent to average house values (studies suggest 1 to 3 percent) and the average house is $145,000;
- Air quality price is based on average market value of pollution reduction credits in Southern California, USA;
- In estimating residential energy use for summer cooling we ignore commercial and industrial savings, but suggest additional savings of around 40% of total residential or $3.3 million or $25.60 per street tree (calculation table found in the original document)

Recalculating the Gross annual benefits for a typical Adelaide street tree

Household Benefits
Energy savings **$64**(Based on assessment of Killicoat et al. (2002))
Aesthetics/others **$65** (Based on assessment of Killicoat et al. (2002))
Capital appreciation **$72** (Based on a median house value of $360,000 and assuming 2% pa appreciation)

Local Government Benefits
Storm water **$6.50** (Based on assessment of Killicoat et al. (2002))
Repaving Savings **$180** (Moore 2009[27]

Community Value
Air Quality (reduced pollution) **$34.50** ((Based on assessment of Killicoat et al. (2002))
Reduced CO_2 Emissions **$1.00** (Based on assessment of Killicoat et al. (2002))
CO_2 sequestration **$1.40** (based on absorption figures for a mature deciduous tree with a CO2 trading price of $20.00 per tonne)

Estimated Gross Benefit, $424.40 pa

Assuming a 60 year average life cycle, estimated gross benefit per tree, $25,500
All assumptions mirror those made in the Killicoat paper. Where estimates have been revised or updated, extrapolations have been made from other studies. In the absence of adequate data on tree numbers, prices, and computer modelling, the numbers remain, at best, a revised 'guesstimate'. While the authors of the original document were 'confident that the gross benefits would actually be significantly higher if a proper study could be undertaken', the likelihood of underestimation is here compounded because many of the values used are in 2002 dollars. Hopefully, the increasing significance of the economic value of trees as community assets, will challenge others to a more accurate assessment of their worth.

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[27] This calculation is the value of road surface protection only. It assumes a tree with a canopy diameter of 6m set in a two metre nature strip, with a two metre paved footpath. Hence no savings are calculated re paving

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URBAN FOREST: RISK STARTED THE BALL ROLLING – SO WHAT WILL SUSTAIN IT?

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Introduction

My 2003 essay, 'As We Think - So We Manage', considered how influential language was in shaping response to tree-infrastructure interactions. For government, insurers, utilities and many 'asphalt-hardened' engineers, tree removal was the first rather than the last consideration. In the words of architect and author Robin Boyd this was 'clearing the decks for action'.

I suggested that decisions based on 'short-term economic expediency' had become the *modus-operandi* in considering options for managing trees in rapidly changing urban environs characterised by even more concrete, glass and asphalt.

Today's essay looks at the passage of tree management from 2003 to 2009 with the New South Wales city of Newcastle as a point of reference.

It is widely acknowledged that there are major financial shortfalls with implications for the sustainability of Councils across Australia struggling with the costs of maintaining and renewing their built infrastructure. This has implications for the future of 'green infrastructure' i.e. street and park trees, creeks and bushland in urban areas.

Infrastructure traditionally refers to built assets like roads, bridges, and stormwater constructions such as drains and culverts. It has not included natural resources such as trees, creeks and wetlands. Since the natural resources managed by local government are in the main not defined or managed as assets, then many councils will find it extremely difficult to secure the finance and resources needed to maintain, let alone 'renew', their green infrastructure.

Communities, corporate and business interests, officials and elected representatives must be brought 'up to speed' on the fundamental contributions of 'green infrastructure'. There can be no urban sustainability without adequate, healthy and managed natural assets. No amount of road building, footpath construction, pipe laying and cable stringing will sustain cities in the long term if the underpinning natural resources are not in the equation. For natural resource managers and advocates the task is not only to improve mainstream understanding of urban trees, creeks and bushland, but also to quantify the contributions of these priceless assets to our ecological and financial sustainability.

As We Think - So We Manage: Risk management as the 2003 focus

The phrase 'as we think - so we manage' encapsulates the way language influences responses to risk and tree management. Determinations on trees were and still are framed around the urban tree as a cost and risk centre, with tree removal resolving that risk and providing a cost benefit. In the absence of quantified tree benefits the costs of trees remains the foundation for decisions.

That death or even serious injury by trees is rare fails to mitigate the widely held view that large trees are 'dangerous'. The myth that trees are sentient beings that have intentions such as 'seeking' and 'invading' pipes is deeply ingrained. Some utilities and commercial enterprises reinforce these myths in order to gain work or support for the policies that remove trees and prevent replanting as a cost cutting exercise.

My 2003 essay also discussed the State Wide Insurance Best Practice trees and tree roots manual that Judy Fakes and I revised. The State Wide framework and the revised trees and tree roots manual were important drivers for Newcastle's pilot tree information and management system.

From 2003 to 2009: The emergence of asset management

Asset management was in its infancy in local government in 2003. But since then Newcastle has made a quantum leap by acknowledging and incorporating natural resources as an asset group in

their own right. By 2007 the Council had adopted an urban forest policy and had started to develop a systematic, proactive approach to managing the public tree resource.

The inclusion of street and park trees in the city assets portfolio and the adoption of the Urban Forest policy are the foundations on which tree asset management is now being built. Today's conversation is about canopy benefits and on how to define and sustain an optimal canopy through time. There is discussion not only about the cost of maintaining existing public tree assets, but also about the costs of canopy renewal. Since trees are now acknowledged assets, there is a need for a tree asset management plan. Once again we are set to move into uncharted territory!

The systematic renewal or 'rotation' of the urban tree canopy has been absent from municipal conversation until very recently, despite cities and municipalities nationwide facing the renewal costs of two or more generational cohorts of cultivated trees. Couple this scenario with aging and declining built infrastructure systems, and it becomes obvious that the need to secure resources and funding is at a critical point.

Newcastle Council crossed an important threshold in 2006-2007 when it formally acknowledged natural resources as an asset group in their own right. Few councils have taken this step to date but they will need to do so as they travel the path to financial sustainability.

I will try now to outline why this occurred at Newcastle. Council committed funds in its 2005 Management Plan to develop an urban forest policy and city greening project. Ian McKenzie, a Newcastle City Councillor (Greens) was the main political support for the project. I was seconded as Project Co-coordinator under direction of a control group of Group Managers from three Council departments. A working group, comprising three Service Managers and I, thus launched into an uncharted policy domain.

Towards the end of 2005, we ran a series of facilitated workshops to sensitise Councillors, senior management, staff and community to the concept of urban forest and the practices of urban forestry as they might apply to Newcastle. The workshops expressly canvassed the opinions and aspirations of participants to inform and refine policy development.

By early 2006 we had a first draft for the urban forest background paper, policy and action plan. The framework for action established four key response areas containing key actions as follows:

1.Leadership and direction
- a.Newcastle Greening Plan
- b.Research
- c.State of Environment reporting

2.Managing vegetation assets
- a.Major Assets Preservation Program (MAPP)
- b.Tree maintenance service levels
- c.User pays option
- d.Community land management

3.Guiding activities
- a.LEP framework – vegetation
- b.Tree management policy and technical manuals
- c.Development contributions

4.Partnering with the community
- a.GreenAssist scheme
- b.NeighbourWoods program
- c.Institutional partnerships
- d.Community information and advice

This holistic framework was necessary because of the ubiquitous distribution of the urban tree canopy. Of particular interest to my discussion here, is the recommendation to bring public trees into the Major Assets Preservation Program (action 2a above). Our key response for managing vegetation assets was unequivocal:

> *A programmed asset management approach for all tree and vegetation assets will be implemented through the Major Assets Preservation Program. Supporting information and planning systems will be developed or upgraded, including those relating to asset inventory, inspection, complaints, maintenance scheduling and natural asset accounting.*

At the time that we were developing the urban forest action plan a review had commenced into the financial sustainability of the City Council. The review by Review Today Pty Ltd [(1)] under the direction of Research Director Professor Percy Allan AM, became known within Council as the 'Percy Report'. Terms of reference for the review included an assessment of the state of existing Council infrastructure and an estimate of the cost of fixing existing infrastructure and services.

In a recent interview with Council's Asset Manager, I found that in 2006 Professor Allan did not regard natural resources (e.g. trees) as part of the asset mix under review. However during the early stages of his review, Council management argued strongly and successfully for the inclusion of natural resources.

The argument was essentially pragmatic: street trees and to a lesser degree park trees imposed a cost since they were often the cause of footpath, kerbs and drainage repairs and so they had to be accounted for. They also argued that the community wanted trees to remain part of the city form and therefore trees should be managed in the same way as built assets.

The genesis of the 'trees are assets' argument came in part from the urban forest draft key action for a programmed asset maintenance approach for public trees and vegetation. It was coincidental that the financial sustainability review was being developed after the organisation-wide urban forest workshops had been held. The workshops influenced the framing of the argument for trees as assets.

Unfortunately, senior management at the time removed many of the urban forest working group's draft key actions before putting the final policy to Council. This was not simply a disappointment for the policy team: it was an error of judgment in that it retained the existing non-integrated and diffuse structure that green infrastructure planning and administration had foundered on in the first place.

On a positive note, Council did implement the 'trees as assets' key action, even before the urban forest policy was adopted. At that time, I joined the Asset Management Team developing the tree component of the natural assets program.

Completed in March 2007, the financial sustainability review reported the city's infrastructure backlog at $134 million with a further $630 million of infrastructure renewal in the next 20 years.

The report profiled Newcastle's major asset groups as follows:

- Regional and local roads (including pavements, street lighting, bridges, etc) $552 million
- **Natural assets (eg street and park trees, urban creeks) $127 million**
- Storm water (e.g. pits, pipes, culverts) $460 million
- Buildings and structures (e.g. retaining and river walls, bridges and culverts) $471 million
- Recreational assets (e.g. parks and sports grounds) $6 million
- Cultural assets (e.g. art works and museum exhibits) $69 million

The total replacement value of the city's infrastructure was $1,685 million. From 2007 to 2009 the Asset Management team researched, designed and implemented the Tree Asset Management System (TAMS) as a wholly in-house project. Data collection for the entire street and park tree population was completed in 2008, and the work orders system was finalised in 2009.

The City Wide Maintenance Policy Tree Amendment adopted in 2008, gave Councillors, staff and the community clear direction in dealing with public trees and work requests. The amendment assigned priority to risk management and also to works that extend tree asset life e.g. formative pruning of new trees.

What happens next?

Recent New South Wales legislation is seeking to change local government financial reporting and asset management. The Integrated Planning and reporting framework and fair value system are driving the state agenda.

The draft *Local Government Amendment Planning and Reporting Bill (2009)* and *Local Government (General) Amendment (Planning and Reporting) Regulation* require all New South Wales local councils to develop a strategic and Sustainable Approach to Asset Management (SAMP).

Future infrastructure funding support will depend on Council plans being implemented. Unfortunately, the legislation is focused on built assets. However, since Newcastle has already incorporated its natural resource base within its asset portfolio it is now well positioned on a path to financial sustainability. (Table1)

Newcastle's inaugural Strategic Asset Management Plan (SAMP) will initially deal with natural assets under a built asset data management framework. This presents some interesting challenges since natural and built assets are fundamentally different. For instance one depreciates, while the other appreciates! The language of asset management is itself a challenge for anyone whose life work has been dealing with natural systems and living things. But that is the challenge ahead - like it or not!

Table 1: Summary of the Newcastle assets portfolio

Built Assets	Natural Assets and Open Space
Bridges	Estuaries / creek lines / catchments
Roads	Urban trees
Drainage	Parks
Buildings	Open space
Footpaths	Marine coastline / beaches / seawalls
Kerbs	Wetlands and bushland
Sport and recreation facilities	Riparian zones

Table 2: Summary of activities and issues relevant to urban forest management 2003 – 2009

2003	**NSW LGA Urban Forest Policy** adopted.
2005	**Newcastle City Greening and Urban Forest** project. A two-year project under direction of cross-organisation management team.
	Urban forest workshop series. Facilitated workshops for councillors, senior management, community and business groups, and Council staff. Prompted debate and discussion on urban forest and tree management.
2006	**Trees (Disputes Between Neighbours) Act (NSW)** Councils exempt from definition of a neighbour.
2007	**The Newcastle Report: issues for sustainability.** Natural resources included in the review of infrastructure.
	Asset Manager assumes responsibility for public trees under the Major Asset Preservation Program (MAPP). City Arborist transferred to Asset Management
	Natural Assets coordinator appointed to Asset Management with responsibility for bushland, stormwater, creeks and street trees.
	Urban Forest Background paper posted on Council website: details the underpinning for the Urban Forest policy
	Newcastle Urban Forest Policy adopted
	DCP 4.10 Tree Management adopted
	Urban Forest Policy implementation becomes the responsibility of Principal Strategist, New Communities and Green Corridors
	(SEPP) State Environmental Planning Policy (Infrastructure) 2007 (NSW) greater autonomy for works and maintenance for energy, rail, communications, water, education and other entities. Utilities have discretion on tree removal without Council approval.
2008	**Newcastle City Wide Maintenance Policy - Public Tree Amendment** adopted. Policy assigns work priority to risk and to work that extends tree useful life. Whole-of-life tree maintenance adopted
	Tree Asset Management System (TAMS) design in-house. Data capture on 103,000 trees and 29,000 potential sites
	TAMS loaded to corporate mapping system & accessible to all users including Councillors

	Strategic Asset Management Plan (SAMP) commenced. Plan aims to guide holistic and sustainable management of natural and built assets in the LGA
	LiDAR capture of Newcastle LGA. Tree canopy stratified to five height strata. Analysis in progress for canopy cover by precinct, suburb and LGA. Future monitoring to determine changes to canopy cover.
2009	**Urban Forest Technical Manual** supports DCP and guides public and private works affecting trees
	Draft Street Tree Master Plan for public exhibition September 2009
	TAMS data analysis in progress as basis for Tree Asset Management Plan
	Council sustainability review and organisational restructure commenced. Major changes to structure and all levels of management
	Street tree marketing & publicity campaign designed. To commence February 2010
	Trees (Disputes Between Neighbours) Act 2006 (NSW) Government review commenced. Councils may be defined as a 'neighbour'
	Draft Local Government Amendment Planning and Reporting Bill (2009) (**NSW)** and **Local Government (General) Amendment (Planning and Reporting) Regulation.** All Councils to develop a strategic and sustainable approach to Asset Management (AM). Future infrastructure funding from government depends on plans being implemented.
	National Broadband Network. Roll out of fibre-optic cables by in-ground or attached to power poles, creating significant implications for street trees
	Widespread uptake of Wi-Fi technology. Implications emerging for signal interference from trees
	Solar panel installations. Federal subsidy program. Conflicts emerging with shade from public and private trees
	Solar powered school speed warning signs. Conflicts emerging from tree shade.

Research rings alarm bells for backyards and private trees

Queensland's Griffith University investigated the disappearance of backyards (and trees) from new subdivision housing in Australia. It found that the traditional 30-40% plot coverage had increased to 50-60% resulting in the elimination of private backyards. The research suggested that the pursuit of large floor space as a financial investment took precedence over lifestyle choices. The new housing is characteristically single story, deep plan on slab.

The study pointed to planning controls as a driver and raised questions about the social and environmental costs from the loss of backyard space and trees. With the exception of Adelaide, all other Australian cities were found to have allowed large footprint housing on small allotments and as a result the once traditional backyard has almost completely disappeared.

The loss of private garden space (and canopy trees) has implications not only for community health, and especially for children's health and development, but also increases the cost of storm-water management, air quality management, biodiversity, and energy conservation.

The public domain component of new housing subdivisions is characterised by narrowed roads; roll over kerbs, and gaping 'stencil-crete' driveways consuming space once given to street trees.

The development style described above is increasingly popular. An extract from an article published in the Sydney Morning Herald in July 2009 is revealing:

> *V.L, 30, this week became the third resident of the first release of land, Banksia Rise, after paying $483,000 for a four-bedroom house with her partner B.F. The 1½-hour commute to the city to work as a legal secretary was a concern, she said, but "we were willing to travel to get our foot in the door". "We bought new because under the first-home owners grant you got more [if you bought new]." Department of Planning figures show new building on the city's fringe this financial year making up just under 20 per cent of all construction, compared with 10 per cent in 2005-06. Cornish Group, a developer, says turnover is 10 times that seen last year. A hillside of new homes has sprung up accordingly.*

The Urban Heat Island: Western Sydney in the spotlight

Greening Australia [4] examined temperature records and reports a strong Urban Heat Island Effect in western Sydney, which, unlike coastal suburbs, does not receive the moderating influence of a cooling sea breeze. The examination found:

- Over the past 40 years all western Sydney weather stations had experienced a rise in annual temperatures over and above what would be expected through global warming
- The gap between coastal Sydney temperatures and western Sydney temperatures had widened.
- The number of extreme temperature events had risen dramatically

Greening Australia proposed a number of actions to mitigate the observed UHI effect:

- Increasing tree cover as street trees, in backyards and as broad scale revegetation
- Using light colored roofs instead of dark colored
- Minimise energy use: especially at peak periods (e.g. through solar hot water systems)

The GA recommended actions highlight some interesting dilemmas. Firstly, existing and new subdivision roads are not designed to accommodate the sort of shade trees required to cool anthropogenic surfaces without conflicting with pavement and a plethora of utilities at maturity. Secondly, shade trees will conflict with solar panels. This is already driving pressure for tree removals in established urban areas and will suppress new planting in the suburbs. Thirdly, new homes have no gardens and thus no backyards in which to plant trees.

We cannot rely on planting street trees or backyard trees to retrofit shade because decades of non-integrated urban planning and poor design means there is no space available. There are solutions, but they will not be palatable at least not until a crisis point is reached in the future.

Authorities could, for instance, enact planning controls to cap building footprints at 35% of allotment area and allow a second storey for those desirous of greater floor space. We could re-design suburban streets to be pedestrian-centric thoroughfares that permit vehicles on pedestrian terms. We could narrow road pavement (and save on asphalt and energy costs), plant potentially large crowned shade trees in sub-surface vaults, and redirect storm-water to benefit the trees – we could even insist that utilities design their ubiquitous and fragile infrastructure so that it accommodates rather than excludes green infrastructure in future. We could even give part of our redesigned streets over to resident initiated horticulture and agriculture production.

Unfortunately, by any standards these ideas appear radical since they challenge the nation's egocentric obsession with private transport. To be successfully implemented, there would also need to be a change of approach from the utilities sector away from dictating, and more towards serving the community.

On a positive note, it is good to hear that Australian health authorities are about to engage in the 'green infrastructure' debate, bringing research supporting substantive health improvements from green infrastructure into being, in particular creating healthy parks.

Is Asset Management the best way for street trees?

The answer is unequivocally 'yes'. The following is illustrative: *"Whose *%$#&^* idea was it to make trees assets?"* This came from a road maintenance coordinator confronted with the responsibility to consult with the trees coordinator before resurfacing a Council car park where trees had dislodged 'his' kerbs. Herein is evidence of the importance of public trees being part of the assets portfolio.

When public trees are managed as assets they gain stature, identification and a recorded work history. Assets get consideration notwithstanding the personal views of those who disagree with their existence. It does not matter whether the asset is a road, culvert, creek or tree. Arbitrary and expedient tree removal or injury is no longer acceptable since it degrades the asset base and imposes avoidable costs.

Today's asset design decisions warrant careful forethought

Today's decisions will shape the cities of the future: the cities and suburbs in which today's children will make their homes and raise families. A seemingly uneventful exchange of views and a resolution about street dimensions in Newcastle in 1913 has had a profound influence on the city's trees 96 years later.

Colonial architect and town planner (Sir) John Sulman [(2)] (1849-1934) designed the Hamilton Garden Suburb[(3)] in 1913 for the Australian Agricultural Company, proposing a 20ft nature strips on either side of a 60ft carriageway.

The nature strip was to be 20ft with the footpath 16ft with trees planted 4ft from road edge. The trees were to be spaced 33ft apart. Colonel Charles Ranclaud from the AA Company replied to Sulman on 3rd of March 1913 questioning the footpath width:

> *Thanks for your of 26th Ultimo.....We note proposals as to the 100ft avenues, but also that you show a 16ft footpath an a 66ft street. We trust this is not a material point to the new design as the local custom is 12ft footpaths and local Councils might demur at an alteration.*

Sulman replied on 4 March 1913,

> *Your favour of the 3rd just to hand. As regards the 16ft footpath and 66ft street, I am quite aware that it is not the usual custom, which is 12ft, but the sooner the latter is abandoned, the better I think it would be for both the Councils and the public: for the Councils because it would save in metalling if the street is to be metalled all over, and for the public because it reduces dust, and for both because it permits of the planting of trees at any time in a suitable position, whereas 12ft does not. . . . . .A 34ft roadway is ample for any traffic that the ordinary 66ft subdivision road is likely to carry. If, however, it is likely to have considerable traffic (like Hunter Street) then no doubt a 12ft footpath is preferable, but in that case the planting of trees should be definitely abandoned for all time.*

Planting of trees 'Abandoned for all time'!

If the AA Co had accepted the Sulman's advice Newcastle might not be so burdened with extensive and costly pavement and structural damage and the impending removal of much of its iconic arboreal heritage

Despite the AA Co view, Newcastle residents still wanted the shade and amenity of street trees and they and their Councils (there were 9 small Councils at the time) planted thousands of trees in the new, narrow footways. Two main planting eras in the 1930's and 1980's followed. Most of the trees now need to be replaced because Council can no longer sustain the level of claims for infrastructure and drainage problems resulting from the lack of root space.

Are there any lessons here?

YES. It is important for public trees to be acknowledged and managed as infrastructure assets.
YES. Space will only be considered worthy of assigning to urban trees if the true benefits of tree canopies are fully quantified, for which research is critically needed.
YES. Urban forestry integrated in the city assets, planning and operational systems is the most promising approach to sustaining the benefits of tree canopies in the increasingly dense cities of the future.

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HALF TIME IN THE TREENET AVENUES OF HONOUR 1915-2015 PROJECT

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In 2004 at the 5th National Street Tree Symposium, the TREENET Avenues of Honour 1915-2015 Project was launched. It is 'a national project to honour with a tree the memory of every individual who has made the supreme sacrifice on behalf of all Australians, by documenting, preserving and reinstating the original, and establishing new Avenues of Honour, by the Centenary of Anzac in 2015.'[1]

It appeared a daunting challenge at the time but one that would be met given the 10 years TREENET had to undertake the task. Moreover it would provide the ideal opportunity to roll out all the new theories and practices that the emerging urban arboricultural profession in Australia was articulating at TREENET Symposia. This was because although Australians might not value trees for all the reasons we appreciate, one could be confident that when it came to valuing them as symbols of commemoration they would embrace the project. In the process they would learn a lot about the challenge that we as horticulturalists and arboriculturalists face daily in managing our urban forests.

In 2009, we are 5 years down the track and in footy terms it's half time. At the moment the mission seems even more daunting, bordering on impossible, given that we can't claim to have kicked too many goals in terms of planting trees. Moreover it sometimes seems that some players who I thought would be on our team seem to be kicking the ball in the opposite direction! Reading through the Symposia Proceedings of the past 10 years, particularly those subsequent to 2004 has provided plenty of food for thought and challenged many of the simplistic assumptions that I had at the outset. So well considered are the contributions by these authors that I can do no better than to quote verbatim from many of these papers as I take stock of our performance to date and develop a new game plan based on the lessons to be learned from looking back over them.

A logical starting point for the project was to research the history of Avenues of Honour in Australia and determine where they were planted. Historical research is not my long suit so I recruited Sarah Cockerell to 'look into it' and 5 years later she is now completing her PhD on the topic. She has presented three papers since 2004 and has uncovered a number of previously lost avenues. I have not yet commenced turning this information into practical action. However my association with Sarah has progressed into something very special. I have also recruited her to the Unley Concert Band, which led to both of us to take part in the dawn service on Anzac Day this year at the Australian War Memorial at Villers Bretonneux. We also did a quick VTA of the ailing chestnut trees at the top of the Champs Elysses as we marched to the tomb of the 'unknown soldier' under the Arc de Triomphe. So we are slowly getting the hang of dealing with real trees in significant Avenues.

April 2009: The Unley Concert Band leads the VTA party down the Champs Elysses.

Sarah[2] shed some light on the background of Australian Avenues of Honour in her presentation in 2004:

> *'One theory as to why the Avenue of Honour was so popular in Australia during and after WW1 was soldiers recollections of the manicured tree avenues of France in particular and Western Europe in general (Haddow 1987). These impressions of landscape brought back by the returning soldiers may have suggested avenues as a fitting memorial structure. However there is no evidence for any one source for the avenue concept. Historical records about the planning of avenues rarely credit one person with the idea or explain what influenced the decision. Whatever the inspiration the concept was a popular one…. The exact number of avenues ever planted is unlikely to be conclusively known as where avenues have been lost there are often no surviving records of their existence. What is clear is that the avenue was and still is a popular memorial type in Australia.'*

John Dargavel[3] made the distinction between Avenues as a statement of patriotic pride or as expressions of grief in his observation:

> *'The largest avenue was planted at Ballarat by 500 young women, the 'Lucas Girls', from a local clothing factory. They planted one tree for the 3000 men, and a few nurses, who went to war. They were a patriotic group who strongly supported the war effort. Their planting has to be seen in the context of the intense social and political controversy over conscription. Notably, both referenda on conscription were narrowly defeated. Most of the other avenues were planted after the war with one tree for each man who had died. They were expressions of grief rather than patriotism.*
>
> *Like the stone war memorials, the avenues were created by local committees and were not centrally organised. However, the avenues had a much more domestic and personal ambience and were often planted by women or children. This contrasts markedly with the stone memorials—and the later ANZAC Day ceremonials around the stone memorials—from which women were virtually excluded. The Avenues enhanced the town's amenity by creating a green entry, whereas the memorials took a central position.'*

With respect to patriotism or grief as motivators for the project, I have to confess to having a foot in both camps. As I was born on April 25th in 1948 I was always reminded by my mother's sadness on Anzac Day over the loss of her only brother Lt Walter Claude Sheldon, the last of the 48th battalion mortally wounded in action in the closing days of the WW 1. He was my only Uncle and I'd missed him by 33 years. In learning more about his courage and achievements through the excellent AWM (Australian War Memorial) website just prior to departing for the Western front this April, I was filled with both pride and grief. He was recommended for the Military Cross four times, the Military Medal twice and the exalted Belgian Croix de Guerre for his final and fatal storming of the Hindenberg Line whilst attached to the 27th American Division. He was awarded none of these. Medals and decorations have as much to do with luck as they do merit. The family never planted a tree for Claude but in 2004 I dedicated my efforts in the AoH Project to his memory. My recent visit to the battlefields and cemeteries of the Somme at a time when thousands of Australians were on the same pilgrimage convinced me that my mixed sentiments of patriotism and personal grief were common and ready to be expressed in a re-emergence of the Avenue as a memorial.

It is interesting that Dargavel contrasts the roles of granite and greenery in commemoration and the historical record of exclusivity attributed to stone memorials. Exactly the same subtle but powerful distinction was made recently in Adelaide when the opportunity arose to plant an Avenue of Honour in the median of West Terrace, a major perimeter road of the CBD. There would be 58 trees planted to honour the 58 South Australians killed in action in Vietnam. Thousands of commuters would pass their way each day and have the opportunity to reflect on their sacrifice. There was a lot of support for the proposed Avenue. The Adelaide City Council had budgeted for an upgrade so the money was available, the DTEI (Highways Dept) who are responsible for the road were supportive, and Dr Bob Such, MP and TREENET Management Committee member, had promoted the idea widely as well. But in the end, the proposal was not embraced by the RSL SA because there was already a perfectly adequate new stone memorial to the Vietnam conflict in place at the Torrens Parade ground, which is the central position around which Anzac Day ceremonies and Vietnam Remembrance services, on August 18, are conducted each year. The RSL SA didn't oppose the idea: but a more positive response to the initiative may have got the ball rolling. I don't blame the RSL SA for this lost opportunity, more my overconfident assumption that 'honouring with a tree the memory of every

individual' by creating a green entry to the city had equal value to a stone memorial. After Dargavel's warning I should have done more to get the RSL on board at the outset.

Back in 2005, Sarah and I reported[5]:

> *'The Avenues project has really only just begun. We have historical and arboricultural details on only a fraction of the Avenues identified and have not even begun to implement replanting or restoration plans. Currently we are steadily forming links with other community groups who are already researching, restoring and maintaining their own local avenues. Clearly this project is very timely and judging by the ever increasing community awareness and concern it is guaranteed to succeed.*

What still needs to be done?

- *Further promotion of the project for community awareness and support.*
- *Contacts network expanded, especially local community and RSL groups.*
- *Record oral history and locate records of known Avenues where possible.*
- *Photograph and record GIS data for existing avenues and assess the condition of trees and plaques.*
- *Publish freely all information on website including searchable list of names associated with trees and locations of relevant avenues.*
- *Encourage local schools, community groups and organisations to be involved in all aspects of the project, especially restoration and replanting.*
- *Commence long term monitoring of trees and plaques.*
- *Determine with others appropriate strategies for commemorating all unrepresented combatants lost in service.*
- *Negotiate sites for new Avenues with State and Federal road authorities.*
- *Plant new Avenues for a new century and for all unrepresented combatants lost in service.*

In 2005 we could talk about a plan! However in the same year, Adrian Howard, founder of the highly successful project to restore Soldiers Walk in Hobart, was able to talk of achievement[6]. The Avenue was established in 1917 and had fallen into a neglected state.

> *'In 2002, Friends of Soldiers Walk (FOSW) began a series of working bees under the aegis of the Hobart City Council Bush Care program. These working bees focussed initially on clearing competing smaller vegetation around the trees and later extended to a six-metre radius around the canopies. Number plates were also installed to allow identification of Avenue trees.'*

Their management plan set

> *'August 3rd 2014, which is the 97th anniversary of the first plantings, as the goal for total restoration. This was chosen, as August 4th 2014 is the centenary of the outbreak of war. All missing trees will be replaced as the main priority followed by the dead and the unwell, with family agreement.*
>
> *In 2003, FOSW received a grant from the Hobart City Council to develop a website and a map of the Avenue. In 2004, the HCC endorsed a management plan for the Avenue, developed in cooperation with FOSW with a commitment to the restoration of the Avenue by 2014 and an allocation of $20,000 per year over the decade for replacement trees and maintenance on the Avenue. In addition, other budgets have been used to resurface the path, install new signage and other works along the Avenue. The Management plan includes provision for the replacement of not only missing trees but missing sites and the installation of new plaques at each tree. 'For every soldier a tree, for every tree a plaque' was the basic slogan for FOSW's efforts and this has now been accepted as a proper goal under the plan.'*

Here was one Avenue that would be restored over 12 years and we were hoping to facilitate the same outcome for a nation of avenues in 10! The Howard paper documented the components of a successful plan and highlighted the fundamental need for a committed community leader, a champion for the cause, like Adrian, to gather support and drive each project. The other basic need was money, and lots of it!

We have a number of emerging champions dotted around the country, and over the next year the TREENET project will try to identify them to find out how we can assist.

Charlotte Wells from Willunga is one such local champion. In 2005 she set about establishing the first next generation Avenue of Honour in collaboration with a number of organisations including the City of Onkaparinga, the local RSL branches, DTEI and TREENET amongst others. The aim is to plant 100 trees for 100 years and it has been decided that these should be Quercus suber, Cork oak, after an inspection of the magnificent specimens if the Arboretum.

Apart from technical support, TREENET also needs to identify major sources of funding so that we can deliver that support. Most importantly we need to set up a comprehensive online interactive database so that we can follow the action around the country and promote the cause of restoration of the dwindling number of original avenues.

At the 7th Symposium in 2006 I reported on the progress thus far as follows[10]:

2004

- *Project initiated by Director of Treenet and approved by Management Committee.*
- *Site visits to ACT, NSW, Vic, and WA.*
- *AoH project launched at the 5th National Street Tree Symposium at the Waite Arboretum. Keynote presentations made to 200 delegates and100 rosemary bushes propagated from material originating from Anzac Cove in 1915 planted in RSL sanctioned ceremony.*
- *Website www.avenuesofhonour.org commenced.*
- *Survey of Avenues nationwide commenced. Over 100 councils contacted.*
- *Relationships with key stakeholders established.*

2005

- *Promotion of project via radio, newspaper and magazine articles and commencement of community feedback*
- *Funding sought ($75k) from Dept of Veteran Affairs for appointment of full time project officer and IT support for the project. No response during the year.*
- *Letters written to all Federal politicians outlining the project and asking for help in making appropriate contacts in each electorate. Over 40 positive responses received including personal response from the PM and the Leader of Opposition.*
- *Network expanded, especially local community and RSL groups.*
- *Rosemary cuttings from Gallipoli Rosemary hedge planted at 2004 Symposium distributed to Greenhills Propagation Nursery in Vic and Aitken and Newman in Queensland. Intention is to release plants for sale to public in 2006 in order to raise funds for the project.*

2006

- *Response from Dept Veteran Affairs received. Standard application form for $3k offered. No action pursued for further direct funding.*
- *Application to Dept of Veteran Affairs for permission to use "Anzac" in the naming of the Gallipoli rosemary.*
- *Sarah Cockerell (TREENET) awarded PhD studentship to study Avenues of Honour.*
- *Ben Kenyon (Treenet Advisory Board) volunteers to produce draft standards for recording Avenues of Honour.*
- *ABC2 runs segment on Australia Wide on Anzac Day promoting project and rosemary.*
- *A number of journals run stories on the project.*
- *Successful negotiations with nursery industry leads to national release of Gallipoli Rosemary on November 11th 2006. Treenet to receive 50 cents per plant sold to support project.*
- *To date 350 sites around Australia under investigation.*

In 2006 I was more into raising money for the project than looking for opportunities to plant Avenues. The commercialisation of the Gallipoli Rosemary started out with promise but almost ended in disaster when plants with a non royalty paying substitute label were found on sale by an observant member of our Advisory Board in NSW. Prompt action by the unsuspecting vendor and a great deal of goodwill by others in the Nursery Industry saved the day and we are now beginning to see a steady stream,

soon to become a torrent I hope, of funds into the AoH account. This will initially fund the creation and maintenance of the interactive website.

At the same symposium, Ben Kenyon presented his ideas on the kind of data that the website would collect[11]. In a very comprehensive discussion paper, as a practicing arboricultural consultant, Kenyon provided the basic requirements for assessing condition. He also turned his attention to the recording and display of the personal record of each person honoured with a tree.

The database aims were to:

- *Develop an online database that documents the location and current condition of each tree within an existing or future Avenue of Honour across Australia.*
- *To catalogue each tree that has been planted to honour an Australian soldier and detail the location and condition of corresponding plaques. Where possible, personal information on the soldier honoured will also be included.*
- *Detail generic information on each of the Avenues of Honour.*

The database is a geospatial database: that is, all of the information contained within the database can be displayed and utilised in a map format through GIS programs such as MapInfo, ArcView or AutoCAD. It is envisaged that users of the database will utilise and search the information in a similar manner to that of 'Google Earth'.

The Kenyon paper is an excellent start in the development of the online database and the 'Google Maps' street view technology is an exciting tool in its interpretation and management.

In 2007 Lyndal Plant and Neridah Parke[13] presented a paper, the purpose of which was 'to describe Brisbane City Council's journey so far in researching, recording, promoting, protecting and restoring memorial tree plantings in support of the national project. Some of the stories are revealed, as well as the lessons learned and proposed next steps.'

Encouragingly it recorded that:

'Once the word was out, numerous anecdotal stories began pouring in. The value of our contracted, qualified historian and the support of our own Heritage Unit staff ensured that these stories were carefully screened and verification sought in documented records. Initial drafts were also rechecked with each contributor. Many of the original avenues or individual memorial tree plantings still remain today.'

The progress on three Avenues in Brisbane was reported with the reassurance that:

'Steps are underway to add those sites that are not already listed to these Registers. More importantly, as part of the identification and assessment of all significant trees on public land in Brisbane, the memorial plantings have been assessed by a qualified arborist and scheduled for regular maintenance visits. Already, many have been mulched to help them survive the drought. Where possible, every effort will be made to involve the local community in the care and protection of the sites.'

Brisbane is an excellent example of a city that has embraced the Avenues of Honour 2015 Project and to date has been best on ground in the first half of our metaphorical footy match.

Recently in Adelaide, the City of Burnside donned a guernsey and went out on a limb to replace the dying and dead elms in Prescott Tce, Rose Park that were planted in 1919 to honour the memory of 23 local fallen heroes. Seven of those original trees are missing and replacements have struggled. The Council produced a comprehensive report and options paper and the community was consulted. I was shocked on my return from the Western Front to see that this responsible and well considered initiative was meeting strong resistance from a very vocal minority, mostly residents of the street who were worried about property values and who seemed to pay scant regard to the original purpose of the Avenue. In the end, the more widely supported and practical option of staged block replacement between cross streets was rejected by the community and restoration of the Avenue in the short term is on a back burner. However nature is on the side of the fallen, as trees 'like us that are left grow old and the years condemn' so in a few short years there will be no trees left to fight over and commonsense will prevail.

There have been several important papers presented since 2004 that provide valuable insights into what is happening around the country as communities are forced to come to grips with dying heritage trees.

In 2004 a paper by Parker, May and Moore[4] on the challenge of mature tree replacement reported on four studies that were 'conducted to further the understanding of the many facets of tree replacement.'

These are:

- *the Mature Tree Management Study,*
- *the Mature Tree Costs Analysis,*
- *the Tree Establishment Experiment, and*
- *the Root Recolonisation Experiment.*

Drawing on the findings from all four studies, some general conclusions and recommendations were made on the tree replacement process.

- *The processes that exist in tree management organisations for tree removal, planning and planting represent positive advances in the management sophistication required to produce tree populations that will fulfil the requirements and benefits of an urban forest.*
- *Advanced planning is important to coordinate the timing of replacement activities in relation to the activities on nearby plantings.*
- *Tree policies that call for a certain number of trees to be planted each year are positive as they instigate the renewal of the landscape.*
- *Tree establishment programs are important in publicly managed landscapes.*
- *Flexibility and adaptability are important when approaching tree replacement. Some organisations are using both staged replacements, to maintain the aesthetics in an area while the replacement trees are growing, and full-street replants to create streets with a uniform avenue effect.*
- *In some cases it may be possible to use different replacement tactics based on the importance of the landscape feature or street.*
- *While the mentality of maintaining trees until they die or become hazardous is positive in that the desire exists to care for and retain trees in the landscape, it also limits effective long-term management as the ability to remove trees is important for coordinating replacement programs.*
- *The skill and professionalism of tree managers will have a major impact on the successful planning and management of tree replacement and the future of the treescapes.*
- *Tree record databases offer the potential for greater strategic planning of tree replacement, however in many organisations the sophistication of systems and minimal updating of records currently limit their use.*
- *It was possible to establish and obtain adequate growth from trees in an inter-planting replacement situation. However, the success of this method will be dependent on the tree species involved and the local factors in a particular case.*
- *When planting replacement trees near existing vegetation there will be root invasion of the planting hole, which could be expected to result in a high level of competition between trees for edaphic resources.*
- *Large planting holes are recommended when planting trees in competitive environments.*
- *The use of temporary root barriers to restrict the re-colonisation of planting holes by surrounding roots requires more research and may only be appropriate in highly competitive sites. The size of the soil volume contained in the root barrier will impact on the growth of the tree.*

For much of Melbourne's history, tree replacement has largely been reactive to tree failures. Tree management is now moving to more active processes, with prioritising of removals and deliberate staging of works. The challenge now is to increase the proactive management of tree populations, to allow for the coordinated and continual replacement of trees in our urban landscapes.

This provided plenty of support for the idea of block replacement ahead of inter-planting, as individual trees die in Avenues. There are many potential problems to this approach as I found out in Prescott Tce. There are no trees to commemorate seven of the 23 lives honoured in the Avenue but what do we do with the trees that are still alive and still have a family connection to the original planting? I am confident on the evidence of previous failures, and the findings in this report on planting hole re-

colonisation and the resultant loss of amenity, that we have to find a way of dealing with negative community responses to removing living trees for the greater good.

I am very fortunate to be a member of the ACT's Urban Forest Renewal Program's (UFRP) Expert Reference Group which is tackling this issue head on in a most comprehensive way. Many of the findings will be put to the test in the streets of Canberra and the results will be of national significance as other local government organisations and the Avenues of Honour 2015 project adopt the ideas.

At this Symposium Ian Shears is presenting a follow up to his 2005 paper which outlined Melbourne's strategies for replacing aging boulevards[8]. He said:

> *'Community support for these strategies is of paramount importance. The removal of trees is invariably unpopular and especially so in high profile landscapes. While landscape professionals can clearly see the immediate need to remove hazardous or declining trees, the public will often respond strongly against removing trees that are still alive. An important part of these strategies is the preservation of heritage values, with the significance of plantings in major parks established through Conservation Analysis and Master Planning. Determining what was previously planted however often requires research of literature, anecdotal accounts and council records. This research is essential to ensure that replanting is in line with the period of significance of the particular landscape.'*

I agree absolutely with the sentiment of preserving heritage values but worry about where that may lead in practical terms to the restoration and replacement of existing Avenues of Honour.

I have only just come into contact with the Burra charter which was used by one objector to sink the Prescott proposal based on an argument that seemed to fit the built environment very well but gets lost in its interpretation with dynamic living systems. I don't think I like the word "Burra Charter" very much unless it's a bus heading north on a post symposium tour! I'm not a supporter of mandatory replacement of the original species as often they proved to be poor selections. You can't do the same thing and expect a different result! Elms seem to have a life around 80 years in Adelaide. If some oaks such as Q suber or Q ilex had been planted in 1919, Prescott Avenue would be in great condition.

In her 2005 paper on the Heritage trees of 2115, Judy Fakes[9] reported a more successful outcome for the replacement of 33 Ficus in the Domain. The idea of replacing mature living trees for the greater good met with strong resistance from the usual vocal minority and it looked like the RBG would be stuck with the problem of maintaining dangerous trees they didn't want. Thankfully Judy was able to record that:

> *In the end, the court found in favour of the Royal Botanic Gardens and Domain Trust. All but one of the trees was removed and the 33 new trees were planted. The attention given by the media to the planting was almost non-existent.*
>
> *Despite the drama, the removal and replanting process allowed for the testing and remediation of the soil; the species selected were chosen on a number of criteria including resistance to compaction, low susceptibility to Fig Psyllids and heritage values.*
>
> *This small but landmark project is the taste of things to come as the public, politicians and landscape managers come to the realisation that landscapes are dynamic and the largest and most conspicuous elements, the trees, don't last forever.*

Could we be winning?

A very important paper was presented in 2006 by Dr Karen Olsen[12] titled 'Reality bites both ways: Heritage values and urban tree management'. For me it has been a reality check. It even talks about the Burra Charter! It is difficult to select the best bits of this excellent paper but the opening paragraph should get you downloading the whole document from the website.

> *'Who has not had a sinking feeling on discovering that the highly hazardous, structurally poor, uneven-canopied, failing or senescent tree in a local street or park is listed as being of heritage significance? Why does reality have a nasty habit of biting in the midst of our visions, dreams, plans and programs for developing and managing a better, future urban landscape?*

For managers of trees, streetscapes and avenues, there is no doubt that the reality of respecting and responding to community and heritage values and obligations can be frustrating and individual's or community groups' actions can at times seem obstructionist.

On the other hand, for heritage professionals, the very nature of the heritage fabric of trees as living, vegetative matter, might seem to add an annoying complication to the aims of heritage conservation to keep and care appropriately for culturally significant places we have inherited.

The idea that 'reality bites' reflects a range of potential responses to the issue of heritage and trees, anywhere on the spectrum from sharp cynicism to pragmatism, from wise hindsight to grim determination – or, usually, any combination of these, from stakeholders on all sides of a given situation. The aim of this paper is to understand why and how it is that 'reality bites both ways' in the tree management and heritage management. This includes recognising that the realities of both heritage and management by their very nature generate highly emotional responses and reactions. It also includes seeing that each of these realities can offer to its 'opposite' specific insights that can then generate a more holistic value for trees, streetscapes and avenues which is greater than the sum of its parts.

In other words, reality biting can be a useful tool to help us look further than just the immediate problem at hand.'

I feel better already!

Finally the paper on managing and assessing aging and mature trees by Martin Norris[7] in 2005 was a very thorough treatise on the topic but in the end he boiled it all down to a few simple words. No footy coach addressing a team 10 goals down at half time could say it better.

'Whilst planning is important in managing the complex matrices involving biological entities; the future of the urban forest, whether the community has grand avenues of historical mature trees, has parks with venerated veteran trees, whether we manage our urban areas as ecosystems or merely have streets lined with the latest designer tree clone has nothing to do with biological, economic, engineering, amenity, etc issues; the single most important factor that will influence the urban forest that we have in the future rests solely on philosophy.

Philosophy reflects our attitudes, beliefs, values, and thinking. Once a philosophy is determined you can pick a management strategy that will deliver.

Managing aging trees is not difficult. It merely requires vision, that vision is a reflection of a philosophy. What is your philosophy going to be?'

As a man fond of acronyms I've coined a new phrase that describes my philosophy on the establishment of new Avenues. It's called Street Tree and Urban Forest Friendly Engineered Design. Now I have something to say to the opposition!

Sarah has finished 'looking into it' and will shortly have completed her PhD thesis. It will add substantially to the body of knowledge summarised in her 2008 paper[14]. I'll have something to work with.

2010 is the start of the 3rd quarter and I'm kicking with the wind!

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CITY OF MELBOURNE: AN URBAN GREENING PERSPECTIVE

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Introduction

Over the past 10 years there has been a significant shift in the way that the City of Melbourne regards the role that trees play within its urban fabric. In a period of time well short of the life span of a long-lived urban tree, there has been a significant shift from trees being viewed from predominantly aesthetic and heritage perspectives to an understanding that trees are an integral component of the complex green infrastructure of the city. This new perspective looks at the 'urban forest' from a range of environmental, economic and social parameters that can be measured in benefits to the health of the community, in energy savings, air quality improvement and carbon sequestration.
The changing perspective of trees has been motivated largely by the imperative to respond to a changing environment. Drought, climate change, urban densification and sustainability have been fundamental drivers in shifting the comprehension of and commitment to the role of trees in the urban environment.

Aesthetics and heritage

Heritage landscapes and ageing trees

Using Council's 'tree amenity valuation formula' the total value of the City of Melbourne's trees is estimated to be over $600 million. The overall age distribution of the City's tree population is skewed to older age trees, leading to potential loss of large numbers of trees over the next 10-20 years. Loss of such a large number of trees could have a devastating effect on the amenity of parks, gardens, streets and public spaces. This asset is irreplaceable in the short term and the tree population requires close monitoring and management to ensure its continued good health.

Melbourne has some of the most significant stands of mature Elm trees remaining in the world following the destruction of many of the Elm populations in the Northern Hemisphere by Dutch Elm Disease. The Elms lining the major boulevards of Victoria Parade and Royal Parade, along with the avenues of trees in the Fitzroy Gardens are listed on the National Trust Significant Tree Register. Most of the city's boulevard and avenue trees however, were planted between the late 1800s and early 1900s and are nearing the end of their lives.

Strategy for the Replacement of Ageing, High Risk and Drought-Affected Trees (2003)

In 2003 it was estimated that 30% of the existing tree population would require replacement over the next decade as a result of declining health due to ageing, drought or other factors. A sustainable and progressive replacement program for Melbourne's tree assets was developed to ensure that the trees are systematically replaced, rather than to allow large numbers of trees to die at any one time thus causing a rapid degradation of the City's majestic parks and boulevards.

This strategy represents a sustainable and progressive replacement program for Melbourne's mature trees. The key components of the strategy are: to implement a progressive planting and replacement program for trees in boulevards, streets and parks; to increase the robustness, diversity and viability of tree species with selection responding to local climate conditions, urban context and desirable community outcomes; ensuring that tree species are selected and managed to minimise resource inputs; and to ensure that tree species are selected to preserve the heritage and amenity values of Melbourne's parks, gardens and streetscapes. Two key components of the Strategy were the Precinct Tree Planting Plans and the Boulevard and Avenue Replacement Program:

Precinct Tree Planting Plans

Eight separate precinct tree planting plans were developed in 2003 for Melbourne's 'local areas' (Southbank, South Yarra, Kensington, East Melbourne and Jolimont, Carlton, Fisherman's Bend, North and West Melbourne, and Parkville). These plans were created to strategically guide new tree planting and the replacement of existing trees where in decline, and were developed through extensive consultation with local residents and residents' associations. The development of the plans has provided a vehicle to engage with the community and provide a sense of active participation in

decisions about the public realm by residents. In developing these plans, the aim was to preserve and foster the local character and 'sense of place' of each precinct by ensuring that a range of distinctive species were identified and selected. These ten year plans involved planting an additional 5,482 trees in 182 streets across the local areas. By 2008 (mid-way through this ten year plan), the City had already achieved 96 per cent of this goal.

Boulevards and Major Avenues Replacement Strategy
This guides the City of Melbourne's approach to ensuring the perpetuation of these principal city structuring features for future generations. The significance and value of the overall boulevard or avenue is far greater than the collective value of single trees in the boulevard or avenue. Replacing trees in the major boulevards such as St Kilda Road, Flemington Road, Victoria Parade and Royal Parade, and the major avenues in gardens such as Fitzroy, Treasury, Flagstaff and Carlton Gardens, and Fawkner and Yarra Parks, presents particular challenges. As individual trees die they generally can not be effectively replanted with new individual trees, as the new trees are unable to compete adequately for light and water from their neighbouring mature trees. Thus interposed plantings seldom develop into healthy, fully developed mature trees in keeping with the overall character of an avenue.

The only effective way to genuinely achieve an avenue or boulevard of long-term high visual and environmental integrity is to remove and replant sections or groups of trees. This preferred solution, however, is likely to cause considerable community concern as some of the trees that need to be removed may appear to be healthy. Tree issues have a very high profile in the community and all tree issues require extensive stakeholder and resident consultation, and achieving community consensus is a highly time-consuming process. This underlines the role of negotiation to get real outcomes on the ground, particularly as there are limited windows of opportunity when plantings can occur. To date, Council has successfully replaced avenues in Fitzroy, Carlton and Treasury Gardens and Fawkner Park and street sections in Swan Street and Princes Park Drive. Replacement of sections of the St Kilda Road boulevard is anticipated for winter 2010 following approval (jointly by City of Melbourne and City of Port Phillip) and public release of the St Kilda Road Master Plan.

For avenues in parks where limited future lifespan is anticipated, planting of suitable single species trees in adjoining areas can be undertaken, therefore when the avenue is replaced in its segment or entirety, the loss of amenity will be minimised because there will be advanced trees already growing nearby.

The cumulative impact of implementation of these strategies has resulted in the formative revitalisation of Melbourne's urban streetscapes and landscapes. In 2003, Council endorsed the strategy to replace 14,290 ageing trees within ten years. By 2008 (mid-way through this ten year plan), the City had achieved 67 per cent of this goal.

Heritage vs Sustainability issues
A prominent arena in which heritage and future landscapes in a climate changed environment can collide is in the management of culturally-significant heritage-listed landscapes. Where decision-making around tree planting and replacement in these landscapes previously largely consisted of a spatial and/or temporal response to tree planting motivated by replacing 'like with like' species, it is now acknowledged that the climate in which these original landscapes were established is very different from today and vastly different from future climate conditions.

A number of previously planted tree species are no longer suited to a drier climate likely to involve extremes of weather and less available supplementary water. In these situations it is appropriate that sound horticultural decision-making carries greater weight than perceived cultural or heritage values in order to provide sustainable landscapes into the future.

A case in point has been the culturally significant Birdwood Avenue adjacent to the Shrine Reserve where an avenue of Lombardy Poplars required replanting. The 'heritage' requirements led to a 'like with like' replacement a little over five years ago. Today over 60 % of the replanted trees have again failed, leading to further replacement of the avenue in which current discussions are lending appropriate weight to use of an alternate species such as Lemon-Scented Gum with a more suitable range of tolerances.

Carlton Gardens Tree Conservation Strategy (2006)
The World Heritage listed Carlton Gardens has provided an excellent opportunity to examine the complexity of layers of significance related to the various planting periods and to develop a list of species, distribution and spatial layouts that will guide tree planting over the next 15-20 years. Studies of existing trees, early plans, early correspondence, nursery lists and early photographs have led to a good understanding of the location and timing of planting of individual species This information has then been related to existing conditions which, when combined with current knowledge of species performance and the range of attributes recognised as positive in an urban sense, will guide future species selection.

Drought and climate change

One of today's primary challenges revolves around the delivery of water to existing trees that have grown for many years under high irrigation regimes, higher rainfall and cooler temperatures. With predicted hotter and dryer conditions including increased extremes of weather, this means that species selection and sophisticated management of limited water resources will be a key to the successful and sustainable provision of urban greening.

Drought
Melbourne's drought is now in its twelfth year following its onset in 1997. These conditions have negatively impacted on the long-term health of many of the City's trees and have accelerated the decline of many ageing trees and consequently hastened the need for tree replacement. Recently observed trends in climate change have identified rainfall reduction as 17% over long-term data. This reflects a projection set by the CSIRO and used in the City of Melbourne's 'City as a Catchment' strategy (refer below). It is also supported by analysis of the rainfall of the last 10 years at the Melbourne Regional Office of the Bureau of Meteorology.

Council initiated water reduction strategies in 2000, and since 2007 Stage 3a water restrictions and Council's Water Management Plan have been in place. The City negotiated with the water authorities (City West Water and South East Water) and obtained exemptions within an approved Water Conservation Plan to use up to 50 per cent of the water used in the base year 2005/2006. The water was earmarked for the city's trees because they represent the most valuable and irreplaceable horticultural assets. Without these agreements in place the City of Melbourne would only have been able to apply less than 10 per cent of the irrigation water used in the base year 2005/2006.

The response to drought in the City of Melbourne has significantly changed the approach to provision of water to trees. Of the city's tree stock approximately 15,000 trees have been grown in turf areas with regular irrigation. These include park trees and those grown in turf medians such as the major boulevards. Irrigation systems in the past have generally been designed to water the park surface, median or nature strip grass using manual or automatic surface sprinklers. Although this method of watering keeps the grass green it is not efficient in watering trees as it encourages them to develop surface root systems. Regardless of the species of trees and because of historical horticultural practices and the perception that water is a limitless commodity, trees have become dependent on regular surface watering and are less drought tolerant. Many of the trees in the City of Melbourne have been stressed over recent years as a result of low soil moisture.

The severity of the problem has increased over the past couple of years. In response to the drought and movement away from using turf sprays to irrigate trees, Council has applied a range of alternative ways to deliver water effectively to tree root systems and maintain soil moisture at levels to maintain trees in a healthy condition:

- Soil moisture readings are taken in the City's main gardens and boulevards in order to inform water application by monitoring the available water for the trees. The City's irrigation systems are being changed in order to ensure that the trees are provided with adequate water.
- Over 170km of sub-surface drip lines have been installed, hooked up to existing infrastructure. These are considered to be a temporary measure and a more permanent and robust system has been developed to deliver water efficiently in a sustainable way (refer below).
- A fleet of water tankers and water-filled barriers have been brought in to supply water to drought stressed trees that cannot be adequately watered using the irrigation systems. The water tankers supply reclaimed water from the Royal Park Wetlands (Trin Warren Tam-boore).

- Recycled mulch has been placed under a large number of tree species in parks and gardens that are more susceptible to the dry conditions.

The City of Melbourne decided, in early 2007, to investigate longer-term watering techniques that could be used to maintain trees located in high profile streets and boulevards in a healthy condition. Restricted root systems, highly variable soils, high levels of traffic and high exposure characterise these trees. Following a trial to investigate a range of techniques including drip watering, tree watering well products and a watering trench, the trench was considered to have the advantage of providing a wider distribution of water, to allow a relatively large volume of water to be delivered rapidly and, if necessary, to allow grass to be grown over the surface. Water distribution from the trench was found to be typically in the range of 500 mm laterally, beyond the edge of the trench, at a depth of 500 mm. The trench watering system has been installed along the majority of Royal Parade, in sections of St Kilda Road and in sections of Birrarung Marr riverside park.

Planning for low water futures
Along with the substantial decrease in rainfall associated with the drought, Melbourne is likely to experience a sustained period of increased temperatures and drier conditions. The City needs to put in place a policy framework and implementation programs to increase resilience to the projected impacts of climate change and extreme climate variability, including water-scarce and possibly even water-abundant conditions, and urban heating.

Responding to climate change calls for the design of landscapes across a spectrum from conservation through to creating urban ecologies (TW: 20). This includes preserving and protecting existing landscape assets; repairing, managing, reinforcing and improving the urban/natural environment interface; and actively integrating new landscape assets (including natural features, built landscapes) into the urban environment.

The role of trees and vegetation in rainwater and stormwater harvesting can not be overstated in terms of the benefits they provide in terms of water retention and therefore savings on using alternative water sources, and improving water quality.

Total Watermark – City as a Catchment strategy (2009)
The 'City as a Catchment' model has been developed by the City of Melbourne as the most strategic way to apply best practice sustainable water management practices in the urban landscape. The strategy promotes a localised water management model to reduce reliance on systems that impact other regions and provides a framework that contributes to climate change adaptation. While it recognises the important role of the natural catchment it works primarily with the artificial city catchment (including its roads, roofs and impermeable surfaces) to minimise water consumption and improve water quality.

The city as a catchment approach explores interactions between supply, the quality and quantity of stormwater and wastewater, land use, climate, social capital and the receiving waterways (rivers and bays). Furthermore, it is an adaptation strategy in response to climate change. It provides the basis for moving towards an informed 'city as an ecosystem' approach that encompasses greenhouse mitigation and habitat protection and stretches beyond single municipal boundaries.

Domain Parklands Estimated Irrigation Requirements Case Study (2009)
In planning for a low water future an estimation of irrigation requirements for parkland has been undertaken by the City of Melbourne. Determining an estimate of irrigation requirements for parkland ensures that we are putting the needs of our landscapes first. This 'demand side' analysis of water needs for the Domain Precinct represents a new, best practice approach to water budgeting and planning. Essentially this involved a case study to determine irrespective of the source the volume of water required by the Domain Parklands to be maintained at a healthy level.

Water Sensitive Urban Design
In addition to changes in irrigation design and practice a number of Water Sensitive Urban Design projects have been implemented to capture and clean stormwater runoff. Primarily sited in street locations, a wide range of pit designs have sought to enhance the below-ground tree environment with successful outcomes in terms of tree growth and reduced reliance on supplementary watering. It has been estimated that trees planted in WSUD pits require about 70% less supplementary water than

trees in traditional tree pits during the establishment phase. Well designed below-ground environments also provide adequate growing space for larger stature trees giving rise to increased environmental benefits and less damage to surrounding infrastructure. WSUD tree pits have been implemented in Acland Street South Yarra, Little Bourke Street and Little Collins Street with excellent results in tree growth.

Raingardens developed in small inner city laneways with resident support not only capture roof runoff and provide planting locations for trees and other vegetation, but have converted otherwise dull surrounds to well used social gathering spots. The increased use of permeable pavements is providing an essential source of water for trees and other vegetation. On a larger scale the Royal Park Wetlands is providing up to 3 million litres of reclaimed water weekly that is directed to parkland, sports grounds and tree watering.

Urban Heat Island effect

There is increasing awareness of the benefits of vegetation in the urban environment to mitigate the effects of the Urban Heat Island. Green spaces and vegetative surfaces provide shading to prevent direct solar radiative energy and create microclimates through evaporative cooling and shading, making the urban environment more comfortable to live in. A city-wide urban heat island management strategy will address the problem from the small scale (e.g. encouraging green walls and roofs) to the large (e.g. linked parklands, environmental corridors).

Thermal imaging is being used to map the surface temperature of the urban environment. This information will be used to guide the planting of trees for shade and introduction of other green infrastructure to reduce urban temperatures. By studying the temperatures of surface treatments we will also inform urban design principles for future urban landscape and built form materials.

It has been estimated that increasing tree cover by 10 per cent will reduce the surface temperature of a city between 3 and 4 degrees Celsius (CABE: 19). The prediction of a long-term hotter and drier climate therefore underlines the imperative to protect existing trees and establish new plantations to mitigate the anticipated increase in extreme heat events.

What has until recently been less well understood is the vital role of water availability to maintain optimum conditions of the landscape assets for heat absorption: ie. not just the spaces and assets themselves, but their ability to absorb and retain heat (Coutts, Beringer, Jimi & Tapper 2008). The increases in vegetation cover to mitigate UHI must be accompanied by water retention strategies in order to enhance the effectiveness of the vegetation. Loss or stress of vegetative cover significantly reduces evapotranspiration underlining the benefits of utilising available stormwater through water retention strategies, stormwater capture and re-use to re-integrate water back into the urban landscape.

Sustainability and TBL outcomes

As we head into a future of increasing urban densities, potential extremes of climate change, and increasing heat island effects, the role of trees and vegetation in the urban environment is increasingly important. In response to these challenges, the Urban Greening Strategy will quantifying the role of trees and other green infrastructure in mitigating these potential effects and responding to a range of social, environmental, planning and economic issues. Analysis of the urban areas through leading technology in thermal imaging and GIS evaluation (e.g. of percentage vegetative cover) will guide tree planting and urban greening over the next decade or so.

The Strategy is intended to form a basis for tree planning, management and planting programs and initiatives such as the **'urban forest', urban agriculture, community gardens, green roofs and green walls** in the city. The greatest benefits will emerge from understanding how the green space network and urban networks interact, and developing a coordinated strategy to integrate them. This represents a genuinely three-dimensional approach in a spatial sense, and requires coordinated inter-disciplinary, public and private, and inter-governmental perspectives and planning.

Urban densification and city structure

'Future Melbourne Community Plan' is Council's strategy for growth of the city by creating more livable and sustainable urban living and to meet our emerging challenges. It supports and promotes more compact, consolidated and higher density development in the inner city. There are challenges in achieving this intensification for living and working in a dense urban structure while maintaining

community liveability. This calls for climate-smart built environments and provision of green space that provides increased social amenity in intense urban landscapes.

'Transforming Australian Cities for a more financially viable and sustainable future' (2009) is a recent joint initiative between the City of Melbourne and Victorian Government that addresses urban infill within the existing infrastructure of the city. The study focuses on increasing densities along road-based transport corridors as key development areas, and also highlights the complementary qualities of the existing suburbs located in between. These areas are intended to effectively become the new 'green wedges' of the future city: greener, capable of collecting and purifying stormwater, generating renewable energy and with more productive landscapes so as to reduce the overall ecological footprint of the city, making it more sustainable (TAC: 23).

Green roofs and walls

Another recent collaborative initiative (between the City of Melbourne and Committee for Melbourne Future Focus Group) has been the 'Growing Up – the blueprint to green-roof Melbourne' competition and research program.

Green roofs and walls are sustainable and regenerative roof landscapes that reduce the impacts of urban development on our communities (FFG: 2). There are many compelling arguments for incorporating green roofs in Melbourne's future development: they reduce energy costs, increase the value of buildings including rentals and resale, support the efficiency and retention of employees, and are very appealing to residents seeking the replacement of green spaces as the nature of property occupancy in Melbourne transforms.

Internationally, green roofs and walls have for some time been integrated into sustainable design and policy initiatives, so while Australia has been comparatively slow to embrace green roof technology, we can now capitalise on this significant body of international expertise (FFG: 1).

Green roofs offer a variety of benefits to building owners and the city which, most significantly, assist in adapting and increasing resilience to climate change while assisting to provide additional amenity spaces and supplementing public open space.

Specific benefits include:

- As 'micro-landscapes' that can retain water, they reduce stormwater volume and water flow, helping to alleviate the pressure on stormwater infrastructure systems
- As thermal insulators they reduce the urban heat island effect by lowering ambient air temperatures
- They offer additional capacity as carbon sinks and sequester this atmospheric carbon dioxide for very long periods of time, thereby improving air quality
- They create sustainable interactive community spaces where people can interact, overcoming problems of 'vertical living' and isolation, and making workers happier by enhancing their surroundings, improving business profitability.

Policy instruments for implementation include:

- Developing industry standards and guidance on green roof implementation technologies
- Recognition of green roofs in planning schemes, including utilising zoning provisions and offering planning incentives
- Offering a range of financial incentives such as offset of public open space contributions, fee incentive models to reduce storm water charges, direct subsidies, density bonuses or other financing schemes

Community gardens

Community engagement and improved biodiversity should be primary objectives from which other benefits in climate change mitigation will flow (CABE: 25). While Council does not yet have a specific policy to guide the development of community gardens in the municipality, demand for community garden space is emerging through a number of Council programs and it is widely acknowledged that community gardening meets a range of social development and environmental objectives: they build community; improve health and social wellbeing; reduce environmental impact; create opportunities for purposeful recreation and social engagement; and maintain and support cultural identity.

Urban green areas can offer a significant source of sustainable food production, and the longer-term aim of Council is to seek to provide allotment land to meet demand and encourage local food production, particularly in areas of significant new development.

Conclusion

In these times of prolonged drought and climate change, it's an extremely complex task to nurture and safeguard Melbourne's urban tree population. The vital role that green infrastructure will play in preparing cities for climate change can not be overstated. 'Mature trees are significant assets to our environment and our society … 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 in return.' (Moore, 2007)

At the 'traditional' end of the spectrum, maintaining historically significant plantings requires balancing the competing interests of passionate residents – looking to maintain our forefathers' vision for Melbourne with its majestic avenues of European trees – with the need to plant sustainable options for future generations.

At the current end, regardless of debates around how to calculate mass and dollar values of carbon sequestration by trees, the recognition of the need for Climate Change Adaptation has greatly increased public awareness of trees in cities, the impact of trees on the urban microclimate, and the opportunity to have the real value of urban value calculated and built into future decision-making processes (Moore, 2007).

CABE's 'Hallmarks of a Sustainable City' aptly identifies that it's therefore not just a responsibility for government and the private sector to take on, but a positive choice for government to make and the community to support. The framework and incentives for developing sustainable urban landscapes should be designed to deliver both climate change adaptation and increased prosperity built upon a sustainable economy.

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PEOPLE AND TREES: PROVIDING BENEFITS, OVERCOMING IMPEDIMENTS

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1.INTRODUCTION

The present paper deals with an area that would be familiar to many in the audience on a daily basis, as they manage trees in urban environments with people. Audience members would also be well aware that it is an area fraught with difficulties, as any community includes people with a vast range of attitudes towards trees. Urban tree management involves managing not just the trees, but also the people, particularly their preferences and expectations, regarding the trees in their community.

As our knowledge of tree biology continues to improve, and as we understand more and more about what trees require for establishment and continued healthy growth, we are better placed to know what we should be doing to provide what trees need, even if constraints in the trees' environments often make this difficult. The same cannot be said for our knowledge and understanding of people in relation to trees. Whilst there is an increasing body of research on the benefits to people of 'green environments', including trees and other plants, there has been little research to date on people's perceptions of, and attitudes towards, trees. Yet people have a profound impact on the existence and survival of urban trees, and whether or not we can achieve worthwhile and sustainable urban forests.

Trees and other plants have the potential to make enormous contributions to the economic, environmental and social sustainability of our human settlements. This potential, however, will not be realised unless stronger, personal and meaningful connections are made between people and plants, such that more people are more vocal in demanding green, treed environments in which to live. This, in turn, requires a better understanding of the diversity of people and how this affects their perception of plants – their past experiences, understanding and knowledge, flexibility and enthusiasm, not to mention the more usual descriptors of age, gender, race and socioeconomic backgrounds.

This paper provides an update on 'Trees, Urban Ecology and Community Health' (Tarran, 2006) looking particularly at recent developments, such as our evolving knowledge of benefits to people in regards to their psychological and physical health, as well as business activity in towns and cities. The paper also looks at people's attitudes to trees, including tree appearance and presence at various locations. These findings are discussed in the context of current issues such as continuing population growth (including immigration), increasing densities in cities and towns, responding to climate change and health problems in relation to activity and obesity.

2.THE CONTEXT - URBAN ECOLOGY

Over half the people around the world now live in urban ecosystems and in many western countries the proportion is closer to 80-90%. These ecosystems consist of various components such as the biotic community (humans, as well as locally native and introduced species of flora, fauna and micro-organisms) and the physical environment (both natural features and built infrastructure).

The relatively new field of urban ecology studies the patterns and processes of urban ecosystems, using the theory and methods of both natural and social sciences in an integrated manner (Grimm ***et al.***, 2008). It is hoped that this research will lead to ways of making and managing settlements where people live, work and play such that greater attention is given to supporting functional ecosystems that ultimately underpin our survival; as well as strengthening the resilience of communities through attention to social capital. By 2006, ideas in urban ecology were being explored in journal articles (e.g. Niemela, 1999; Pickett ***et al.***, 1997; Platt, 2004). Ecological models developed in natural areas were applied to urban areas (Lord ***et al.***, 2003), with the city itself being viewed as an ecosystem created by humans specifically for dwelling (McIntyre ***et al.***, 2000).

Until about the 1980s, cities and nature were widely viewed as mutually exclusive (Platt, 2004) and this partly explains why urban and suburban landscapes had not been studied by ecologists, who traditionally preferred to research 'pristine' ecosystems, often in remote areas with minimal human impacts. Although there has been an understanding of the interdependence between cities and nature for a long time (Alberti, 2008), the natural sciences of ecology and the social sciences of cities have operated independently of each other until relatively recently. Interest in urban ecology developed in the 1990s, probably as a result of growing awareness of the following phenomena:

- increasing urbanisation and a realisation that urban areas needed to be better understood and made as habitable, safe and pleasant as possible
- recognition by ecologists that disturbed or impacted ecosystems were more common than 'pristine' ecosystems and worthy of study in their own right
- increasing concern about the effects of humans on ecosystems (Wallbridge, 1997), including use of fresh water, transformation of the land surface and loss of biodiversity
- recognition of a sustainability crisis emerging in urban areas
- realisation that 'ecological services' provided by nature to human society (Daily, 1997) could operate in urban areas

More recently, people have realised that urban areas are 'hot spots' that drive environmental change at local, regional and even global scales (Grimm ***et al***., 2008). With increasing urbanisation and increasing populations within cities come increased material demands of production and human consumption. People today are focussing on both global and local changes, and it is becoming apparent that, whilst cities generate problems as regards sustainability, they will also have to provide the solutions. Substantial books on urban ecology have just started to appear (e.g. Marzluff ***et al***., 2008; Alberti, 2008). Similarly, new books on sustainable urbanism, green urbanism and green cities continue to appear (e.g. Farr, 2008; Beatley with Newman, 2009; Birch & Wachter, 2008).

The development of urban ecology has important consequences for urban tree and urban forest management and will hopefully lead to greater recognition of the importance of these components. Trees and other plants, the photosynthetic organisms of our planet, have long been recognised as a critical part of natural ecosystems, since they have the capacity to harness the sun's energy and produce food, both for themselves and for other organisms. The urban forest, and particularly the tree component, is the most conspicuous element of 'nature' in urban ecosystems and has a vital role to play in urban ecology. Urban forest ecology is discussed by Rowntree (2008) who notes that the concept of the urban forest ecosystem enlarges the scope of the urban forest to include humans and requires us to think about urban forest costs and benefits in ecosystems across space and over time. Humans both deforest and afforest land, and both processes change the functioning of whole ecosystems without us knowing the magnitude of both the costs and benefits.

The urban forest provides a range of benefits to people and other organisms, with benefits to people including environmental, aesthetic, social, psychological and economic benefits. It is likely that plants will play an increasingly important role in both mitigation and adaptation strategies for climate change (Tarran, 2009). Well placed trees offering shade and evapotranspirational cooling can reduce electricity requirements, reducing carbon dioxide emissions from power plants, whilst simultaneously absorbing carbon dioxide during photosynthesis. Tree canopies that can capture and hold rain, and then deliver it into the soil will become more valued for this role. As sustainable cities focus more on public transport and walkable streets, the shade provided by trees will become more valued and space will be redistributed away from sealed roads and towards tree-shaded pathways. Whilst water availability is a current focus in towns and cities of southern and south-eastern Australia, it may be that, in the future, local food production will also move into focus, with a role for urban trees in this regard. However, water availability may be so restricted that it may determine species selection for the urban forest, or even whether the existence of an urban forest is possible.

3.BENEFITS TO PEOPLE AND COMMUNITY HEALTH: AN UPDATE

3.1SOCIAL AND PSYCHOLOGICAL HEALTH AND WELL-BEING AT HOME AND WORK

By 2006, there was already substantial information on the positive roles that urban trees (and urban nature more generally) can play in community health, with a focus on the social and psychological benefits associated with urban 'green'. Much of the early research was carried out in the USA by Rachel and Stephen Kaplan (Kaplan ***et al***., 1998). Later research was carried out by Frances Kuo and

her co-workers at the University of Illinois Landscape and Human Health Laboratory (LHHL) [previously the Human-Environment Research Laboratory (HERL)] (Landscape and Human Health Laboratory (LHHL), 2009). Their research has built upon work carried out by USDA Forest Service researchers, including social scientists (Dwyer *et al*., 1991 & 1992), and Charles Lewis (Lewis, 1996).

Studies of the relationship between people and nature carried out over 25 years (Kaplan *et al.*, 1998) have indicated that natural environments, including ordinary vegetated landscapes experienced close-at-hand on a daily basis, can foster well-being and enhance people's ability to function effectively. Benefits to people go well beyond mere enjoyment. Such landscapes allow people 'time out' to recover from mental fatigue, with its associated impatience, lack of focus and risk-taking, and facilitate restoration so that people are, once again, comfortable, civil and effective.

There are numerous case studies that have been carried out demonstrating the restorative power of nature, often when merely viewed through a window:

- surgical patients recovering after operations (Ulrich, 1984), requiring shorter stays
- prisoners, requiring fewer health service interventions (Moore, 1981)
- people in work environments, having greater job satisfaction and well-being (Kaplan *et al.*, 1988; Kaplan, 1993)
- children moved to greener housing, experiencing improved cognitive functioning (Wells, 2000)
- drivers recovering more quickly from stress and coping better with further stress (Parsons *et al.*, 1998)

Frances Kuo and her co-workers (LHHL, 2009) are studying how residents of inner city areas in Chicago respond to trees and other vegetation and how the physical and psychological health of individuals and communities can improve when nearby nature and natural views are present. As a result of extensive research, Kuo (2001) suggests that nature may be an essential component of a fit human habitat, given the apparent effects of nature on blood pressure, heart rate, mood, day-to-day effectiveness, social behaviour, cognitive functioning and work performance. She goes on to say that "regular contact with nature may be as important to our psychological and social health as the regular consumption of fruit and vegetables is to our physical health."

Practical application of their research has resulted in recommendations that:

- people should spend time in green, natural settings to relax and renew their ability to concentrate
- trees should be planted and maintained near homes, schools, work sites and other places where concentration and mental energy were needed most
- indoors, work places should offer a green view from the window
- green spaces should be created, especially in inner city neighbourhoods

Their research is summarised in the following six themes on their website (LHHL, 2009).

(1)Canopy and Crime: Green Streets, not Mean Streets
In a study of a public housing development, it was found that apartment buildings surrounded by trees and greenery were dramatically safer than buildings without green, with total crimes reduced by 52% (Kuo & Sullivan, 2001a). The greener the surroundings, the fewer were the crimes against people (down by 56%) and property (down by 48%). It is believed that greenery helps by reducing aggression, bringing people together outdoors, which increases surveillance, and indicating that a building is cared for by its residents, who watch over it and each other.

(2) Vegetation and Violence or Cooler in the Shade: Aggression and Violence are Reduced with Nature Nearby
In a study of the relationship between the outdoor environment and family violence in an inner city public housing project it was found that families with trees and greenery in their immediate outdoor surroundings had safer domestic environments than families in buildings barren of nature (Kuo & Sullivan, 2001b). Levels of mental fatigue were higher in buildings without nature, and aggression accompanied this mental fatigue.

(3) Kids and Concentration / Go Out and Play: Nature Adds up for ADD Kids
A study of 96 children, formally diagnosed with Attention Deficit Disorder (ADD), found that their symptoms were relieved after contact with nature and that the greener the setting, the greater was the

relief (Faber Taylor *et al.,* 2001). By comparison, activities indoors such as watching TV, or outdoors in paved, non-green areas, left ADD children functioning worse. The information also applies to Attention Deficit Hyperactive Disorder (ADHD). It was recommended that, before beginning activities that demand attention, like school or homework, children should go out and play in a green yard or park. Furthermore, it was suggested that recess in schools should be taken in green schoolyards.

In a subsequent nationwide survey (Kuo & Faber Taylor, 2004), using parents' ratings of the after effects of 49 common after-school and weekend activities on children's symptoms, green outdoor activities reduced symptoms significantly more than did activities conducted in other settings (e.g. indoors or in a built outdoors setting) even when activities were matched across settings (e.g. reading in each setting). Another study (Faber Taylor & Kuo, 2009) found that children professionally diagnosed with ADHD concentrated better after a 20-minute walk in the park than after a downtown walk or a neighbourhood walk of similar length.

(4)Girls and Greenery: Views of Green Help Girls Succeed
A study of 169 inner city children in a public housing development (Faber Taylor *et al*., 2002) found that the greener and more natural a girl's view from home, the better she scores on tests of self-discipline (including tests of concentration, impulse inhibition and delay of gratification). The greater a girl's self-discipline, the better she is able to avoid dangerous, unhealthy or problem behaviours and behave in ways that foster life success. It was suggested that the practice of constructing treeless residential developments might have important unintended costs.

(5) Neighbours and Nature or Nice to See You: How Trees Build a Neighbourhood
In an observational study of 59 common outdoor spaces of a large public housing development, it was found that the more trees and grass present, the more those spaces were used by residents (Sullivan et *al.,* 2004), creating more opportunities for informal social interaction. Compared to residents living near barren spaces, residents closer to green spaces enjoyed more social activities, had more visitors, knew more of their neighbours and had stronger feelings of belonging. In another study using interviews with 145 (female) residents of 28 high-rise buildings of a public housing development, it was found that the presence of trees and grass supported common space use and informal social contact amongst neighbours (Kuo *et al.,* 1998).

(6) Plants and Poverty or Green Relief: Trees Ease Poverty in Inner City Neighbourhoods
In a study of 145 urban public housing residents randomly assigned to buildings with and without nearby nature, attentional functioning and effectiveness in managing major life issues were compared (Kuo, 2001). When trees and greenery were immediately outside their apartments, inner city residents coped better with the demands of living in poverty, felt more hopeful about the future, and managed their most important problems more effectively. Kuo noted that ‘it is striking that the presence of a few trees and some grass outside a 16-storey apartment building could have any measurable effect on its inhabitants' functioning. It is all the more surprising that such a modest dose of nature could enhance an individual's capacity to manage the most important issues in her life, with an effect size comparable to that of major factors such as health and age.’

3.2 STREETSCAPES, BUSINESS AND CONSUMER ENVIRONMENTS

In 2006, there was little to report in regards to our understanding of economic benefits to business arising from the urban forest. Whilst it was known that residential property values benefited from tree cover or the presence of parks nearby, research had only just begun into the economic benefits to business that flow from urban forests (Wolf, 2003). A substantial study in New York (Bisco Werner *et al*., undated) found that the urban forest was important for the economics of districts and the stability of nearby communities. Trees made good business sense in terms of market identity, customer preference, lower vacancy rates and providing a competitive edge.

Trees in business districts traditionally receive a mixed response from the business sector. Some merchants value them as an important amenity for potential customers, providing a more appealing consumer environment, whilst other merchants overlook their contribution to business success and focus on annoyances instead (e.g. reduced signage visibility, seasonal debris and security issues).

Recently, there has been much more research in this area, particularly by Kathleen Wolf (Human Dimensions of Urban Forestry and Urban Greening, 2009). Her research addresses several areas, including nature and consumer environments (especially trees, streetscapes and business districts). Based on her findings, Wolf (2005b) encourages merchants and marketers to look ‘beyond the door of

the store' and recognise that streetscape character, like the 'atmospherics' inside a store, can influence shopper response in a positive way, resulting in a return on the green investment. Furthermore, the provision of trees in business districts can assist broader environmental and sustainability outcomes for the city as a whole, ameliorating urban heat islands, reducing energy use, improving air quality, sequestering carbon dioxide and managing stormwater.

Early research (Wolf, 2003) looked into the potential economic contributions of trees to retail settings in revitalising business districts of mid-size cities (population about 100,000). It was found that consumer behaviour was positively correlated with streetscape greening, in that green retail streetscapes were perceived as being higher in visual quality and comfort and were expected to have higher-quality products. Potential shoppers were willing to travel further and longer, to visit more often and for longer, and to pay more for parking when visiting retail places with trees. Higher visual quality ratings of retail streetscapes occurred when a full-canopy forest was present, defining the mood and character of the street (Wolf, 2004a). Even if buildings were well maintained, or of historic character, a lack of trees and dominance of buildings resulted in low streetscape ratings.

A study comparing the values of consumers (residents) and business owners to trees in business districts (Wolf, 2004b) found that both groups gave higher ratings to streets with trees. However, it appears that merchants have significantly less appreciation for trees than do the customers they wish to attract to their shops and that merchants place significantly less value on the benefits provided by trees. Attitudes about tree annoyances were more closely shared by both groups of people but the business respondents were more annoyed by leaf and flower fall than were the residents.

Similar aspects of trees and retail business districts have been investigated in small towns and cities (10-20,000 people) (Wolf, 2005a) and in strip malls (narrow bands of businesses along roads) (Wolf, 2009). In both cases, retention or restoration of a local customer base was an issue and the potential contribution of trees was investigated. For small towns and cities, it was found that the presence of trees in retail settings improved perception of the area, such that it had a better atmosphere, image and comfort level, and was a preferable place to visit and dine out (Wolf, 2005a). People were prepared to travel longer to retail districts with trees, and would stay longer, visit more often, and pay more for parking as well. They were also willing to pay about 9% more for a range of products in treed retail districts, an amount termed an 'amenity margin' (Wolf, 2005a).

In the case of strip malls (Wolf, 2009), trees and associated vegetation enhanced people's judgments of visual quality the most, and were linked to a perception of significantly better business conditions and interactions for the vegetated malls, better patronage and a willingness to pay about 9% more for goods in these malls. Planning and management recommendations were made such as consolidating planting areas, using vegetation 'frames' to identify areas, selecting tree species that have high and open canopies, and moving and consolidating signage to a front location.

3.3TREES, TRAFFIC SAFETY AND CRASH RISK

Over the past 30 years, as interest in the benefits of the urban forest has increased, those charged with managing the urban forest have realised that urban streetscapes are places where urban forestry meets transportation policy (Wolf & Bratton, 2006). The usual outcome is that transportation officials and policies tend to limit or exclude urban trees because of safety concerns.

Currently there is a greater focus on the sustainability and livability of cities and towns. Crash data in the USA is now being re-examined to understand the circumstances of tree collisions in urban areas so that trees can be designed into streetscapes more safely. Roadside trees can actually protect pedestrians against cars that are out of control and having trees at regular spacings can help drivers establish an appropriate speed and focus on the roadway edge (Centre for Transportation Research and Education (CTRE), 2008). Views of nature while driving can help drivers recover from stress and cope better with further stress (Parsons *et al*., 1998).

Deterrence and mitigation are the main approaches to improving roadside safety (Wolf & Bratton, 2006). Deterrence emphasises the importance of keeping cars on the road (e.g. by design and engineering), whilst mitigation aims to reduce the severity of the consequences when drivers leave the road ('run-offs'). Mitigation often involves removing, relocating, altering and shielding hazards, such as poles and trees. Tree crashes are severe in that they are more likely to be fatal or incapacitating than other crashes, even though they may occur less frequently than other types of crashes. Tree crashes represented just 2% of all traffic accidents in the USA in 2002, with a fatality rate of 6% (Wolf

& Bratton, 2006). In New South Wales in 2007, tree crashes represented just 4.4% of all crashes, with a fatality rate of 3.1% (Roads and Traffic Authority (RTA) NSW, 2008). However, as a percentage of all *fatal* crashes in NSW in 2007, those associated with tree crashes represented 15.6% and those associated with fences, posts and poles was 12.1% (RTA NSW, 2008). Over 65% of all *fatal* crashes involved no object being hit. To put these numbers into perspective, it is worth noting that alcohol was involved in 20% of the fatal crashes, speeding in 32% and fatigue in 20%. These percentages may actually be much higher, since data is not easily collected for speeding or fatigue, and the alcohol status was unknown in another 19% of the fatal crashes.

To avoid crashes with solid objects, a clear zone of a prescribed width from the road's edge may be specified. For example, on an urban arterial road, at locations where run-offs are likely to occur such as bends, a clear zone of 2.5m from the road's edge is recommended (Traffic Authority of New South Wales (TA NSW), 1987). However, at other locations, and where unobstructed sight distances are not required, trees need only be 1 m from the road's edge. In the USA, clear zone distances vary, based on traffic volumes, speeds and roadside geometry (Wolf & Bratton, 2006). Guidelines are less distinct for urban roads, but 0.5m is the minimum clear zone on urban low speed, local roads with kerbs. Nevertheless, some states have increased their minimum to 3.0m (CTRE, 2008).

Whilst this research is still in its early stages, a clear case has been made to research urban road crash data, as distinct from rural road crash data, so that information is available to better integrate trees into the planning and design of urban roadsides (Wolf & Bratton, 2006). Initial results in the USA (CTRE, 2008) indicated that the fixed object crash frequency in urban areas decreased at a 1.5 m object setback distance, making it the most effective setback distance and that there was no need to adhere to the commonly greater setback distance of 3.0 m.

3.4PHYSICAL ACTIVITY AND HEALTH: BENEFITS IN MANAGING DISEASE

Recently, there has been a greater focus on physical activity and health, particularly amongst the elderly and the young, given the aging populations in western countries and problems amongst the young (and others) as regards being overweight or obese. Since these issues are occurring at a time of increased urbanisation, people are looking towards increases in physical activity in towns and cities as potential solutions. With the psychological and social benefits of 'green environments' already well established (section 3.1), more attention is being directed towards physical activity in urban green environments. Yet urbanisation itself threatens the maintenance of these areas. Whilst trees are not the only components of green environments, they are a significant part, given their size and longevity.

Human health is defined as 'a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity' (WHO (1948) in Tzoulas *et al*., 2007). Recent epidemiological studies are beginning to provide evidence of the positive relationship between well-being, health and green places (de Vries *et al.*, 2003), including the importance of walkable green spaces to senior citizens (Takano *et al*., 2002). Integrating our understanding of the role of trees and other vegetation, also known as 'green infrastructure', with our understanding of human health will advance this area of research and provide better land use planning and management outcomes (e.g. Tzoulas *et al*., 2007).

Green infrastructure performs multiple roles in towns and cities i.e. recreation, maintenance of biodiversity, city structure, cultural identity, environmental quality and biological solutions to technical problems (Sandstrom, 2002). It comprises all natural, semi-natural and artificial networks of multifunctional ecological systems within, around and between urban areas, at all spatial scales (Sandstrom, 2002; Tzoulas *et al.*, 2007). A component of 'green infrastructure' is the urban forest which includes all the woody vegetation in and around urban areas, on both public and private property, whether deliberately planted or as a remnant of vegetation pre-dating urbanisation.

Whereas 'green infrastructure' includes more plant types (such as grasses and herbs, as well as trees and shrubs), the main distinction between 'green infrastructure' and the urban forest lies in their basis. Green infrastructure emphasises the multiple purposes of green areas and takes an ecological systems approach in identifying these areas, whereas the urban forest takes a structural approach, focussing on relatively long-lived woody plant material. This is not to say that the urban forest does not perform as an ecological system, providing ecological services and environmental benefits to people; we are increasingly recognising that this is, indeed, the case.

Another term for urban green environments is 'green space' or 'open space', but since these tend to emphasise the recreational role of these areas, and have unfortunate connotations of 'emptiness'

(space), the term ‘green infrastructure’ is preferred. Another benefit of the term ‘green infrastructure’ is that it is seen to afford the same significance to these areas as ‘technological infrastructure’ has traditionally had in urban planning (Sandstrom, 2002).

In Australia, our cities and towns usually have the full range of ecosystem types comprising ‘green infrastructure’. The street and park tree components of the urban forest would usually be considered as part of the artificial ecosystems of Green Infrastructure, whereas trees and shrubs (along with herbs and grasses) in a park revegetated with locally indigenous plants might be considered a semi-natural ecosystem, and an area of remnant bushland would be considered a natural ecosystem.

Evidence for the importance of ‘green infrastructure’ to human health comes from studies in three main areas (Tzoulas *et al*., 2007): epidemiological studies, experimental studies and survey studies. Experimental studies (section 3.1) indicate that natural views and green places restore attention fatigue, quicken recovery of cognitive performance, provide relaxation, increase positive emotions, allow recovery from stress, reduce symptoms in children with ADD, increase the effectiveness of people in facing major crises and lessen aggression by reducing mental fatigue (Tzoulas *et al*., 2007).

The epidemiological studies are particularly interesting because they have brought public health and medical researchers into the ecological area. De Vries *et al.* (2003) explored the relationship between green areas and health in over 10,000 people in the Netherlands using two different datasets, one on self-reported health and one on the amount of greenspace in their living environment. The study was controlled for socioeconomic and demographic characteristics, as well as for the level of urban-ness. People living in a greener environment were significantly healthier on all three health indicators (number of symptoms experienced, perceived general health and a score indicating propensity to mental health problems). The level of urban-ness influenced health in that people in highly urban areas had more symptoms and a higher risk of mental illness; however, the amount of greenspace was more strongly related to the health indicators, and in a way that gave better health outcomes.

The positive link between greenspace and health was found to be most apparent among the elderly, housewives and people from lower socioeconomic groups. Whilst the mechanism linking greenness to health was not studied, suggested possibilities included less polluted environments, greater contact with greenspace, or more physical activity. It was also suggested that, if it was ultimately found that greenspace in people's living environments actually *made* people healthier, rather than just being related to perceived health, then the densification of cities, which can remove greenspace, may turn out to have unexpected negative health consequences.

A follow up study, along similar lines and involving over 250,000 people (Maas *et al*., 2006), studied the strength of the relationship between the amount of greenspace in people's living environments and the perceived general health for different socioeconomic, age, and locational (i.e. urban or rural) groups. The percentage of greenspace inside a 1km and a 3km radius had a significant relationship to perceived general health. The relationship was generally present at all degrees of urban-ness, from very strong to non-urban. The overall relationship was somewhat stronger for lower socioeconomic groups. The groups that seem to benefit more from the presence of green areas in their living environment are the elderly, youth and people with lower levels of education. The study emphasised that greenspace should not be considered a luxury, but rather as having a central position in spatial planning policy, especially for the groups identified above.

Other epidemiological studies on mortality rates (Takano *et al*., 2002; Tanaka *et al*., 1996), and controlled for age, sex, marital and socioeconomic status, found that people with access to green places had greater longevity. Increased survival of senior citizens was significantly linked to having parks and tree lined streets near their residence; having walkable green streets and spaces nearby was a significant predictor for survival over the following five years (Takano *et al*., 2002).

There is an increasing body of literature on physical activity, particularly walking, in residential environments and links with health, including reducing obesity. For example, it has been shown that high levels of greenery in residential environments are associated with being physically active and not being overweight or obese (Ellaway *et al*., 2005). Whilst parks have long been perceived as important sites of physical activity, contributing to human health (Maller *et al*., 2002), there is a more recent focus on streets as sites for walking to maintain health, especially for elderly people. Green elements, such as trees along the street, front gardens and parks, have been found to be important aspects in making streets attractive for walking (Borst *et al*., 2008).

A framework linking 'green infrastructure', ecosystem function and services, and human health has been suggested by Tzoulas *et al.* (2007), whereby green infrastructure, through its provision of ecosystem functions and services, creates the environmental settings for health of both individuals and communities. Health in this context is considered in its broadest meaning, including socioeconomic health (e.g. income, employment, education, housing, services etc.), community health (e.g. community identity and empowerment, social capital and culture), physical health (e.g. cardiovascular, endocrine, bone tissue etc.) and psychological health (e.g. relaxation, attention and cognitive capacity, positive emotions etc.). There are potential economic implications of 'green infrastructure' for health effects and health service budgets, and these need to be researched.

4.ATTITUDES TOWARDS TREES: PERCEPTIONS, PREFERENCES AND RESPONSES

Understanding the social attitudes of urban dwellers towards nature, including attitudes towards trees, is important in managing urban forests. In 2006, a continuum of values was provided (Tarran, 2006) involving both subconscious and conscious components (Miller, 1997) via five groups of people:

- those with a love of and dependency on nature e.g. wilderness dwellers
- those who seek renewal in nature e.g. weekend bushwalkers
- those who prefer tamed nature e.g. people enjoying backyard or motorised outdoor recreation
- 'nature neutrals' e.g. people who are not interested in nature and are comfortable without nature
- 'nature haters' e.g. people who see nature as messy, threatening and in need of control

As well, the condition known as 'plant blindness' (Moss Warner, 2004) was mentioned: that is, the inability of some people to even notice plants, let alone to recognise their importance to people and the biosphere, or to appreciate their aesthetic and biological features. This could be an increasing group, in view of urbanisation, changes in housing types, and reduced contact with nature in daily life.

This information was based on observation rather than any serious study. Yet the importance of humans, as the dominant influence on urban ecosystems and urban forests, is undeniable. More recently, it appears that people's attitudes towards nature, and towards trees (to some extent), are being researched. This is being driven, in part, by the necessity of bringing about changes in people's environmental behaviour as we attempt to move towards more sustainable cities. As urban environmental managers seek to introduce programs such as recycling and water conservation, they are finding they need to understand better the attitudes of urban dwellers towards nature.

Studies on perceptions of, responses to and preferences for trees and urban forests fall into several categories, such as the:

- shape and appearance of trees and their canopies
- presence of trees in front and back yards
- presence of trees near workplaces, in streets and in cities

4.1SHAPE AND APPEARANCE OF TREES AND THEIR CANOPIES

There are some studies dealing with people's perceptions of trees and their canopies, in an attempt to understand landscape preferences. The findings of these studies may assist with species selection that will meet with approval by urban dwellers, particularly on a visual basis.

Spreading and globe tree shapes, and comparable species examples such as acacia and oak, are preferred over conical (and conifer) and columnar forms by people from a range of countries including the United States, Canada, Australia, Brazil, Israel and Japan (Sommer & Summit, 1996). Whilst there was also a preference for trees most common in early experience (e.g. people who grew up with conifers tended to rate them more highly), the characteristics of the spreading and globe shapes in themselves played a greater role in the common preferences for these shapes across different nationalities. A similar study (Sommer, 1997) including countries with other environments (South Africa, Zimbabwe, Estonia, Italy, Switzerland and the US-Mexico border) confirmed the previous findings. It is suggested that preference for tree shape is related to early human evolution and derives from landscape features of the East African savannah in which areas were selected as habitat based on their provision of features that contributed to human survival. Spreading trees offered both refuge (shelter) and prospect (the ability to climb up and see into the distance) (Summit & Sommer, 1999). The preference for a spreading tree form was confirmed by Lohr and Pearson-Mims (2006) who also

found that people reported feeling happier, friendlier and more attentive, but less angry, sad and fearful, when looking at urban scenes with trees than the same scenes with inanimate objects.

Williams (2002) studied resident preferences for street trees in Melbourne, Australia, via a photo-questionnaire involving trees photographed in local streets. This study thus evaluated multiple tree characteristics, such as form, size and foliage texture, within the context of the street, including overhead wires, roads and footpaths. A preference was found for trees with a spreading, oval or globe form, but unlike previous studies (e.g. Sommer & Summit, 1996; Sommer, 1997; Summit & Sommer, 1999) the globe forms were more preferred than the spreading forms. Williams' study did however confirm previous findings of the relatively low preference for conical and columnar forms. The most preferred trees tended to be those in the category of introduced, deciduous trees, which were medium to large and with relatively large and coarse foliage; it was not possible, however, to relate the preference to any single character of these trees. There was also a preference for medium-sized trees over both smaller and larger trees, for trees with coarser foliage (broadleaved trees) compared with finer foliage (conifers and Australian trees with needle-like foliage), and for trees with balanced canopies compared with irregular canopies. It appeared that older respondents had lower preference for large trees, whilst more highly educated respondents had significantly higher preference for large, primarily native, trees. There were no significant differences in average preference for 'native Australian' trees (from the local area or elsewhere in Australia) or 'introduced' trees (trees from countries overseas).

4.2PRESENCE OF TREES IN FRONT AND BACK YARDS

People may have different attitudes to trees, depending on the location of the trees, whether it be a distant forest of natural bush, a plantation of exotic pines, or trees in an urban bushland remnant, a public street or park, or in their own yards. People's attitudes to trees can be explored by investigating how they engage with trees on their own properties, where they have a greater level of control over tree planting, pruning and removal. Of interest are whether people choose to include trees in or exclude trees from their front and back yards, and the reasons for their decisions.

Using a large study of 226 backyards and backyarders in Sydney and Wollongong, Head and Muir (2005) extracted data from 21 participants looking at attitudes towards trees, both positive and negative, that reflect ownership, association and attachment. This sample included differences in educational level, ethnicity, age, gender, occupancy time and size of backyard. Not surprisingly, diverse sets of attitudes were found. Trees were variously seen as powerful, dangerous and beloved. The most frequently cited reason for tree removal related to danger, disease or size, whilst the most important reasons for planting trees related to aesthetics and creating habitat for birds, with provision of shade cited less often. People used the word 'love' to describe their attachments to particular trees in their backyards and then explained this love, via social value, aesthetics or bird attraction. Dangerous trees were identified as such because of disease, age, angle, shedding large branches, planted too close together, wind affected, fire hazard or a threat to plumbing. Although some people did not view large trees in their backyard as a threat to security, others stated a general belief that gum trees didn't belong in suburban back yards.

Head and Muir (2005) made some interesting suggestions about attitudes to trees based on people's perceptions of trees as occupying a zone where "nature" and "home" overlapped. Whilst some people seemed to be aware that native plants might be appropriate for environmental reasons, their own needs and personal sense of aesthetics took precedence, albeit with some sense of guilt. Removal of trees aroused more guilt than removal of shrubs and ground cover, even though all layers are important for habitat and biodiversity. Other people, who were strongly committed to restoring locally indigenous trees to their area, were highly critical of neighbours' choices of (exotic) trees for planting or reasons given for removing locally native trees. The study suggests that some people exclude trees from their backyard when they perceive nature and the environment as something 'out there', beyond the home. On the other hand, when people have a view of nature that is more fluid and can move into the 'home' zone, they are more comfortable with including trees in their backyard. A third group of people, who expressed a strong sense of connectedness to nature, had a strong commitment to including trees in their backyards, including restoring the indigenous tree layer.

A few studies on western cities with extensive suburbs, particularly in the USA, have examined the relationship between socioeconomic status and characteristics of urban vegetation (e.g. see Kirkpatrick *et al.*, 2007). The general finding is that tree cover is greater in areas with higher socioeconomic status (higher levels of income and/or education). Garden size plays an overwhelming

role in determining garden composition as well (Smith *et al*., 2005), with larger gardens being more likely to contain trees taller than 2-3m. The reasons why tree presence could be directly related to socioeconomic status have not been determined, but could include (Kirkpatrick *et al*., 2007) the fact that the rich have larger gardens or better land for growing trees; other factors could include ethnicity, home ownership, imitation, education, age of owners and age of suburb.

Kirkpatrick *et al.* (2007), studying 1550 front gardens randomly selected across Hobart suburbs (50 gardens from each of the 31 suburbs), covering socioeconomic and environmental variation, found that household income was the best predictor of the percentage frequency of trees (taller than 8m) in front gardens. Gardens that had more clayey soils and those at a higher altitude also had more trees. Overall however, most front gardens were medium-sized and most (70%) had no trees. Of the 13 garden types identified, trees were most often present in the types described as 'shrubs with bush trees' (including retained native trees) and 'complex native' (which included planted locally native and other Australian plants); these were also the categories containing the most large gardens. However, garden size in itself was not a significant predictor of tree presence. Trees were also often present in 'productive', 'woodland' and 'simple native' gardens, but notably absent in 'non-gardens' (lawn and/or artificial surfaces), 'complex flower' gardens and 'exotic shrub' gardens.

In speculating as to why there were fewer or no trees in the gardens of lower socioeconomic areas, Kirkpatrick *et al.* (2007) suggested, based on ideas of Seddon (1997), that people of lower socioeconomic status may find that the garden is one of the few places where they can exercise control in their lives and that such control is more readily achievable in the absence of trees. These findings for Hobart, where the poorer suburbs had mostly Australian-born people, may not apply to Melbourne and Sydney, where comparable areas have substantial recent immigrant populations.

Another line of research has looked at the cultural background and landscape history of different groups of people to determine whether these factors affect the perception of the urban forest.

Toronto, Canada, is a multicultural city, in which four culturally distinct populations (British, Chinese, Italian and Portuguese) were identified and studied, using a random selection of 50 households of each population, controlled for income and housing type (Fraser & Kenney, 2000). Vegetation inventories were conducted on each property and face-to-face interviews gathered information on:

(a) the changes they had made or would make to their gardens
(b) what kind of tree they would plant on their property (large shade, small ornamental, fruit or none)
(c) their order of preference for images of five front yards (lawn, vegetable/fruit, two shade trees, ornamental shrubs or brick patio)
(d) their order of preference for four different park types (playing field, flower garden, playground and hiking path) and whether the city would be improved or degraded by more of each type
(e) demographics (home ownership, years at house, age and time in Canada)

Fraser and Kenney (2000) found that there was a clear difference between the populations in terms of the type of tree each group would prefer to plant: the British preferred shade trees, the Italians preferred fruit trees, the Portuguese preferred either fruit or ornamental trees, and the Chinese preferred no tree at all. Whilst all communities preferred shrub front gardens, the British had the strongest preference for shrub and shade tree gardens, whilst the Chinese reacted more favourably to lawn and brick patio. In relation to the park types, only the British reacted favourably to the hiking trail, with the other three communities preferring flower gardens. In their own back yards, the British had the most shade and ornamental trees, while the Italians and Portuguese had the most fruit trees. It was felt that these differences could be linked to both cultural background and landscape history.

It is apparent that, in the case of the urban forest on private land, cultural differences can create another layer of complexity in developing an urban forest strategy. Given that different cultural perceptions exist, managers can try to work with these differences, recognising that ecological and climatological benefits may be sub-optimal, or they can ignore these differences, and face resistance or sabotage from some parts of the community, or they can attempt to educate diverse communities about the benefits of larger trees in urban areas.

There have been some studies of the gardens of different migrant cultural groups in Australia (e.g. Armstrong, 1999; Head *et al.*, 2004), but these have tended to focus less on the tree aspect *per se* and more on the experience of migration and the links between people and plants in their new environments. These links often involve food production, as a way of sustaining their cuisine and

other aspects of their culture. Trees that are mentioned as important are, for example, figs, lemons and olives in the Greek community (Armstrong, 1999), stone fruit, lemon, mango and nut trees in the Macedonian community (Head *et al*., 2004) and tropical fruit (mango, pawpaw, loquat and longan) and citrus (grapefruit, mandarin and lemon) trees in the Vietnamese community (Head *et al*., 2004). Other trees were not common in these back yards. The gardens of British migrants, on the other hand, contained tree-and-shrub layers combining 'native' Australian plants and exotic plants, but little in the way of food trees, most often just a single lemon tree (Head *et al*., 2004). Intensive back yard food production seemed to break down amongst the next generation in suburban Australia, with aspects retained as part of heritage alongside increasing use of 'native' shrub-and-tree layers.

Although there is anecdotal evidence of a desire for residents to remove trees from their properties after severe events, such as bushfires or major storms, there is little documented research into this phenomenon. Studying (non-development) tree removal request data in Canberra, both before and after the major bushfires of January 2003, Gilbert and Brack (2007) found that there was a substantial increase in requests lodged in February 2003, but by February 2004 the number of requests had returned to February 2002 levels, indicating a response that declines relatively quickly. Since the approval rate remained the same during the increase in requests to remove trees, it appears that the reasons for requesting tree removal were justified and that the bushfires may have just provided an incentive for people to request tree removal for reasons that pre-dated the fires.

4.3PRESENCE OF TREES NEAR WORKPLACES, IN STREETS AND IN CITIES

Reasons given for the inadequate funding of the urban forest are often that the benefits are pure public goods (Bisco Werner *et al*., undated), widely dispersed and not priced (Vesely, 2007), with further complications arising from the fact that the urban forest is in multiple ownerships. Quantitative information on urban forest benefits and residents' valuations of the urban forest are both needed to facilitate better funding, either through better public awareness of potential values that may be lost or through management decisions based on cost-benefit analyses (Tyrvainen & Miettinen, 2000).

Quantitative information on urban forest benefits has been steadily increasing (e.g. see Dwyer *et al*., 1992; McPherson *et al*., 1999; McPherson & Simpson, 2002; Brack, 2002) and has been facilitated by specialised software packages such as CITYGreen (undated) and i-Tree (undated). There is, however, less information about residents' valuations of the urban forest.

Using contingent valuation methodology (since market data does not exist), Vesely (2007) measured the perceived monetary value of avoiding a 20% decrease in the urban tree estate on the public and private land of 15 cities in New Zealand (mainly in Auckland and Wellington). On average, households were willing to pay about NZ$184/yr for 3 years to avoid a 20% reduction in their local tree estate. When volunteer work was used as an alternative to monetary measure, it was found that 66% of the sample agreed to contribute 4 hours per year.

The study also revealed other information about the residents' perceptions of the urban forest, since they were first encouraged to think about the beneficial and negative effects of city trees. A pre-study indicated that, on average, city residents named only three benefits of having trees in the city, so the questionnaire was designed to ensure that they had a broader understanding of the benefits. The main findings were that -

(a) of nine benefits listed for the urban forest, aesthetics was considered most important, followed by having nature in the city, habitat for wildlife and fresh air
(b) of seven listed negative effects of the urban forest, only one (causing drainage problems) was more important than the lowest ranked benefit; leaf drop was considered the least problematic
(c) about half the city residents felt that there were the right number of city trees, while slightly less than half felt that there were not enough; only 2% felt that there were too many trees
(d) people were motivated to take care of trees mainly by the benefits provided by the trees to them, but also to some extent by having benefits available for future generations
(e) in relation to the seriousness of a possible 20% reduction in the urban forest, about half the residents considered it to be either 'extremely serious' or 'very serious'

Very little research has been carried out addressing landscapes near workplaces and employees' reactions to them. Kaplan (2007), using a survey and photo-questionnaire, assessed employees' attitudes to their nearby natural setting. She found that having a view of large trees was consistently related to greater satisfaction with the nearby natural environment, but that a great number of large trees were not required - even a few large trees can make a substantial difference. In terms of desired

changes to the landscape, having more trees and more landscaping were strongly endorsed, but having more flowers received the strongest endorsement. The presence of mowed grass around the workplace had no bearing on participants' satisfaction with any aspect of the natural environment.

5.OVERCOMING IMPEDIMENTS

In 2006, impediments to realising the potential of urban forest benefits to assist the health of urban dwellers were only briefly mentioned in two areas:

- firstly, given that the benefits provided by urban trees could be enjoyed by anyone free of charge once planted, it was likely that the economic market would discount or ignore their value
- secondly, that trees would also be ignored by some groups in society i.e. people who have no interest in nature (or trees), who actively hate trees, or who are 'blind' to their importance

Ways of overcoming these impediments were also only mentioned in passing:

- firstly, that we needed to market the importance of the urban forest more widely to other decision-makers and the public, and in more creative ways
- secondly, that we needed to position urban trees as a normal part of city infrastructure, so that quality space and adequate resources would be automatically provided for them
- thirdly, that we needed much more local research in Australia, to guide the development of urban forestry and urban ecology here

Whilst it would be possible to compile an extensive list of impediments to establishing worthwhile and sustainable urban forests, the present paper will focus on just a few of the key impediments and then suggest some possible ways forward, particularly those than can address multiple impediments simultaneously.

5.1LACK OF RECOGNITION OF VALUE OF URBAN TREES AND FORESTS

Lack of widespread recognition of the value of urban trees and forests, especially for the extensive and multiple benefits they provide to people, remains one of the major problems. This lack of recognition includes a failure to understand or appreciate the benefits in a qualitative way, as well as a failure to place an economic value on these benefits. Whilst there is increasing recognition of these benefits within a small group of professionals whose work involves trees or interacts with them, many other professionals, and the general public, have little idea of these benefits. People who work and are immersed in a particular area often find it difficult to fully understand how little other people know of the area. The case of the New Zealand study, where pre-testing revealed that members of the general public were aware of only three benefits of trees, comes to mind (Vesely, 2007).

This lack of recognition and value is probably just a subset of a general lack of understanding of urban areas, sustainability, urban ecosystems and the like. Just as people have been slow to appreciate the benefits of urban trees and forests, so have they been slow to understand and value the ecosystem services provided by nature to us.

Of particular significance is the lack of recognition of the value of urban trees and forests at a national level, let alone a state level. At present, the vast majority of the work in promoting urban trees and forests is done at the local government and community level. This has many advantages in building support for sustainable communities and helping people engage with their local ecosystems. However, national recognition of issues is an important landmark. It provides focus and elevates issues to a prominence that can never be otherwise achieved. National recognition facilitates broad scale strategic planning, with long term research and action plans. It can coordinate research and technology transfer programs across the country to minimise duplication and allow all towns and cities to benefit from available information. Central to all this activity, and flowing on from national recognition, is national funding at a level that can achieve significant advances.

One aspect of the environment that has received national attention, and where understanding has grown, is water use and sustainability, including urban water. This, however, has been achieved through reaching a crisis situation, with a prolonged dry period in eastern and southern Australia, much publicity as regards water storage (dam) levels, water restrictions in many cities and towns, and decisions to build energy-intensive water infrastructure, such as desalination plants. It appears that a serious and immediate crisis is needed to bring about awareness of environmental issues.

Our challenge in urban trees and forests is to achieve recognition and support before a crisis emerges. It doesn't do to dwell on how much of our existing urban forests would need to be lost before the perception of a crisis brought about awareness of their value.

5.2LACK OF PROVISION OF QUALITY SPACE AND OTHER RESOURCES

Lack of quality space remains an impediment to establishing trees and other vegetation in towns and cities. Large trees are needed to maximise environmental benefits, since large canopy size increases the value of benefits like shading, evaporative cooling, and air pollutant and water interception. For health benefits, 'green' is needed, but there has been less research into the importance of the type of green; it may well be that some level of tree canopy is also needed in this regard. Trees need both below ground and above ground space, for root, trunk and canopy growth, yet they are unable to make a primary claim on space in our cities and towns.

Added to this is the increasing problem of densification of towns and cities, as people seek to make cities more concentrated, to make use of existing built infrastructure, and to reduce urban sprawl. Densification will reduce the availability of quality space for trees and the urban forest even more, and, more worryingly, in a way that is permanent and not easily reversible.

One area where this is all too evident is in the proliferation of suburbs of 'McMansions', also known as too-big houses, monster houses, starter castles and garage Mahals (Nasar & Stamps, 2009). Many of these suburbs are being created without an urban forest or, indeed, much green. We simply do not know how these suburbs will fare in the future, when energy may be too expensive for continuous air-conditioning (in the absence of trees and well-designed houses) and children may lack green places to restore their concentration capacities or undertake physical exercise.

5.3FRAGMENTATION WITHIN GREEN INFRASTRUCTURE

It is possible that, in focussing on trees, just one component of green infrastructure, we are hindering the greater acceptance of the concept of green infrastructure as fundamental to cities and towns. The same comment applies to all the other groups who are concerned with their own particular aspects of 'green' in cities and towns: those concerned with revegetating degraded rivers and creeks, pocket parks, home gardens, community food gardens, bushland remnants, roof gardens, playing fields, recreating locally indigenous landscapes etc.

It may be that the fragmentation itself, and inter-group debates and disagreements, weakens the case for green infrastructure or, at the very least, causes some important main messages to be lost in the detail of the debates.

5.4COMPETITION FOR WATER AND IMPACTS OF CLIMATE CHANGE

Within urban areas, there is competition for water, both between green infrastructure categories (e.g. trees, grassed areas, floral displays and food production) and between green infrastructure and other uses (e.g. cleaning and provision of water features in the landscape). With decreasing availability of urban water, given climate change and increasing populations, there may be greater impediments to establishing and maintaining urban trees and forests if the species selected require more water than can be provided by the local rainfall, both as regards its extent and variability. Nevertheless, there are locally indigenous trees and exotic trees that can survive in and are suitable for urban areas. The issue of weediness, however, does need to be addressed in the case of introduced species that survive easily in local soils and climates.

Of possible concern in the future, with greater attention being paid to the energy costs of food transport and dwindling supplies of oil, is the potential conflict between food supply and other components of green infrastructure, such as urban trees and forests. It may be that available urban space, water and fertiliser will be increasingly devoted to food production.

5.5SOME WAYS FORWARD

(1)National recognition of green infrastructure, including urban trees and forests

Ultimately, we need to gain recognition, at a national level, of the importance of green infrastructure, including urban trees and forests in Australia. Significant advances have been made in urban forestry in both the USA (since the 1980s) and the UK (since the early 2000s) by having national bodies making representations at the highest levels and influencing government policies. In these countries,

plant scientists and social scientists worked together within a forestry-related national body to develop research programs in urban and community forestry, reallocating funds to urban areas in the process.

In Australia, we need to identify a 'champion' national body to promote green infrastructure, urban trees and forests. Nevertheless, it is worthwhile noting that The Wentworth Group of Concerned Scientists did much to get water onto the national agenda. As regards Commonwealth departments in Australia (Australian Government, 2009), the most promising ones appear to be:

- Environment, Water, Heritage and the Arts (includes human settlements, plants, biodiversity, water, climate change etc.)
- Innovation, Industry, Science and Research (includes CSIRO and Cooperative Research Centres)
- Health and Ageing is also relevant, via public health and disease prevention, and health of target groups such as indigenous populations, the youth and the elderly

Early research at the US Department of Agriculture (USDA) Forest Service research stations led to a landmark, well-funded study on Chicago's Urban Forest Ecosystem (McPherson ***et al.***, 1994) which became the model for subsequent studies throughout the USA. The 1990 Farm Bill (amending the Cooperative Forestry Assistance Act of 1978) led to the creation of the National Urban and Community Forest Advisory Council (NUCFAC) which drafted a National Research Agenda for Urban Forestry in 1991 (Makra & Watson, 2003). Thus, early research was undertaken in a strategic and coordinated way. This Agenda was revised in 2003 (Makra & Watson, 2003). In 2004, an inventory of urban forestry programs throughout the USA was undertaken and the USDA Forest Service Urban and Community Forestry Program was assessed (HortScience, Inc. & The Aslan Group, 2004). Recent documents prepared by NUCFAC include the 'National Research Plan for Urban Forestry: 2005-2015' (Clark ***et al***., 2004) and the 'Ten-year Action Plan 2006-2016' (NUCFAC, 2005).

In the UK, it appears that their version of urban forestry, that is, trees, woodlands and the natural environment, has received a similar boost, via the involvement of the national Forestry Commission of Great Britain (2009), in particular through their Forest Research programs. In the early 2000s, they appear to have expanded into social science research, alongside their traditional scientific research. They now have a strong health and well-being component in their research program. Recently, their research centres were reorganised to include Forestry and Climate Change, Human and Ecological Services as well as the traditional area of Forest Resources and Management.

(2)An Alliance of Green Infrastructure Providers

To achieve national recognition, I believe we need a group with the national, long-term public good at its core, to promote green infrastructure, including urban trees and forests. For urban trees and forests, it may be best to present trees as part of the green infrastructure 'package' that also includes shrubs and grasses, green walls and roof gardens, community food (productive) gardens, pocket parks, revegetated riverbanks, bushland remnants, and recreated indigenous landscapes.

Just as we moved from individual trees, to urban forests, so the next logical step forward may be to green infrastructure in cities and towns. This has the advantage of positioning plants as central to urban ecosystems and hence to the ecosystem functions and services provided to urban areas and urban dwellers. Furthermore, this recognises the role of green infrastructure in creating the environmental settings for the health and well-being of both individuals and communities.

The Alliance of Green Infrastructure Providers needs to include the extensive range of green infrastructure categories in Australia and the special attributes of our 'green', such as our unique biodiversity (resulting from Australia's environmental history), the links between indigenous people and plants, the presence of remnant bushland in and near cities and towns, and the cultural overlays of recent immigration during the last 220 years, including tree planting, garden making, revegetation programs and bush regeneration. Given the diversity of this group, its members would need to work through philosophical differences to arrive at a stage where the greater good is served by recognising the commonality of our commitment to green infrastructure, rather than by debating the relative merits of different types of green.

(3)Continued engagement with people through tree and other "green" stories

People are storytellers; and a powerful way of engagement and awareness-raising is through stories. We need to continue to talk about trees, gardens, parks and bushland, in the past, present and future, and to embed these stories in our culture. We need to engage with other groups, like social scientists,

garden historians, and artists, to learn more about people-plant interactions. Perhaps we need more creativity in the ways we help people to see trees and the links between people and trees.

It is interesting to note that trees have recently appeared as a prominent part of the Sculpture by the Sea (2008) exhibition in Sydney NSW, along the coastal walk between Bondi and Tamarama: family trees with roots that spread far and wide, a tree representing our lifeboat and connection to nature, and a tree suspended between the land and sky. In the USA, an art commission to commemorate the centennial of the Grand Concourse in the Bronx, a tree lined avenue, saw it turned into a long boulevard of talking trees: a tree museum, with trees connecting to oral guides of Bronx history (The New York Times, 2009). Along the Concourse, 100 trees were marked out, giving a phone number and code to listen to short recordings of people speaking about the Bronx, their lives and their work.

6.CONCLUSION

Although the benefits of trees and other vegetation to humans living in cities and towns are being increasingly studied and even quantified, we are yet to achieve full recognition of these benefits by all parties involved in urban planning and management. Benefits of 'green infrastructure' are mostly promoted at the local government and community levels, but are not yet recognised at national or state levels. Furthermore, many people themselves are yet to recognise the diverse benefits provided by trees and other plants and advocate more strongly for their right to live in green cities and towns.

At the same time, we are losing 'green infrastructure' and potential spaces for future 'green infrastructure' as we continue to build and consolidate our cities and towns. In some cases, the loss of space, especially for trees, cannot easily be reversed.

The emerging evidence of powerful health benefits associated with green in urban areas should serve as a wake up call that existing trees and vegetation in cities should not be taken for granted, nor readily removed as we increase urban densities. Furthermore, we need to seriously re-think current development that 'designs out' spaces for significant areas of trees and other vegetation, given the likely future adverse consequences for human health.

It is critical, at this late stage in our process of urbanisation in Australia, that an Alliance of Green Infrastructure Providers engages with both people and their national, representative decision-makers, to position Green Infrastructure as an essential component of liveable, sustainable urban ecosystems.

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ARE YOUR URBAN TREES IN THE CLIMATE CHANGE AND SUSTAINABILITY SPOTLIGHT?

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INTRODUCTION:

At the 8th Treenet Symposium in 2007 the recommendations and targets of the Brisbane Climate Change and Energy Action Plan were outlined. The Plan combines responses to the impacts of climate change for Brisbane with broader sustainability actions. The Lord Mayor is passionately committed to the Green Heart CitySmart Program which, in partnership with the community, is now implementing the Plan by investing significantly in actions across the themes of water, energy, and waste management, reducing emissions, greening Brisbane and active travel.

> "Green Heart CitySmart is about working with our community to achieve house by house, street by street and suburb by suburb climate action that will help our city become the most ecologically diverse and sustainable city in Australia" – Brisbane Lord Mayor, Campbell Newman.

This has provided the opportunity to promote the positive role that urban trees play in mitigating the impacts of climate change, and the integration of urban tree outcomes across all of the action themes. This paper outlines:

- some of the common elements of climate change and sustainability action plans in local government,
- the difference between adaptation actions and mitigation actions,
- where urban trees currently and potentially fit in those actions, and
- uses examples from Brisbane, Melbourne and overseas cities, to show the opportunities and benefits that the climate change and sustainability spotlight is bringing to urban tree management.

ELEMENTS OF CLIMATE CHANGE AND SUSTAINABILITY ACTION PLANS

Climate changes in Australian cities, such as increasing temperatures, sea level rise, changing rainfall patterns, and more frequent and intense climatic events such as storms, cyclones and heat waves, have been identified. Federal, State and Local governments have responsibilities to the community to manage the risks climate change presents to the environment, society and the economy. The Australian Government's Department of Climate Change has recently updated its guidance on "Climate Change adaptation actions for Local Government" (2009). It identifies the strong connection between climate change actions and fundamental risk management, good planning, design, efficient services and resource management. Therefore, most local government action planning simply reviews existing tools, both regulatory and non-regulatory, in the context of the new climate change risks. Given the additional connections with environmental, social and economic sustainability, climate change action plans often refer to, or are combined with, sustainability action plans. The climate change issue has therefore hastened many local authorities towards water, waste and energy efficiency, land use planning revision and many other environmentally responsible actions. Table 1 lists the common elements and topic areas of climate change and sustainability action plans. Insurers of local authorities are also beginning to scrutinise climate change action plans, given the greater exposure to public class actions, and informing councils with no plans that they may not be insurable (Donovan Burton- Climate Change Risk Pty Ltd).

Table 1: Elements of local government climate change and sustainability action plans

Functions	Actions
Greenhouse gas emission reduction/offset	• Emission reduction targets • Purchasing offsets for Council emission producing activities • Support for active and public transport infrastructure

Energy, Water, Waste Management	• Energy and water consumption reduction targets, rebates, incentives • Landfill waste reduction targets • Energy production from landfill gas • Purchasing green energy for Council infrastructure
Land use & buildings	• Reviews of coastal and flood prone land use controls • Support for compact/denser development and transit orientated development • Sustainable "green" building regulations, ratings, incentives, demonstrations
Public health & safety	• Reviews of disaster management plans - fire, flood, storm, wastewater overflow, disease, etc • Support shade provision/sun smart programs
Biodiversity protection	• Open space and vulnerable natural area protection • Habitat rehabilitation offsets • Revision of weed management plans
Community engagement	• Community, business partnerships, education, awareness • Expert advisory panels, auditing, reviewing implementation

ADAPTATION ACTIONS VERSUS MITIGATION ACTIONS

Except for the actions that help reduce greenhouse gas emissions which cause climate change, all of the actions listed in Table 1 are termed *adaptations*. Adaptations are adjustments to existing activities and practices to reduce vulnerability to the impacts of climate change. Whereas actions which lead to moderating the severity of climatic conditions themselves, or the causes of climate change, are termed *mitigations*. Mitigation may seem far more proactive and direct. However, the current Federal Government debates about emission trading and emission reduction targets are because of the perception of high economic costs of such policies versus measurable climatic moderations.

Far from being a 'cop-out', adaptation actions, especially those that can provide a net benefit or multiple benefits to the environment, society and/or the economy, are more easily justified. For example, the City of Salisbury has required the installation of wetlands, to contain stormwater on site, as much as possible, in all new subdivisions. This initiative provides both greater flood control and reduction of peak flow rates of up to 80%, and an alternative source of water for irrigation. These are adaptations to both flood and drought events that may be more frequent in a changing climate. However, the wetlands initiative provides many other benefits such as reductions in traditional stormwater infrastructure provision and maintenance, water quality improvements, opportunities for recreation and biodiversity enhancement (Department of Climate Change).

WHERE URBAN TREES FIT IN CLIMATE CHANGE AND SUSTAINABILITY ACTIONS

When climate change impacts were first being considered by local authorities, urban trees were often treated as the victims or part of the problem. Responses included calls to stop planting trees because they use water or remove more trees because of subsidence risks during prolonged drought. Tree plantings that were permitted were expected to be drought, pollution and storm tolerant tree species and excluded from near waterways where greater flood flows may be needed.

Next, tree planting, not necessarily urban trees, exploded into the emission offset spotlight. Tree planting offsets could be purchased for every emission producing activity and product, providing 'green absolution' for everything from motor car use, air travel, plastic water bottles, to mobile phone batteries. Some of those tree plantings were offering co-benefits such as habitat enhancement, and saline land regeneration.

Urban tree planting and tree cover protection fit as both climate change mitigation and adaptation actions, with potential to deliver multiple benefits supporting sustainable urban form and function. They mitigate climate change impacts not only by sequestering greenhouse gas emissions, but also by helping to indirectly avoid and reduce emissions through the cooling effects of their shade and evapotranspiration. They are also integral to many adaptation actions including land use change, sustainable infrastructure, social resilience, active and public transport uptake, water cycle

management, public health, and community engagement. Coutts et al (2009), for example, suggests that the form and intensity of the urban heat island (UHI) in Melbourne can be mitigated by retaining and re-integrating urban stormwater to provide greater evaporation and transpiration. Urban stormwater, in turn, supports urban tree cover and its shade provides even more UHI mitigation. Most climate change and sustainability action plans have been slow to recognise the roles of urban trees, and have limited the focus to natural areas, biodiversity threats, fire risks, some reforestation or offsets.

EXAMPLES OF URBAN TREES IN CLIMATE CHANGE AND SUSTAINABILITY SPOTLIGHT

Some of the multiple benefits of urban trees are beginning to move into the climate change and sustainability action planning spotlight. This, in turn, is providing new opportunities for investment and innovative partnerships in better urban tree management. After all, the mitigation and adaptation potential of urban trees can only be optimised when they are well-maintained, healthy, and low risk to the communities they live amongst.

Examples of where urban trees have been moving into the climate change and sustainability action spotlight in Brisbane, Sacramento, New York City and Toronto are provided below.

Neighbourhood Shadeways and Subtropical Boulevards – Brisbane City Council

In 2008-09, 11,430 new street trees were planted in Brisbane, bringing the estimated street tree population to 550,000. Almost three quarters were planted by local residents at Saturday morning community planting events, and 10% of those plantings were funded by project partners. The Neighbourhood Shadeways program is aiming to increase tree shade/canopy cover to 50% along footpaths and bikeways. City Planning branch partners are providing more shady, comfortable and attractive pathways in areas of the city where more compact urban form and higher residential dwelling targets are being sought. Their support also helps make active and public transport options more attractive, and supplements open space provision and connections. **If shady pathways helped to reduce the number of kilometres of private car travel by just 1/100thannually, the greenhouse gas emissions avoided is estimated to be around an additional 25% of what is sequestered directly by the trees themselves.**

All major transport upgrade projects in Brisbane are required to design for maximum tree retention and where tree removal is unavoidable, new plantings must be provided to achieve **no net canopy area loss within 3 years of the project completion**. This supports Subtropical Boulevard outcomes on major city entry roads, which in turn support sustainability actions including multi-modal transport and shaded pavements, especially in retail and residential precincts.

Sacramento Regional Greenprint- Sacramento Tree Foundation (STF)

In 1990 the Sacramento Municipal Utility District (SMUD) (electricity generator and distributor) sponsored the planting of 500,000 shade trees as the cornerstone project of their investment in energy efficiency. The Sacramento Tree Foundation provided the technical expertise and hands-on advice to ensure tree plantings near homes, schools and other buildings were chosen and positioned for maximum summer cooling benefit and minimum ongoing maintenance and risk. Achieving up to 30% reductions in summer cooling demand at a cost of around $3m, SMUD quoted the project as one it's most reliable and cost effective energy efficiency programs.

In 2005 the STF broadened its goals of maximising the multiple benefits of shade trees to the whole Sacramento region. The Regional Greenprint aims to improve air quality, energy conservation, business vitality, roadway surface lifespan, water quality, stormwater mitigation, skin cancer prevention and property values worth an estimated $105.5 million dollars in benefits per year, by doubling the regions tree canopy to an average of 35%**. "The Greenprint invites our region's cities and counties to develop livable and sustainable communities by building the best urban forests" (2005).**

Million Trees NYC- New York City

By adding 1 million more trees to the five boroughs, New York City plans to build upon the climate change and sustainability benefits of their urban forest already quantified in 2007 at:

- $24.9m in carbon storage
- $35m/yr stormwater interception by street trees
- $27m/yr in energy savings, and
- 2,200 tonnes per year of dust and air pollution removal

In the 2008 Journal of Epidemiology and Community Health, researchers also reported that the incidence of asthma in 4-5 year old children in New York City was a quantum of 25% lower for every increase of 343 trees per square kilometre.

"Time to Tackle Toronto's warming"

The City of Toronto plans to double the extent of urban tree canopy to 34% by 2020. Preliminary results from an urban heat island study, found tree lined residential areas among the coolest locations in the city. The following actions have been identified as climate change adaptation options to deal with extreme heat events like their 2005 summer.

- **Maintain healthy green spaces**, including practicing integrated plant health care to increase the health and survival of over 500,000 street trees and 2.5million trees in parks
- **Plant more trees, particularly in deficient areas** to reduce summer ambient air temperatures around buildings and entire neighbourhoods. Toronto is keen to focus on local hotspots, especially in low-income neighbourhoods where people are less likely to afford air-conditioning
- **Encourage use of cool (high albedo) roof materials** which reflect, rather than absorb, a greater amount solar radiation
- **Plant green roofs**
- **Plant green walls**
- **Use more lighter-coloured materials, porous paving and reduce hard surfaces**- Toronto Green Development Standard recommends using light-coloured materials for 50% of the hardscape around buildings.

CONCLUSION:

Urban tree planting and tree cover protection fit as both climate change mitigation and adaptation actions, with potential to deliver multiple benefits supporting sustainable urban form and function. Some of the multiple benefits of urban trees are beginning to move into the climate change and sustainability action planning spotlight. This, in turn, is providing new opportunities for investment and innovative partnerships in better urban tree management.

Lessons learned from cities such as Brisbane, Sacramento, New York City and Toronto may help other local and regional authorities move urban trees and their proper management into the climate change and sustainability action spotlight.

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PLANNING FOR TREES IN URBAN ENVIRONMENTS

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Introduction

Trees should be an essential, rather than merely a desirable part of our cities. Street trees provide the city with a wide range of benefits, with large, mature trees maximising those benefits (Geiger 2004). The city, however, comprises an extremely hostile environment in which trees must survive and grow, and the challenges of life in the city are often exacerbated by unsustainable planning and design practices (Spirn 1984). Two key challenges for street tree managers are: providing the conditions to grow healthy, long lived trees; and minimising conflicts between trees and the surrounding urban infrastructure (Harris, Clark et al. 2004). Planning for trees in cities should be based on a sound understanding of the attitudes, perceptions and practices of those involved in the planning and design of urban environments. In 2009 a study was undertaken of the attitudes and practices of urban tree managers in the Adelaide metropolitan region. The study was part of a wider doctoral research project aimed at developing a more sustainable paradigm for urban tree planting, known as Tree Sensitive Urban Design.

Methodology

Traditionally research into the urban forest has had a quantitative focus. Quantitative research, such as survey research, is characterised by the use of pre-determined instruments of data collection, with closed-ended questions, producing numerical, statistical data. Sampling is a key consideration where the aim is to predict the responses of a larger population from the responses of a smaller group (Groat and Wang 2002).

An alternative research strategy to quantitative research is qualitative research, which has its origins in the social sciences, but has more recently been adopted by a wide range of disciplines (Miles and Huberman 1994). Qualitative methods allow researchers to explore an issue in greater depth, or to discover the meaning of a phenomenon (Creswell and Plano Clark 2007). Qualitative research tends to approach the field of research without a pre-determined hypothesis, with the focus on developing understanding and potentially creating new knowledge. Qualitative methods include in-depth interviews using open-ended questions, producing data in the form of words, transcripts and quotations, rather than numbers. Qualitative analysis may involve the progressive categorisation of data into meaningful patterns. A recent paper noted the absence of qualitative research in the urban forestry literature, and the potential for its use in examining a range of urban forestry issues (McLean, Jensen et al. 2007). It was concluded that quantitative research could provide deeper understanding in the four main themes identified in recent urban forestry literature: economic costs and benefits; ecological and environmental benefits; social benefits and perceptions; and urban forestry policy.

In this study, in-depth interviews were conducted with street tree managers and related professionals, from nineteen Councils in the Adelaide metropolitan region (Table 1). Councils were categorised into eastern, western and outer suburban sub-regions having broadly similar physical settings and patterns of urban development.

Table 1: Organisations interviewed

Councils		
Eastern suburban	**Western suburban**	**Outer suburban**
Adelaide Hills	Charles Sturt	Gawler
Burnside	Holdfast Bay	Mount Barker
Campbelltown	Marion	Onkaparinga
Mitcham	Port Adelaide Enfield	Playford
Norwood Payneham St. Peters	Prospect	Salisbury
Unley	West Torrens	Tea Tree Gully
Walkerville		

Participants occupied a variety of formal positions within each Council (Table 2). Structured in-depth interviews were conducted in the workplace, using a set of fixed questions, but with open-ended

responses. Interviews were taped and transcribed for approval by each participant. Interviews were also conducted on the basis of anonymity and confidentiality.

Table 2: Position of participant

Participant position	Number
Parks, gardens, open space managers	4
Landscape architect, urban designers	4
Operations, infrastructure managers	3
Arborist, horticulturist, tree manager	6
Natural resource manager	2

The following sections provide a summary of key findings related to: street tree benefits and issues; constraints on, and future threats to urban street tree planting; 'best practices' which should be adopted; and factors that may limit the adoption of those practices. Selected verbatim quotations of participants are also included where appropriate. Emerging themes from the data included categorisation of data as either: physical and design factors; human factors; or organisational factors.

Street tree benefits

Question: What do you see as the main benefits of street trees?

Table 3: Perceived street tree benefits

Benefit categories	
Visual	Urban amenity
	Visual character
	Suburb desirability
	Streetscape appeal
	Identity, legibility
Environmental	Many
	Climatic-shade
	Air quality
	Water-runoff
Ecological	Biodiversity, corridors
	Location factors
Economic	Real estate values
	Other quantifiable
Social	Human well-being
	Cultural, heritage
Source: compiled from participant interviews.	

> '*Tree planting is a relatively cheap way of improving the amenity and character of an area. Trees provide shade. They soften the line of the road and infrastructure, and create light and shade.*' E2

The economic, environmental and human benefits of street trees are well recognised by tree managers, however the benefit most emphasised is their mainly visual role in creating character and amenity in urban streets and suburbs. Street trees provide amenity, visual character and streetscape appeal. In established urban areas, the presence of matures street trees make certain streets and suburbs more desirable places to live, and their benefits are often reflected in higher real estate values. In such areas there may be strong local resident support for retaining existing trees.

> '*When a person drives down the street, the biggest impact is the tree. And the leafiest suburbs, that's why the value of the houses are higher than elsewhere, because it's usually the leafy streets, or leafy suburbs.*' O1

In developing outer suburban areas street tree planting also plays a significant role in creating local character and identity.

There is a long list of environmental benefits including impacts on urban climate, air quality and stormwater management. However the most frequently mentioned factor is shade, with its multiple benefits for pedestrians, vehicles, and the urban heat island effect. According to one participant:

"Number one is shade, and obviously you can go on about that forever.' O5

The ecological benefits of street trees are less emphasised and depend more on location, being of greater significance as biodiversity corridors in outer urban areas. Perceived economic benefits relate mainly to property values. There is an awareness of the relationship between urban greening and human well-being, however this is less tangible and more difficult to communicate to the public than the more obvious visual benefits. In the words of one participant:

'*The most important benefit, they maintain quality of life and community. A lot of people don't see that.*' E4

Street tree issues

Question: What do you see as the main issues or problems associated with street trees?

Table 4: Perceived street tree issues.

Issue categories	
Physical	
Urban development	Urban infill
	New subdivision
Lack of space	Verge widths
	Authority constraints
Infrastructure	Conflicts
	Hardscape-damage, liability
	Services-conflicts, ETSA pruning
Water	Restrictions-drought, climate change
	Loss of alternative sources
	Mature trees
Tree species	Past decisions
	Selection criteria
Human	
Resident attitudes	Nuisance-ageing population
	Property damage-liability
	Vandalism, removal
Organisational	
Attitudes	Engineers, planners etc.
Source: compiled from participant interviews.	

'*The other problem I have, this will sound strange, is the residents. Residents like trees, but they seem to have a passion for disliking the tree that's in front of their house. Because things drop leaves you see. And every tree has got problem, or a fault, or a branch that's fallen, or something like that. And it always seems to be the tree in front of their house, never the neighbour's tree. And trying to keep them happy.*' E7

There are a number of street tree issues that must be dealt with by urban tree managers. The major issue emphasised is the human dimension of negative community attitudes to street trees. Residents are thought to be less tolerant of nuisance factors, especially leaf litter, and this can be linked to the ageing of the population, with older residents less tolerant of 'mess', and their ability to deal with it. Related factors include perceived property damage and associated liability issues.

'*If you look at the complaints coming through the city here, it's that older generation that are house proud, and tidying up the trees mess has got beyond them*' O4

Other key issues include tree-infrastructure conflicts, especially with hardscape and underground services, exacerbated in areas with narrow verges and constraints on space. According to one inner suburban participant:

'*Probably the main area is the conflicts with infrastructure. We're very tight, we're inner suburban, we're dealing with narrow footpaths in the context of people who want a canopy tree. And it's not always possible*' E6

And an outer suburban Council noted:

> '*The lack of physical space to plant trees, particularly in the verges is probably the biggest issue.*' O2

ETSA pruning practices are a major concern, especially in bushfire prone areas.

> '*ETSA are a problem and they have always been a problem. Their disregard of correct pruning techniques, hiding behind the claim they must provide power to customers, at the expense of street trees, is false and irresponsible.*' W5

Water availability is also an issue, in terms of the impacts of water restrictions, drought and climate change.

> '*I've found the biggest strain with the tree network, over the last 8 years, has been the climatic conditions. It's had a hell of an impact on streetscapes.*' W6

Water restrictions have impacted on mature trees as well as tree establishment practices, seen partly as a consequence of past inappropriate (but unforeseen) species selection. A particular concern for street trees has been the loss of a supplementary water source from suburban front gardens.

> '*People used to water nature strips, and the grass areas their side of the fence. I think that moisture in a lot of instances got to the trees. Well that's been excluded from the equation and the trees are suffering.*' W6

Constraints on street tree planting

Question: What do you see as the main constraints to successful street tree planting and establishment?

Table 5: Perceived constraints on street tree planting.

Constraint categories	
Physical	
Local conditions	Climate, soils etc.
	Character, urban form
Lack of space	Verge widths
	Authority constraints
Water	Restrictions-drought, climate change
	Species choice
Organisational	
Attitudes	Engineers, planners
Resources	Funding-budgets, best practices
	Staff-levels, training
Source: compiled from participant interviews.	

Different Councils experience different constraints depending on locational factors such as physical setting (soils, climate, coastal etc.) or local urban character. However, according to one participant the main constraint comprises:

> '*Resources, and knowledge, and standards.*' O6

Some of the main constraints on street tree planting relate to internal organisational factors, in terms of internal resourcing. However staffing resources are seen as more of an issue than funding and budgets.

> '*Internal resources. Just the maintenance requirements. We are trying to play catch up to understand what we have out there and need to maintain and look after, and therefore in the future replace or plan for replacement.*' W3

Staffing issues include staffing levels (especially for establishment and maintenance), staff skills and knowledge, and the adherence to appropriate standards and specifications.

'*Most people planting a tree have some idea, but best practices are not always followed.* ' O6

Some participants expressed a preference to cut back on the number of trees planted in order to more successfully manage the existing tree stock.

Another perceived constraint comprises water restrictions associated with drought and climate change.

'*The obvious one is water.*' E1

An increasing lack of space for tree planting is also a constraint, due to narrowing verge widths and the constraints imposed by various authorities.
'*The lack of space in verges for planting is a particular problem.*' O2

And according to one Council:

'*The trees don't have a chance-if we follow the letter of the law. Which we obviously don't, because if we did the tree wouldn't exist.*' E7

Future threats to street trees

Question: What do you see as the main threats to the future of street trees in urban areas?

Table 6: Perceived threats to future street tree planting.

Threat categories	
Physical	
Urban development	General-space, hard surfaces
Urban infill	Street tree loss
	Driveways, services, reduced frontages
	Planning process
	Urban greening implications
New subdivisions	Verge widths
	Tree damage
Water	Restrictions-drought, climate change
	Mature trees
	Species selection
Human	
Resident attitudes	Nuisance, damage, vandalism
Organisational	
Planning and management	Priorities, funding etc.
Source: compiled from participant interviews.	

Two major factors were identified as future threats to urban street tree planting: water restrictions and urban development.

'*Probably the biggest threat as I see it is the water restriction issue. Finding supplementary water for trees.*' E6

Water restrictions, as a consequence of drought or climate change, and loss of supplementary water sources for street trees, are seen as a current and future threat to both new tree plantings and to established mature trees. Future climatic change is also seen as impacting on species selection.

'*And the climatic conditions you have to take into account. The selection of trees to install is quite limited if the future trends are taken into account.*' O4

The effects of climate change could also be more widespread.

'*Increase in global temperatures - we've seen the effects of that already. If that is going to continue it will be even more difficult to establish our urban forest.*' W5

The other main threat is seen as the nature of urban development: infill development in established inner urban areas, and new land division in the outer developing suburbs.

'*Infill is probably going to be the biggest threat.*' O1

Urban infill (or consolidation) is characterised by 'two for one' subdivision of existing allotments, reducing private tree cover, but also impacting on street trees. More and wider crossovers, additional service connections and reduced frontages result in the loss of existing trees, and a reduction in opportunities for future street tree planting.

> ' *I find the amount of development is increasing, and so we are dealing with street trees being lost, and also limiting the number of trees in front of properties as they are being subdivided. And peoples preference for double driveways or crossovers, 6m crossovers.*' W1

Issues associated with urban infill are seen as a consequence of the planning approval process in which individual street trees are lost, without consideration of their role and value in contributing to the wider urban forest, and pressures for increased rate revenue in Councils.

> '*I think there is an issue with the subdivision of blocks. There's no doubt about it, it's usually the tree that will suffer in something like this. That to me would be the number one issue for street trees. They are under pressure to get that through planning. It's more rates.*' W4

The wider implications of this urban infill process were also raised. Urban infill leads to smaller allotments, with less private open space, and less vegetation and tree cover. This will place more pressure on Councils for the provision of open space and urban greening in the public realm, including streets. But at the same time, existing street trees are being threatened, and it is becoming increasingly difficult to plant large trees in streets. The problem is exacerbated by an un-coordinated approach to urban consolidation that fails to provide additional public greening to compensate for the loss of private greening. Instead urban infill occurs in an incremental fashion which does not consider the cumulative effects of individual decisions on the urban forest. For urban densification needs to occur it should be accompanied by a coordinated program of urban greening.

> '*And it's part of the government's 20/20 strategy to increase population through urban infill. So we've got that conflict coming in and we're trying to say, with the street tree, and they want big leafy green streets, how do you do that when you've got urban infill and you've got narrow footpaths.*' W2

One participant summed up the situation as:

> '*Space and population: as the population becomes more dense we need more greenery for those benefits. But as the population gets more dense there's more pressure on space, more difficult to grow trees.*' E4

In the developing outer urban areas the main threat is seen in the design and construction of new subdivisions. In these areas streetscape design and street tree planting are often undertaken by the developer rather than the Council. Developers are seen as being driven primarily by economic forces and may seek smaller allotments and reduced road widths to increase lot yields.

> '*With increasing urban development comes small blocks with narrow verges to get maximum block yield for the developers.*' O2

Often the verge width will suffer under these pressures, with the needs of trees being given a low priority. This can result in reduced opportunities for tree planting, especially planting of larger tree species. Trees must also compete with the other services being squeezed into the available verge space.

> '*And the width of the verge itself has reduced. The road space now is seen as being a minimal thing. Developers try to maximise the size of the lots and squash the road and try and condense everything into a smaller footprint. Then trying to install the required range of infrastructure, from a developer's point of view, or from a provision point of view, stormwater, power, sewer, electricity, everything else, in a new subdivision tends to be underground, as*

well as a footpath on top of the ground. It doesn't leave much opportunity in a verge width of approximately 2m, and that's it.' O4

Instances were also cited in which developers have prepared initial concepts which include extensive tree planting, but the trees and original intention become lost in compromises in the long and drawn out development process, where competing demands for space or budgets result in reduced provision for trees.

'*Not just in Council, within the development industry too, trees are seen as a necessary evil in some instances. A cost for developers. You need to watch out you don't get them trying to cut costs at that end. Trees are still the afterthought, they're not front of mind.*' O6

A related issue in new subdivisions involves damage to trees after installation. Developers often plant street trees at the same time as other street infrastructure is installed, to assist in the marketing of allotments. However, during the subsequent housing construction process trees are damaged, with builders and contractors using the verge as a de-facto work site.

'*I believe the trouble often is that street trees are installed just after the road and civil works is completed, and before the houses are even finished, so they tend to get trashed during construction.*' O2

And:

'*The contractors see the verge as theirs, and if there is a tree in the road, then it's not big so it doesn't matter.*' O4

Some Council's are interested in pursuing a tree bonding option, subject to legal approval.

Most viable practices

Question: What practices do you consider to be most viable to grow healthier trees in urban streets, or to reduce tree/infrastructure conflicts?

Table 7: Perceived best practices

Best practice categories	
General	Combination of things
	Getting the basics right
Planning and design practices	
Streetscape design	Increased space
	Opportunities-narrower roads, wider verges
	Long term costs-benefits
Tree pits	Increased rooting space
	Best arboricultural. practices-soil, mulch etc.
	Technical-trenching, root directors, guards etc.
Infrastructure	Priorities to trees
	ABC, CST
Water management	Mulching, additives, water-wells etc.
WSUD	Stormwater harvesting
	Permeable paving
	Subdivision design
Species selection	Matching tree and site
	Selection criteria
Planting & establishment practices	
Tree stock	Quality
	Size
Aftercare	Establishment
	Watering regime
	Formative pruning
Source: compiled from participant interviews.	

To many Council's there is no single best practice, but rather a combination of many factors, which:

'*Would involve the accommodation of a lot of things.*' W3

To others it is mainly a focus on getting the basics right, in terms of tree planting and establishment practices, rather than elaborate technical solutions.

'*So just doing the right planting.*' E3

Many Council's therefore focus on best practices in terms of tree stock selection, planting practices and aftercare. Improving the quality of planting stock is seen as requiring a more critical approach to what is accepted, and building long term relationships with growers and suppliers.

'*Selection, first and foremost. That's where we are falling down at the moment. I'm saying to blokes, don't just take delivery, go and pick them up, go and have a good look.*' E7

Aftercare is also considered critical.

'*Again planting I think can make a lot of gains just in getting the right process. It's like children- the first formative years are important. You get it right and from then on the tree will be a good tree.*' E7

The two key aftercare concerns are water management and formative pruning:

'*And again a proper maintenance regime particularly with water requirements.*' O3

'*Formative pruning's the other one. Just getting it right for the early stage. That early, timely formative pruning will save you dollars down the track.*' E7

In terms of design practices, the major concern is to provide trees with more space in the design of the street. There is a need to provide realistic space based on the future size of the tree to minimise future conflicts.

'*We try and give the tree as much room as we can. That's the key. Not trying to put a square peg in a round hole.*' E3

Particular attention needs to be given to the provision of adequate space around the base of the tree.

'*The ideal would be to create more growing space around the trunk.*' E6

One option with potential is the creation of wider verges by narrowing traffic lane widths.

'*I think, narrower streets with wider verges.*' E7

Trees should also be afforded equal priority with other street infrastructure in the planning process.

'*As long as they give us the space to grow trees. It's the trouble we seem to have, when you put your sewer, gas, electricity and everything else in. There should be an ideal design where they can put all that stuff out in the road, and give us room to plant our trees. They should plant the tree first and then put everything else around it somehow.*' O1

Allocating more space is also seen as an investment in terms of reducing long term costs.

'*Recognition that if you plant a tree you get a certain level of management, maintenance costs associated with it. But if you can't get a tree in there and give it enough room, you will get issues with it.* ' E2

Provision of adequate space also extends below ground, in terms of providing adequate root volumes, appropriate soil preparation and using best arboricultural planting practices. Mulching and the use of additives such as Terra-cottem are also mentioned. Technologies such as root directors, structural soils and tree guards can also play a role in more confined urban settings.

'*For me it would be the below ground space, opportunities. You can consider everything at surface level. But it's that whole below ground infrastructure you have to look at. The tree needs to establish a root network to support itself structurally, but also health wise. If we can try and provide something in that sense to develop a root base that is healthy, the tree will survive and cause less impacts into its environment, where the built form doesn't give much space for tree installations.*' O4

There is also a high level of interest in the possible application of Water Sensitive Urban Design (WSUD) techniques, particularly the use of practices which can provide trees with additional water sources in the face of the stresses imposed by water restrictions, drought and climate change. Two approaches of interest are stormwater harvesting and the use of permeable paving. Techniques need to be developed to divert road runoff to tree pits.

'*Ideally get all that water running off roads and doing something more productive and efficient is essential.*' W5

More extensive use of permeable paving can also dramatically increase infiltration into the sub-soil.

'*Ideally - have a surface that is permeable so that more water is absorbed by the tree stock.*' W2

Factors preventing the adoption of best practices

Question: What factors do you consider may prevent or limit the adoption of these practices?

Table 8: Perceived factors preventing adoption of best practices.

Limiting factor categories	
Organisational	
Resources	
Lack of funding	Budgets
	Costs- of maintenance, best practices
	But will still plant trees
Staff	Skills
	Turnover
Knowledge	
Lack of knowledge	Knowledge of best practices
	Knowledge of engineers etc.
Lack of awareness of benefits	Strategic level, elected members
	Engineers, planners
	Asset managers
	Community
Management practices	Priorities
	Change resistance
	Lack of forward planning
Externalities	Role of developers
	Role of service authorities
	Future liability
Source: compiled from participant interviews.	

According to one inner suburban Council:

'*I think it's a testing time over the next 5-10 years for the urban forest* ' E6

The main obstacles to the adoption of best practices are seen as relating to internal Council organisation. The two key factors identified were: a lack of resources to implement best practices; and a lack of knowledge and awareness by others who may influence the tree planting process. Council resource issues cover two broad areas: funding resources and staff resources. Funding includes consideration of costs, budgets, maintenance and the cost of implementing improved practices. However cost is not always seen as a factor which would realistically prevent future tree planting.

'*At the end of the day, it would probably go down to costing. Cost is always a factor. But I don't think it's going to limit us.* ' E3

And:

'*Money? It's not that - if the organisation thinks it is important it will find the money, move it from other budget areas.*' E2

Staff issues are considered significant, including a lack of adequate training, staff turnover, continuity and the role of contractors.

'*I've tried training at the depot. It's a cultural thing as is often the case these days. It's a matter of getting to them to actually understand.*' E7

'*It's difficult because the minute you get someone on the right track they leave. It's a never ending battle.*' E7

To many tree managers, lack of education and knowledge by others is seen as the key obstacle to improved practices. This includes the need to educate other professions, such as engineers and planners, about basic tree requirements.

'*And educate the engineers too about how they can modify a few areas of their design to accommodate your design. And here they are open to different ideas.*' E1

And also awareness of what does constitute latest 'best practices' particularly through sharing of knowledge between Councils.

'*How it all works: are there other Councils undertaking these practices that you can get information from?*' E1

Another key factor is the widespread lack of education regarding the benefits delivered by street trees. This includes at the strategic level of directors and elected members, and at the operational level of planners, engineers, and asset managers.

'*Education …Information needs to be consistent and directed at the engineers and managers together with our elected members. If you have them on board you have a better understanding and a more sympathetic ear.*' W5

Education of street tree benefits also needs to be directed to the wider community, to offset perceived negative attitudes to trees. One suggested answer is the use of demonstration projects.

'*Maybe the answer is committing to one particular project and showing that as an example, you set the trend from that point on. It never ceases to amaze me how people have differing views on trees.*' E7

Other limiting factors relate to Council organisation and priorities:

'*From a Council perspective, only ourselves prevent or limit the adoption of the practices.*' E5

Obstacles include engineering driven priorities in which trees are an afterthought, a dominant civil design culture, lack of flexibility and an asset management focus.

'*People treating trees as an afterthought and not getting any professional advice on how to do it properly.*' O6

'*We are like most Councils: the priority has been on the engineering focus. Trying to flip that around: it's the big challenge that we face.*' E6

'*There's a huge push in local government for asset management plans at present. That's about maintaining your assets. It's fundamentally hard infrastructure related. I'm not sure trees even have to be looked at as part of the asset management plan. So there you are almost*

> *going against what the arborists and horticulturists want, which is that priority given to trees.* ' E6

A related issue includes organisational resistance to change.

> '*Conservative nature of local government-in terms of what ifs and finances. Legitimate concerns, need data.*' E4

To some, street tree requirements need to be mandatory (as is the case for other types of infrastructure), rather than merely optional.

> '*It's got to be mandatory - in the specifications.*' O6

Finally there are also some other limiting factors outside of the Council organisation which are less directly managed. One of these is the role of service authorities.

> '*However we always seem to fight with the service suppliers, the Origin's, ETSA's, Telstra's, the kerb and gutter guy.*' *That sort of thing that can undo so much good work.*' E5

Another externality is that of dealing with developers whose main focus may be on costs.

> '*I think cost is often the biggest one. The lot yield of areas by developers who want to maximise their yield. Because they are responsible for putting in the infrastructure, there's a huge cost of developing land. So that's the biggest issue, the financials.*' O2

Conclusions

Street trees are seen as providing the city with a wide range of environmental benefits, especially shade. However, from the point of view of residents, the most obvious benefits are visual, in terms of creating attractive and appealing streets and suburbs. On the other hand, street trees can be associated with a number of problems, especially negative community attitudes to 'mess' and related issues, especially amongst the ageing population. Street trees are also involved in conflicts with urban infrastructure, both hardscape and services, both above and below ground (notably with electricity service providers).

A key constraint on street tree planting relates to Council resources, not just funding, but importantly human resources. Some Council's cite a need to cut back on planting levels to focus on more effective management of their existing tree stock. Lack of space in urban streets, both above and below ground, is also a constraint, with narrower verges and competition for space with a range of other authorities. Water restrictions, as a consequence of drought or climate change, are also a constraint on tree planting and on the survival of mature trees. Lack of water is also seen as a potential threat to the future of the urban forest. The other main threat is urban development itself, both urban infill and new subdivisions. Infill development results in loss of existing trees and loss of opportunities for future street tree planting. In new subdivisions there may be a reduction in space available for street tree planting, especially larger trees, and damage to trees planted at the same time that other street infrastructure is installed. A more coordinated approach is required to ensure that urban greening occurs alongside urban densification.

Best practices which should be adopted would include a combination of many factors, rather than one 'silver bullet', as well as the need to 'get the basics right'. Better planting and establishment practices include the selection of better quality tree stock, and appropriate aftercare including watering regimes and formative pruning. Urban streets also need to be designed to provide more space for trees. And trees should be given at least equal priority to other forms of street infrastructure. Considerable scope is also seen for the more widespread adoption of WSUD practices, especially the diversion of urban stormwater to street tree pits, and increased use of permeable paving. Many of the factors which may limit or prevent the adoption of these practices are seen as being part of internal Council organisation, in two key areas: resources and knowledge. Funding is a constraint, but few Council's envisage that lack of funding would limit or prevent future tree planting, if trees remain a priority with the community. Lack of knowledge by others is a key factor, both of the requirements of trees, and the benefits they deliver. This includes elected members, staff such as engineers, planners and asset managers, and the wider community.

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ARE WE THERE YET?
LEARNING FROM THE PAST: LESSONS FOR THE FUTURE

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Summary
The City of Sydney (the City) has undergone a massive change in its awareness, understanding and appreciation of trees within the past 10 years. Numerous tree management policies have been written, adopted and executed.

Now we have to keep the momentum going. With the adopted policies and thousands of trees planted, is Sydney there yet? Will we ever get there? And where is there?

This paper discusses the City's evolution over the past 10 years, with expanding boundaries, growing tree population and increased community awareness about the importance of trees in our urban environments. It will also briefly cover the future vision of tree management in the City, and the integral role of the urban forest in the City's 2030 Sustainable Sydney strategy.

The City
The City has a high profile due to its geographic location, the presence of icons such as the Harbour Bridge and Opera House makes it a major tourist destination, and the central business district houses many Australian and international financial, legal and other prominent businesses. Apart from its commercial core, the City also has a significant residential component.

The City's Local Government Area (LGA) covers approximately 26 square kilometres. Stretching from the harbour side suburbs of The Rocks, Barangaroo, Pyrmont, Woolloomooloo and Rushcutters Bay, through the Central Business District (CBD) and inner City suburbs of Surry Hills, Kings Cross, Darlinghurst, Chippendale, Redfern, Glebe, Newtown and to our southern residential and industrial areas of Alexandria and Rosebery.

Within the boundaries of the City of Sydney, waterways and some public areas are under the executive control of various State Government agencies. These include the Sydney Harbour Foreshore Authority, the Department of Transport, Sydney Ports Corporation, the Centennial and Moore Park Trust, and the Royal Botanic Gardens and Domain Trust.

The City provides numerous services to a wide range of clients, including residents, businesses and visitors, whilst managing an enormous portfolio of assets that vary in size, value and scope.
The City is responsible for the management of 42,000 public trees in its parks and streets and tens of thousands more on private property and in the grounds of institutions such as universities and schools. These are the major component of the City's green assets.

The Timeline
Ten years ago Sydney was preparing for the 2000 Olympics. Sydney was used to throwing a large one night New Years Eve party, but now had to deliver a two week party on the world stage. The preparation for the Olympics resulted in a huge capital works and maintenance program. Roads, footpaths, parks and tree planting works were rolled out on a large scale.

In 1999, the City of Sydney was a much smaller local government area than it is today. It comprised only of the CBD and the Pyrmont and Ultimo areas, and a tree population of 9,000 street and park trees. The trees were managed by contracted external service providers, and works were largely programmed.

During 2003 and 2004, the City underwent a massive transformation in size and focus, with the amalgamations with South Sydney Council and a portion of Leichhardt Council. Once predominately business focused; the City now encompassed large resident areas, and had to (and still is) operating under three different LEPs, numerous DCP's and the transition of staff and services.

In relation to tree management, the City went from having no tree management team and old policies, to a team of six staff, each of whom holds a Diploma of Arboriculture (AQF 5). This led to the development and adoption of numerous policies and management plans for our 19th century parks, and saw over 6,000 advanced street trees planted since 2004.

The provision of tree maintenance services was also reviewed and high quality specifications were developed to ensure the City's trees are managed in a programmed way and to best practice principles. This led to the City's street trees, and half of the park trees, being maintained by external service providers (ie. contracted).

Our service providers must employ AQF Level 2 and 3 staff for certain works, (except trainees) and 95% of our internal tree maintenance team also hold a minimum AQF Level 2 – with many planning to progress through to AQF 3, and one completing the Diploma of Arboriculture (AQF 5). The continued upgrading of arboricultural qualifications is imperative.

Within a 10 year period, the City local government area has almost tripled, and the tree population has increased ten fold. Human resources and financial budgets have been increased to manage this change, and to ensure that the City undertakes best practice tree management.

In addition, the growing awareness and attitudes across Council about the importance of trees – from the roadway and footpath crews, through to the planners, has steadily increased and improved. This improvement has come from both the 'top down', through the Lord Mayor and Councillors, and the CEO, and also from the 'bottom up' as more individuals are aware of and understand climate change.

The table below highlights the City's evolution and existing tree management practises.

Table 1 - Tree Management Timeline

	1999	**2003**	**2004**	**2009**
Area of LGA	9km^2	15km^2 Amalgamation with South Sydney & parts of Leichhardt Council	26 km^2 Amalgamation with remaining 100% of South Sydney Council	26km^2
Tree Population **Street** **Park** **Private (est)**	7,500 1,300 4,000	13,000 4,500 40,000	22,500 11,000 80,000	28,500 11,400 80,000
Tree Maintenance Budget	$450,000	$1.1m	$2.2m	$3.6m
Capital Works Budget (tree planting)	$1m	$500k	$1m -$2m pa	$500,000
Service Provision	100% contract	100% contract	50% contract 50% internal	100% street trees under contract 50/50% park trees contract / internal
Style of Service Provision	Young Trees Programmed Mature Trees Reactive	CBD 100% Programmed New areas 100% reactive	2004 - Transition of all contracted works to 100% programmed 80% internal works reactive	100% programmed

Policies (in existence or developed)	1976 Tree Preservation Order (TPO)	1976 TPO Draft Street Tree Masterplan (STMP)	2004 TPO (adopted) Draft STMP Draft Urban Tree M'ment Policy (UTMP)	2004 TPO 2005 STMP (adopted) 2005 UTMP (adopted) 2006 Register of Significant Trees (adopted) Hyde Park Tree Management Plan (TMP) Redfern Park TMP Observatory Hill TMP Draft Victoria Park TMP Draft Wentworth Park TMP
	1999	**2003**	**2004**	**2009**
Tree Management Team	None – works were undertaken by parks maintenance	1 x Street Tree Contract Coordinator	1 x City Arborist 1 x Tree Management Coordinator 1 x Street Tree Coordinator 2 x Tree Management Officer	1 x City Arborist 1 x Tree Management Coordinator 2 x Street Tree Coordinators 2 x Tree Management Officers
Politics	Labour	Labour	Independent (since early 2004)	Independent

Improved Maintenance Specifications

The shift from reactive to programmed works has greatly changed the management of our trees, their health, structure and longevity, and has certainly reduced the numbers of customer requests received.

The reduction of customer service requests (CSM) are shown in the graphs below. Note the first graph shows the 'East and West' areas of the City, the areas that were transferred in 2004, and the steady decline in customer requests. 2004/05 year figures would spike as the transition to programmed works focused on main streets, streets with high numbers of requests, aged trees etc. Note that the 2005 figures do not include requests received via email – and so would sit higher than 06/07.

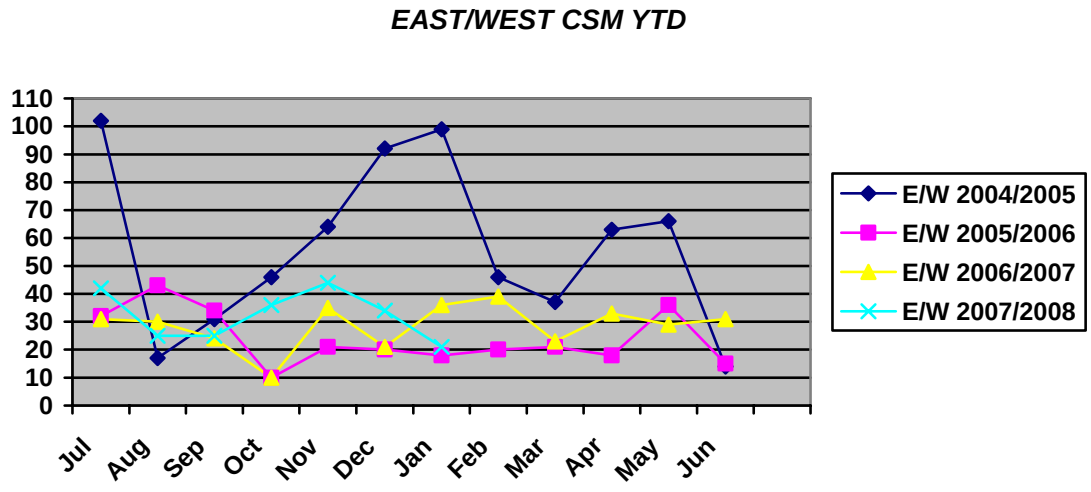

Figure 1. Number of customer requests received from 2004 to 2008.
Source: Citywide Monthly Report, January 2008

Following the decision to contract all street tree maintenance works in December 2007, all street trees are now maintained on a programmed basis. Each tree is assessed annually, logged into an electronic database, and works performed as required.
The following graph highlights the steady decline in customer requests as a result of the programmed pruning. Note transition of reactive services requests from internal team to contractors occurred through March and April 2008 – hence the steady increase of numbers.

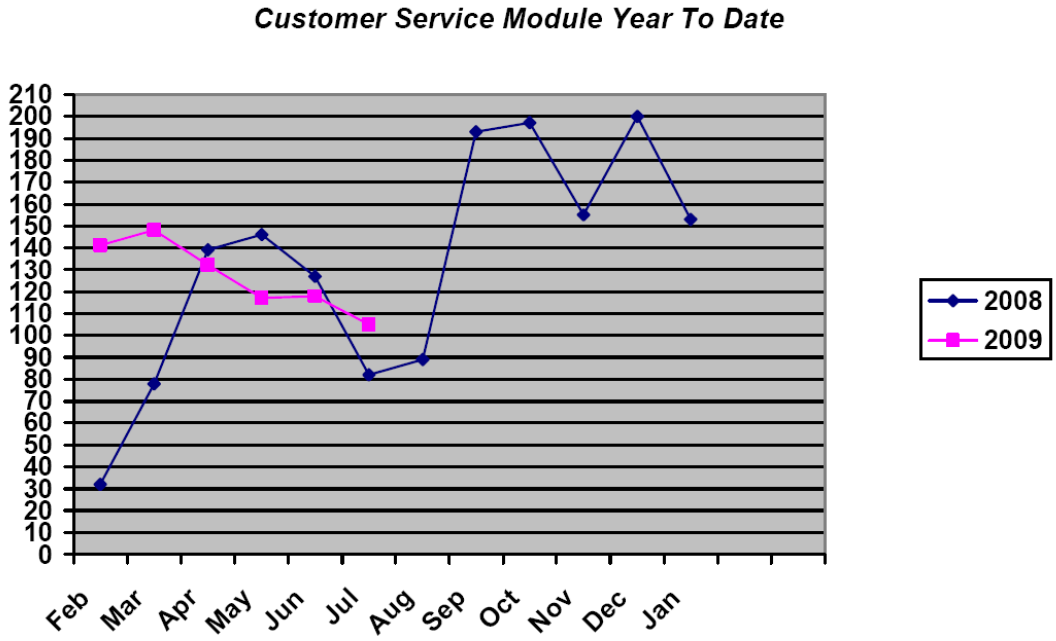

Figure 2. Number of customer requests received from Feb 2008 to July 2009.
Source: Citywide Monthly Report, July 2009

The first year of programmed works is similar to a critical works package, where the main safety issues are targeted (footpath, road & house clearances, defects, deadwood) coupled with the formative pruning of young trees.

The second year requires all clearances to be achieved, defects removed/addressed and formative pruning to have commenced on all trees. The works are staged to limit a mass amount of tree pruning undertaken within the first or second year.

As the community understands that Council will undertake regular maintenance, the complaints regarding trees have dropped significantly. It is expected that as each year progresses, customer requests will continue to drop until an estimated plateau of 50 requests per month. With the trees' details recorded into the electronic tree database, it is easier to manage a customer, and their complaint, when it occurs.

The electronic database will also allow improved data analysis and statistical modelling for managing the existing and planned future tree population. This may include detailed species profile in relation to maintenance timeframes and costs of managing particular tree species (ie native compared to exotic).

The Future

'Sustainable Sydney 2030 - Green, Global and Connected' is the City's vision. This vision, now policy, responds to the current challenges (eg. global warming, declining affordable housing), by detailing the moves and actions required to transform the City into becoming:

- Green – an environmental leader, successful sustainable community
- Global – an innovative City , creatively growing a sustainable global community
- Connected – moving easily between villages to connect with each other and the world

The 'SS2030' strategy demonstrates that the City is an organisation that constantly focuses on sustainable practices that continue to service the community, while protecting the interest of the natural environment and while remaining fiscally responsible.

Greening Sydney

The future of tree management will soon be captured within a wide range of policies, strategies and actions. The City is due to commence the development of a Greening Sydney strategy that aligns with 'SS2030'. This includes the following draft actions that the City will undertake itself, coupled with actively empowering the community to be involved in the greening of their City.

While some of the components listed below are already being implemented or undertaken on a daily basis, there are also significant policies proposed for development. It is envisaged that the Greening Sydney strategy will provide a systematic framework for the management of all green infrastructure across the local government area.

The Greening Sydney strategy proposes to include the following key policies, strategies and actions:

Urban Forestry Policy

- Measure the City's urban canopy
- Develop Urban Forestry Policy
- Set 2030 targets to increase canopy

Tree Protection

- Strengthen tree protection through the inclusion of canopy coverage targets set in a City Plan DCP
- Review Significant Tree Register

Street Tree Planting

- Review Street Tree Master Plan (which specifies each streets species for planting)
- Plant in all available footpath locations
- Build road blisters and plant trees into roads and lanes, and implement water sensitive urban design (WSUD) opportunities

Greening Sydney's arterial transport and utility corridors

- Landscaping of rail corridors, arterial roads, utility corridors and redundant road reserves

Greening new development

- Develop a Green Roofs Policy and
- Develop a Landscape Policy for inclusion within City Plan DCP

Summary

The City has proven it has sustained its focus, momentum and commitment to best practise tree management.

Is Sydney there yet? And where is there?
We are certainly well on our way. To give an analogy of the family holiday – the City is driving an eco car, driven collectively by our Council, Executive and expert staff. We are towing a caravan behind us, filled with a demanding community, State and Federal Governments, climate change sceptics, and fat possums, on our way to the ultimate holiday destination called the 'Continued Improvement of the Urban Forest.'

Will we ever get there?
As we are managing a living organism, whose life cycle changes and evolves: so too does our management of trees. Ten years ago the City never expected to undergo such a rapid transformation; however it has managed the transition process exceptionally well. The Greening Sydney plan will progress the holistic management of the urban forest, and like the never ending family holiday car trip, will always be on our way.

Acknowledgements
I would like to thank the City's excellent tree management team (past and present), who work tirelessly in a complex, sensitive and demanding environment. Their hard work and commitment has led to the City's position as the benchmark in NSW, and an industry leader within Australia, for the development and implementation of tree management policies that make a daily difference to residents and visitors in the City of Sydney.

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CAN STREET TREES SURVIVE DROUGHT? THE ANSWER LIES IN THE SOIL!

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Introduction
The recent run of drier then average years and dwindling urban water supplies have tree managers looking for strategies to maintain the health of their tree populations.

While the soil plays a role in tree drought tolerance, the answer to drought tolerance in part is also in the tree. Trees must basically match the climates they grow in. We are going to have to make some changes to our tree populations with time if, as climate change predictions suggest, the last 12 years is a foretaste of what is to come. I am not saying that we require totally new tree populations; but we will need populations with different compositions that we currently maintain.

Having said that, can we do anything to improve our trees' access to water? In the discussion below I am not going to address irrigation practices for trees. I am assuming that in an ideal world street trees do not require irrigation for survival. You can debate that proposition as you wish. I am also going to be thinking aloud to some extent as there are no correct solutions available. Rather there are a number of approaches we could take and we are going to have to a bit of trial and error work to find the best approaches for us in our various locations.

The basics state that a tree's water reserve is a function of climate and soil water reservoir size. If unconfined, a tree will grow its root system to its genetic limits. The volume of soil it accesses is the spread (width) by the depth of the roots. As we know the spread will be 2-3 times the spread of the canopy and the depth will be up to 8-10m. The tree doesn't access water equally from all that volume though. Deep roots in particular can be less dense but presumably make some contribution to water supply. Geoff Connellan's work with City of Melbourne showed elms using water from 1m deep (the limit of the study).

Methods for calculating root volumes for trees vary. Two commonly used ones are Jim Urban's linear model of tree size and root volume and Patricia Lindsey and Nina Bassuk's model based on tree canopy area and climate variables.

The urban situation

In cities, tree roots are often constrained in size. This can result in stress but our understanding of what is actually going on under our streets is very poor (inherent difficulty of studying root distribution) and we all know trees that we can't explain the performance of. They obviously have access to water supplies that we can't explain. Leaking pipes and unpredictable patterns of root breakout are usually the explanations.

To get the best for trees we should be aiming to maximise soil volumes available for root growth.

Beyond the tree pit-strategies for increasing root volumes

1. Lateral root channels: Jim Urban and Ed Gilman have both shown illustrations of lateral trenches under paving being used to direct tree roots out of the planting pit and into the surrounding soil.

2. Vertical root channels: published data shows tree roots can be found many metres deep. We often assume that deep roots are not important but in our climate we should at least think about this. Gary Watson wonders about the effect of production systems of tap root and plunger root development. Are our trees limited by poor soil conditions that limit vertical root growth? Why not bore holes at the base of tree pouts to allow vertical root exploration? It needs no more than the loose material to be replaced without compaction. Gypsum could be added is the excavated material is dispersive.

3. Engineered soils under paving

3.1 Suspended paving systems (vaults) allow soil to be excavated, replaced, cultivated and modified to encourage tree root growth. The modified soil is protected from compaction because the paving is not supported by the soil (we assume that the site is well managed so that the soil is not compacted before the paving is put in place).

3.2 The Silva Cell ® system can be seen as a version of this approach where the soil is not required to support the paving because of the internal support provided by the plastic cells that make up this approach.

3.2 The other approaches use soil that can be compacted to support paving and still have functionality for water and air movement and root penetration. These are either coarse sand or the bimodal (structural) soils that were refined by Nina Bassuk's group at Cornell University.

All these systems have pros and cons. They are all more expensive than just digging a tree pit. They have different capacity to retain water and nutrients. Each has its adherents and advocates. When comparing the claims made for each system, remember to compare apples with apples.

There are now applications of all these systems that can be seen. The Potter Garden at The RBG Melbourne is a good demonstration of bimodal soil and how successfully it can provide for tree growth. Silva Cell has been used in many applications in the USA and Canada. I am not aware of any Australian applications, but have no doubt they do exist.

Exploiting runoff and storm water for trees

Paving obviously intercepts rainfall and diverts it from soil infiltration. As a consequence, the soil surface available for rainfall interception for an open-grown tree is often restricted for urban trees. Many tree managers are exploring options for recapturing this water and placing the tree and its soil between the surface and the storm water drain. There are two potential benefits of this. One is obviously increasing the amount of rainfall that is available for tree use. Remember though that these systems don't make it rain. In a long term drought the trees will not be getting any more water than if they weren't getting special treatment. The other benefit is pollutant scrubbing from runoff water (part of the WSUD model of development). This process is called biofiltration.

Design Options

1. No curbs

Water flows off the road onto the root zone. This increases the apparent rainfall over the root zone. It could be an informal treatment for a paved road or may be coupled with a grassed swale system. Issues are mostly maintenance ones in that wet soil is soft and if the site has poor infiltration rates mowing and other functions are hampered. This option is really only useful in low level developments and in areas that don't require vehicle access.

2. Storm water capture systems

These usually fit into conventionally curbed streets. The water is picked up and either dumped onto the surface of the root zone (either under a paved footpath (eg Bourke St., Docklands, Melbourne) or into a 'rain garden') or is piped around the tree under the paving. The latter approach is most feasible for retrofitted systems but I think there is still a considerable amount of work to be done designing and evaluating retrofitted systems. The main limits of this approach are the volume of the capture component, especially if the soil has low permeability. That is, the capture component fills quickly but can't accept any more water until infiltration has occurred. Some of my observations on soil properties in the section on permeable paving below also apply here. Long-term performance of these systems and issues such as litter and soil accumulation are yet to be resolved elegantly.

Enhanced soil surface protection

1. Mulch

In locations where surface strength is not required but enhanced permeability and/or protection from pedestrian traffic is required, a mulched surface may be the best solution. Mulches generally maintain or improve surface permeability and also protect from compaction pressures. The main issues are associated with maintenance of mulch integrity especially in high traffic areas.

The use of decomposed granite as a soil surface treatment around trees has become very common. While simple to specify and install, there are still questions about its performance. Testing that I have been involved in shows that granitic sand can have limited permeability to water and oxygen under

quite high levels of compaction but this will depend on the mix of coarse and fine particles in the mix. To my knowledge, no grading or classification of granitic sand is done at the quarry so supply is what is available on the day. The low water infiltration rate means that these surfaces will not be effective under high intensity rainfall or runoff conditions and thus water will not be absorbed and erosion can occur.

2. Permeable paving
There is now a great deal of information available for the construction of these systems. They are generally useful in areas of low traffic density (car parking areas, pedestrian zones, infrequent load zones eg emergency vehicle access). Choice of paving will be affected by many criteria. The best performance of these systems, both for capture of infiltration water and scrubbing of pollutants will occur where the soil under the paving has a moderate infiltration rate. If waterlogging is a risk the system requires drainage. If storm water scrubbing is required then the system must be drained.

A recent study by Justin Morgenroth at University of Canterbury (LBG 3) using *Platanus orientalis* shows enhanced tree growth under permeable concrete as compared with normal concrete. Soil moisture content and soil aeration were very similar under both paving types (wetter and less well-aerated than the unpaved control) but soil was better-aerated at depth under permeable concrete. This work reinforces the position that simply placing a permeable pavement on 'normal' soil may not enhance tree performance because of poor aeration. The use of better-drained soils may be important for getting the most from permeable paving.

A trail planting in Ithaca, New York has CU Structural Soil placed under porous asphalt in a car park. The porous asphalt covers the parking spots but not the traffic zones. Tree growth in cutouts is very strong (personal observation, October 2008). Similar approaches could use Silva Cell or compacted coarse sand or gravel.

Permeability of soil is easily tested but recommendations for performance criteria are more difficult. Current Victorian recommendations for bio-filtration systems have infiltration rates (saturated hydraulic conductivity) of 100-200mm per hour. This can only be achieved with quite sandy soils. There is anecdotal evidence of tree management problems in rain gardens built of such sandy material. While the bio-filter is only a small part of the trees total root volume, that issue is probably less critical, as long as soil conditions elsewhere allow root breakout.

Liz Denman has shown in her PhD work at Burnley that trees can grow in model bio-filtration systems. Tree growth was enhanced by the nutrients in synthetic stormwater and the presence of trees improved nutrient scrubbing. She found no real differences between the four tree species (*Platanus orientalis, Lophostemon confertus, Callistemon salignus* and *Eucalyptus polyanthemos*) that she evaluated, despite their quite different environmental adaptations. The best performance came from a soil with a drainage rate of 5mm/h which is much lower than current bio-filtration recommendations and is also lower than the limits set by AS 4419 (Soils for landscape and garden use). This work seems to suggest that where trees are to be used as part of bio-filtration schemes, specific soil requirements may exist that separate tree systems from other bio-filtration systems. Drainage rates in the range 20-50mm/h seem to me to be more useful for trees. Currently the role of trees is not being as carefully examined as other parts of these systems.

Trunk flow and water capture

Qingfu Xiao and Greg McPherson have published a modeling study that shows that leafy tree canopies can capture up to about 80% of a rainfall event. Some of this captured water is directed along the branches and down the trunk, with the remainder dripping to the ground or being lost as evaporation. Trunk flow is presumably a very important source of tree water in paved and compacted soils. Consideration must be given to soil conditions around the base of the tree trunk to ensure that as much of this trunk flow water as possible is captured and directed into the soil. Various mulches and gravels will assist in this. The use of tree grates will also be effective, but there are real concerns about their use. This issue deserves further consideration.

Conclusions

Meeting tree soil volume requirements in urban areas is difficult. There are interesting options available to help meet the multiple demands placed on soil but it is challenging to get serious attention to be paid to them. Perceived cost is often an issue and this usually occurs because no early budgetary allocations were made in the planning process. More successful examples will no doubt

help. Soil capture of runoff for street tree growth is also feasible but is still in its infancy. It would be nice to have the funding for some formal evaluation of these systems. It is highly likely that in Australia it is the practicing tree managers who will do the development and evaluation work that is needed to see if these approaches are, in fact, useful to us.

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Invitation to Institutional Membership 2010 (Associations)

Institutional Membership of TREENET is open to all not-for-profit organisations with an interest in urban trees.

Industry Associations are eligible for Institutional Membership (Associations) status, valid until **31st December 2010** for the annual investment of **$600** (Inc GST).

TREENET:
TREENET (Tree and Roadway Experimental and Educational Network) is the National Research and Education organisation for urban trees. It is a not for profit organisation based at the University of Adelaide's Waite Arboretum.

TREENET is advised by a National Board of over 50 voting members who have been selected for their expertise in relevant fields.

TREENET maintains a freely accessible website **www.treenet.org** with information on all aspects of urban trees and related technologies and products.

TREENET is the home of the Avenues of Honour 1915-2015 project, which is recognised nationally as a most significant urban forest initiative. **www.avenuesofhonour.org**

The Benefits:
Complimentary attendance, for one Elected Member, or other Honorary Position within your organisation at the **11th National Street Tree Symposium** at the National Wine Centre and the Waite Arboretum **2nd-3rd September 2010**

A 10% discount on the registration cost will apply to all financial members of your organisation attending the annual symposium.

A gratuity equal to 10% of the registration cost will be offered to your organisation for each paying member attending the annual symposium as a financial member of your organisation. .

A free copy of the Symposium proceedings will be mailed to your organisation after September 2010

Your organisation has the right to promote your membership of TREENET in all publications and media in the current financial year.

You will receive a certificate suitable for framing for public display acknowledging your membership.

Your organisation will be **listed as an Institutional Member at www.treenet.org with a direct link provided to your website**.

By supporting **TREENET** you are contributing to the efficient and effective management of our urban forests and helping to ensure the continuation of research programs of direct benefit to your organisation and to the wider community.

For further information contact:
David Lawry OAM
Director TREENET
Ph (08) 83037078
Mob 0418806803
david@treenet.com.au

Invitation to Institutional Membership 2010
(Government, Research, and Educational Organisations)

Institutional Membership is open to Local, State and Federal government bodies who have an interest in promoting research and education relating to urban trees, particularly those in the public domain. Individual membership is not offered. The cost is **$900 (**Inc GST) per calendar year, renewable each January.

TREENET:

TREENET is the National Research and Education organisation for urban arboriculture based at the University of Adelaide's Waite Arboretum.

TREENET maintains a freely accessible website www.treenet.org with up to date information on all aspects of urban trees, related technologies, products and services.

TREENET is the founding organisation responsible for the coordination, management, and promotion of **The Avenues of Honour 1915-2015 Project** www.avenuesofhonour.org

The Benefits of becoming an Institutional Member of TREENET:

Complimentary attendance, for one Elected Member, or other Honorary (unpaid) individual from your organisation at the **11th National Street Tree Symposium** at the National Wine Centre and the Waite Arboretum 2nd-3rd September 2010.

A 20% discount on the registration cost will apply to all paid staff of your organisation attending the Symposium or the Post Symposium tour. Some discounts relating to services and products provided by Sponsors may also apply.

Your organisation will be eligible to participate in TREENET trials. In association with Urrbrae TAFE and the Nursery Industry, TREENET is producing small numbers of trees for trialling in your neighbourhood that may be better adapted to the changing climatic conditions affected by global warming. These uncommon species are sourced from the Waite Arboretum and elsewhere and will be made available at cost exclusively to Institutional Members. In addition TREENET is producing the Gallipoli Rosemary for purchase at Institutional Members wholesale rates. Local Government IM's will have privileged access to emerging stormwater technology such as the TREENET kerb inlet.

Your organisation has the right to promote your Institutional Membership of TREENET in all publications and media in the current financial year.

Acknowledgement of your organisation's Institutional Membership status will be provided online with a direct link to your website. You will also receive a Certificate of Appreciation to promote your commitment to the urban forest and in particular the aims of **TREENET**.

By supporting **TREENET** you are contributing to the efficient and effective management of our urban forests and helping to ensure the continuation of research programs of direct benefit to your organisation and to the wider community.

For further information contact:

David Lawry OAM
Director TREENET
Ph (08) 8303 7078
Mob 0418 806 803
david@treenet.com.au

Treenet Sponsorship Packages (for the 2010 calendar year)

Bronze $2000 (+gst) 20 packages available 2010

- Right to promote Treenet sponsorship
- Framed Certificate presented at the 11th National Street Tree Symposium 2nd-3rd September 2010
- Website Exposure (1 time unit per sponsor)
- Direct link from treenet.org to your business website.
- Acknowledged in Symposium proceedings and on conference banners (text only no logo).
- Promotional material can be included in Symposium satchels.
- Free poster display space available at Symposium (up to one side of standard display board)
- 1 Symposium seat and 20% discount on additional attendances.

Silver $4000 (+gst) 6 packages available 2010

- Right to promote Treenet sponsorship
- Framed Certificate presented at the 11th National Street Tree Symposium 2nd-3rd September 2010
- Website Exposure (2 time units per sponsor)
- Direct link from treenet.org to your business website
- 1 separate page on website made available for your own promotional messages. You have access to update info when you wish.
- Acknowledged in Symposium proceedings and on conference banners (logo)
- Promotional material can be included in Symposium satchels.
- 1 free trade display space at Symposium.
- 2 Symposium seats and 20% discount on additional attendances.

Gold $8,000 (+gst) 2 packages available 2010

- Right to promote Treenet sponsorship
- Framed Certificate presented at the 11th National Street Tree Symposium 2nd-3rd September 2010
- Website Exposure (4 time units per sponsor)
- Direct link from treenet.org to your business website
- 2 separate pages on website made available for your own promotional messages. You have access to update info when you wish.
- Acknowledged in Symposium proceedings and on conference banners (logo)
- Promotional material can be included in Symposium satchels.
- 2 free trade display spaces at Symposium
- 4 Symposium seats and 20% discount on additional attendances.

Platinum $16,000 (+gst) 1 package available 2010

- Right to promote Treenet sponsorship
- Framed Certificate presented at the 11th National Street Tree Symposium 2nd-3rd September 2010
- Website Exposure (permanent display at top of each page)
- Direct link from treenet.org to your business website.
- 4 separate pages on website made available for your own promotional messages. You have access to update info when you wish.

- Acknowledged in Symposium proceedings and on conference banners (logo)
- Promotional material can be included in Symposium satchels.
- 4 free trade display spaces at Symposium
- 8 Symposium seats and 20% discount on additional attendances.
- Invitation to address delegates at 2010 Symposium.