Proceedings of the

12th National Street Tree Symposium 2011

INSTRUCTIONS: To move through the Proceedings use the left & right arrow keys on the keyboard. Click ‘Back to Contents’ at the top of the page to return to the Table of Contents.
ISBN: 978-0-9805572-5-1

TREENET Proceedings of the 12th National Street Tree Symposium 2011
Author/Contributor: Lawry, David; and Merrett, Bridget (eds)
Date of Publication: September 2011 ~ 137pp.
## Contents

<table>
<thead>
<tr>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>INSTITUTIONAL MEMBERS OF TREENET 2011</td>
<td>2</td>
</tr>
<tr>
<td>TREENET MANAGEMENT COMMITTEE AND ADVISORY BOARD 2011</td>
<td>3</td>
</tr>
<tr>
<td>TREENET Incorporated Constitution</td>
<td>5</td>
</tr>
<tr>
<td>Invitation to Institutional Membership 2011 (Association)</td>
<td>12</td>
</tr>
<tr>
<td>Invitation to Institutional Membership 2011 (Government)</td>
<td>13</td>
</tr>
<tr>
<td>Invitation to Institutional Membership 2011 (Corporate)</td>
<td>14</td>
</tr>
<tr>
<td>Speaker and Panellist Profiles</td>
<td>15</td>
</tr>
<tr>
<td>12th National Street Tree Symposium Programme</td>
<td>24</td>
</tr>
<tr>
<td>Best practice design and implementation of urban tree planting – Victoria Avenue Pedestrian Mall upgrade, Chatswood NSW</td>
<td>25</td>
</tr>
<tr>
<td>Robert Smart AAILA, ISA</td>
<td></td>
</tr>
<tr>
<td>Arboricultural strategies for climate change</td>
<td>43</td>
</tr>
<tr>
<td>Greg M Moore</td>
<td></td>
</tr>
<tr>
<td>Studying the effects of rising atmospheric CO₂ concentration on the water use efficiency of <em>Eucalyptus saligna</em></td>
<td>51</td>
</tr>
<tr>
<td>Dr Craig Barton</td>
<td></td>
</tr>
<tr>
<td>The use of trees in urban stormwater management</td>
<td>57</td>
</tr>
<tr>
<td>E.C. Denman, P.B. May, G.M. Moore</td>
<td></td>
</tr>
<tr>
<td>Update on the development of a tree inventory at Hume City Council</td>
<td>67</td>
</tr>
<tr>
<td>Jason Summers</td>
<td></td>
</tr>
<tr>
<td>Independent inquiry into management of trees on public land: Final report extract</td>
<td>71</td>
</tr>
<tr>
<td>Brian Cunningham</td>
<td></td>
</tr>
<tr>
<td>Culturally significant trees review</td>
<td>96</td>
</tr>
<tr>
<td>David Cooney</td>
<td></td>
</tr>
<tr>
<td>Literature Review - Culturally Significant Tree Project</td>
<td>98</td>
</tr>
<tr>
<td>Sam Cassar</td>
<td></td>
</tr>
<tr>
<td>Culturally significant trees: A brief TREENET case study</td>
<td>117</td>
</tr>
<tr>
<td>Greg M Moore</td>
<td></td>
</tr>
<tr>
<td>A short history of tree planting and a summary of content from key documents posted on the Newcastle City Council website on investigations into the Laman Street Hills Fig trees</td>
<td>120</td>
</tr>
<tr>
<td>Philip Hewett</td>
<td></td>
</tr>
<tr>
<td>What is required of an expert witness?</td>
<td>125</td>
</tr>
<tr>
<td>Judy Fakes</td>
<td></td>
</tr>
</tbody>
</table>

*The 12th National Street Tree Symposium 2011*
INSTITUTIONAL MEMBERS OF TREENET 2011

ASSOCIATIONS
Australian Institute of Landscape Architects SA (AILA SA)
Institute of Australian Consulting Arboriculturists (IACA)
International Society of Arboriculture (Australia Chapter) Ltd. (ISAAC)
Local Government Tree Resources Association (NSW)
National Arborist Association of Australia (NAAA)
Nursery & Garden Industry SA Inc (NGISA)
Queensland Association of Arboriculture (QAA)
South Australian Society of Arboriculture (SASA)

GOVERNMENT
Adelaide City Council
Albury City Council
Berri Barmera Council
Botanic Gardens of Adelaide
Brisbane City Council
Campbelltown City Council
City of Belmont
City of Burnside
City of Canning
City of Charles Sturt
City of Holdfast Bay
City of Marion
City of Melbourne
City of Melville
City of Mitcham
City of Norwood, Payneham and St Peters
City of Playford
City of Port Adelaide Enfield
City of Port Augusta
City of Sydney
City of Unley
City of West Torrens
City of Yarra
Corporation of the Town of Walkerville
District Council of Mount Barker
District Council of the Copper Coast
District Council of Yorke Peninsula
Horsham Rural City Council
Hurstville City Council
Moorabool Shire Council
Moreland City Council
Naracoorte Lucindale Council
Newcastle City Council
Parks, Conservation and Lands ACT
Randwick City Council
Renmark Paringa Council
Rural City of Murray Bridge
TAFESA - Urrbrae Campus
Toowoomba Regional Council
Wagga Wagga City Council
Whyalla City Council

CORPORATE
Arbortrack Australasia PTY LTD
Department for Transport, Energy and Infrastructure
Vermeer Sales and Service Pty Ltd
TerraCottem Australasia Pty Ltd
Active Tree Services
Advanced Arbor Services
Arbor Centre
Arborman Tree Solutions
Austral Tree Services
Fleming’s Nurseries
Homewood Consulting
HR Products
Humphris Nurseries
Metropolitan Tree Growers Pty Ltd
Mt William Advanced Tree Nursery
Sydney Metro Tree Services
Tree Dimensions
Treelologic
Trentcom APS Pty Ltd
Quantified Tree Risk Assessment Limited (QTRA)
The Adelaide Tree Surgery

Click here to visit the TREENET website to find out more about our Institutional Members.
TREENET MANAGEMENT COMMITTEE AND ADVISORY BOARD 2011

TREENET MANAGEMENT COMMITTEE

**Chairperson:** Dr Greg Moore
**Director:** David Lawry OAM *(ex officio)*
**Secretary:** Dr Jennifer Gardner *(ex officio)*
**Treasurer:** Robin Eley *(ex officio)*
**Members:** Judy Fakes
Tim Johnson
Brian Measday *(ex officio)*
Hon Dr Bob Such MP
John Zwar

TREENET ADVISORY BOARD

**TREENET**

David Lawry OAM Director TREENET and 1915-2015 Avenues of Honour Project SA

Brian Measday Chartered Accountant, Honorary Treasurer TREENET SA

Robin Eley Chief Financial Officer 1915-2015 Avenues of Honour Project SA

**Educational and Research Institutions**

Prof Chris Daniels Professor of Urban Ecology University SA SA
Judy Fakes Head Teacher Parks, Gardens & Arboriculture Ryde College of TAFE. NSW
Dr Jennifer Gardner Director, Waite Arboretum Management Committee TREENET SA
Trevor Hancock University of Adelaide, SARDI, Biometrics SA SA
Dr David Jones Assoc. Professor Director Landscape Architecture, University Adelaide SA
Dr Greg Moore Research Assoc. Burnley School of Resource Management and Geography Chair TREENET VIC
Dr Dean Nicolle Flinders University, Director, Currency Creek Arboretum SA
Dr Brian Richards Volunteer Waite Arboretum. Retired CSIRO soil scientist SA
Prof. Randy Stringer Professor Head of Discipline of Ag, Food and Wine University of Adel. SA
Debra Walkley Principal TAFE SA Urrbrae and Mt Barker Campuses SA
John Zwar TAFE SA Urrbrae Campus SA

**Nursery Industry**

Ian Brown Mt William Advanced Tree Nursery VIC
Ross Clark Trees Impact NSW
John Fitzgibbon Metropolitan Trees VIC
Geoffrey Fuller CEO Nursery & Garden Industry of South Australia SA
Kevin Handreck Netherwood Horticultural Consultants SA
Peter Lawton Trentcom VIC
Hamish Mitchell Speciality Trees VIC
Community
Hon Dr Bob Such Independent Member for Fisher Management Committee TREENET SA

Arboricultural & Allied Professions
Jan Allen Terra Ark QLD
Peter Bishop Bunya Solutions QLD
Rob Bodenstaff Arbor Centre WA
Sam Cassar Symatree SA
Sam Cowie Leaf and Limb Horticultural Consultancy Qld
Stephen Frank Treelogic Pty Ltd VIC
David Galwey Tree Dimensions VIC
Craig Hallam ENSPEC SA
Phillip Hewett Neighbour Woods NSW
Ben Kenyon Homewood Consulting VIC
Phillip Kenyon Kenyon's Quality Tree Care VIC
Kym Knight Tree Environs SA
Michael Palamountain Tree Environs SA
Mark Willcocks Active Tree Services NSW
Sue Wylie TreeTalk Arboricultural Consulting NSW

Landscape Architects and Urban Planners
Jared Barnes City of Adelaide SA
Martin Ely Arbordesign SA
Michael Heath Chair National Trust SA Significant Tree Committee SA

Legal
Arnold Laurencis Civil & Commercial Barristers & Solicitors Pty Ltd SA
Brian Preston Chief Justice of the NSW Land and Environment Court NSW

Local Governments (users of research outcomes)
David Cooney District Council of Mt Barker SA
Craig Hinton Frankston City Council, President ISAAC VIC
Tim Johnson City of Mitcham SA Management Committee TREENET
Bernard Keays Moreton Bay Regional Council QLD
Christopher Lawry District Council of Mt Barker SA
Martin Norris Wellington Shire Council VIC
Lyndal Plant Brisbane City Council QLD
Deon Schumann City of Port Augusta SA
Jason Summers Hume City Council VIC
Karen Sweeney City of Sydney NSW

State Governments
Kiah Martin Royal Botanic Gardens Melbourne, Women of the Trees VIC
Henry Polec Department of Transport Energy and Infrastructure SA
TREENET Incorporated Constitution

1. NAME
The name of the Association is "TREENET Incorporated"

2. DEFINITIONS
2.2 “Association” means the above named Association.
2.3 “Management Committee” means the committee referred to in Rule 11.
2.4 “Advisory Board” means the Board referred to in Rule 12.

3. VISION AND AIMS
3.1 Vision
The vision of the Association is to enhance the role of trees in the urban forest and to engage the community in this endeavour.
3.2 Aims
The aims of the Association are:
3.2.1 To develop and maintain an interactive web application to facilitate the exchange of information relating to urban forests.
3.2.2 To promote research and education relating to urban forests including holding symposia.
3.2.3 To establish and maintain a public fund to be called TREENET Fund for the specific purpose of supporting the environmental purposes of TREENET Inc. The Fund is established to receive all gifts of money or property for this purpose and any money received because of such gifts must be credited to its bank account. The Fund must not receive any other money or property into its account and it must comply with subdivision 30-E of the Income Tax Assessment Act 1997.

4. POWERS
The Association shall have all the powers conferred by Section 25 of the Act.

5. MEMBERSHIP
5.1 Membership
When an organisation or person has agreed to become a member of the Association and has paid the Association’s membership fee where it applies, then that organisation or person will be admitted to membership pursuant to the Constitution, and their name shall be entered in the Association’s Register of Members.
5.2 Classes of Member
There shall be five classes of member:
5.2.1 Management Committee Member
This class shall consist of all members of the Management Committee as described in Rule 11.1. Management Committee Members will have the right to receive notice of and attend all meetings.
5.2.2 Advisory Board Member
This class shall consist of natural persons who have been invited by the
Management Committee to be on the Advisory Board and agreed. Advisory
Board Members will have the right to receive notice of, and attend, the Annual
General Meeting and other General Meetings as called. The term of appointment
will be for the calendar year.

5.2.3 Associate Member
This class shall consist of natural persons who register an interest in joining the
Association and who subscribe to the aims of the Association.

5.2.4 Institutional Member
This class shall consist of research and educational institutions, government
bodies, businesses and associations who are financial members. Institutional
Members will have the right to receive notice of, and attend, the Annual General
Meeting and other General Meetings as called.

5.2.5 Honorary Life Member
This class shall consist of natural persons who have been granted Honorary
membership at the discretion of the Management Committee. Honorary Life
Members will have the right to receive notice of and attend the Annual General
Meeting and other General Meetings as called.

5.3 Votes
Members may exercise the following voting entitlements:

5.3.1 Management Committee Member – 1 vote
5.3.2 Advisory Board Member – 1 vote
5.3.3 Associate Member – members of this class shall have no votes
5.3.4 Institutional Member – financial members – 1 vote by representation or proxy
5.3.5 Honorary Life Member – 1 vote

5.4 Register of Members
A Register of Members shall be kept which contains the name, postal or electronic
address, class of membership and subscription details of each Member and the date of
joining the Association.

5.5 No Transfer of Rights
The rights and privileges of a Member shall not be transferable and shall cease upon such
an organisation or person ceasing to be a Member.

6. MEMBERSHIP FEES
The Management Committee shall from time to time set the terms and conditions of membership
fees, if any, for the different classes of membership.

7. CESSATION OF MEMBERSHIP
Membership may cease by resignation, expulsion or non payment of fees.

7.1 Resignation
Members shall cease to be a member by notifying the Association by whatever means the
Management Committee might direct from time to time.
7.2 Expulsion

If any Member wilfully refuses or neglects to comply with the provisions of the Constitution, or is guilty of any conduct which in the opinion of the Management Committee is unbecoming to a Member or prejudicial to the interests of the Association, the Committee shall have the power to expel the member from the Association PROVIDED THAT at least one month before the Committee Meeting at which a resolution for the Member’s expulsion is to be considered, the Member shall have been given notice of such meeting and what is alleged against them and of the intended resolution for their expulsion, and they shall at such meeting and before the passing of such resolution have had an opportunity to give oral or written explanation for their defence.

7.3 Non-payment of Fees

If a Member has not paid fees as agreed in the terms and conditions and has been notified in writing by the Association of this failure, then the Member shall cease to be a Member of the Association unless the prescribed fee is paid by the date as notified.

8. PROPERTY AND FINANCE

8.1 The funds and other property of the Association shall be managed and controlled by the Management Committee and shall be used only for the vision and aims of the Association.

8.2 All cheques, negotiable instruments and orders drawn by the Association shall be signed by two persons designated by the Management Committee.

8.3 Subject to Rule 8.1, the surplus funds of the Association may be invested in such manner as the Management Committee sees fit, except direct equities.

8.4 The accounts of the Association shall be audited annually.

8.5 The financial year of the Association shall be from 1 July to 30 June.

8.6 The Association shall prepare financial accounts at the end of each financial year.

9. NOT-FOR-PROFIT

The assets and income of the Association shall be applied solely in furtherance of its above-mentioned vision and aims and no portion shall be distributed directly or indirectly to the members of the Association except as bona fide compensation for services rendered or for reimbursement for expenses incurred.

10. MEETINGS OF THE ASSOCIATION

10.1 The Annual General Meeting shall be held at such time as the Management Committee shall determine.

10.2 Any Motion that any voting Member proposes to move at the Annual General Meeting including a proposal to alter the Constitution shall be given in writing to the Management Committee at least four weeks before the meeting.

10.3 At least 21 days before the Annual General Meeting or any other General Meeting, notice shall be given by written or electronic form sent to all members of the Association entitled to vote, but any accidental omission to give notice to any voting member shall not invalidate the meeting.

10.4 At the Annual General Meeting, ordinary business shall be the presentation of the audited financial accounts, election of the Management Committee and the appointment of an auditor.

10.5 Each voting member present shall be entitled to one vote. In case of an equality of votes, the Chair shall have a second or casting vote.
10.6 A Special General Meeting may be requested by ten voting members presenting an agenda to the Management Committee, the agenda being signed by all ten members. The Management Committee must within 14 days give notice of a Special General Meeting to be at least 21 days from the notice date. The Special General Meeting will be limited to the agenda items plus other items of which the Committee gives notice. Once the agenda items have been resolved by consensus, resolution or vote they cannot be used again to call a Special General Meeting for 52 weeks from the meeting date.

10.7 An Advisory Board Member shall be entitled to appoint in writing a natural person, who is also an Advisory Board Member of the Association, to be his or her proxy, and to vote on his or her behalf at any general meeting of the Association.

11. MANAGEMENT COMMITTEE

11.1 Membership of the Management Committee
The Management Committee will comprise six elected members drawn from education and research, business and government sectors of the community and three *ex officio* members as follows:

11.1.1 An academic from a tertiary educational institution
11.1.2 A member of Local Government
11.1.3 Four other members
11.1.4 The Director of Waite Arboretum will be a member *ex officio* and may also represent The University of Adelaide with consent from the University
11.1.5 The Directors of Treenet and the Treasurer of Treenet will be members *ex officio*.

11.2 Elections

11.2.1 The elected members of the Management Committee shall be elected annually by voting members of the Association at the Annual General Meeting.

11.2.2 Where the number of candidates for membership of the Management Committee exceeds the maximum number, elections shall be held by secret ballot of members at the Annual General Meeting entitled to vote. In the case of an equality of votes, the Chair shall have a second or casting vote.

11.2.3 The nomination of a candidate for membership of the Management Committee must be in writing, signed by a proposer (who must be an Advisory Board member) and by the nominee. The nomination must be delivered to the Director of the Association before such time as the Management Committee shall determine.

11.2.4 Subject to Rule 11.1, the Management Committee shall have the power to co-opt further Committee members and to fill casual vacancies.

11.3 Office Bearers
The Office Bearers of the Association shall be:

Chair
Director & Public Officer *ex officio*
Treasurer *ex officio*

11.4 Procedures Generally
The Management Committee may meet in person or confer by video or telephone conferencing, email or by other electronic means for the dispatch of business and subject to the Constitution, otherwise regulate its meetings as it thinks fit.
11.5 Calling of Committee Meetings

11.5.1 The Management Committee shall meet or confer at least four times per year as described in 11.4. Notice of the meeting or conference shall be given in writing to each Committee Member.

11.5.2 The position of any Committee member absent for three consecutive meetings or conferences without leave of absence shall automatically become vacant. Acceptance of an apology shall be deemed grant of such leave.

11.6 Chair

The Chair shall take the chair at meetings. In his or her absence, the Committee shall appoint a member of the Committee to chair the meeting.

11.7 Decisions of Questions

Questions arising before a meeting of the Committee shall be decided by a majority vote. In case of an equality of votes, the chair shall have a second or casting vote.

11.8 Reporting

The Management Committee shall be responsible to the Association and shall present an annual report, including the audited financial accounts, to each Annual General Meeting.

11.9 Auditor

The Management Committee shall appoint an auditor of the Association, who will hold office until the next Annual General Meeting of the Association.

12. ADVISORY BOARD

12.1 There shall be an Advisory Board of the Association.

12.2 The Advisory Board will comprise persons who are competent and willing to provide advice to the Association in their individual areas of expertise, and to liaise with other bodies and institutions for the purpose of facilitating the flow of information between the Association and those other bodies and institutions, and facilitating the implementation of projects which the Association undertakes in furtherance of its aims.

12.3 Members of the Advisory Board shall have no power or authority to represent the Association in any dealings between the Association and third parties.

12.4 The Advisory Board shall meet at such times and places as the Management Committee shall determine.

12.5 The Chair of the Management Committee will take the chair at meetings of the Advisory Board.

13. QUORUMS

13.1 The quorum at general meetings of the Association shall be six members entitled to vote.

13.2 The quorum at Management Committee meetings shall be three members.

14. AUTHORITY TO ENTER INTO CONTRACTS OR AGREEMENTS

The Association shall not be committed to any binding contract or Agreement except pursuant to a resolution of the Management Committee and the instrument shall be signed by at least two members of the Committee.

The 12th National Street Tree Symposium 2011
15. DISSOLUTION

15.1 The Association shall be dissolved if a resolution to this effect is carried by a three-quarters majority voting in person or by proxy at a general meeting, 21 days notice of the proposed resolution having been given to all members entitled to vote.

15.2 In the event of the Association being dissolved, the amount that remains after such dissolution and the satisfaction of all debts and liabilities shall be transferred to the University of Adelaide, for expenditure on the Waite Arboretum only.

16. ALTERATION TO THE CONSTITUTION

This Constitution may be altered by resolution of a majority of three-quarters of members entitled to vote and who cast a vote in person or by proxy at a general meeting. Written notice of amendments shall be posted to all members entitled to vote at the same time as the notice of the meeting.

17. REQUIREMENTS OF THE PUBLIC FUND

The organisation must inform the Department responsible for the environment as soon as possible if:

- it changes its name or the name of its public fund; or
- there is any change to the membership of the management committee of the public fund; or
- there has been any departure from the model rules for public funds set out in the Guidelines to the Register of Environmental Organizations.

18. MINISTERIAL RULES

The organisation agrees to comply with any rules that the Treasurer and the Minister with responsibility for the environment may make to ensure that gifts made to the fund are only used for its principal purpose.

19. CONDUIT POLICY

Any allocation of funds or property to other persons or organizations will be made in accordance with the established purposes of the organisation and not be influenced by the preference of the donor.

20. WINDING-UP

In case of the winding-up of the Fund, any surplus assets are to be transferred to another fund with similar objectives that is on the Register of Environmental Organizations.

21. STATISTICAL INFORMATION

Statistical information requested by the Department on donations to the Public Fund will be provided within four months of the end of the financial year.

An audited financial statement for the organisation and its public fund will be supplied with the annual statistical return. The statement will provide information on the expenditure of public fund monies and the management of public fund assets.
22. RULES FOR THE PUBLIC FUND

22.1 The objective of the fund is to support the organization’s environmental purpose.

22.2 Members of the public are to be invited to make gifts of money or property to the fund for the environmental purposes of the organisation.

22.3 Money from interest on donations, income derived from donated property, and money from the realisation of such property is to be deposited into the fund.

22.4 A separate bank account is to be opened to deposit money donated to the fund, including interest accruing thereon, and gifts to it are to be kept separate from other funds of the organisation.

22.5 Receipts are to be issued in the name of the fund and proper accounting records and procedures are to be kept and used for the fund.

22.6 The fund will be operated on a not-for-profit basis.

22.7 A committee of management of no fewer than three persons will administer the fund. The committee will be appointed by the organisation. A majority of the members of the committee are required to be ‘responsible persons’ as defined by the Guidelines to the Register of Environmental Organizations.
Invitation to Institutional Membership 2011 (Association)

Institutional Membership (Association) is open to all not-for-profit organisations and professional associations who support research and education relating to urban trees and who value representation in the urban forest network that is TREENET.

The cost is $600 (exc GST) for the 2011 calendar year.

About TREENET:

- TREENET is the National research and education body 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 implementing the vision of The Avenues of Honour 1915-2015 Project www.avenuesofhonour.org

The benefits of Association Institutional Membership of TREENET:

Ownership of a unique Institutional Member Code that will allow your members to access many valuable online offers including, but not limited to

- Complimentary attendance for one nominated individual from your organisation at the 12th National Street Tree Symposium at the National Wine Centre and the Waite Arboretum 1st-2nd September 2011. The value of this alone is $550.
- 20% discount on the registration cost for all your membership for the annual Symposium and for other TREENET workshops.
- Acknowledgement of your organisation’s Institutional Membership status will be provided online with a direct link to your website.

In return, your organisation’s membership will help TREENET achieve these aims:

- To enhance the body of knowledge that exists about street trees.
- To foster research in the area.
- To distribute resulting information to all those who may find it useful
- To facilitate co-operation and the free exchange of information.

Click here to visit the TREENET website for more information on Institutional Membership.

For further information contact:

David Lawry OAM
Director TREENET
Ph (08) 8303 7078
Mob 0418 806 803
david@treenet.org

The 12th National Street Tree Symposium 2011
12
Invitation to Institutional Membership 2011 (Government)

Institutional Membership (Government) is open to Local, State and Federal Government organisations who support research and education relating to urban trees and who value representation in the growing network of urban forest professionals that is TREENET.

The cost is $1,000 (Exc GST) for the 2011 calendar year.

About TREENET:

- **TREENET** is the National research and education body for urban arboriculture based at the University of Adelaide’s Waite Arboretum.
- **TREENET** maintains a freely accessible website [www.treenet.org](http://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 implementing the vision of The Avenues of Honour 1915-2015 Project [www.avenuesofhonour.org](http://www.avenuesofhonour.org)

The benefits of Government Institutional Membership of TREENET:

Ownership of a unique **Institutional Member Code** that will allow your members to access many valuable online offers including, but not limited to:

- **Complimentary attendance** for any one individual from your organisation at the **12th National Street Tree Symposium** at the National Wine Centre and the Waite Arboretum 1st-2nd September 2011.
- **20% discount** on the registration cost for all additional Symposium attendees and for other TREENET workshops.
- **Participation** in TREENET trials, such as:
  - **Species Trials.** TREENET is producing small numbers of trees for trialling in your neighbourhood that may be better adapted to the changing climatic conditions influenced by global warming. These uncommon species are sourced from the Waite Arboretum and elsewhere, and are available at cost exclusively to Institutional Members.
  - **WSUD Trials.** One TREENET inlet will be supplied **free of charge** on request for trialling and collection of data.
- **Assistance** where possible by phone or email on local urban tree matters.
- **Acknowledgement** of your organisation’s Institutional Membership status will be provided online with a direct link to your website.

Click here to visit the TREENET website for more information on Institutional Membership.

For further information contact:

David Lawry OAM  
Director TREENET  
Ph (08) 8303 7078  
Mob 0418 806 803  
david@treenet.org
Invitation to Institutional Membership 2011 (Corporate)

Institutional Membership (Corporate) is open to all industry organisations that support research and education relating to urban trees and who value representation in the growing network of urban forest professionals that is TREENET.

The cost is $1,000 (exc GST) for the 2011 calendar year.

About TREENET:

- TREENET is the National research and education body for urban arboriculture based at the University of Adelaide’s Waite Arboretum.

- TREENET maintains a freely accessible website [www.treenet.org](http://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 implementing the vision of The Avenues of Honour 1915-2015 Project [www.avenuesofhonour.org](http://www.avenuesofhonour.org)

The benefits of Corporate Institutional Membership of TREENET:

Ownership of a unique Institutional Member Code that will allow your members to access many valuable online offers including, but not limited to:

- Complimentary attendance for any one individual from your organisation at the 12th National Street Tree Symposium at the National Wine Centre and the Waite Arboretum 1st-2nd September 2011.

- 20% discount on the registration cost for all additional Symposium attendees and for other TREENET workshops. Assistance where possible by phone or email on local urban tree matters

- Acknowledgement of your organisation’s Institutional Membership status will be provided online with a direct link to your website.

Click here to visit the TREENET website for more information on Institutional Membership.

For further information contact:

David Lawry OAM
Director TREENET
Ph (08) 8303 7078
Mob 0418 806 803
david@treenet.org
Dr Greg Moore

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.
Robert Smart AAILA, ISA

Rob has formal qualifications in Landscape Architecture, Arboriculture and Business Management. He has more than 21 years experience in landscape design and site planning and is currently the sole Director of Arterra Design. Arterra is a multi-award winning landscape consulting practice established in 1995. Arterra has worked on over 750 projects on the east coast of Australia, and from Darwin to Melbourne.

Some of the more notable projects completed by Arterra include:

- Sydney of City Street Tree Master Plan Review 2011
- Chatswood Mall Refurbishment, Chatswood 2010
- Hurstville Memorial Square Refurbishment, Hurstville 2000
- Bradfield Plaza in Bradfield Park South, Milsons Point 2003
- Murrays Beach Pool and Recreation Centre, Murrays Beach 2010
- Sovereign Hills Main Street, Port Macquarie 2005-2008
- Stonecutters Ridge Estate - Parks, Streetscape and Golf Course Landscape, Blacktown 2006-present
- Warragamba Dam Auxiliary Spillway Development, Warragamba 1999-2004

Rob has worked on a huge variety of both private sector and public projects, including urban parklands, large scale revegetation and bushland restoration projects, constructed wetlands and large scale commercial residential developments. Robert is a Registered Landscape Architect with a Bachelor Degree in Landscape Architecture (1st Class Hons) from the University of NSW, Sydney, 1990. He has also completed a Diploma of Horticulture (Arboriculture), from Ryde TAFE in 2010 and was the TAFE State Medal Winner for that course. Robert has also a Business Management Advanced Certificate, from North Sydney TAFE, 1993.

Dr Craig Barton

Craig Barton joined State Forests of NSW* in 2000 as a research officer investigating methods of improving forest carbon accounting. He studied the relationship between above and belowground biomass in trees under a range of conditions and investigated the potential of ground penetrating radar to determine root biomass. In 2002 he moved into research into dryland forestry and tree water use and leads a small team investigating the potential of trees to mitigate dryland salinity.

He is currently a senior research scientist and holds an adjunct research fellowship at the University of Western Sydney where he spends part of his time running the whole tree chambers at the Hawkesbury Forest Experiment. This project initially funded by the Australian Greenhouse Office and subsequently the Department of Climate Change and Department of Agriculture, Fisheries and Forests aims to improve our understanding of the impacts of climate change on Australia’s forests and woodlands.

*NSW Department of Primary Industries was formed on July 1, 2004 through an amalgamation of NSW Agriculture, NSW Fisheries, State Forests of NSW and the NSW Department of Mineral Resources.
Liz Denman
Liz is a horticulturist who completed her PhD in the School of Land and Environment at The University of Melbourne. The PhD research investigated the potential to use street tree biofiltration systems to remove nitrogen and phosphorus from urban stormwater. Her major interests include the establishment and management of vegetation in urban areas and also the environmental benefits afforded by plants in the landscape. Liz works at Homewood Consulting as a consulting arborist and at VicRoads in the Landscape and Urban Design section of Technical Consulting.

Jason Summers
Jason has worked in local government for more than 14 years, and is currently employed as the Parks and Open Space Manager at Hume City Council. Jason is responsible for managing council’s parks and open space assets and infrastructure, council’s urban forest and natural assets. Jason studied Applied Science in Horticulture specialising in Arboriculture, Nursery Production and Environmental management at the Burnley Horticultural College. Whilst studying he climbed trees in his own family business known as the Tree Crew for more than 8 years. Later he went on to complete a Masters by research in Forest Science looking at cloning blackwoods for farm forestry at Melbourne University.

Jason has a keen interest in Urban Forest Management and the positive impact trees have on the urban environment. A member of the Treenet Advisory Board and on the Austep® committee and convener of the Basalt Plains Urban Forest Group, Jason is active in trying to improve standards in the industry and disseminate information amongst his peers. His major achievement in the last few years has been the ongoing development of the Hume Tree Management System that has revolutionised the way Council manages its urban forest as an asset of the community. He likes to plant large trees where he can that will be admired and treasured by people in the future long after he has gone. Jason has recently been promoted to the role of Manager Parks & Open Space at Hume City Council.

Brian Cunningham
Brian has over 18 years experience as a Chief Executive in both the Private and Public Sectors. He has wide ranging experience in leading organisations over that time in the following industries and sectors in State and National markets:

- Sports Leadership and Management
- Training/Education/Workforce Development
- Manufacturing and Business Sustainability
- International Market Development
- Science, Technology and Innovation
- Small Business and Regional Development

Brian has high level management experience in leading organisations (ranging from $20 mill turnover and 100 staff to $480 mill turnover with over 6000 staff) through significant change. Brian is probably best known in Australian Rules Football states in Australia for his key leadership role in the successful tender for an Australian Football League Club franchise licence in 1994. This resulted in Port Adelaide Football Club entering the National competition in 1997. As CE Brian subsequently drove the development of this state based sporting club to a highly successful National football league entity in the period 1996-2004.

Brian was recruited into the State Government in 2005 and held two key senior roles as the Chief Executive of the Department of Further Education, Employment, Science and Technology (DFFEST) and also Chief Executive of the Department of Trade and Economic Development (DTED) over a five year period. He has performed the role as Chairman of various National and State Government committees in the spheres of Training, Education and also Economic Development.
In 2010 Brian moved out of the public sector and has taken up several private sector Board Director roles. In addition he formed his own private consultancy company specialising in high level strategic advice in the above sectors, executive coaching with a focus on people strategies for high performance.

He was appointed by the State Executive Committee of the Local Government Association of South Australia (LGA) in mid-2010 to chair an independent Inquiry into the management of trees located on land under the care and control of councils. The purpose of the Inquiry was to provide independent advice to the Local Government Association on the most appropriate future management regime for trees on public land taking into account current and possible future changes in climatic conditions. Brian is a Fellow of the Australian Institute of Company Directors and holds a Bachelor of Science and a Diploma in Education.

David Cooney

David Cooney is currently a Senior Policy planner at the District Council of Mount Barker, one of the most rapidly expanding peri urban townships in Australia.

He has had extensive experience in Local Government in rural, urban and outer metropolitan areas in the fields of horticulture, environmental management and planning.

He was motivated by the lack of standard protocols in the identification assessment and management of culturally significant landscapes to initiate and head up an LGA funded review of current procedures and options for the future.

Sam Cassar

Sam Cassar has experience and qualifications in Horticulture/Arboriculture and Landscape Design. These experiences include some 15 years in local government and six years in private practices.

Sam’s experiences in local government includes: Asset Manager Park Lands and Open Space for the City of Adelaide; Horticultural Planner for the City of Charles Sturt; and Senior Horticulturalist with the City of Norwood, Payneham and St Peters.

In 2006 Sam Cassar left local government and established Symatree Pty Ltd. Symatree is a consulting service providing Arboriculture, Landscape Design and Urban Horticultural services to both the public and private sectors. The services Symatree provides include:

- Significant tree assessment and advice;
- Landscape design, specification development and implementation;
- Management of trees on construction sites;
- Tree audits and condition surveys; and
- Tree and horticultural policy and procedural development and implementation.

Sam Cassar’s tertiary qualifications are pre-dominantly within the urban horticultural profession, including a Bachelor of Applied Science (Horticulture) and Associate Diploma (Horticulture) both obtained from Burnley College, now part of the University of Melbourne. Sam also has a Graduate Diploma in Design from the University of Adelaide, a trade level qualification in gardening from the Adelaide Botanic Gardens and Certificate IV in Workplace Training from Maxima. Sam was awarded the John Inglis Lothian Memorial Prize for excellence in Horticulture in 1991. Sam is also involved with the University of Adelaide engaged as a Tutor with the School of Architecture, Landscape Architecture and Urban Design. He has been tutoring for the past six years.
Philip Hewett
Arboriculturist
Email: philharmonic1@bigpond.com
Mobile: 0411 754 115

For some 30 years Philip has been engrossed in private and municipal tree administration in town planning, landscape and asset management and tree preservation. In 1986, after four years as Tree Officer for Hobart City Council he joined NSW TAFE where he gained his teaching qualifications and taught horticulture at Ryde College. Four years later he left for another bout of municipal trees this time at Wyong Council. He later established an arboriculture consultancy before returning for a third foray into local government, this time at Newcastle. Now semi-retired, Philip still widely promotes the importance of urban forest to our urban communities. His numerous public presentations derive from extensive practical experience at the working interface of public trees, Council administration and the communities they serve. Philip was appointed Acting Commissioner in the NSW Land & Environment Court in 2010.

Judy Fakes
Judy Fakes is a full-time Commissioner in the NSW Land & Environment Court. Her previous position was Head Teacher of Parks, Gardens & Arboriculture at Ryde College of TAFE where for 30 years she specialised in the teaching of the theory and practice of soil science and arboriculture. She has qualifications in Agricultural Science, Education, Tree Surgery and Forestry. She is a member of a number of committees including Australian Standards, TREENET and Sydney Royal Botanic Gardens Horticulture Committee and has close links with a number of professional industry associations. Judy has been a strong supporter of TREENET since its foundation year 1997 and in 2005 was crowned Queen of TREENET in recognition of her outstanding contribution to Australian Arboriculture. Although this may be viewed as an office without Constitutional powers Judy continues to serve TREENET royally as a valued member of the Management Committee.

David Bevan
David Bevan has been working as a reporter and broadcaster in South Australia for 20 years. His first job was writing for the "Footy Budget" which is odd because he knows nothing about Aussie rules football! Actually he knows nothing about any kind of football.

Despite this shaky start, he's managed to make a living covering the most important newsroom rounds... police, courts and politics. He's worked for ABC Radio, TV and the local daily, The Advertiser. In 1994, Wakefield Press published David's book-length account of the Australian European War Crimes prosecution, "A Case to Answer".

In 2000 he joined 891 ABC Adelaide and in 2001 presented the morning program with Philip Satchell. "I like to think I was apprenticed to a master craftsman in Philip" he says. In March 2002 David teamed up with friend and colleague Matthew Abraham to present the 891 morning program and they haven't looked back since. In January 2011, the pair moved into the 891 Breakfast timeslot, to present 'Breakfast with Bite' from 06:00am till 09:00am.
Chris Lawry
Chris is the Urban Forest Officer for the District Council of Mount Barker which is located on rural land in the Adelaide Hills. The predominantly rural zoning is interconnected with rapidly expanding urban and peri urban townships. The Mount Barker township is the largest hills suburb which has often been described as the most rapidly growing non-coastal area in Australia.

He therefore has the responsibility of guiding Council and developers down the path toward creating a liveable city whilst retaining as much of the precious remnant woodland resource and historic exotic rural landscape values as possible. Chris graduated from Burnley College in 2003 with a Diploma in Arboriculture.

Michelle Lensink
Michelle Lensink has been a member of the Legislative Council since 2003. A Physiotherapist by profession, she became involved with the Young Liberals before securing a position with Federal MP Christopher Pyne and later Robert Lawson, the State Minister for the Ageing and Disability Services. Ms Lensink entered the Legislative Council following the retirement of Diana Laidlaw, who had wished to be replaced by a young woman. She is now the Deputy Leader of the Opposition in the Legislative Council and her portfolio responsibilities include Environment and Conservation, Sustainability and Climate Change, the Status of Women, Youth and Consumer Affairs.

Michelle Lensink has been a regular and knowledgeable attendee at recent TREENET Symposia and workshops and is working closely with TREENET and the SA Society of Arboriculture to ensure the new regulations to the Significant Tree Act protect the integrity of Adelaide’s urban forest and set it on a sustainable course of management.

Bob Such
Dr Bob Such has been the Member for Fisher since 1989. He is an Independent in the South Australian Parliament. He is a former Minister for Employment, Training and Further Education and Minister for Youth Affairs and a former Deputy Speaker and Chairman of Committees and Speaker of the House of Assembly. He has a PhD in environmental politics, a BA (Hons) majoring in economics, a Diploma of Teaching and a Diploma of Education.

He has been a member of several Parliamentary Standing Committees (Economic and Finance, Social Development, Environment, Resources and Development) and chaired various Select Committees – Youth Justice, Cemeteries, Education. He belongs to numerous community groups.

Bob has served for a number of years on the TREENET Management committee and is an active urban forester in the Parliament of SA through his promotion of legislation to protect the State’s significant trees in particular and his raising of public awareness of the importance of trees in general.
Dr Jennifer Gardner
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.

Tim Johnson
Tim Johnson has more than 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.

David Lawry
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.

James Smith
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 fauNature, a company which aims to “bring people and wildlife together”. James’ principle focus is in urban and peri-urban environments.
Pat Kenyon
As a second generation arborist, Pat Kenyon is passionate for trees and their environment. In 1998 he established an arboricultural business called Tree Tactics Pty Ltd. Tree Tactics is a successful company with a team of 15 employees. The company provides professional services of tree pruning and tree removals by using qualified tree climbers.

For three years pat has been working closely with the Victorian Tree Industry Organisation (VTIO) as President. For the importance of our future Arboricultural Industry the VTIO has been working closely with fellow Victorian Arborists to focus on the development of safe practices in Arboriculture.

Through his experience as an arborist, Pat strongly feels a need to promote a healthy environment for flora and fauna within an urban forest. Over the past 12 months Pat has played a major role in developing artificial habitat by the use of dead or decaying trees. This habitat creation is providing homes for a diverse range of animal and insects.

With the development of Tree Tactics and the contribution of time to the VTIO, Pat has developed extensive communication skills and gained relationships throughout and beyond the Arboricultural Industry nationally and internationally.

Phil Kenyon
Phil Kenyon is the elder of the famous Kenyon tribe of Victorian arborists. His 35 years experience in the tree industry is underpinned by Diplomas in Horticultural Science and Technical teaching.

Phil’s significant contribution to Australian Arboriculture is however born out of his passion for the bush and his great gift as a communicator and a mentor to his many students or work colleagues. Phil established the diploma and TAFE level courses at Burnley College and is a regular contributor to Symposia, workshops and Arb camps. He is a member of the TREENET Advisory Board.

Dr Sigfredo Fuentes
Sigfredo studied at the University of Talca in Chile a degree in Agronomy specialising in Irrigation and Agrometeorology. He came to Australia in 2000 to work as an Irrigation Specialist for Darling Irrigation Pty. In 2005 he received his PhD from the University of Western Sydney (UWS). He was also a Postdoctoral research fellow at UWS, The University of Technology Sydney and The University of Adelaide, before his current appointment as Lecturer in Viticulture at The University of Adelaide. His research interests ranges from the responses of trees and crops to water availability, elevated CO₂ and temperature. He has expertise in advanced instrumentation and computing to monitor different aspects of soil moisture and physiological changes of plants using remote sensing in the field. Currently he is combining this expertise with robotics to automate critical measurements in the field that could give more accurate insights of the effect of climate change in plants.
Robert Prince (NGIA)
Robert Prince is the Chief Executive Officer of the Nursery & Garden Industry Australia. Robert has been involved in the agriculture/horticulture industry for more than 30 years with roles in New Zealand, South Africa and Australia. Robert has been with the Nursery & Garden Industry Australia since 2007 and in his current role since 2008. NGIA is focussed on increasing the awareness of the value of plants in the Australian urban environment. The current industry research and development activities are focused on supporting an increase in plantings and canopy cover in urban areas.
12th National Street Tree Symposium Programme

Thursday, September 1
Day 1 at the National Wine Centre, Adelaide

<table>
<thead>
<tr>
<th>Time</th>
<th>Presenter</th>
<th>Topic</th>
</tr>
</thead>
<tbody>
<tr>
<td>9:00 - 9:25 am</td>
<td>Dr Greg Moore</td>
<td>TREENET Chair</td>
</tr>
<tr>
<td>9:25 - 9:45 am</td>
<td>Rob Smart</td>
<td>Landscape Architect</td>
</tr>
<tr>
<td>9:45 - 10:30 am</td>
<td>Dr Greg Moore</td>
<td>TREENET Chair</td>
</tr>
<tr>
<td>10:30 - 11:00 am</td>
<td>Morning Tea</td>
<td></td>
</tr>
<tr>
<td>11:00 - 11:30 am</td>
<td>Dr Craig Barton</td>
<td>Forests NSW</td>
</tr>
<tr>
<td>11:30 - 12:00 pm</td>
<td>Lisa Dermer</td>
<td>Homewood Consulting</td>
</tr>
<tr>
<td>12:00 - 12:30 pm</td>
<td>Jason Summers</td>
<td>City of Home</td>
</tr>
<tr>
<td>12:30 - 1:30 pm</td>
<td>Lunch</td>
<td></td>
</tr>
<tr>
<td>1:30 - 2:30 pm</td>
<td>Brian Cunningham</td>
<td>Chair of LGA inquiry into Management of Trees on Public Land</td>
</tr>
<tr>
<td>2:00 - 2:30 pm</td>
<td>Panel</td>
<td>David Cooney, Dr Greg Moore, Phil Hewett</td>
</tr>
<tr>
<td>2:30 - 3:00 pm</td>
<td>Judy Fakes</td>
<td>Commissioner NSW Environment Court</td>
</tr>
<tr>
<td>3:00 - 3:30 pm</td>
<td>Afternoon Tea</td>
<td></td>
</tr>
<tr>
<td>3:30 - 4:00 pm</td>
<td>Dr Greg Moore</td>
<td>TREENET Chair</td>
</tr>
<tr>
<td>4:00 - 4:30 pm</td>
<td>Phil Hewett</td>
<td>Acting Commissioner NSW Environment Court</td>
</tr>
<tr>
<td>4:30 - 5:00 pm</td>
<td>Judy Fakes</td>
<td>Commissioner NSW Environment Court and leading urban forest</td>
</tr>
<tr>
<td>5:15 - 7:00 pm</td>
<td>Social Networking</td>
<td></td>
</tr>
</tbody>
</table>

Friday, September 2
Day 2 at the Waite Arboretum

Today you will participate in 4 practical sessions and your choice of one extended workshop

<table>
<thead>
<tr>
<th>Time</th>
<th>Duration</th>
<th>Topic</th>
</tr>
</thead>
<tbody>
<tr>
<td>9:00 - 9:40 am</td>
<td>40 mins</td>
<td>C and H2O sequestration</td>
</tr>
<tr>
<td>9:40 - 10:25 am</td>
<td>40 mins</td>
<td>Out of Africa</td>
</tr>
<tr>
<td>10:25 - 11:00 am</td>
<td>30 mins</td>
<td>WSUD, the science and the technology</td>
</tr>
<tr>
<td>11:00 - 11:40 am</td>
<td>40 mins</td>
<td>Habitat trees</td>
</tr>
<tr>
<td>11:40 - 12:25 am</td>
<td>40 mins</td>
<td>PhD and Pat Konyan, James Smith</td>
</tr>
<tr>
<td>12:25 - 1:00 pm</td>
<td>60 mins</td>
<td>Lunch</td>
</tr>
<tr>
<td>1:00 - 1:30 pm</td>
<td>85 mins</td>
<td>Workshops</td>
</tr>
<tr>
<td>1:30 - 2:30 pm</td>
<td></td>
<td>Presenters</td>
</tr>
<tr>
<td>2:30 - 3:00 pm</td>
<td>20 mins</td>
<td>Refreshments and Wrap up</td>
</tr>
<tr>
<td>3:00 - 3:30 pm</td>
<td>30 mins</td>
<td>AGM</td>
</tr>
</tbody>
</table>

Interactive

VIDEO recordings of Day 1 and Day 2 will be available on the Treenet website following the Symposium. Click here to view the videos.

The 2011 Proceedings Papers (Day 1) and Practical Workshop Notes (Day 2) are also available on the Treenet website. Click here to download the files.
Best practice design and implementation of urban tree planting – Victoria Avenue Pedestrian Mall upgrade, Chatswood NSW

Robert Smart AAILA, ISA
Director, Registered Landscape Architect, Consulting Arborist
Arterra Design Pty Ltd

Background
Arterra Design is a professional consultancy specialising in landscape architecture, site planning, consulting arboriculture and water sensitive urban design. Our mission is to design, communicate and construct memorable places that are creative, elegant, functional and enduring.

Willoughby Council engaged Arterra in May 2009 to design and document the upgrade works to Victoria Avenue Mall, in Chatswood. Chatswood is a major business and shopping hub in Sydney’s northern suburbs. It had been approximately 21 years since the creation of the mall. The brief required Arterra to review previous schemes and preliminary designs prepared by Council and previous consultants. Arterra then developed a new, simple design which rationalised the use of space in the mall. Council resolved to adopt the design as put forward by Arterra. It was then documented and put out to tender. Construction works commenced early in 2010 and were completed in early 2011. During the design process there were regular meetings with Jeff Ellis, Project Director and Gary Parsons, Property Contracts Coordinator with Willoughby Council who in turn negotiated and met with many other Council staff and service providers. A budget had previously been allocated by the Council of $3.16 million for the project.

This paper outlines the possibilities and constraints which were explored in the development of the preferred design. In particular it focuses on the initiatives that were developed to ensure the best possible outcomes for the proposed new tree planting within the mall. Other items are discussed to provide a background into the multiple factors that must be considered and addressed, alongside the tree planting, in major urban environments such as Chatswood Mall.

Brief history of Chatswood Mall
The following summarises the chronological history of the development of Chatswood and in particular the development of the mall to the western side of Chatswood Station commonly known as Chatswood Mall.

- 1836 – Area originally known as Kings Plains – Richard Hays Harnett (later it was his 2nd wife after whom Chatswood Station was named – her name was Charlotte but was shortened to Chattie and then turned into “Chats” “Wood”)
- 1860 – Much of the Chatswood area was essentially dominated by orchards
- 1865 – Willoughby was proclaimed as a Municipality
- 1882 – Victoria Ave area was cleared by the Baldry family
- 1887 – Construction started on the North Shore Railway
- 1890 – Market gardens flourished and Chatswood Railway Station was opened
- 1890-1900 – Saw a huge building boom now that there was ready transport to the area
- 1898 – Trams were extended throughout Chatswood and up to the railway station along Victoria Ave.
- 1900-1940s – Most retail development was on the western side of the railway.
- 1959 – The focus shifted to the eastern side with both Waltons and Grace Bros opening stores
- 1988 – A new bus interchange was built
- 1989 – Victoria Mall was created by closing the road between the station and Anderson Ave to the east.
- 2005-2008 – The Epping to Chatswood Railway was constructed resulting in a major upgrade of the station and impacting on the existing mall.
- 2007-2010 – Civic Place to the eastern end of Chatswood Mall was designed and constructed.
- 2009-2010 – Victoria Ave Mall was identified as needing refurbishment and planned to be upgraded to coincide with the opening of the Civic Place.
The existing pedestrianised portions of Victoria Avenue and the intersecting Victor Street formed the major part of the site that was to be upgraded. The footpath on the eastern side of Orchard Road above the interchange was also to be included in the upgrade. This represented a site area of approximately 4300m² of pedestrian mall. The main mall was 165m long and a standard road reserve width of 20m wide. It also included portions of the adjoining Orchard Road and Victor Street.

Chatswood Mall is a major hub of pedestrian activity. It provides important links between the Chatswood station and the newly upgraded Civic Place and the major shopping centres within the Chatswood CBD. The construction of the new Rail/Bus Interchange had left the existing pavement torn up and patched. The space, at the beginning of 2009, appeared very old and tired and in great need of an upgrade. The existing trees, although some in reasonable health, had not achieved their true potential. Upon excavation they exhibited extremely restricted root structures.

Arterra Design’s scope on the project
Arterra was engaged and contracted to perform the following key components of the project:

- Conceptual design and refinement of the designs until accepted by Council.
- Contract documentation of the approved design, including co-ordination with all the other necessary sub-consultants.
- Assistance to the Council in Construction Contract establishment, and advice on the Contract and Construction realities.
- Co-ordination of necessary soil testing.
- Periodic quality control.
Existing use of the site

The site was used in various ways:

- It was a major pedestrian corridor linking the Railway/Bus Interchange and the western side of the CBD with the eastern side of the CBD and adjoining residents.
- It was the home of a variety of small shops and food outlets, banks, a Westfield shopping centre entrance, Lemon Grove centre, and the Orchard Tavern Hotel.
- It accommodated weekly markets and outdoor café seating.
- It was a stage for performances and special events.
- It was an access way for service and delivery vehicles.

Existing site features & trees

Existing physical features of the site:

- Victoria Avenue falls from the railway interchange down to Anderson Street at 1 in 20 and there is a cross fall on the adjoining Victor Street of a corresponding 1:20.
- The cross-sectional profile of the mall was similar to a typical road profile. It crowned in the centre and there was a swale on each side, seven metres in from the building line.
- The existing light posts, raised planter boxes, seats, bins and trees were loosely aligned in two rows. One each side of the mall roughly corresponding with the two original road kerbs.
- There was a shade structure at the intersection of Victor Street and Victoria Avenue.
- There were many existing underground services and surface access pits.
- Shop awnings extended into the mall 3 m on each side. Shop signs hung below the awning leaving a clearance of between 2.5 to 4 m.
- Victor Street was a popular sitting area, particularly in the winter because it caught the sun.
- There was a concrete base under the existing paving.
- The remnant base of the old tram line was thought to run through the mall just north of the centre line.

There was one Honey Locust, Gleditsia triacanthos ‘Sunburst’ and a further 28 smooth-leaved elms, Ulmus minor ‘Variegata’ existing within the mall. A detailed and independent arborist assessment of the existing trees was carried out. Generally the trees were considered to be in reasonable condition and vigour. However they were noted as having a relatively short safe useful life expectancy (S.U.L.E) of 5 to 15 years and they had only moderate significance. It was considered that they could be retained if desired, but should not constrain any proposed development. It was also noted that any substantial upgrade works to the mall would be likely to adversely affect the trees, given their planting often within raised and restrictive planter boxes. Also any future redevelopment of adjoining properties would be likely to affect the trees given their proximity to the awnings and building line.

From a landscape architectural perspective, Arterra believed the trees would never reach their full potential and were already compromised because they were very close to and overlapping the building awnings. Given that the life expectancy of the proposed pavement works was far greater than the S.U.L.E rating for the trees, it was recommended they be replaced.

The existing vehicular and pedestrian circulation was separated into three zones by the two rows of trees and furnishings. The two outer zones provided shelter and window-shopping opportunities for pedestrians but could only accommodate very small delivery vans. The central zone could accommodate larger service vehicles and large numbers of pedestrians and commuters moving through the space.
Figure 2: View of Victoria Avenue (Chatswood Mall) in 2009 in obvious need of an upgrade with paving heavily impacted by infrastructure upgrades and much of the furniture and fixtures now damaged and unco-ordinated. Note the position and location for the existing trees. (Photo: Arterra)

**Key project constraints**

As with all urban design projects the development had several key constraints which needed to be managed and designed as part of the work. The major factors that needed to be dealt with and addressed included:

- Client brief and desires / Fixed budget / Council politics – shops had to remain accessible throughout upgrade.
- Existing services and structures – Many major lines that could not be moved, insufficient time and budget to relocate.
- Existing grades – Shop front entries, existing sub-base/structures concrete, services, meant that major grade changes were impractical. There was also very thick concrete associated with the old tram tracks construction.
- Essential Circulation - Pedestrian, vehicles, emergency vehicles, stalls and activities needed to be accommodated.
- Existing drainage was under-utilised and there was a client desire to undertake stormwater treatment / WSUD / passive irrigation, within the realities of the space and services.
- The proposed paving type, style and performance were critical to the design.
- Trees and soil – If to be successful in the long term, it was essential to achieve soil volume, specifications, and correct species selection.
- Artwork – There was a key desire to achieve integration of meaningful public art.
- Use Program – The area needed to accommodate functions, events, and markets.
Figure 3: View early construction work illustrating one of the key constraints the soil conditions and existing tram track sleepers and massive concrete footings. (Photo: Arterra)

The concept design – A ‘clear’ vision

The final design solution replaced the existing two rows of trees with a single row in the centre of the mall. The existing light posts, planter boxes and furniture were replaced with new multi function light poles and new furniture aligned with the trees in a central spine through the mall. In short, the main idea was to de-clutter the space and open up areas for multiple uses and pedestrian movement. The stormwater was to be better controlled and utilised – using the existing grades to funnel water to the trees, filter through the soil medium and then discharge to the existing drainage system. A major public artwork was created at the highest point as one enters the Mall from Chatswood Station.

The circulation was divided into two zones, one on each side of the central spine. The overall clear circulation space therefore was slightly increased. More importantly, it became rationalised and more versatile than the existing circulation pattern. There was still a zone in the middle of the mall where people could take refuge under the trees. Each side of the mall now caters to window-shopping and large numbers of pedestrians and commuters moving through the space as well as large and small delivery and service vehicles.

The proposed design allows for outdoor café seating in the central spine as well as market stalls similar to the previous set-up. The existing shade structure at the intersection of Victor Road and Victoria Avenue was removed. This area was kept open and available for events, performances and temporary structures such as a Christmas Trees, temporary stages or marquees.

A variety of materials were considered for the paving finish. Maintenance staff, councils accessibility officer and various other Council office staff were all consulted. The proposed material chosen was a dark grey granite paving known as ‘Austral Black’. It is a highly durable material, of Australian origin, which has been used extensively in the Sydney CDB and many other urban centres.

It was used in two formats. The larger format covered the majority of the space. It was 400 mm wide by varying lengths, 400, 500 and 600. It was laid in a running bond across the mall. This makes the mall feel wider and the varying lengths allow greater flexibility for future repairs or modifications.
The smaller format known as ‘muffin tops’ are a modern version of a cobble stone which have a more even surface than traditional cobbles. These were used as highlights in the central spine and the two drainage swales. They also defined the areas that will be available for outdoor café seating.

Figure 4: Concept design of the refurbishment with new signature tree planting to centre of mall, soil volumes were accommodated clear of services and generous pedestrian movement spaces adjacent to shops. (Image: Arterra)

Figure 5: Artists impression of the mall as designed by Arterra. (Image: Arterra Interactive)
Proposed detailed landscape features and elements
A detailed analysis of currently available lighting and furnishings was carried out. Along with the new tree planting, the following new features were included in the upgrade:

- Timber bench seats with timber back rests, metal frame and arms.
- Informal seating opportunities provided via a series of sculptural concrete seatwall forms surrounding the base of the trees.
- Additional garbage bins.
- A filtered water drinking fountain and bottle refill.
- Multi function light poles similar to others already used in the Chatswood CBD. They included provisions for banners, power outlets and public address systems.
- Public telephone stands.
- Signage.

Proposed tree selection and placement
A detailed selection process was carried out to assess suitable replacement tree species. This was a highly political and emotive topic and resulted in many of the normal debates about native versus exotic, evergreen versus deciduous, large versus small. Consideration had to be given to flowering and fruit drop, branch height and forms, tolerance to urban conditions and most importantly availability in large nursery production sizes (due to short lead time). A short list of four species was presented to Council staff for review and further consideration. The preferred and proposed species was the Chinese Elm, *Ulmus parvifolia*. It is a handsome broad and spreading deciduous tree. It has proven itself to be hardy and reliable in urban settings throughout Sydney. It is not known to be highly allergenic and is not a tree which drops a lot of fruit, seed or flowers which may become messy and slippery. The deciduous habit allowed summer shade and winter sun.

It was determined that each tree would require approximately 60-70 m$^3$ of fertile growing soil to reach their full size and remain healthy long into the future. It was anticipated that the soil would need be to be fully imported because the existing sub-grade would not be suitable for growth. This was verified during construction and excavation.

Located in the middle of the mall at 15 metre centres the new trees will have room to develop a full and balanced canopy without colliding into building awnings or each other.
Tree planting and soil design
As defined in numerous arboricultural references, some of the key limiting factors to the growth and establishment of trees in urban area are inadequate soil volumes, poor soil quality and below ground conditions. As we were going to remove the existing trees, it was our aim to ensure that any new trees proposed were installed with best-practice tree planting in mind. History also showed that the space is very likely to be refurbished in 20-30 years time and we wanted to design a system that may allow the trees to withstand 2-3 refurbishments without being removed or overly affected by future work.

Provision of adequate soil volume was essential. Soil volume calculations were based on Lindsey and Bassuk (1991) which, in summary, specified 0.6m$^3$ of soil for every m$^2$ of tree crown projection. It was also noted that the surface area is often more important than the depth. The calculations undertaken were based on an ultimate 10-12m spreads on the chosen trees, and therefore each tree needed approximately 67m$^3$ of soil to sustain long term healthy growth. We wanted to aim high because construction realities will always nibble away at the final volumes. For example non-vertical excavations of trench sides, services, footings, slab depths and other variations all potentially limit the final available soil volumes.

In the final design we spaced the trees so that each tree will achieve its full canopy and shape, while still allowing for the necessary clear space for the central activity zone, overhead structures and emergency vehicle access. This resulted in 10 new trees within the mall. To achieve approximately 60m$^3$ of soil per tree on average, a total of 600m$^3$ of new soil was needed. At an ideal depth of soil, of say 600 mm deep, this equated to a surface area of 1000 m$^2$. This was almost ¼ of the malls area and therefore impractical to achieve as an open soil area in a heavily used urban space. We also wanted the trees to be able to share soil volumes as well, so it was important to connect the soil available to the trees. We also had restrictions on the depth that we could drain using existing drainage infrastructure. So how could we do it?
During the design several options were explored to achieve the usable soil volumes beneath the pavement. These included:

- Structural soils (i.e. Filler soils within a structural aggregate such as those developed by Cornell University and utilised extensively at the Sydney 2000 Olympic site),
- ‘Arborgreen’ rigid plastic reinforcing cells, and
- Suspended concrete slab on piers.

Each of these potential solutions was developed and costed. In summary the most cost effective solution on a large scale area, in the circumstances specific to Chatswood Mall, was the suspended concrete slab on piers. It is important to stress that every project would need to be assessed on its merits and special circumstances.

Structural soils were considered difficult to install and handle on the restricted site, relatively costly to acquire, and difficult to ensure consistent quality of supply and installation. There were also questions and doubts as to the total effective soil volume being taken up by the structural aggregates. There was also need to install transition layers between the structural soil and the overlying pavements which further impacted soil volumes available to the trees.

The rigid plastic reinforcing cells were seriously considered but proved to be economically unfeasible on such as large scale. They also involved difficulties and costs in engineering as to how they were to be ‘bedded’ at the base of the trench and finished at the top to achieve the satisfactory paving surface over the top. At that time, the available cells also did not easily allow services and subsoil drainage to be threaded through them.

In the final solution, a suspended reinforced concrete slab was chosen. This solution ended up costing far less than the other systems and provided numerous other benefits such as an air gap beneath the paving and the soil, maximum available soil volumes, and the ability to choose whatever soil we wanted to be placed in the trench without any structural or other considerations other than those required by the tree. It was also a system readily understood and accepted by the engineers and contractors. The only major down side was the inability to easily access any areas beneath the slab without compromising the structure. This was seen as an advantage for the trees as it may limit the desire to change or remove the slab in the future and therefore protect the roots from potential damage.

The final design resulted in an 800 mm depth of soil plus a 100 mm transition layer, plus a 150 mm subsoil drainage layer. Soil that is used in the tree pits and immediately under the pavement is 400 mm deep 90% sand-10% Menangle soil. The soil outside of the trees immediate planting pits, in the lower part of the profile, is a structural soil filler soil, with heavy clay content, good water holding, high CEC, and replicates a natural soil profile. It is 400 mm deep. The transition layer was a coarse recycled glass sand that bridged the drainage layer particle size, allowing a natural filtration between the drainage layer and the clay soils above. This prevented the need for the traditional but usually troublesome filter fabric layer, that often blocks subsoil drainage in the longer term.

The top 300 mm immediately around the planted tree is a typical imported ‘garden mix’ soil - 85% sand, 10% Menangle soil, and 5% organic matter. This is mainly for planting the shrubs surrounding each tree.
Figure 8: Longitudinal section view of the tree pit and soil profile at a typical tree planting pit - illustrating the relationship of the different soil layers and the pavements and other infrastructure. (Image: Arterra)
Figure 9: View of the continuous trench and supporting piers within the tree pits. Note the careful placement of the materials in the designed layers with care not to traffic and compact placed soils. The lowest darker layer is a fine gravel drainage layer topped by a bridging layer of coarse glass sand to avoid the use of filter fabrics. In the background the layer of ‘clay’ topsoil is placed as a 400m layer over the entire area apart from the tree planting pits themselves which needed a higher hydraulic conductivity. (Photo: Arterra)

Figure 10: View of the continuous trench with the upper sandy topsoil layer installed above the clay layer. Within this layer the multiple perforated drain lines that linked between tree pits under the pavement were installed. These provide passive irrigation during rainfall but otherwise facilitated aeration to the soil under the pavement. (Photo: Arterra)
Figure 11: View of the tree pit after the concrete slab was poured over the continuous soil trench, leaving just the tree planting hole. Note the filter fabric that was placed over the installed soil in the tree pit to avoid contamination of the soil with building materials while paving and other works were being finalised. (Photo: Arterra)

Figure 12: View of the tree pit after paving was completed but just prior to tree planting. Levels of the trees were finally adjusted and all conduits and services were installed to the designed levels prior to tree installation. (Photo: Arterra)
Figure 13: View of the trees being installed in the prepared tree pits. Note the slinging of trees via the root ball with a trunk sling only used to stabilise the tree. (Photo: Arterra)

Figure 14: Tree lines and levels were carefully adjusted with reference to the position of north at the nursery. Trees were root pruned prior to leaving the nursery and then supplied wrapped and burlapped to facilitate ease of planting and installation. Lower hession fabric left to rot in place to minimise further disturbance. Note the water applied directly to the root ball upon installation. (Photo: Arterra)
Water Sensitive Urban Design / Passive Irrigation

Although the health and well being of the trees was of the most critical importance, WSUD was still thought of seriously and the soils designed accordingly. The soils had to be conducive to water flow through, therefore a sandy mix (90% sand -10% Menangle soil) was required where the surface water entered the tree pits.

Stormwater was designed to pond in tree pit to approximately 50-100 mm depth. Virtually all the pavement drains to the tree pits to passively water the trees and then filters through the soil, removing many nutrients and pollutants. Roof water from surrounding buildings and awnings, where it was reasonable to do so, has also been re-routed to surcharge pits within the tree pit where the pit fills up and spreads out on the surface of the tree pit and then goes through soil medium.

In extreme rainfall events the tree pit fills up with water to a depth of 150 mm. Water then starts to discharge directly into a second raised inlet pit which is connected directly to the main stormwater system.

Air breather tubes were designed to come out of the stormwater pits using flexible 100 mm diameter perforated plastic pipes. When they are not filled with water (i.e. most off the time) they are filled with air to aerate the soil. When filled with water, the water runs down the slotted pipes and waters the soil under the slab and improves passive irrigation and helps prevent ‘droughtiness’ that may occur under the impermeable pavement surfaces.

There is no artificial irrigation system installed, although potable water taps for establishment watering and cleaning etc. have been installed in some of the tree pits.

Figure 15: WSUD was incorporated into the design. Each tree pit receives surface water from the surrounding pavement which is filtered through the soil medium to drainage layer and subsurface drain lines below. Most surrounding roof water is also directed to the tree pits via a surcharge pit (centre foreground). This pit has the air tubes/drainage lines which also distribute water to the rest of the soil profile under the pavement. If the rainfall is particularly intense the tree pit is designed to pond and then overflow into a slightly raised stormwater inlet (left of photo) to discharge directly to the stormwater system. (Photo: Arterra)
Conclusion
Using a limited pallet of materials and a very simple layout the upgrade transformed the aesthetics of the mall and maximised the flexibility of the space to provide for a wide variety of uses and events. The incorporation of WSUD principals have contributed to the ongoing improvements in the management of water quality in the city and the health of the trees. Using proven strategies to provide the best possible growing conditions to the new trees in the centre of the mall they will spread to form a natural green canopy over the space for the enjoyment of all. The quality and classic nature of the materials will ensure the mall retains a clean and contemporary appearance long into the future. The attention to the unseen below ground aspects of the project will hopefully see the trees retained even through the next 2 or 3 upgrades and become a valuable asset to the urban forest and character of Chatswood’s central shopping district for a very long time.
Figure 17: Photo of completed mall illustrating the calmer sitting zone and trees in the centre of the mall and the generous circulation spaces on either side for pedestrians and window-shopping. (Photo: Arterra)

Figure 18: Photo of completed mall illustrating the calmer sitting zone and trees in the centre of the mall and the generous circulation spaces on either side for pedestrians and window-shopping. (Photo: Arterra)
Figure 19: Photo of the sculptural seating walls integral to the WSUD initiatives and also a vibrant lighting feature by night. (Photo: Arterra)

Figure 20: Photo of the signature artwork, abstractly depicting the WSUD initiatives of the project and the active markets commonly held in the space occurring in the background. (Photo: Arterra).
References
Lindsey, Patricia and Bassuk, Nina. 1991. Specifying soil volumes to meet the water needs of mature urban street trees and trees in containers. Journal of Arboriculture Vol. 17, No.6: 141-149.

Project Credits
Client & Contract Superintendent Willoughby City Council
Landscape Architects / Lead Consultant Arterra Design

Consulting Arborist Treewise Men (Peter Caster)
Structural and Civil Engineering GW Engineering
Hydraulic Engineering / WSUD Advice Equatica
Electrical and Lighting WSP Lincolne Scott / Vision Design
Soil Advice and Testing Sydney Environmental and Soil Laboratory
Concrete Seat Form Advice Advanced Custom Concrete
Tree Supply Trees Impact
Head Contractor / Construction Landscape Solutions
Arboricultural strategies for climate change

Greg M Moore
Burnley College, University of Melbourne
500 Yarra Boulevard, Richmond, Australia 3121

Introduction
While it is usually assumed that the impacts of climate change on street trees and urban forests will be deleterious, the real scenario will be more subtle. Some species will benefit from climate change and others will be disadvantaged. Some cities will be largely unaffected while others will experience major changes in the vegetation of public open space. It is an ill wind that blows nobody good and the winds of climate change will bring good and bad for tree managers.

All ecosystems will be affected by climate change that includes increases in global air temperatures, increases in atmospheric CO₂ concentrations, change in the patterns and amounts of annual precipitation, more frequent and intense storms and changes in the frequency and severity of wildfires (IPCC 2007).

It is difficult to predict the impact that change might have on species that constitute streetscapes and urban forests, but the most significant factors likely to impact on species making up urban forests are:

- increased temperatures
- changes to rainfall patterns
- greater storm intensities
- more severe droughts
- altered fire frequencies affecting peri-urban areas

The impacts of climate change on urban trees will not be uniform which will make decisions related to planning and managing urban forests difficult. However, understanding tree biology and physiology will allow active tree management. It may be possible to take advantage of some of the changes brought on by climate change to manage urban trees and forests so that they can cope more effectively and efficiently with likely changes. This paper presents a number of scenarios relevant to urban street trees and urban forests and strategies that might be useful to arborists as climate changes.

Urban arboricultural strategic management

Tree selection
Many trees that are widely planted in cities and regarded as great urban trees are renowned for their wide tolerance ranges. They have great environmental resilience and tolerance of a wide range of soil, rainfall and temperature conditions. In Australia, many of the common native urban trees come from populations that have wide and extensive natural distributions. Careful provenance selection and breeding using temperature and drought tolerance as criteria should ensure that there are suitable intraspecific selections to meet urban planting demands (Table 1).
Table 1: Simplified strategic management matrix for urban trees during climate change (Moore 2011)

<table>
<thead>
<tr>
<th>Species Characteristics</th>
<th>Likely Impact of Climate Change</th>
<th>Management Strategy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Widely dispersed over a broad range</td>
<td>Low</td>
<td>Select propagation material from appropriate provenance</td>
</tr>
<tr>
<td>Higher temperature and drought tolerance</td>
<td>Low</td>
<td>Monitor performance and expand planting</td>
</tr>
<tr>
<td>Restricted range</td>
<td>High negative</td>
<td>Monitor performance and consider related species with tolerance of warmer, drier conditions</td>
</tr>
<tr>
<td>Prone to insect grazing as higher temperatures lead to increased insect numbers</td>
<td>High negative</td>
<td>Monitor insect number and use integrated pest management with extreme high wind and temperature days</td>
</tr>
<tr>
<td>Luxury water user with little capacity for stomatal control</td>
<td>High negative</td>
<td>May only be viable where irrigation is available</td>
</tr>
<tr>
<td>Possession of adaptations to high levels of environmental stress</td>
<td>Low</td>
<td>Make full use of available adaptations above and below ground and over time</td>
</tr>
<tr>
<td>General stress tolerators</td>
<td>Low</td>
<td>Monitor performance and expand planting</td>
</tr>
<tr>
<td>General stress avoiders</td>
<td>High negative</td>
<td>Monitor performance and plant only where favourable management conditions allow survival</td>
</tr>
<tr>
<td>Drought prone or reduced urban growth with limited water availability</td>
<td>High negative</td>
<td>Plant only in urban areas where irrigation is practical and efficient</td>
</tr>
<tr>
<td>Species prone to native mistletoe infection</td>
<td>Moderate positive</td>
<td>There may be reduced mistletoe numbers due to hot windy days, which could be an advantage in mistletoe management</td>
</tr>
<tr>
<td>Seed set reduced, especially if night temperatures rise</td>
<td>Moderate positive</td>
<td>May be an advantage when fruits or seeds are problematic in cities</td>
</tr>
<tr>
<td>Increased photosynthetic rate for many species if water is available</td>
<td>Moderate positive</td>
<td>May be an advantage with higher establishment, growth rate and denser canopy</td>
</tr>
<tr>
<td>Increased respiratory rate over a wide range of increased temperatures</td>
<td>Moderate positive</td>
<td>Enhanced tree establishment, growth and canopy density with efficient irrigation</td>
</tr>
<tr>
<td>Higher transpiration rate as temperatures rise</td>
<td>High negative</td>
<td>May only survive if irrigated</td>
</tr>
<tr>
<td>Frost sensitive when young</td>
<td>Moderate positive</td>
<td>Small, young trees may be grown without protection from frost</td>
</tr>
</tbody>
</table>

If species’ ranges are limited, there is the option of selecting different species from within a genus. This is the case with the genera, *Eucalyptus* and *Acacia* within Australia, where there are large numbers of related ands often visually similar species occupying a broad range of habitats. For Australian species, studies on the provenances of *Lophostemon confertus* (Williams 1996) and *Tristaniopsis laurina* (Looker 2001) from different climate and soil conditions have been undertaken, which provide data for making urban selections for changed climates.

**Street tree establishment**

Warmer temperatures may allow more rapid tree growth if there is sufficient water available (Clark *et al.* 2011). In some cities this would allow easier and more rapid street tree establishment. Trees that may have been restricted in their planting due to frost sensitivity may be considered for planting or planted at an earlier age as the frequency of frosts and their intensity reduces (Table 1).
Furthermore, the warmer temperatures should see more rapid root growth so that when street trees are planted root systems should extend into the surrounding soil from the root plate and planting hole more rapidly. This should enhance overall tree growth allowing a more rapid and efficient tree establishment. This would be beneficial for street trees where rapid early growth and establishment is considered an advantage as trees make an impact on the streetscape more quickly.

To capitalize on these advantages, however, there must be attention to ensuring that there is sufficient water available so that growth is not restricted. There must also be action in relation to insect grazers. As temperatures increase the numbers of insects attacking street trees are likely to rise and the period over which they graze is likely to be longer. This could have a devastating effect of individual trees and urban forests (van Mantgem et al. 2009).

Street tree strategy, Eucalypts and Lignotubers

Lignotubers are swellings that develop at the base of the stems of most eucalypts and which occur either at or just below the soil surface. These ‘woody tubers’ have the same anatomical features as the tree stem (Jacobs 1955; Chattaway 1958; Bamber and Mullette 1978), and Carrodus and Blake (1970) found that the carbohydrate content of the stem and the lignotuber were not significantly different. Their real significance is as a reservoir of a large number of protected, dormant buds (Carrodus and Blake 1970). The basal burls of northern hemisphere trees would appear to be similar structures.

Lignotubers are vital adaptations for the survival and persistence of eucalypts under adverse growing conditions (Jacobs 1955; Chattaway 1958; Carrodus and Blake 1970). Regeneration of trees from lignotuberous shoots after damage due to wind, drought, salt, waterlogging, fire, grazing and insect attack enhances the eucalypts’ resistance to, or recovery from, environmental stresses (Jacobs 1955).

Not all eucalypts possess lignotubers. There are species such as *E. regnans*, *E. fastigata* and *E. delegatensis* which do not possess lignotubers at any stage of their development. In other species such as *E. obliqua* and *E. camaldulensis*, some populations possess lignotubers while others do not (Table 2). In these situations, the populations growing in harsh, stressful environments usually have lignotubers and their counterparts in cooler, wetter, more temperate environments do not. This may be a useful characteristic in selecting eucalypts for future use in urban environments – lignotuberous species are likely to be harder than non-lignotuberous species as climate warms and dries. Within a species, lignotuberous populations will tend to be harder than their non-lignotuberous relatives.

**Table 2: Some non-lignotuberous species and some which may or may not possess a lignotuber (Moore 1981).**

<table>
<thead>
<tr>
<th>Non-lignotuberous species</th>
<th>Species which may or may not be lignotuberous</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>E. regnans</em></td>
<td><em>E. camaldulensis</em></td>
</tr>
<tr>
<td><em>E. delegatensis</em></td>
<td></td>
</tr>
<tr>
<td><em>E. grandis</em></td>
<td><em>E. obliqua</em></td>
</tr>
<tr>
<td><em>E. diversicolor</em></td>
<td></td>
</tr>
<tr>
<td><em>E. gomphocephala</em></td>
<td></td>
</tr>
<tr>
<td><em>E. nitens</em></td>
<td></td>
</tr>
<tr>
<td><em>E. astringens</em></td>
<td></td>
</tr>
<tr>
<td><em>E. pilularis</em></td>
<td></td>
</tr>
</tbody>
</table>

Even when lignotuberous shoots are produced, survival is not guaranteed as many will subsequently die, but those which survive often grow at very rapid rates. If more than one lignotuberous shoot survives and develops, their point of attachment to the trunk may be compromised and so arboricultural intervention may be required. However, the existence of a lignotuber and a well-developed root system represent a substantial urban asset and they should be used where appropriate for rapid tree re-establishment.
Strange and unusual benefits of climate change

As with many environmental matters, climate change will have both positive and deleterious aspects. Biological homeostatic mechanisms mean that ecosystems and their components tend to counter change to remain in equilibrium. This usually means that there are predictable and unpredictable consequences when human beings significantly alter ecosystems. Thus while there is a justifiable focus on the negative effects of climate change there will be benefits, some of which will be strange, unusual and expected.

Elm leaf beetle deaths

Climate change may have diverse and unexpected effects on trees and urban forests (Kramer et al. 2000). Usually insect predation increases as temperatures rise due to large increases in insect population numbers in warmer weather. The increased insect grazing often outpaces increased tree growth in the warming climate leading to significant increases in tree mortality (van Mantgem et al. 2009).

In many parts of south-eastern Australia, elm leaf beetles have proved a significant pest affecting European elms since the mid 1990s. During the prolonged dry period they caused significant damage leaving entire tree canopies with shot hole symptoms and adding to the stress experienced by the trees. However, on the record hot day of February 7th 2009 in Victoria when temperatures rose to 46.4°C, under the canopies of many mature elm trees in Melbourne, large numbers of elm leaf beetles were found dead. The beetles had not survived the high temperatures and strong winds but the foliage had.

A favourable winter and spring followed and many trees showed recovery from the years of below average rainfall. Furthermore foliage was not decimated by elm leaf beetle grazing over the following summer. Continued good rainfall saw another fine spring and summer in 2010-11 with many trees showing even more impressive recovery from the long dry period with fuller canopies and greater leaf production. This resulted in a display of autumnal colour in 2011 that was widely commented upon (Webb 2011).

The killing of insect pests may have been more widespread in its occurrence than reports suggest and if this is so there may be the possibility of integrating elm leaf beetle control programs, such as banding and spraying with predictions of hot windy days. Such a strategic opportunity might prove both environmentally and economically beneficial.

The physiology of autumn colour

The autumnal colours have been brilliant in Victoria and for much of south-eastern Australia in 2011. In some ways it is a return to the autumn splendour of the past, but the additional colour has not been simply enhanced by a nostalgic view through rose coloured glasses. The added colour is real and understanding why gives us a glimpse not only of plant biology but what might happen as the climate warms (Webb 2011).

The colours are much brighter this year because the weather – excellent spring and summer rainfall – has allowed luxuriant foliage growth for the first time after the fourteen years during which we endured below average rainfall. The prolonged dry period resulted in a thinning of tree canopies and premature and sporadic leaf shedding. Trees, such as elms and planes, were subdued by the dry, warm weather, shedding leaves over summer as drought stress took its toll. When autumn came there were fewer leaves to shed and these were duller. So autumn crept almost unnoticed upon winter.

In 2011, prolific growth has seen trees retain a full canopy of bright green foliage over summer and into early autumn. Then colder autumn days triggered a full and rapid withdrawal of chlorophyll from leaves revealing the yellow and browns in a matter of days. Leaves have been shed simultaneously, quickly and in huge numbers. Furthermore, there have been many more fallen leaves rustling in the breeze, for walking and scuffing your way through and for raking and composting!

The mild spring and summer that allowed trees to retain their leaves also resulted in trees accumulating large amounts of sugar from extended photosynthetic activity. So much sugar was produced that some was converted to pigments such as anthocyanins which are stored in the vacuoles of leaf cells. These pigments can range in colour from pale yellows, through the various oranges, to the most wonderful deep crimsons and reds. When the temperatures drop, once again the removal of chlorophyll is triggered, but instead of the pale yellow and browns emerging, in species such as liquidambar, maples and claret ash, the hues are orange and red.
The long warm dry period may have provided a glimpse of what global climate change might have in store. There may be long dry periods in a warmer future but there will still be mild wet summers and cold autumnal days from time to time. When this occurs autumn colour will be back in all its glory, and it will be noticed. Perhaps for once we do know what we’ve got before it’s gone, or at least before it becomes rarer as climate warms!

Tree physiology and mistletoe

Over the years of below average rainfall in south eastern Australia (1997-2010), a number of very old remnant native trees, particularly river red gums (*Eucalyptus camaldulensis*), died due to heavy infestation with mistletoes and the subsequent effects of drought. The mistletoes are native species too (mainly *Amyema* species or *Muellerina eucalyptoides*) and have their place in the ecology of plant communities, but mistletoe numbers seem to have increased due to spread by exotic birds and changed fire regimes.

Mistletoes are essentially water parasites on the host species, and the host branch beyond the point of mistletoe attachment often dies. Many of the old trees that died, or are in danger of dying, were carrying in excess of 40-50 individual mistletoe plants, which is excessive. These trees are often the last significant seed trees on the sites from which future generations of trees can be sourced.

The situation calls for sophisticated and professional management by those managing significant landscapes. Older trees should be surveyed to ascertain mistletoe numbers. Steps should then be taken to remove most, but not all of the mistletoe plants if infestations are considered to be excessive. A large native tree with a full canopy and good condition should cope with about 5 or 6 mistletoe plants. Any mistletoe in excess of this number should be removed by cutting the mistletoes at the base, but not cutting into the host tree. Such a balanced management approach should see sustainable management of both mistletoes and their hosts for future generations of Australians.

While it is usually assumed that the effects of climate change will be negative, and they may be, there will be some advantages. In Victoria, in February 2009 when temperatures rose to 46.4°C, an unexpected consequence of the high temperatures was the killing of many of the mistletoes affecting older eucalypts (Table 3). The foliage on the trees survived as it seemed to cope with the high temperatures and strong winds. Interestingly, similar mistletoe deaths have been observed in non-eucalypt species, including *Platanus x acerfolia* and several *Prunus* species. The effect of high winds and temperatures in killing mistletoes may thus have a broader impact on urban tree species.

For one *Eucalyptus camaldulensis* specimen, over 50 of the 60 mistletoes growing on it died and 2 years later the tree remains largely mistletoe-free. *E camaldulensis* is a luxury water user with very limited stomatal control (Pate and McComb 1981) and there is some evidence (Davidson, True and Pate 1989) that at least some of the mistletoes also have poor stomatal regulation. This would appear logical as there would be little advantage for a water and nutrient parasite to have stomatal control when it has first access to the hosts water and nutrient stream.
Table 3: Number of mistletoe growing on Eucalyptus camaldulensis trees prior to, one month, and 30 months after
the 46.4°C day of February 7, 2009.

<table>
<thead>
<tr>
<th>Tree Type</th>
<th># of Trees</th>
<th># of living mistletoe per tree prior to 46.4°C day</th>
<th># of living mistletoe per tree 1 mth after 46.4°C day</th>
<th>Total # of mistletoe 30 mths after 46.4°C day</th>
<th># of new mistletoe after Feb 7 2011</th>
<th># of living mistletoe prior to 46.4°C day</th>
</tr>
</thead>
<tbody>
<tr>
<td>Young</td>
<td>10</td>
<td>2</td>
<td>0</td>
<td>20</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Young</td>
<td>10</td>
<td>1</td>
<td>0</td>
<td>10</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Young</td>
<td>5</td>
<td>3</td>
<td>0</td>
<td>15</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Semi</td>
<td>5</td>
<td>6</td>
<td>0</td>
<td>30</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Semi</td>
<td>4</td>
<td>5</td>
<td>0</td>
<td>20</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Semi</td>
<td>1</td>
<td>4</td>
<td>0</td>
<td>4</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Mat</td>
<td>1</td>
<td>60</td>
<td>10</td>
<td>50</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td>Mat</td>
<td>1</td>
<td>12</td>
<td>2</td>
<td>10</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Mat</td>
<td>1</td>
<td>20</td>
<td>4</td>
<td>16</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>Mat</td>
<td>1</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Mat</td>
<td>1</td>
<td>4</td>
<td>1</td>
<td>3</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Mat</td>
<td>4</td>
<td>5</td>
<td>2(8)</td>
<td>12</td>
<td>2</td>
<td>10</td>
</tr>
<tr>
<td>Mat</td>
<td>2</td>
<td>8</td>
<td>1(2)</td>
<td>14</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>TOTAL</td>
<td>46</td>
<td>237</td>
<td>27</td>
<td>210</td>
<td>9</td>
<td>31</td>
</tr>
</tbody>
</table>

Note: Mat are older large trees >20m height with dbh >40cm, Semi are semi-mature trees <15m height with 20<dbh<40cm and Young are trees <10m in height and with dbh<20cm.

However on days of extreme high temperature and wind it seemed that the mistletoe reached permanent wilting before at least some host species, resulting in the death of the parasite. The pattern of mistletoe death is consistent with this hypothesis as nearly all of the mistletoe on the extremities of the canopy died while those that survived seemed to be on older, larger branches within the canopy and closer to the trunk. Furthermore, after the death of the mistletoe, many of the host trees produced significant epicormic growth on the ad axial parts of branches close to the dead mistletoe.

Once again there is a strategic opportunity for urban tree managers to integrate climatic events with mistletoe control programs. It appears that hot windy days may have a role similar to fire in limiting mistletoe numbers, which could prove very useful especially in peri-urban areas where the occurrence of fire is rare or the risks of fire are too great.

Efficient water use on hot windy days

If water is available, most trees time their stomatal opening to coincide with sunrise. They anticipate the right level of light for photosynthesis to maximise both light and water use. Consequently, most tree species tend to photosynthesize most effectively and efficiently in the morning.

However, if water is limiting many, but not all, tree species will close their stomata, often sometime between around noon and 2pm. The trees then conserve water but may go into water deficit with a declining internal water potential, which can adversely affect growth and development. Thus the trees need to restore their internal osmotic balance by taking up water before the next morning. Many trees recharge their water deficits from the soil overnight and just before dawn they are back to normal internal water potential.
Therefore irrigation in the early morning allows trees to maintain photosynthetic activity before water becomes limiting. Thus with shallow spreading root systems typical of urban trees, early morning irrigation using drippers or leaky pipe under mulch is a logical strategy to maximise growth and foliage development. This should provide effective urban tree development and establishment while ensuring high levels of water use efficiency.

**Trees can mitigate flood damage by slowing water flows**

Under the climate change scenarios predicted for south-eastern Australia there will be more severe weather events more often with associated stronger winds and more intense rainfall. In many places there will be reduced annual rainfall but more intense summer rainfall, leading to major summer flooding events.

While it has long been appreciated that trees have a role in mitigating localised flooding in urban areas by holding and absorbing water during intense rainfall events (Moore 2006; Killicoat *et al.* 2002), it seems to have been forgotten that planting trees along waterways can reduce the rates of water flow during floods. A consequence of this is that trees may also spread the flood waters over a greater area, which may be problematic. However, if properly planned along urban waterways where mitigation basins are common, planting trees can slow the water and reduce the risks of soil erosion and infrastructure damage due to flooding.

Along Taylor’s Creek, Keilor, trees planted in a revegetation scheme in the mid 1980s have slowed flood water, reducing erosion and stream side scouring. The waters are spread over a greater area but this is available and so does not result in damage. An unexpected consequence has been that litter is spread away from the creek and so does not enter the Maribyrnong River or Port Philip Bay. The economic benefits of both reduced erosion and easier local litter collection could be readily established.

**Conclusion**

Rising sea levels are not just the result of the melting of the polar icecaps, but also from the expansion of water as temperature increases. Most major Australian cites are at, or near, sea level as they are or were ports. This means that in many of these cities there is likely to be at least some inundation, even if it is locally restricted. There will be a need to redevelop and protect significant urban areas from these rising seas. This may provide an opportunity to develop new sustainable urban forests under conditions where they thrive.

It is worrying that at a time when urban trees and public open space are finally being recognised as the urban infrastructure assets that they are, that public and private open space and urban forests are being threatened and lost in all major Australian cities. In all cites, in-fill and high density developments are putting the benefits of open space for future generations at risk. This will impact on the capacity of cities and regions to counter at least some of the effects of global climate change, which will have a deleterious affect on human health, social structures and the economic components of our society as well as the environment.

It is frustrating that just when it is becoming clear that the future sustainability of our cities requires open space and urban forest canopy that they are being lost. There are significant opportunities for proactive urban tree management in Australian cities that must be captured if our cities are to cope with global climate change.

**Acknowledgements**

The author acknowledges the assistance of Ms E Moore, linguist, for her helpful comments on the manuscript.

**References**


Jacobs M R (1955) Growth habits of the Eucalypts. For and Timb Bureau, Canberra.


Studying the effects of rising atmospheric CO$_2$ concentration on the water use efficiency of *Eucalyptus saligna*

Dr Craig Barton  
NSW Department of Primary Industries

**Introduction**

Atmospheric CO$_2$ concentration ($C_a$) has risen from 280 µmol mol$^{-1}$ to the current concentration of ca. 390 µmol mol$^{-1}$ over the last 150 years, and continues to rise at a rate of 1.5 – 2.0 µmol mol$^{-1}$ per annum (Canadell et al. 2007). Exposure to elevated $C_a$ generally stimulates tree growth (Curtis and Wang 1998; Norby et al. 1999), increases (20 - 80%) leaf level light-saturated photosynthesis ($A_{sat}$; reviewed in Ellsworth et al. 2004; Ainsworth and Rogers 2007), decreases leaf-level stomatal conductance ($g_s$; Berryman et al. 1994; Medlyn et al. 2001; Ainsworth and Rogers 2007), and subsequently increases leaf-level water use efficiency (WUE; Field et al. 1995; Wullschleger et al. 2002; Morgan et al. 2004). Although we have excellent techniques for directly measuring gas exchange in single leaves of plants exposed to elevated $C_a$, few experimental systems resolve gas exchange in elevated $C_a$ at larger scales (Wallin et al. 2001; Dore et al. 2003). Ecophysiological schemes for scaling leaf-level behaviour to larger scales can only approximate CO$_2$ and water fluxes at the whole-tree level. In order to validate such models, we require a system to measure whole-tree fluxes of CO$_2$ and water and their response to the environment.

The Hawkesbury Forest Experiment (HFE) established at the University of Western Sydney’s Hawkesbury campus sought to test the response of Australian plantation *Eucalyptus* to elevated atmospheric [CO$_2$] and drought, and parameterise models to predict effects of these factors on net CO$_2$ assimilation, water use and growth of *Eucalyptus* trees. *Eucalyptus saligna*, a commercial plantation tree of wet sclerophyll forest origin, was successfully exposed to elevated atmospheric [CO$_2$] whilst ambient temperature and humidity conditions were maintained inside whole-tree chambers (WTC). A single *E. saligna* (Sydney Blue Gum) tree was grown from seedling to 6.5 m tall within each of 12 WTCs for more than one year. Six WTCs were maintained at ambient $C_a$ and six WTCs were maintained at elevated $C_a$ (ambient $C_a$ + 240 µmol mol$^{-1}$). All 12 WTCs were controlled to track ambient outside $T_{air}$ and air water vapour deficit ($D_{air}$). Chamber performance characteristics are described in addition to the impact of elevated $C_a$ on the instantaneous water use efficiency and potential implications for forest water use and growth.

**Whole tree chambers**

Twelve whole-tree chambers (WTCs; Fig. 1), previously used in an elevated $C_a$ experiment in a boreal forest in Sweden (Medhurst et al. 2006), were shipped to Australia and installed at the HFE in July 2006 (Barton et al. 2010). Within each WTC, one seedling of *E. saligna* was planted in April 2007 and supplied with an initial fertilisation of 50 g of (NH$_4$)$_2$PO$_4$ and 10 mm of water every 3rd day to ensure good establishment. Six WTCs were operated to track ambient $C_a$ and six WTCs were operated at elevated $C_a$ (ambient $C_a$ + 240 µmol mol$^{-1}$). All 12 WTCs were controlled to track ambient outside $T_{air}$ and air water vapour deficit ($D_{air}$). A treatment target $C_a$ of +240 µmol mol$^{-1}$ was chosen to be similar to $C_a$ used in recent free-air CO$_2$ enrichment experiments, and is anticipated in ca. 50 years (Pacala and Sokolow 2004).

The temperature control system consisted of a central refrigeration plant that cooled a glycol/water solution to slightly below (1-2°C) the dew-point temperature of the ambient air. The coolant was delivered to each WTC, where it circulated through a large surface area heat exchanger (2 m x 1 m) mounted in housing on the south side of the WTC. WTC air was continuously circulated through the housing by a frequency controlled fan at a rate of approximately 10,000 m$^3$ hr$^{-1}$. Variable baffles regulated by a microprocessor controller in each WTC diverted a portion of the air through the heat exchanger, where it was cooled to the temperature of the coolant before re-entering the WTC (Fig. 1). Excess moisture in the airstream, resulting from transpiration by the tree, was condensed, and then collected and measured using a small tipping bucket pluviometer with a 5 mL resolution (Rain-o-matic, Pronamic, Denmark).
Whole tree carbon and water fluxes

Each WTC was operated as a hybrid between an open-mode and null-balance gas exchange system (Medhurst et al. 2006). Air volume in the WTC was 50 m$^3$ with a continuous supply of fresh air entering the WTC at a rate of 10 L s$^{-1}$. A manually adjustable iris orifice allowed adjustment of the flow of fresh air while a digital manometer constantly monitored the pressure drop across the orifice, and thus allowed continuous measurement of the airflow. Pure CO$_2$ was metered into this air stream to maintain the chamber at its target $C_a$; hence, the null-balance aspect of whole-tree gas exchange. Air was continuously sampled from each WTC and from a reference line mounted 5 m above the ground, and transported through heated tubing to a manifolded set of 13 three-way solenoid valves, eventually reaching the central infra-red gas analyser (IRGA; Licor 7000, Li-Cor Lincoln, Nebraska) in the control cabin. The IRGA measured the concentration of CO$_2$ and water vapour in the chamber air and a mass balance calculation then provided an estimate of carbon and water fluxes. A full cycle of measurements, including all 12 WTCs and two reference readings, took 14 minutes; whole-tree CO$_2$ and H$_2$O fluxes were calculated every cycle (see Barton et al. 2010 for full description of chamber function).

Tree chamber performance

The whole tree chambers maintained the target CO$_2$ concentrations close to the target values (< 15 ppm deviation from target 90% of the time). Night time respiration by the tree canopy led to slightly higher than target values of CO$_2$ in ambient chambers as there was no ability to remove excess CO$_2$; this discrepancy dissipated rapidly on sunrise as photosynthesis commenced. Despite high radiation loads at high ambient temperatures, we were able to control $T_{air}$ within ± 1°C for 90% of the time across a range of temperatures from -2.8 to 43.8°C. $T_{a}^{-1}$ in the WTCs increased by 1 - 2°C relative to ambient air in the few minutes after dawn, when $T_{air}$ was close to dew point. This transient increase was due to the maintenance of coolant liquid at or slightly below dew point. Under such conditions, there was no temperature differential between the heat exchanger and the chamber air. In addition, when extremely dry air (dew point temperature of -1°C) and high $T_{air}$ (35°C) conditions occurred, the cooling unit was unable to chill the coolant to the target value. Although a sufficient temperature reduction was maintained to enable regulation of chamber temperatures, WTC humidity was higher than outside air. Under such extreme conditions, $D_{air}$ was ~ 4 kPa in the WTCs while outside $D_{air}$ was ~ 5 kPa; failure to control humidity during these transient and extreme conditions was rare. A small difference in chamber $D_{air}$ was observed in relation to tree size and transpiration rate. As trees get bigger they intercept a higher proportion of the radiation load on the chamber furthermore rapidly transpiring trees effectively self cool and so require less cooling from the control system. This variable partitioning of the radiation load between sensible and latent heat combined with the common temperature of the coolant among chambers makes it difficult to match the humidity and temperature simultaneously among chambers. It is important to take this into account when analysing the data (Barton et al. 2011). Subsequent modifications to the temperature control system allowing different temperatures of cooling coil at each chamber has improved the ability to independently regulate temperature and humidity among trees of varying size and transpiration rates and a new experiment studying the interaction of rising $C_a$ and temperature on *Eucalyptus globulus* is underway.
Figure 1 Schematic diagram of a whole-tree chamber. The modular chamber consisted of three main components (A, B-D, and E): the chamber base (soil compartment), the tree chamber (aboveground compartment) and a cooling unit placed directly outside the chamber. The diameter of the WTC was 3.25 m. The chamber base (A) was approximately 0.45 m high. The tree chamber consisted of a bottom (B) and top (D) section with a height of 2.5 m and 3.0 m, respectively. An extra section (C), with a height of 2.65 m was added as the trees grew. Major components of the system are indicated in the diagram with numbers: (1) pipe for circulating the chamber air through the cooling unit; a cooling unit (E) consisting of: (2) frequency-controlled fan (0 - 12,000 m³ h⁻¹); (3) dampers to regulate the amount of air going through the cooling unit; (4) large-surface area heat exchanger; (5) circulating a glycol/water solution maintained at ambient dew point temperature; and (6) fresh air inlet; (7) fan for fresh air; (8) iris damper for flow control of fresh air intake; (9) safety fan connected to a diesel generator, which starts in case of power failure; and (10) a 12-V controlled safety damper working in parallel with a similar damper at the top of the WTC; (11) root barrier to depth of 1 m (see Barton et al. 2010 for full description).
**Instantaneous Transpiration Efficiency**

Instantaneous transpiration efficiency is defined as the ratio of carbon uptake per unit water transpired and as such is sensitive to any changes in both photosynthesis and stomatal conductance in response to elevated $C_a$. While it is well-known that ITE increases with rising $C_a$ (Rogers *et al.* 1983; Eamus 1991; Drake *et al.* 1997), we hypothesised that ITE increases *in proportion to* $C_a$. The hypothesis that ITE increases in proportion to $C_a$ follows (Medlyn *et al.* 2011) from the original theory of optimal stomatal behaviour proposed by Cowan & Farquhar (1977). Stomatal conductance is subject to a trade-off between carbon uptake and water loss. The theory of Cowan & Farquhar (1977) defines the optimal stomatal conductance as that which maximises daily photosynthetic carbon uptake for a given daily water loss. Data from the whole tree chambers allows us to test this hypothesis at both leaf and whole tree scales.

We increased $C_a$ by 60% and so according to the hypothesis the ITE should also have increased by 60%. We calculated the mean value for ITE for each chamber in 2 hour windows from dawn to dusk for each day between 14th April 2008 and 3rd March 2009 and then calculated the mean value across ambient or elevated CO$_2$ chambers. Because the vapour pressure deficit was slightly different among chambers and this influences transpiration rate it was necessary to use VPD as a covariate in the analysis. Plotting ITE against VPD and calculating the ratio of elevated to ambient at various values of VPD allowed us to test the hypothesis that ITE increased in proportion to the rise in CO$_2$ (Figure 2). The ratios are shown at the bottom of the chart and do indeed show that the response of ITE is proportional to the rise in CO$_2$ (see Barton *et al.* 2011 for a more detailed analysis).

![Figure 2 Instantaneous Transpiration efficiency (A/E) plotted against chamber vapor pressure deficit for ambient and elevated chambers. Each point is the mean of three chambers during a 2 hour window from dawn to dusk when light (PPFD) was >600 µmol m$^{-2}$ s$^{-1}$. The numbers at the bottom of the chart are the ratio of ITE in elevated chambers to that in ambient chambers at a range of values of VPD.](image-url)
Conclusions
The ratio of CO$_2$ uptake ($A$) to transpiration rate ($E$), the instantaneous transpiration efficiency (ITE), is important because it reflects efficiency of resource use by plants and canopies. At larger scales, canopy ITE affects trade-offs between carbon sequestration and water availability (Jackson et al. 2005).

We found that ITE is strongly dependent on vapour pressure deficit ($D$), showing that $D$ needs to be carefully monitored and used in analyses of ITE. When differences in $D$ were taken into account, ITE was directly proportional to the atmospheric CO$_2$ concentration ($C_a$) at both leaf and canopy scales in *Eucalyptus saligna*; literature data appears to support this general conclusion. Importantly, these results allow us to predict the effect of elevated $C_a$ on $E$, where effects on $A$ are known. In our study, we found that $A$ was more enhanced by $C_a$ at higher $D$, and from this finding were able to explain the $C_a$ effect on $E$ and its interaction with $D$.

Acknowledgements
The Hawkesbury Forest Experiment involves a number of collaborators from multiple institutions. The results presented here are being published in the scientific literature and full accreditation is provided in those papers. The Hawkesbury Forest Experiment was supported by the Australian Greenhouse Office Grant 0506/0085 and subsequently by the Commonwealth Department of Climate Change. Additional funding was received from the NSW Department of Environment and Climate Change (Grant T07/CAG/16), and the Australian Research Council (Grants DP0881221 and DP0881765). The whole-tree chambers were provided by the Swedish University of Agricultural Sciences.

References


The use of trees in urban stormwater management

E.C. Denman, P.B. May, G.M. Moore
University of Melbourne

This paper has been presented previously at the Urban Trees Research Conference, “Trees, people and the built environment”, 13 & 14 April 2011, Birmingham, UK and the ISA Annual Conference, 25 – 27 April 2011, Sydney.

Abstract
Sustainable stormwater management presents unique challenges and opportunities in the urban built environment. The disposal of stormwater directly from impervious urban surfaces into surrounding waterways is detrimental to the aquatic environment. In response to this, processes such as evapotranspiration and soil and groundwater recharge are increasingly being used so that hydrological patterns of urban areas more closely mimic natural areas. Vegetation, including urban trees, affects many of these processes and is an important component of stormwater management.

An experiment was conducted in Melbourne, Australia to assess the potential role of street trees in urban biofiltration systems. Four tree species, *Eucalyptus polyanthemos* (Red Box), *Lophostemon confertus* (Brush Box), *Callistemon salignus* (Willow Bottlebrush) and *Platanus orientalis* (Oriental Plane) were grown in three different constructed soil profiles, including one chosen for its low, and potentially growth limiting drainage rate. The plants were irrigated with tapwater (potable) or a model stormwater solution. In general, tree growth, in all soils, was increased when the irrigation was with the model stormwater solution.

Compared to unplanted controls, the presence of trees in the biofiltration system resulted in significant reductions of the soluble nitrogen and phosphorus concentrations of the stormwater. In general, biofiltration systems effectively reduced the filterable reactive phosphorus (FRP) concentration of stormwater. The treatment of nitrate plus nitrite (NO\textsubscript{x}) concentration of stormwater was more variable from planted systems with reductions achieved during cooler months while NO\textsubscript{x} was generated during warmer months.

Species selection did not appear to be an important element in terms of system success. Profile planted with the deciduous species performed similarly in terms of nutrient removal to the systems with evergreen species, although there was some seasonal variation. Incorporating street tree plantings as stormwater treatment measures offers an exciting opportunity to create multi-functional landscapes.

Keywords: trees, stormwater, biofiltration

Introduction
Urbanisation changes many attributes of the land that is developed. One of these is a reduction in the permeability of surfaces that can lead to modified patterns of runoff and increased loads of pollutants entering downstream waterways. The degree of impervious surfaces or perhaps more importantly, the nature of the pathway between where the stormwater is generated and where it flows into the receiving waters, can be important predictors of the extent of disturbance to the health of aquatic ecosystems (Taylor et al., 2004, Walsh, 2004, Hatt et al., 2004). Approaches that are used to offset this disturbance are known by various names that include water-sensitive urban design (WSUD) (Australia), sustainable urban drainage systems (SUDS) (UK) and low impact development (LID) (USA). Urban trees are an important component of these more sustainable approaches to stormwater management.

Biofiltration systems, also known are raingardens or biofilters, are one of the strategies used as part of WSUD to improve the quality and reduce the quantity of urban stormwater runoff. Biofiltration systems direct stormwater runoff into a treatment area that has plants growing in a moderately permeable soil. The run-off percolates through the system and a combination of physical, chemical and biological processes reduces the nutrient and sediment load of the runoff. The volume and speed of delivery of run-off directed into waterways is also reduced if stormwater is retained within the systems. Most biofilters use herbaceous species (grasses, sedges and rushes are common) but in highly urbanised locations, such as streets, trees may be more suitable vegetation. While an extensive literature exists that discusses the performance of predominantly herbaceous biofiltration systems (Davis et al., 2006, Blecken et al., 2007, Henderson et al.,...
2007, Bratieres et al., 2008, Read et al., 2008) systems using large, woody vegetation are less well documented.

This paper examines existing literature on the performance of woody plants in stormwater management systems and also reports on an experiment that investigated the use of four street tree species (Eucalyptus polyanthemos, Lophostemon confertus, Callistemon salignus and Platanus orientalis) in model infiltration systems. All of these species are used as street trees in south-eastern Australia.

**The use of woody plants in stormwater management systems**

Urban trees can contribute to stormwater management in a number of ways. Stormwater run-off can be reduced by the evaporation of rainfall intercepted by the canopy and transpiration losses, while stormwater quality can be improved by retention of pollutants in soil and plant uptake (Stovin et al. 2008).

**Stormwater quantity**

**Rainfall interception in canopy**

The volume of runoff is reduced by the evaporation of rainfall from leaf surfaces within the tree canopy. Rainfall interception by trees in the parks and streets of a Californian city equated to 1.6% of total precipitation and a saving of $3.80 per tree on expenditure for stormwater management (Xiao and McPherson, 2002). Rainfall interception is maximised with large, evergreen tree species (Xiao and McPherson, 2002).

**Increased infiltration of rainfall and soil water storage**

Trees can increase the rate or amount of soil water infiltration and subsequently increase soil and groundwater recharge. A proportion of the rainfall temporarily held on the canopy will flow down the stem and trunk (Xiao et al. 2000). In highly impervious areas this trunk flow increases the likelihood that rainfall is directed into soil at the base of the tree rather than onto surrounding impervious surfaces.

Tree pits can be designed to maximise water storage. The use of structural soil under pavement areas such as carparks and footpaths to retain stormwater is an example of this. By providing increased rooting volumes through the use of structural soils, these systems should support larger-sized trees and will further mitigate stormwater by rainfall interception and retention within the soil (Day et al., 2008). Fraxinus pennsylvanica and Quercus bicolor grew successfully in structural soil planting pits that were designed to retain stormwater (Bartens et al., 2009).

The percolation of stormwater through compacted soil layers can also be increased by tree root growth. The saturated hydraulic conductivity (SHC) of a compacted subsoil layer under structural soil was 1.79 mm hr\(^{-1}\) (27-fold higher) with Fraxinus pennsylvanica (green ash) than in unplanted systems (Bartens et al., 2008). Acer rubrum (red maple) and Quercus velutina (black oak) increased the saturated hydraulic conductivity of compacted clay soil in less than 12 weeks after planting (Bartens et al., 2008).

**Stormwater quality**

**Pollutant removal**

In addition to reducing the quantity of urban run-off, vegetation and its associated soil can play an important role in removing nutrients and heavy metals from stormwater (Davis et al., 2001, Henderson et al., 2007, Read et al., 2008) To date there has been limited research of the performance of individual plant species in biofiltration systems, with two notable exceptions, Read et al. (2008) and Bratieres et al. (2008). These two studies investigated a range of plant species, varying in size from rushes to large shrubs or small trees, indigenous to south-eastern Australia.
This research

The seasonal performance of street tree species in biofiltration systems is largely unknown. A study was designed to assess the combined performance of street trees and tree soils as part of an integrated urban stormwater treatment system. The proposed treatment system could be retrofitted into most urban streets, either at the time of tree replacement, or to amend an existing planting. Stormwater from the road and footpath is directed along the gutter and into the biofiltration system. The soil surface is set at a designed depth below the surrounding surfaces, referred to as the extended detention depth, allowing stormwater to fill this space during rain events. The systems are designed so that if the detention depth is filled, additional stormwater is bypassed into the conventional stormwater management systems to avoid flooding.

Methods

The experiment was designed to evaluate both tree growth responses and also the efficacy of nutrient removal of these biofiltration systems. Trees were grown outdoors in experimental biofiltration systems, constructed with 240 mm diameter columns, cut into 600 mm lengths. The constructed soil profiles were 500 mm deep with 10% (v:v) composted green waste added to the surface 200 mm. The three soils used were sands with saturated hydraulic conductivities (SHC) of 4, 95 and 170 mm h\(^{-1}\) and the soils are referred to as low, medium and high SHC soil respectively. The hydraulic conductivity of the slowest draining soil was below the range 20-1000 mm h\(^{-1}\) stipulated in the Australian Standard AS4419 ‘Soils for landscaping and garden use’ (Standards Australia, 2003).

The four species selected are common in urban landscapes in southern Australia (Frank et al., 2006) and three are Australian species. The tree species chosen come from a range of climates and environments and were chosen in part to investigate innate differences in response to the regular inundation that would be expected in biofiltration systems. The evergreen trees were planted in late March to early April 2003 and the deciduous trees in June 2003. The application of simulated run-off commenced in September of the same year.

The trees were irrigated using tapwater or a model stormwater solution and compared to unplanted, control profiles. The profiles received weekly applications of approximately 100 mm depth of either tapwater or stormwater. The chemical composition of the simulated stormwater was adapted from one devised by Davis et al. (2001) and included 2 mg L\(^{-1}\) NO\(_x\)-N, 4 mg L\(^{-1}\) organic-N and 0.6 mg L\(^{-1}\) phosphate-P as well as a heavy metal (copper) and dissolved solids (sodium chloride and magnesium chloride). As suspended solids were not included in the synthetic stormwater the implications of surface clogging and changes in hydraulic performance over time were not investigated.

The model soil profiles were raised off the ground, allowing collection of leachate following simulated run-off events. An irrigation system was used to deliver the simulated runoff events. All profiles received a volume of tapwater via a microspray within a 500 mL plastic food container, and the addition of stormwater concentrate in this container prior to the system running created the simulated stormwater solution.

Data collected during the experiment included final above-ground plant biomass as well as soluble nitrogen and phosphorus concentration of the leachate over time. For above-ground biomass measurements all trees were harvested at the completion of the experiment, oven dried (70°C for 48 hours) and weighed. Sampling of leachate from the constructed profiles for nutrient analysis was undertaken from December 2003 until December 2004. On 10 occasions during the 13-month period the leachate was collected from the base of the systems for two hours after a simulated runoff event. Filtered (0.45 µm) samples were analysed for NO\(_x\) and FRP using colorimetric methods and an Alpkem (Perstorp Analytical) segmented flow autoanaylsier. In some instances, typically in higher evaporative demand months towards the end of the experiment, all of the applied water was retained within the soil and no leachate drained from the profiles. The concentration was recorded as a missing value.

Analysis of variance (ANOVA) was used to make overall comparison between treatment means and differences were recorded as significant at the five per cent level (p<0.05). Paired comparisons were made using the least significant difference (LSD). For the vegetation growth data n=8 and for the nutrient concentration of leachate from the biofiltration systems data n=3.
Results

Tree growth

All four tree species grew well in all three soils, including one chosen for its low, and potentially growth limiting drainage rate. Above-ground growth of *C. salignus, L. confertus* and *P. orientalis* was increased when the irrigation was with the model stormwater solution rather than tapwater (Table 1). *E. polyanthemos* growth was similar with tapwater water and stormwater applications in the low and high SHC soils.

**Table 1: Above-ground dry weight (g): species, soil and water quality interaction**

<table>
<thead>
<tr>
<th>Species</th>
<th>Tap water</th>
<th>Storm water</th>
<th>Tap water</th>
<th>Storm water</th>
<th>Tap water</th>
<th>Storm water</th>
</tr>
</thead>
<tbody>
<tr>
<td>(^{\text{a}})C. salignus</td>
<td>136 b</td>
<td>265 fg</td>
<td>168 cd</td>
<td>266 fg</td>
<td>133 b</td>
<td>233 fg</td>
</tr>
<tr>
<td>(^{\text{a}})E. polyanthemos</td>
<td>174 cd</td>
<td>177 cd</td>
<td>149 bcd</td>
<td>243 fg</td>
<td>131 b</td>
<td>159 bcd</td>
</tr>
<tr>
<td>(^{\text{a}})L. confertus</td>
<td>147 bcd</td>
<td>273 g</td>
<td>155 bcd</td>
<td>255 fg</td>
<td>129 b</td>
<td>219 ef</td>
</tr>
<tr>
<td>(^{\text{a}})P. orientalis</td>
<td>86 a</td>
<td>182 de</td>
<td>85 a</td>
<td>150 bcd</td>
<td>89 a</td>
<td>143 bc</td>
</tr>
</tbody>
</table>

\(^{\text{a}}\) means followed by the same letter down the column and across the row are not significantly (p<0.05) different

\(^{\text{b}}\) means are back log transformed

While successful tree growth has been confirmed, the systems must also treat stormwater to successfully function in terms of biofiltration. This study focused on nutrient removal, a component of stormwater treatment.

Nutrient removal

Compared to unplanted controls, the presence of trees resulted in significant reductions of soluble nitrogen and phosphorus concentration of leachate. The pattern of FRP concentration of leachate over time was similar between the unplanted and planted profiles (Figure 1). The leachate concentration of FRP was higher during the warmer months and in particular early in the experiment. The unplanted low SHC soil profiles were very effective in reducing the FRP concentration of stormwater. Conversely, FRP seemed to be generated within the unplanted, medium and high SHC soil profiles with higher concentrations of the leachate than the input stormwater during most events (Figure 1).

The effectiveness of planted profiles at reducing the FRP concentration of stormwater was variable. The low SHC soil planted profiles greatly reduced the FRP concentration of stormwater input for all events (Figure 1). The medium and high SHC soil planted profiles had little effect at the start of the experiment, with leachate FRP concentrations similar to the input stormwater. However, following the first summer, good reductions of FRP concentrations were achieved from profiles with these two soils (Figure 1).
During the first few months of the experiment the leachate FRP concentration was high from systems planted with all four species (Figure 2). During winter (June to August) the FRP concentration of leachate from the profiles with the deciduous species was relatively similar to the leachate from those planted with evergreen species. The spike of FRP in late spring (November 2004, Figure 1) was due to high concentrations in leachate from *P. orientalis* profiles (Figure 2).
The pattern of NO\textsubscript{x} concentration of leachate over time was generally similar in both the unplanted and planted profiles (Figure 3). The leachate concentration of NO\textsubscript{x} was typically higher during the warmer months. The spike observed in July is most likely an artefact of soil core sampling undertaken prior to leachate sampling.

The NO\textsubscript{x} concentration of leachate from the planted profiles was less than from unplanted profiles (Figure 3). NO\textsubscript{x} was consistently generated in the unplanted profiles with the leachate having higher concentrations than the stormwater input during all events. The effectiveness of planted profiles in reducing the NO\textsubscript{x} concentration of stormwater was variable. On all occasions, the planted, low SHC soil profiles had lower concentrations of NO\textsubscript{x} in leachate than the stormwater input. The performance of the planted, medium and high SHC soil profiles was less consistent, with NO\textsubscript{x} being produced during late spring and summer (Figure 3). During the cooler months the concentration of NO\textsubscript{x} in stormwater was reduced by biofiltration through the planted, medium and high SHC soil systems.

Figure 3: NO\textsubscript{x}-N concentration (mg N L\textsuperscript{-1}) of output leachate over time from profiles receiving stormwater over time. The dashed horizontal line represents the stormwater input concentration. * The spike observed in July is most likely due to an artefact of the experimental (soil cores were taken prior for root and soil analysis).
The effect of species on the NO\textsubscript{x} concentration of leachate during the experiment was not large (Figure 4, high SHC soil profiles shown).

![Figure 4: The effect of species on NO\textsubscript{x}-N concentration (mg N L\textsuperscript{-1}) of output leachate from high SHC soil profiles receiving stormwater. The dashed horizontal line represents the stormwater concentration. *The spike observed in July is most likely due to an experimental artefact (soil cores were taken prior for root and soil analysis).]

Discussion

Tree growth

The trees grew well in this experiment and soil selection was not critical for plant growth with regular exposure to small sized run-off events. The low saturated hydraulic conductivity of the low SHC soil used in the experiment would not meet AS 4419-2003 guidelines and these soils may have been expected to have poor aeration. The trees grown in the low SHC soil performed well. However further field evaluation is required to confirm that such soils would be suitable for tree growth. The rate of water infiltration into, and percolation through, the constructed profiles was variable and not necessarily reflective of the different saturated hydraulic conductivity of the three experimental soils (data not shown). The low SHC soil profiles did drain more slowly than the medium and high SHC soil profiles.

As a growing medium for trees, the coarse textured soils used in biofiltration systems inherently have low levels of available nutrients and water. The addition of organic matter to similar sandy soils is common practice in constructing designed tree soils. Greater growth of the trees that received stormwater than tapwater confirms that the systems studied had low levels of nutrition.

NO\textsubscript{x} concentration of leachate

The NO\textsubscript{x} concentration of leachate from planted systems was higher in warmer months. A positive correlation between NO\textsubscript{x} concentration of leachate from biofiltration systems and temperature has been reported (Blecken et al., 2010). Averaged over time, the experimental street tree biofiltration systems reduced the NO\textsubscript{x} concentration of stormwater by 2 to 78% for the various filtration media. Street trees grown in the two faster draining soils were not effective at reducing N concentration, however load removal was adequate (data not shown). This reduction in NO\textsubscript{x} concentration is within reported ranges (Davis et al., 2006, Henderson et al., 2007, Read et al., 2008, Bratieres et al., 2008). Permanently saturated zones designed at the base of biofiltration systems can promote denitrification and increase nitrogen removal performance (Kim et al. 2003).
FRP concentration of leachate

The FRP concentration of stormwater was reduced by an average of 70 to 96% following biofiltration through street tree systems with various filtration media. These reductions are similar to those reported in the literature (Bratieres et al., 2008, Read et al., 2008).

Seasonal patterns of nutrient concentration of leachate

Seasonal patterns of nutrient uptake capacity have been reported for some trees, with maximum rates typically coinciding with active growth periods (Roy and Gardner, 1945, Muñoz et al., 1993, Weinbaum et al., 1978). It was therefore anticipated that nutrient removal performance would be low during winter while the trees were dormant or growing slowly. The peaks in nutrient concentration of leachate from planted profiles occurred during summer and often corresponded to periods when higher water volumes were retained in the biofiltration systems (data not shown), suggesting that the soil was dry. This seasonal pattern of NO\(_x\) and FRP concentration was also observed in the unplanted profiles with considerable leaching of nutrients during summer. This suggests that the soil may be behaving as a larger source of nutrients during these times. That is, the mineralisation of organic matter is higher during the summer in response to higher temperatures (Gessler et al., 1998) or possibly increased soil drying and wetting.

Organic amendment of biofiltration media

Substantial leaching of nitrogen and phosphorus from unplanted soil profiles was found for the duration of this experiment. Despite the potential increase in cation exchange capacity, caution is required if biofiltration media are to be amended with organic matter. In response to high levels of nutrient leaching from organic matter amended soils, Bratieres et al. (2008) recommended that biofiltration soils are not amended. Further field testing is required to ascertain the impact of this recommendation on the long term growth of street trees and stormwater treatment performance.

Species selection for biofiltration systems

Four street tree species with different waterlogging tolerances were evaluated in this study to determine differences in nutrient removal performance. Species selection was not essential to maximise nutrient removal performance of biofiltration systems. The evergreen and deciduous species performed similarly during winter, when the latter had lost leaves. This raises interesting questions about root function and nutrient uptake in dormant trees. \(P.\) \(orientalis\) was less effective at reducing the phosphorus concentration of leachate during the final months of the experiment, although phosphorus load reduction was adequate (data not shown). This reduced performance is possibly related to stresses caused by more severe drying of soil columns in late spring and summer. Further field evaluation is required to investigate the effect of water stress on stormwater treatment performance and the likelihood of it occurring in practice. The ability of trees to withstand drought may be an important selection criterion which requires further evaluation.

Biodiversity of vegetation within our cities is important and street tree selection should not be based on a single criterion. Therefore it is a positive finding that under these experimental conditions the differences in nutrient removal performance between the four species were not large and the planting of any one particular species is not recommended. However, it is acknowledged that the lack of differences reported in this study may reflect the regime of simulated run-off events applied in this study, which may not have been sufficiently large to impose significant deoxygenation stress on the trees.

While the tree species studied behaved similarly it is important to reiterate that for removing nutrients from stormwater, vegetation is a critical component of these systems. Newly planted biofiltration systems will initially behave largely as unvegetated systems, until the root systems have developed sufficiently to colonise large proportions of the filtration medium. Nitrogen and phosphorus leaching, in terms of concentration, was still occurring in the experimental systems nine months after planting and so these systems will take some time to perform effectively. Good post planting practices are important to ensure rapid tree establishment in these systems. As with traditional street tree planting, irrigation is most likely the most critical aspect of post planting maintenance. To avoid water deficit stress, additional irrigation may be required until the tree root systems have established. To optimise tree establishment, the scheduling of irrigation should be proactive rather than reactive (Harris, 1998). The frequency of irrigation post planting is more important than the volume applied (Gilman et al., 1998) due to the small root ball volume and the low water holding capacity of fast draining biofiltration media. To minimise any nutrient leaching from these newly established systems, care must be taken to apply irrigation volumes which can be fully retained within the soil profile.
Conclusion
Trees in urban built areas can contribute in many ways to sustainable stormwater management. The novel use of structural soils to form a stormwater reservoir for urban tree plantings shows promise (Bartens et al., 2009). In the model biofiltration systems used in this research, four common street tree species grew well. Species selection did not appear to be an important element in terms of system success. The one deciduous species behaved similarly to evergreen species, in terms of soluble nitrogen and phosphorus removal, during their dormant period. After the initial summer, the biofiltration systems were successful in reducing FRP concentration. The performance of the systems in reducing NO\textsubscript{x} concentration was more variable and during the warmer months NO\textsubscript{x} was generated in the medium and high SHC soil profiles. This work shows that street trees have the potential to be effective elements in urban biofiltration systems and that field-level evaluation of these systems is required to further elucidate the role of such systems in urban stormwater treatment. Design modifications may be required however if consistent reductions in NO\textsubscript{x} concentration are required.

References


Update on the development of a tree inventory at Hume City Council

Jason Summers
Manager Parks and Open Space – Hume City Council

Development of a tree inventory can be as simple as a list of trees at a location it may be a park or street to a fully GIS based inventory of a City’s tree assets, including risk assessments, GPS locations and allocated work histories. The work involved in the latter is substantial, but the benefits are many and worth the effort.

In 2005 Hume City Council recognised the need to establish a comprehensive street tree inventory now known at the Hume Tree Management System (HTMS). This process began with the formation of a trial inventory encompassing the suburb of Greenvale in Melbourne’s north. The trial enabled council to test the data collection method, evaluate the data collection parameters and establish that the data being collected met the risk management and operational objective of council, before gathering data on hundreds of thousands of trees.

Hume City Council is a growth council in Melbourne’s north with 148,000 trees mapped, risk assessed and works identified. The tasks from the outset seemed large and having done 1 ½ laps of the city the Hume Tree Management Team (HTMT) have learnt a lot and the HTMS has moved on from primarily being used as a risk management tool and now is being used for strategic management and forecast of long term future management requirements of our urban forest. The HTMS and accompanied auditing program allows for the effective allocation of tree management priorities, resource allocation and has proven to be an effective monitoring tool for the success of our proactive tree management program i.e. formative/structural pruning programs, targeted removal and renewal of inappropriate or problematic tree avenues, regulated area assessment program.

The HTMS and accompanied auditing program allows for the effective allocation of tree management priorities and resources allocation. It is a useful tool as Hume City Council is able to measure the success of our proactive tree management program i.e. formative/structural pruning programs, targeted removal and renewal of inappropriate or problematic tree avenues, regulated area assessment program.

The Hume Tree Management Team manage a large number of young trees with more than 5000 planted each year over the past eight years and around 5000-10,000 planted through urban development activities each year. To ensure their successful establishment and reduce the likelihood of structural defects forming in Hume’s future tree stocks, a very specific tree establishment program has been established. Every tree planted within this program receives establishment watering, mulch & weed management for the first 2-3 years; at years 2, 4, and 6 canopy lifting and formatively prune occurs to manage any issues out of our trees before they get too big and expensive to undertake. The HTMS plays an important role in monitoring and management of the council’s program, logging all works as they occur.

HTMS is used to record vacant planting sites, which are used operationally in planning for the annual planting program, to establish planting opportunities, forecasting number and species for ordering and establishing defined characters of an area from a desk top analysis rather than field investigations. In addition an analysis of the HTMS and power line data is undertaken to highlight problem tree/avenues associated with power line assets to flag areas for investigation for the targeted tree renewal program. This process has enabled the removal of and orderly process of replacement of high risk and problematic avenues throughout the City leading to significant reductions in line clearance pruning and reactive works requests.

All tree activities are recorded in the HTMS from inspections, resident requests, pruning, removals, planting and vacant sites. The HTMS is building a valuable special data set and documentary history on trees managed by the Hume City Council which enables valuable strategic analyses of the tree population and/or species to be undertaken.

A full HTMS update which entails the auditing of every tree in the HTMS is undertaken every four years in a rotating cycle throughout four zones within the municipality and a regulated areas audit is undertaken every year to assess high risk trees i.e. tree under power assets, associated with high risk targets including...
playgrounds, kindergartens, child care facilities, public buildings, high use paths etc. These audit updates provide new priority work to be completed, the challenge is to interpret these priorities and develop work flows that enable best value outcomes while managing the risks and public expectations within the available resources.

Some residents don’t understand why council may only prune two trees in a street and often pose the question why did you not prune mine? In most instances it does not require work otherwise it would have been picked up in the annual audit or the four yearly update and works programme. Hume City Council with the aid of the HTMS has moved more to a risk based approach to tree management whereby resources are specifically targeted to the highest risks rather than a scatter gun approach. Strategically this information within our inventory is an untapped gold mine, add our resident requests, call out data, insurance claims and weather data information then the analysis and interpretation is almost endless.

Some very interesting information can be extracted like:

- When do we get the most resident requests, what month of the year?
- When is the windiest month for our city?
- When do most of our trees fail?
- How many requests for help do we get from storm events and at what speed of wind?
- When do people request tree planting?
- Which trees do residents report to prune the most?
- Which species have cost council the most by pruning or insurance claims? How well represented are they in the tree population?

When you spatially analyse all this data against an inventory you can find out some amazing facts.

Whilst having an inventory is great, it creates many challenges to a council or organisation and requires commitment and dedication on an ongoing basis to keep it current and relevant. It is not something to be taken lightly, a lot of time, effort, and blood, sweat and tears are required. The needs to better manage trees in a city are obvious but having adequate resources, both staff and budget, can be a challenge. You really need a champion to drive the program and commit recurrent funds to keep the data updated. The data to be collected is critical and needs to reflect the management challenge of the council or area the inventory is to be used in. Who will collect the data? Should we use in-house resources or contract it out? Hume City Council decided to buy in expertise and contract the work out and commit funds to keep the inventory updated. Working together with our consultant Council has developed, agreed data collection definitions that clearly articulates how council wanted to collect the information and standards to be adhered to.

In the first case we have simply collected all street trees and reserve trees using the data site (Table 1).

<table>
<thead>
<tr>
<th>TITLE</th>
<th>DATA TO BE COLLECTED</th>
</tr>
</thead>
<tbody>
<tr>
<td>UNIQUE ID</td>
<td></td>
</tr>
<tr>
<td>GPS CO-ORDS</td>
<td>N &amp; E AMG COORDINATES</td>
</tr>
<tr>
<td>GENUS/SPECIES</td>
<td></td>
</tr>
<tr>
<td>HEIGHT</td>
<td>METRES ESTIMATED</td>
</tr>
<tr>
<td>DBH RANGE</td>
<td>0-30, 30-60, 60+ CM</td>
</tr>
<tr>
<td>TREE AGE</td>
<td>YOUNG, SEMI MATURE, MATURE</td>
</tr>
<tr>
<td>TREE HEALTH</td>
<td>GOOD, FAIR, POOR, VERY POOR, DEAD</td>
</tr>
<tr>
<td>TREE STRUCTURE</td>
<td>GOOD, FAIR, POOR, VERY POOR, FAILED</td>
</tr>
<tr>
<td>USEFUL LIFE EXPECTANCY</td>
<td>Unsafe or zero years, less than 5, 5 to 10, 10 to 20, 20+</td>
</tr>
<tr>
<td>TREE DATA COLLECTION ATTRIBUTES</td>
<td></td>
</tr>
<tr>
<td>--------------------------------</td>
<td></td>
</tr>
<tr>
<td><strong>TITLE</strong></td>
<td><strong>DATA TO BE COLLECTED</strong></td>
</tr>
<tr>
<td>RESERVE NAME</td>
<td>CAN BE PUT IN POST DATA COLLECTION</td>
</tr>
<tr>
<td>RESERVE / STREET ADDRESS</td>
<td>CAN BE PUT IN POST DATA COLLECTION</td>
</tr>
<tr>
<td>WORKS REQUIRED</td>
<td>REMOVAL, FORMATIVE PRUNING, STRUCTURAL PRUNING, WEIGHT REDUCTION, DEADWOOD REMOVAL, LV WIRE CLEARANCE, HV WIRE CLEARANCE, CANOPY LIFT, VISIBILITY CLEARANCE PRUNING, REMOVE CODOMINANTS, AERIAL INSPECTION,</td>
</tr>
<tr>
<td>RISK SCORE</td>
<td>TO BE CALCULATED FROM THE 5 FIELDS BELOW</td>
</tr>
<tr>
<td>FAILURE POTENTIAL</td>
<td>NONE = 0, LOW = 1, MODERATE = 2, HIGH = 3, VERY HIGH = 4</td>
</tr>
<tr>
<td>FAILURE SIZE</td>
<td>NONE = 0, 0-15 = 1, 15-45 = 2, 45-75 = 3, 75+ = 4</td>
</tr>
<tr>
<td>TARGET PRESENCE</td>
<td>NONE = 0, OCCASIONAL = 1, INTERMITTENT = 2, FREQUENT = 3, CONSTANT = 4</td>
</tr>
<tr>
<td>TARGET VALUE</td>
<td>NONE = 0, LOW = 1, MODERATE = 2, HIGH = 3, VERY HIGH = 4</td>
</tr>
<tr>
<td>DAMAGE PROBABILITY</td>
<td>NONE = 0, LOW = 0.4, MODERATE = 0.6, HIGH = 0.8, VERY HIGH = 1</td>
</tr>
<tr>
<td>WORKS PRIORITY</td>
<td>N/A, VERY LOW, LOW, MODERATE, HIGH, URGENT</td>
</tr>
<tr>
<td>PHOTOS FOR TREES IN HIGH SCORE RANGE</td>
<td>TWO PHOTOS OF TREES WITH HIGH RISK SCORES ONE OVERALL SHOT &amp; OTHER SHOWING RISK CONCERN</td>
</tr>
<tr>
<td>PROXIMITY TO STRUCTURES (INCLUDES FENCES, BUILDINGS, PLAYGROUNDS, SEATS OR PICNIC TABLES ROTUNDAS ETC)</td>
<td>&lt; 4 METRES, OR WITHIN 360° FALL ZONE OF TREE OR NO STRUCTURES PRESENT</td>
</tr>
<tr>
<td>INSPECTION DATE</td>
<td>DATE</td>
</tr>
<tr>
<td>INSPECTORS NAME</td>
<td>NAME</td>
</tr>
</tbody>
</table>
In the six years of operating the HTMS, we are half way through the second lap around the city. Recently a review of system was undertaken brought on by the new Victorian Code of Practice ‘Electric Line Clearance 2010’. The results of this review determined that a slightly difference approach was needed.

This resulted in the development of a regulated areas program, where high risk zones were defined and trees in these areas are audited annually. These included playgrounds, high use areas, trees under powerlines & shopping centres, schools and major roads. This audit would only collect identified works such as trees in powerlines, canopy lifts, dead trees, stumps etc for specific trees. All other trees including these would get a full update and reassessment every four years. So one quarter of the city would be reassessed picking up new plantings, trees removed and the works and risk assessment of all trees. This helps keep the inventory current and works flowing into our contractors and staff.

Primarily the HTMS data is collected and collated by external consultants; however resident requests are management by Hume’s Tree Management Team though the corporate customer request system and work activities are entered by Park Administration staff.

Development of the Hume Tree Management System HTMS is ongoing and there are still areas that require more work to see the full benefits. Council is committed to a continuous improvement program to keep the software and processes up to date. In the near future the Hume City Council will finalise a mobile computing solution for tree inspections to deal with requests, allowing in the field allocation of works to crews or a contractor. The system will be followed by the development of a crew/contractor module that can update the works completed in the inventory to our customer service system. This would assist in stream lining the current hybrid desktop/paper system that needs to be manually entered in after inspections and works are completed.

The system currently provides very basic reporting and only uses 10% of the potential that the data set could provide. The need for improved reporting tools was a significant finding of the recent review.

Creating dashboards to monitor outstanding works and the timelines associated with them and what workloads crew or contractors may have ahead of them. This information is very powerful in submitting budget requests when you know exactly the work load and what resources you have available.

More detailed analysis would reveal many interesting facts about our urban forest, Hume City Council has over six years of detailed data on tree management within the city and this information would help us understand the real story.

It has been an amazing journey that will continue on now that I have become the Parks and Open Space Manager for the entire department. I will have to forward the responsibility to Graham Dear our new Open Space Coordinator who I know will take it to another level.
Independent inquiry into management of trees on public land: Final report extract

Brian Cunningham

The full version of this report is available from www.lga.sa.gov.au/goto/trees

Independent Inquiry into Management of Trees on Public Land
GPO Box 2693
Adelaide SA 5001

The following sections have been extracted from the Final Report.

<table>
<thead>
<tr>
<th>Section number in this extract</th>
<th>Section number in Final Report</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>7</td>
</tr>
<tr>
<td>3</td>
<td>8</td>
</tr>
</tbody>
</table>

1 Overview 72

1.1 The Independent Board of Inquiry 72
1.2 Scope of work 72
1.3 Process of the Inquiry 73
1.4 Definition of Public Land 73
1.5 Risk management terminology 74
1.6 Disclaimer 74

2 Discussion and Recommendations 75

2.1 Synopsis 75
2.2 Tree Management Policy 76
2.3 Proactive management of tree risks 77
2.4 Measures to prevent the development of defects in new plantings 82
2.5 Land Use Planning 83
2.6 Supervision of developments 84
2.7 Training and qualifications 85
2.8 Significant trees 86
2.9 Coordination with utilities 87
2.10 Summary of recommendations 88

3 References 89

The 12th National Street Tree Symposium 2011
71
1. Overview

1.1 The Independent Board of Inquiry

In March 2010 the State Executive Committee of the Local Government Association of South Australia (LGA) agreed to conduct, in conjunction with the LGA Mutual Liability Scheme (MLS), an independent Inquiry into the management of trees located on land under the care and control of councils. The purpose of the Inquiry was to provide independent advice to the Local Government Association on the most appropriate future management regime for trees on public land taking into account current and possible future changes in climatic conditions.

The Inquiry was established in response to incidents where trees on public land caused damage to property and people, some with fatal consequences. Following these incidents, the MLS Board identified tree management as one of the most significant emerging risks for councils and the scheme. Concern had been expressed that severe drought had increase the risk of tree damage and that risks could worsen with future climatic conditions. Notwithstanding these risks, trees are also an important and valued asset. Responsible management requires a balance of these two issues.

To review the benefits and risks of trees, and the framework in which they are managed, the Local Government Association State Executive Committee appointed an Independent Board of Inquiry comprising three members with extensive experience in public administration and Local Government.

The Board comprised:

- Brian Cunningham (chair)
- Peter Lockett and
- Mary Marsland.

To assist the Inquiry with technical analysis, consultation and reporting, the Board engaged the consulting firm Ecological Associates.

1.2 Scope of work

The overall objective of this Inquiry was to provide a strategy to protect and enhance the benefits that trees on public land provide while managing the risks of tree and limb failure to public safety and infrastructure.

The scope of work was as follows.

- Summarise the physiological and physical responses of trees that threaten public safety and infrastructure including tree and limb failure.
- Describe the impact pathways by which trees threaten public safety and infrastructure including limbs or trees falling on people, buildings, powerlines, street lighting, fences, roads etc. and how people and assets are exposed to threats.
- Identify and evaluate the consequences of tree impacts in terms of magnitude (e.g. cost or injury) and likelihood.
- Determine, through consultation with the MLS and other stakeholders, an ‘acceptable level of risk’.
- Identify and evaluate measures to mitigate risks in existing trees such as:
  - surveillance and monitoring
  - tree maintenance (e.g. pruning or watering)
  - planning protocols to reduce exposure, i.e. to isolate trees from human activity and infrastructure
  - tree removal
  - measures that may be outside council’s control such as legislative changes or planning policy.
- Identify measures to minimise risks in future tree plantings such as:
  - planning protocols for tree placement, infrastructure placement and use of space near trees
  - tree species selection
  - measures that may be outside council’s control such as legislative changes or planning policy.
• Evaluate how these risk management measures will affect the values of trees including biodiversity, landscape amenity and heritage.
• Synthesise these investigations in a risk management strategy for adoption by councils that balances the protection of tree benefits with the reduction of risk to acceptable levels and identify the possible resource implications for councils arising from this strategy.
• Make recommendations for the broader use and adoption of the findings.

1.3 Process of the Inquiry
The Inquiry was undertaken independently of the Local Government Association by a Board that has no direct involvement with Local Government in South Australia. The Inquiry Board acted as a neutral agent on key matters where opinions differ both within Local Government and in the wider community.

The first step in the Inquiry was to seek community opinion on:
• the risks and liabilities associated with tree and limb failure on public land
• the social and environmental benefits provided by trees on public land
• current and future tree management strategies.

This involved the preparation of an Issues Paper (released in July 2010) and a call for written submissions from key stakeholders, including local councils, private and public organisations, government agencies and private individuals. In addition, a number of meetings were held with key stakeholder organisations coordinated by Angela Hazebroek of URPS and members of the Board.

Technical expertise was sought from a wide range of experts throughout South Australia and Australia, including council arborists and tree managers, professional arborists, the university and botanical gardens scientists, Treenet and training providers.

The feedback and inputs from a wide variety of community and stakeholder consultations were incorporated into a draft final report and used as a basis for recommendations aimed at mitigating risks associated with tree and limb failure.

The draft final report and findings of the Inquiry were released for consultation to key stakeholders on October 25 2010.

The Final Report presents the findings and recommendations of the Inquiry. It provided:
• an overview of the role of trees in the landscape and the benefits they provide
• a review of the causes of tree and limb failure
• a review of the consequences of tree and limb failure in terms of personal injury, property damage and management costs
• a review of failure issues and their management in South Australia and elsewhere
• recommendations for managing tree and limb failure.

The Local Government Association of South Australia (LGA) State Executive Committee approved the release of the final report of the Independent Inquiry into Management of Trees on Public Land on 20 January 2011 - the final report has been available since then.

The LGA in conjunction with the LGA Mutual Liability Scheme (MLS) conducted a workshop on 31 March 2011 with Councils in South Australia to discuss the implications of the recommendations in the report and possible implementation strategies and resource implications.

Based on the report, the workshop and further research by MLS staff, a final implementation strategy is currently being developed and will be presented for endorsement to the LGA State Executive Committee on 15 September 2011 meeting. All Councils will be advised of the outcomes of this meeting in October 2011 including a timeframe for the development of the various tools and actions contained in the recommendations as endorsed by the Local Government Association State Executive.

1.4 Definition of Public Land
While many of the issues raised in this report are also relevant to private land, this Inquiry is specifically focussed on the risks associated with trees on public land. For the purposes of this Inquiry, public land refers to land owned by councils, and land in the care, control or management of councils pursuant to any Act of Parliament, and includes public roads as defined in the Local Government Act 1999.
1.5 Risk management terminology

Risk management is only one aspect of this Inquiry, but risk management terminology is used throughout this report. The following introduces the reader to terms and concepts adapted from the Australian/New Zealand Standard AS/NZS ISO 31000:2009, Risk management - Principles and guidelines.

Risk assessment involves identifying and evaluating risk factors: what makes tree and limb failure likely?; how are people and infrastructure exposed to falling trees and limbs?; are the risks are acceptable or unacceptable?

Risk management involves developing options (i) to reduce the likelihood of tree and limb failure and (ii) to eliminate or reduce the exposure of people and infrastructure to failure hazards. Risk management options therefore include measures to maintain tree health and integrity, to prune and remove dangerous trees and to plan tree planting or buildings, footpaths, roads and other infrastructure to reduce exposure.

The most appropriate options will depend on the magnitude of the risk. Expensive and dramatic options such as tree removal may be appropriate where tree failure is imminent and lives are threatened. However, risk management options have a cost in terms of their impact on the biodiversity, landscape and other values of trees and the cost of the works. Costs must be balanced against the magnitude of the risk when selecting the most appropriate management option.

Risk Assessment

All trees present a degree of risk, however remote, of injury or property damage – only a small number actually hit someone or something. Trees present risks in relation to:

- the potential for the tree or its limbs to fail AND
- its potential to strike a target.

A target can be anything of value that may be struck when a tree fails (e.g. person, building, fence, vehicle).

The level of risk posed by trees depends on a combination of factors related to the tree itself and the context in which it is growing. Risks are assessed in terms of:

- likelihood of tree or limb failure (in relation to tree health and integrity)
- likelihood of exposure (whether a frequently used playground or a rarely used camp site is exposed)
- target value (whether people, minor infrastructure or major infrastructure are exposed)
- severity of the impact (in relation the size and weight of the tree or limb and the damage it can cause).

Risk assessment methods generally rely on visual inspection of trees by expert arborists who assess the likelihood of tree or limb failure from defects or weakness in the tree. Based on these inspections, a number of risk management options can then be carried out. Inspections may be conducted when a hazardous tree is identified, as part of a strategic tree monitoring program, or when trees are being evaluated for removal for some other purpose, such as to allow developments.

Risk Management

After risks are assessed, the most appropriate management measure is identified. Effective risk management will reduce the likelihood or severity of a risk to an acceptable level. A range of options may be available to achieve this. The most appropriate option must be chosen with respect to costs, which will include:

- impacts on habitat value
- impacts on amenity value
- impacts on heritage value
- the monetary cost of the works.

1.6 Disclaimer

The authors of the report ask readers to note that every care has been taken in the preparation of the analysis, findings and recommendations of this report.
However, councils should be aware that the recommendations of this report are generic and broad in nature, and are intended to provide general guidance to councils across a wide variety of important issues relating to tree management policies and related responsibilities.

Accordingly, councils should have the continuing responsibility to frame, modify or adapt tree management policies in accordance with the particular circumstances (including resources) relevant to each council, and to take such actions under any such policies having regard to the specific prevailing and relevant circumstances. In particular, councils should be ready to obtain specific technical, expert or professional advice when and as required by particular conditions or situations.

2. Discussion and Recommendations

2.1 Synopsis

The following synopsis of findings underpins the recommendations outlined in this chapter.

Trees provide a range of important benefits to the urban environment and as part of the natural landscape. Key benefits include their amenity value, biodiversity value, historic value and in their role in moderating urban temperatures.

There are risks associated with trees, in particular the risk of personal injury and property damage associated with falling trees and limbs. These incidents are very rare; the risks are much lower than for other hazards encountered in daily life, such as motor vehicle accidents.

While the community and the natural landscape benefit from the presence of trees, these impacts, when they do occur, affect individuals. The personal cost of injury or property damage can be very high; occasionally the consequences are tragic.

There are three reasons to believe that the incidence of tree and limb failure (on both public and private land) will increase over the next two to three decades:

- tree senescence – all trees have a natural life span and there is evidence to suggest that a large proportion of existing trees will move into an older senescent age group in which the likelihood of failure is higher;
- urban consolidation – increasing population density in urban areas results in a greater competition for limited space, and evidence shows that the lack of sufficient space for tree canopies and root systems is a significant factor contributing to tree and limb failure; and
- drought and climate change – increasing summer temperatures, reduced rainfall and reduced watering can reduce the health of trees and their capacity to withstand the stresses that trigger tree and limb failure events.

The Local Government Act and Civil Liability Act provide councils in South Australia with a limited immunity from liability for property damage and/or injury caused by trees that are associated with roads. However councils may be liable for damages for personal injury under the common law of negligence. Where an incident occurs, the reasonableness of a council’s behaviour in all the circumstances seems to be a determining factor.

The Inquiry has found that councils in general take a reactive approach to tree risk management. As the incidence of tree and limb failure is likely to grow, the Inquiry does not believe this is a sustainable approach in the long term. Councils and others can intervene to reduce the incidence of tree and limb failure. However, no intervention can eliminate the risks and hazards completely.

Importantly, actions that reduce tree failures improve trees generally; the injuries and defects that lead to failures are reduced, maintenance costs are lower, and trees achieve a better form and live longer. Tree replacement costs are also reduced.

Improvements in tree management must be considered in proportion to tree risks, which vary from council to council according to the profile of their tree population and how people and property are exposed to potential failures.

Community expectations of trees in the landscape and perceptions of risk also vary. It is appropriate that each council forms its own view about the best response to tree management, taking into account
community values, community attitudes to risk, the general public benefit provided by trees, council’s resources and the competing demands on those resources.

The following recommendations are made with the understanding that many regional councils, and some metropolitan councils, have care and control of considerable areas of native or remnant vegetation, particularly along roadsides. The additional complexity and burden (for example, in the case of clean-up after storms) for these councils may cause them to embrace these recommendations on a more limited or staged basis given the resource implications.

2.2 Tree Management Policy

Recommendation 1: The Board recommends that all councils develop and adopt a formal Tree Management Policy with appropriate linkages to the council’s strategic management plans.

A Tree Management Policy provides a central reference point for the management of trees within a council. Although tree management represents a sizable component of the annual budget of many councils, the objectives of this investment are rarely defined. The linkages to the council’s infrastructure and asset management plan and the long term financial plan should be explicit.

A Tree Management Policy sets out the objectives that a council wants to achieve through the management of trees. It guides how trees are planned, how risks are managed, the resources required to achieve the objectives and how other council activities relate to tree management.

A Tree Management Policy:

- sets objectives for trees in the landscape, including the benefits trees provide and how these benefits are realised;
- reflects the setting of the council, including its landscape, history, biodiversity and community expectations;
- provides a long-term perspective, including planning for trees at maturity and planning for tree replacement at the end of their functional life;
- sets out the extent to which councils will formally adopt a framework to proactively manage the risks associated with trees on public land;
- identifies the preferred risk assessment methodology which the council will consistently apply;
- sets out how the council itself will manage its various functions (planning, engineering, parks and gardens etc.) to ensure an integrated approach to managing trees and achieving the objectives of the policy;
- presents ongoing costs in a comprehensive way, to allow efficiencies to be identified and priorities to be targeted;
- identifies future resourcing requirements (e.g. trained staff) and enables plans to be made; and
- identifies the key conflicts related to tree management and how these should be managed, e.g. sharing of information within councils and cooperation with utilities.

Tree Management Policies have been developed by a number of councils in South Australia and interstate. Examples policies and strategies include those developed by the City of Burnside, Hume City Council, Bayside City Council and the City of Sydney.

Recommendation 2: The Board recommends Tree Management Policies be developed through consultation and include procedures to keep the community informed of tree values (including community education programs), the adopted objectives of tree management and how they are being achieved.

Tree Management Policies should reflect the values and interests of the community in each council. There are strongly held opinions within the community of the value and appropriate setting for trees (Appendix C). A Tree Management Policy provides a framework to engage with the community on the benefits and risks of trees and to respond to community values and expectations.

Recommendation 3: The Board recommends the Local Government Association develop a template Tree Management Policy that councils can use to develop their own specific policy.

A substantial proportion of the effort in developing a policy is in determining its scope and content. A single template would simplify this process and would ensure that all policies meet minimum criteria. The template should provide guidance on current legal arrangements in relation to trees, minimum risk management requirements, government policy, information sources and institutional arrangements.
Councils would adapt the template to reflect their local situation and community expectations.

2.3 Proactive management of tree risks

Recommendation 4: The Board recommends all councils adopt a proactive approach to managing the risks in existing trees.

Currently, the majority of councils apply a mostly reactive approach to risk management in existing trees. This involves responding to reports of unsafe trees from the public, incidental observations made by council staff carrying out other duties, and through clean-up operations following major storm events.

The predominantly reactive approach may result from councils’ interpretation of the immunities for liability in the Local Government Act and Civil Liabilities Act. These immunities do not require councils to act to manage risks unless they have been made aware of them. This can encourage councils to minimise their knowledge of risks and thereby reduce the workload and effort to manage tree risks.

However this interpretation can be criticised. If councils did not know of a tree failure risk but a court determines that they should have known, they may be held liable for damages. The immunities will have limited value if councils have adopted policies or practices to deliberately avoid identifying risks that are obvious or reasonable to have known.

Furthermore, it can be argued that it is not in the public interest for councils to avoid knowledge of high risks. Risks may be considered obvious, or reasonable to know, where:

- there is a high degree of exposure (e.g. a park, playground, building or road);
- the tree is large and an impact would be severe; and
- defects are clearly identifiable.

A reactive approach can also be criticised as not being cost-effective. A reactive approach seeks to reduce tree management costs by only responding to incidents when they occur. A proactive approach that identifies risks and manages them would involve a greater initial investment in both costs and skilled resources required. However, councils interstate that have adopted proactive management approaches, report a long term reduction in costs, as the demands to clean-up after storms, to conduct risk-management pruning, to manage community complaints and to manage damage caused by failures are reduced.

The objective of proactive risk management is to increase tree health and integrity. This approach has the benefits of reducing failure risks as well as increasing tree longevity, improving tree structure, tree amenity and biodiversity values.

Several interstate councils have adopted proactive tree management strategies (e.g. City of Sydney, City of Hume). In the City of Hume, the implementation of a proactive management approach has led to significant reductions in the number of tree-related public requests and after-hour callouts (B. Kenyon, pers. comm.). The clean-up effort following severe storms has been reduced from up to 10 – 12 weeks (prior to proactive management) to around half a day. This has resulted in a dramatic decrease in the amount of over-time paid to council staff and reduced the need to employ external contractors to help with storm clean-up. The severity of damage caused by failures is lower due to a reduction in the number of whole tree failures and a reduction in the size of failures. As a consequence, the average size of insurance claims processed for the City of Hume has been reduced substantially (B. Kenyon, pers. comm.).

Anecdotal evidence from some South Australian councils also indicates that the incidence of tree failures has reduced since the implementation of a more proactive tree management approach (e.g. City of Gawler, City of Charles Sturt).

Proactive tree risk management comprises the following elements:

- establishing a register of priority trees which may include trees of high value, high failure potential, high exposure or high public concern;
- assessing (inter alia) tree failure risk;
- identifying actions to manage risk;
- establishing and following a program to implement actions; and
- ongoing tree surveillance and maintenance of the tree register.

The 12th National Street Tree Symposium 2011
77
It is essential that any proactive risk assessment and management procedures that are adopted by councils are carried out as planned, albeit with regard to the resources of the council. Councils will be exposed to claims of negligence if risks are not identified or managed according to adopted procedures.

Proactive management is not appropriate where there are large numbers of trees with low levels of exposure, such as the extensive areas of remnant trees in reserves in regional councils. For regional councils, a proactive management program may be limited to a small number of high-risk trees located in built-up areas or frequently visited tourist attractions.

**Recommendation 5:** The Board recommends all councils have a tree register which is an essential component in the proactive management of tree risks.

**Recommendation 6:** The Board recommends the Local Government Association develop a tree register template, and identify possible technology options to simplify, integrate and coordinate relevant information for decision making. The tree register template can be modified by councils according to their own resources and objectives.

A tree register is a database that records the location, species, condition, values, and risks of trees [104]. It is used to plan work including actions to maintain tree health (such as addressing watering deficiencies), formative pruning, risk management actions (such as pruning or reducing the exposure of targets) or renewal. The data used in the tree register will depend on the adopted tree risk assessment methodology (see Section 6.3).

Some South Australian councils have established registers for a subset of their trees that have high management importance (e.g. significant trees or trees in high use areas). There is a cost to establish the register, and ongoing resources are required to maintain the register.

The scale of a tree register should reflect two key considerations:

- the resources of the council to develop and maintain the register; and
- the risk to personal safety and property associated with tree failure.

The number of trees on the register and the frequency with which they are assessed can be prioritised according to factors such as target occupancy and target value, tree age, species and condition, aesthetic or heritage value, and community expectations. Importantly, tree registers provide a place to store all tree risk assessments, including those made in response to public inquiries. At present most councils do not have formal arrangements for storing and retrieving this data.

The type and amount of information collected will depend on the situation of the tree, where target value and the likelihood of damage will be high for most street trees, but will vary widely amongst reserve trees [109]. Assessment involves visual inspection at ground level, perhaps with the use of binoculars, unless there is a requirement for a more detailed inspection that requires the use of elevated platforms or towers.

Tree registers should include details of the tree’s characteristics and condition as well as the presence of any potential targets that could be impacted by tree failure. Examples of the components that commonly make up a tree register are listed in Table 1.

Most tree registers contain a subset of these components, but tree condition, structural weaknesses, target attributes and failure potential are essential components if the register is to be used for the purpose of risk assessment. The amount of data collected will depend on the Risk Assessment Method selected.

Tree values are an important component for deciding the most appropriate management option. For example, a tree of exceptional size, or of cultural or heritage significance will have greater effort invested into its retention than a poor specimen with little aesthetic appeal. An apparent shortcoming of most tree registers is that they do not take into account biodiversity values such as remnancy status and habitat value (presence of hollows, food sources, wildlife corridor etc.). Environmental values (e.g. energy savings, carbon sequestration, storm-water interception) are also not considered, most likely because these are very difficult to quantify. It is essential to record these values for them to be protected when risk reduction options are determined.

Once established, ongoing funding is required to ensure that the register is maintained and kept up to date through regular tree surveillance. The frequency of assessments will depend on the level of risk identified for each tree.
Table 1: Examples of tree register components (based on tree registers obtained for the City of Burnside, City of Adelaide, City of Hume, Kia Municipal Council, ACT Government, the Botanic Gardens of Adelaide and Homewood Consulting Pty. Ltd.)

<table>
<thead>
<tr>
<th>Component</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Species</td>
<td></td>
</tr>
<tr>
<td>Location</td>
<td></td>
</tr>
<tr>
<td>Characteristics</td>
<td>Size (height, canopy width, trunk diameter)</td>
</tr>
<tr>
<td></td>
<td>Age (juvenile, semi-mature, mature, senescing)</td>
</tr>
<tr>
<td></td>
<td>Previous pruning</td>
</tr>
<tr>
<td>Condition</td>
<td>Leaf density</td>
</tr>
<tr>
<td></td>
<td>Vigour</td>
</tr>
<tr>
<td></td>
<td>Epicormic growth</td>
</tr>
<tr>
<td>Local conditions</td>
<td>Landscape (lawn, windbreak, pavement)</td>
</tr>
<tr>
<td></td>
<td>Recent site disturbance</td>
</tr>
<tr>
<td></td>
<td>Wind exposure</td>
</tr>
<tr>
<td>Structural weaknesses</td>
<td>Dead limbs</td>
</tr>
<tr>
<td></td>
<td>Crown and trunk defects (decay, cracks/splits, included bark, codominant forks etc.)</td>
</tr>
<tr>
<td></td>
<td>Architecture (lean, unbalanced crown, excessive end weight etc.)</td>
</tr>
<tr>
<td></td>
<td>Insects and disease (e.g. borers)</td>
</tr>
<tr>
<td></td>
<td>Root decay or damage</td>
</tr>
<tr>
<td>Space availability</td>
<td>Adequacy of space available for the tree to reach its full potential</td>
</tr>
<tr>
<td>Past pruning</td>
<td>Type of pruning</td>
</tr>
<tr>
<td>Impact to infrastructure</td>
<td>Roots lifting footpaths, roads, kerb, fences etc.</td>
</tr>
<tr>
<td></td>
<td>Proximity to overhead powerlines</td>
</tr>
<tr>
<td></td>
<td>Verge crossings</td>
</tr>
<tr>
<td>Useful life expectancy</td>
<td>E.g. 0, less than 5 years, 5–10 years, 10–20 years, more than 20 years</td>
</tr>
<tr>
<td>Aesthetic value</td>
<td>Shade, impact on aesthetics of block, part of avenue or group, screen, significant tree, heritage value etc.</td>
</tr>
<tr>
<td>Target attributes</td>
<td>Use under tree (road, building, vehicle, pedestrians)</td>
</tr>
<tr>
<td></td>
<td>Frequency of use</td>
</tr>
<tr>
<td></td>
<td>Possibility of moving targets or restricting access</td>
</tr>
<tr>
<td>Risk assessment</td>
<td>Based on failure potential, size of part, and target attributes</td>
</tr>
<tr>
<td>Risk reduction options</td>
<td>Remove target, Pruning, Tree maintenance, Tree removal</td>
</tr>
<tr>
<td>Management actions required</td>
<td>E.g. aerial inspection, removal of dead branches, structural pruning to remove defects, weight reduction, formative pruning, tree removal.</td>
</tr>
<tr>
<td>Work Priority</td>
<td>Urgent, high, moderate, low, very low, none</td>
</tr>
<tr>
<td>Evaluation schedule</td>
<td>Frequency of assessment required</td>
</tr>
</tbody>
</table>

**Recommendation 7: The Board recommends a standard approach be used for collecting data on tree and limb failures across councils in South Australia**

The collection of data on tree failure incidents is required to properly assess risks, to allocate resources to priority issues and to manage trees cost-effectively. Data is also required to correctly identify the causes of failure so that preventative actions can be developed. Councils currently collect little or no tree failure data, so that this risk cannot be compared to other risks that councils manage.

Council staff members currently attend trees that have failed on public land. A number of simple metrics could be collected at this time in a standard form with minor additional effort. A number of high priority areas are set out in Table 2.
Table 2. Tree failure data collection priorities

<table>
<thead>
<tr>
<th>Data</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Species that has failed</td>
<td>Species that fail regularly could be subject to increased surveillance and excluded from future planting lists.</td>
</tr>
<tr>
<td>Tree age</td>
<td>The age at which trees of certain species tend to fail will assist in planning when tree scapes should be renewed.</td>
</tr>
<tr>
<td>Weather conditions at time of failure (wind strength, temperature)</td>
<td>Data on weather conditions will help characterise the causes of failure and whether they can be managed.</td>
</tr>
<tr>
<td>Type (limb, tree) and weight of failure</td>
<td>The severity of the failure will help characterise the severity of risk events.</td>
</tr>
<tr>
<td>Was there a detectable defect (disease, poor architecture, injury, root damage)?</td>
<td>Better information on defects that lead to failure will assist in future diagnosis and prediction of failure.</td>
</tr>
<tr>
<td>Was there a detectable stress (change in paving, change in watering regime)?</td>
<td>Better information on stresses that lead to tree failure will improve management of the space around trees.</td>
</tr>
</tbody>
</table>

A standard approach should be used for data collection across councils in South Australia. While local data collection will assist individual councils in planning tree management, information that can be shared will greatly increase the size and value of the data set and improve management more widely.

The data requirements should be kept simple and quick to record, enter and report. This will increase the likelihood that data collection and reporting is maintained.

Trees that have suffered limb failure should be recorded on the database as a high priority for ongoing surveillance. Trees that have lost limbs are considered to be susceptible to subsequent failures.

**Recommendation 8: The Board recommends all councils adopt the preliminary screening assessment methodology developed by the Botanic Gardens of Adelaide.**

Risk assessment determines the tree management priorities based on the risk of failure.

Preliminary risk assessment methods are available for assessing large numbers of trees. They are rapid and require limited training and have been developed for non-expert use to assess the safety of individual trees in areas of intense public use. A preliminary assessment methodology is suitable for prioritising trees which should be subjected to a more detailed expert evaluation.

The methodology developed by the Botanic Gardens of South Australia has been adapted by the Department for Environment and Natural Resources (DENR) to make risk assessments of large trees with high exposure i.e. picnic grounds, car parks and campsites. This involves a one-day training program carried out by professional arborists, in which DENR staff are trained to carry out basic tree evaluations and risk assessments. Expert arborists are consulted when detailed risk assessment is required, or to validate evaluations that involve some uncertainty.

**Recommendation 9: The Board recommends the Local Government Association explores the development of a South Australian standard or standards for risk assessment and in the interim each council adopt one detailed risk assessment methodology that is well-regarded and ensure relevant staff have been properly trained in its application.**

Detailed risk assessment methods are designed to assess individual trees including the likelihood and nature of failure and the exposure of targets. Detailed risk assessments are appropriate where trees have high biodiversity or landscape value and risk mitigation measures (pruning or removal) would severely impact on these values. They are also appropriate where the value of targets is very high. Detailed risk assessments generally require a high level of arborist expertise and training in a specific methodology.

A number of risk assessment methods have been developed to assess individual trees, which vary in their complexity, subjectivity and outputs. There is an element of uncertainty in all risk assessments – failures are
not entirely predictable and evaluation methods can be affected by personal judgement. Despite efforts over many years a national standard for tree risk assessment has not yet been adopted.

To minimise the inherent degree of uncertainty associated with detailed risk assessments, councils should chose a single methodology that is applied consistently.Councils should also ensure staff are appropriately trained to apply this method.

The Local Government Association could explore the development of a South Australian standard or standards for risk assessment in collaboration with 'Standards Australia' based on similar work on the development of governance standards for SA councils. If a South Australian standard was developed, all SA councils should adopt that standard. Risk assessments methods should be periodically reviewed against best practice.

**Recommendation 10: The Board recommends councils should be aware of and consider the merits of alternative options to manage risk, where the last resort option would be to remove the tree.**

Once a risk assessment has been undertaken, it is necessary to determine what measures need to be undertaken (if any) to manage the risk. The most appropriate options will depend on the magnitude of the risk. Expensive and dramatic options such as tree removal may be appropriate where tree failure is imminent and lives are threatened. However, risk management options have a cost in terms of their impact on the biodiversity, landscape and other values of trees and the cost of the works. Costs must be balanced against the magnitude of the risk when selecting the most appropriate management option.

A particular conflict can arise when assessing large, old trees. These trees usually provide the most valuable habitat (e.g. nesting hollows) but may also pose a greater public risk. It is therefore important to apply a balanced approach when assessing and managing risk, taking both public safety and habitat value into consideration. Where possible, relocation of the target (e.g. infrastructure such as seating and picnic sites) or public exclusion would be a more ecologically sensitive way to reduce risk, rather than limb or tree removal.

Risk management options involve reducing the hazard presented by the tree or reducing target occupation in the vicinity of the tree. The range of options may include:

- **Moving the target** - the exposure of people and property to failing trees and limbs can be reduced by relocating footpaths, picnic tables, benches, campsites, carparks etc. away from dangerous trees. The costs of moving existing infrastructure can be considerable, but can be negligible when infrastructure is first planned.

- **Protecting the target from impact** - structures such as roofs over walkways or picnic areas can be constructed so that they will reduce the impact of falling branches. Such structures must be built to take into account the size of potential failures. Although the costs associated with building large structures can be considerable, they may be appropriate in situations with high pedestrian traffic and high value trees. In some situations, erecting protective shade structures over picnic areas may be more cost-effective than tree removal, or may be considered worthwhile given the value of the tree.

- **Discouraging target occupation** - people are usually drawn to the shade beneath large trees, particularly if the area is grassed. The use of mulch or landscaping can discourage people from occupying the space beneath potentially hazardous trees. This could be complemented by the simultaneous provision of alternative shaded areas.

- **Exclusion from the site** - denying public access to a site containing one or more hazardous trees may be necessary as a temporary or permanent measure if an area is deemed unsafe, for example following a severe storm or bushfire. Placing a fence around a heritage tree or hazardous trees in part of a reserve or campground may be an effective means of separating potential targets from the hazard with little cost.

- **Removal of dangerous branches** - unstable branches may be selectively removed from trees where they present a significant hazard. Branches are unsound if they show signs of decay, injury, cracks or weak branch unions. Branch removal can affect the appearance and habitat value of the tree and can cost thousands of dollars.

- **Pruning** - pruning is a preventative measure to manage tree and limb failure risks. Overextended branches can be shortened to reduce weight and lessen mechanical strain and poor architecture can sometimes be corrected with proper pruning.
• Cabling and bracing - cabling and bracing can be used to manage risk by reducing stress on weakened branch unions and correcting trees with poor architecture. Cabling and bracing is an intensive approach to maintain trees and is usually only carried out if the tree has significant heritage or landscape value.

• Tree removal - removal may be necessary for trees that are fundamentally unsound and present a significant risk to people or property. Trees may be unsound when they are dead, have significant trunk decay, severe root problems, severe lean or poor architecture. Tree removal can cost thousands of dollars and involves the complete loss of the benefits provided by the tree.

2.4 Measures to prevent the development of defects in new plantings

Recommendation 11: The Board recommends that councils develop protocols for site and species selection, nursery stock selection, and planting and establishment techniques.

Many of the defects, that develop in trees and lead to later failure risks, can be prevented by investing effort in the development of sound plants. An additional benefit of these measures, that is unrelated to tree risk management, is that trees will more effectively achieve their landscape, biodiversity or other objectives and will have lower long-term maintenance costs.

Species selection

Sound tree management practices begin with the selection of appropriate species that fulfil the objective(s) for the tree to be planted (e.g. aesthetic, biological or functional requirements), while minimising any negatives that may be associated with that species. It is imperative that species selection takes into account all of the biological and environmental factors that will affect the tree’s life-time performance. New plantings should also consider the species diversity (to lower the incidence of insect and disease outbreaks), and age diversity (to avoid the development of aged cohorts that incur high management costs over a short period of time).

Councils must ensure that tree selection complies with relevant legislation such as the Electricity Act 1996 and the SA Sewerage Act 1929, as well as the requirements of other service providers (e.g. AGL, Origin, Telstra). Where councils opt to plant trees that do not comply with these legal requirements, they must be prepared to provide additional resources to manage trees in accordance with the relevant legislation.

Several councils have established a list of species suitable for planting in their area. Treenet is conducting ongoing trials of species suitable for street tree plantings. While species lists can provide a guide for tree selection within a geographical area, they do not take into account the local conditions associated with a particular site.

More comprehensive tree selection methods could be adopted to define the species most suitable for a particular location. For example, Bayside City Council (Victoria) has developed a protocol that scores the suitability of trees for a given location [122]. The selection method takes into account: tree management (size, form, limb drop potential, pruning tolerance etc.); site condition (tolerance of compaction, salt, drought, disturbance, water logging, shade); community expectation (evergreen/deciduous), indigenous, wildlife benefit, flowering, fruit); and site characteristics (e.g. consistency with current plantings, space availability, powerlines). In addition to providing guidance to council tree managers, a specified tree selection method could be used as a tool for planners and developers, reducing future risks associated with inappropriate species selection.

Nursery stock selection

The selection of high quality nursery stock can be ensured by adopting a set of standards to which councils and developers must adhere. For example, all planting stock used by the Hume City Council must meet the requirements of their Plant Material Supply Specification [123]. Criteria include: specific crown to root ball ratios; absence of pests and diseases; crown symmetry; stem and branch structure with a central leader, not multi trunks; self-supporting trunk (no stakes); trunk position in centre of root ball; root direction (no circling or girdling), and the size of root ball occupancy. This includes a quality control component where both the supplier and the client must inspect stock prior to delivery.

Specifications for the supplying and purchasing of trees have been developed by the National Building Specification (NATSPEC guide: Specifying Trees) [124]. Councils may opt to develop their own specification based on these standards.
Planting and establishment

Specifications should be developed for tree planting and establishment to ensure consistency and best practice methods within councils and to set standards for the planting of trees on development sites. The City of Hume has developed Tree Planting Specifications that include aspects such as the timing of planting, storage and handling, layout, site preparation, planting pit dimensions, root ball preparation, setting of plants within pit, backfilling, staking, water basins, mulching, irrigation and asset registration [123].

The City of Hume is also guided by its Tree Establishment Maintenance Specifications, which standardise practices including irrigation, mulching, water basin maintenance, fertilising, pest and disease control, weed control, pruning, tree protection, performance monitoring, ongoing scheduled and prioritised arboricultural management [123].

New plantings should take into consideration the principles of water sensitive urban design, particularly in light of a changing climate. Measures that maximise storm-water capture and soil water penetration, such as permeable paving and tree pits, will promote the establishment of healthy trees, that are less prone to failure.

Formative pruning

Formative pruning during juvenile life-stages will help to prevent the development of defects as well as maintain a healthy and aesthetic tree population. Many councils are unable to dedicate resources to a regular formative pruning program, and the majority of trees are not maintained once they are established (3 – 5 years after planting).

Pruning of mature trees is mainly undertaken for the purposes of maintaining clearance envelopes (e.g. roads and footpaths, utility cables) and for risk reduction. It is essential that pruning practices are carried out to a standard that avoids the development of structural weaknesses. Techniques such as lopping are now recognised as unacceptable practices in councils but are sometimes still carried out by utility workers during line-clearance operations.

The Australian Standard (AS 4373-1996): Pruning of Amenity Trees describes methods for pruning trees and encourages practices and procedures that reduce the risk of hazard development, branch failure, fungal infection or premature tree death. It includes formative pruning, hazard reduction, selective pruning and thinning. The Standard recommends that “pruning be carried out by tree workers who through related training, on-the-job experience and qualifications are familiar with the principles, techniques and hazards of this work”.

Councils should provide resources for formative pruning programs, and all pruning practises should be carried out in accordance with AS 4373-1996.

2.5 Land Use Planning

Recommendation 12: The Board recommends the Local Government Association approach the Minister for Urban Development and Planning to propose that Development Plans should specifically ensure there is space for trees and that these areas are sufficient to cater for the needs of trees throughout their entire lifespan.

Planning controls have a significant role in reducing future failure risks by:

- reducing the exposure of people and buildings to tree and limb failure; and
- reducing the conflicts for the space required by trees and infrastructure that lead to tree damage.

A major cause of defects that predispose trees to failure is the competition for space required by trees at maturity. Trees require space for roots to provide stability, collect moisture and take up nutrients. Their canopy also requires space to collect light, provide a balanced architecture and to provide aesthetic and other benefits. The canopy and root space may be required for other uses such as powerlines, road way clearance envelopes and sight lines, underground services, road and footpath construction and buildings. These other uses may result in pruning or root damage, which expose trees to infection and may reduce tree stability. Activities that alter the soil environment, particularly introducing impervious paving, can reduce tree health.
Urban developments near large remnant trees can result in tree removal on the grounds of failure risk management. Large remnant trees may be retained in new developments because of their habitat and aesthetic value and because of the requirements of the significant tree provisions of the Development Act. However, if the areas under the trees are planned for high-exposure uses such as gardens or buildings, they result in a high tree failure risk. The eventual removal of the trees for risk management reasons becomes almost inevitable, but could have been avoided if high-exposure uses were excluded from the space around these trees.

As demand for land increases, urban infill and subdivision will continue to rise, and the amount of private land set aside for vegetation will continue to decrease. This will place more pressure on councils to provide green space, and will increase the burden on councils to manage conflicts with trees located on public land. It is therefore essential that Development Plans specifically ensure there is space for trees and that these areas are sufficient to cater for the needs of trees throughout their entire lifespan.

Planning for trees should be considered from three perspectives:

- ensuring sufficient public land (and the associated airspace) is available within new developments and sub-divisions for trees to prosper, especially along suburban streets and in parks and gardens;
- protecting the space that is required for existing trees when they reach maturity; and
- selecting trees that are suited to these spaces.

Planners (in consultation with tree managers) should play a more active role in ensuring sufficient space is allocated to trees to ensure they are protected from competing uses. Development Plans should specify the space required by trees and plan other land uses around them to avoid conflicts. Specific attention is required to the relationship between underground services and the space allocated to trees, and the relationship between street trees, driveways, fences, front yards and the structures on private property. Planning controls can be placed on subdivisions or for the construction of buildings under existing trees to ensure there are spaces for planted trees to fill at maturity.

The selection of tree species is principally the role of tree managers who consider the soil environment and the canopy space available for the tree at maturity.

2.6 Supervision of developments

Recommendation 13: The Board recommends councils should supervise new developments more closely in relation to trees, with similar performance expectations as for other infrastructure.

Recommendation 14: The Board recommends the Local Government Association approach the Minister for Urban Development and Planning to investigate the feasibility of using bonds paid by developers or land owners to reduce the incidence of tree damaging activities associated with development.

Private companies construct new urban developments as commercial enterprises and councils assume responsibility for the public infrastructure of the development including roads, footpaths, parks, and stormwater infrastructure.

Standards are in place to ensure that engineering works are completed to an acceptable high quality and that councils do not assume responsibility for faulty works with long-term liabilities for maintenance and repair. Council planners and engineers usually work closely with developers to ensure that infrastructure complies with standards and the Development Plan. On-site inspections are made before infrastructure is handed over.

Landscaping can be a significant component of new developments, but is rarely subject to the same scrutiny. Reported problems include:

- the tree species that are selected are not reviewed and may be problematic or inappropriate;
- poor nursery stock is used with long term consequences for tree health and integrity;
- planting sites are poorly prepared with long term consequences for tree health and integrity;
- planted trees are not subject to formative pruning, appropriate watering or other care;
- surface drainage patterns are altered, affecting the health of existing trees;
- Australian Standards to protect the canopy and root zone of trees from damage are not followed and not enforced; and
• landscaping and tree planting works are not inspected prior to handover so that defective works are not identified and addressed by the developer.

A closer level of supervision should apply to new developments in relation to trees, with similar expectations as for other infrastructure. Clearer guidance should be given to developers and stricter compliance conditions should be enforced.

This will involve a greater demand on the time of arborists and more resources will be required. However these costs should be considered in relation to the cost of the original investment in tree planting which includes the cost of land set aside for trees, the cost of supply and planting, and the value that trees add to the development. These costs should also be considered in relation to the remediation and maintenance costs borne by councils for substandard landscaping.

Tree-damaging activities could be further reduced by applying bonds to contractors [104]. For example, a bond set aside for the planting and establishment of new trees on development sites would encourage appropriate care and maintenance of trees. This would ensure the establishment of healthy populations of trees with a lower potential to fail. Bonds could also be applied to existing trees to discourage tree-damaging activities during the construction processes. To act as a deterrent the bond would need to be substantial and related to prior valuation [104].

2.7 Training and qualifications

Arborists

Recommendation 15: The Board recommends the Local Government Association engage with the Primary Industry Skills Council, in consultation with relevant industry associations and professional bodies, to review the training standards and practices, and independent quality control for arborist training in South Australia, especially as they compare to other states.

Arborists have a central role in the management of tree failure risks and the promotion of the benefits that trees provide. Arborists are required to evaluate the likelihood of tree failure, to identify measures to reduce risk to acceptable levels while minimising impacts on trees. Arborists are required to supervise work crews undertaking tree management tasks such as pruning and shaping. Arborists also provide advice to other council staff, particularly engineers and planners on measures to avoid damage to trees and to promote tree health.

Arborists are qualified through certificate training in Horticulture — Arboriculture. Certificate III qualifies arborists to independently manage trees, to provide advice on tree planting and maintenance and to evaluate the health and value of trees. Certificate IV provides a higher level of expertise and qualifies arborists to supervise and train staff. Certificate V is a diploma qualification and is suited for arborists who run independent businesses.

The standard of training in South Australia has been consistently questioned by trainers, council staff and independent arborists during this Inquiry. In relation to tree and limb failure, poor training has been particularly associated with:

• incorrectly assessing safe trees as dangerous;
• incorrectly assessing dangerous trees as safe;
• recommending inappropriate measures to mitigate failure risk; and
• poor tree pruning practices.

Poor diagnosis results from inadequate knowledge of tree defects, their causes and effects. Poor pruning for risk management or general clearance requirements can injure trees, further reducing tree health and increasing the likelihood of tree failure in the future.

Training for arborists in South Australia is provided by public and private training providers. A number of issues have been raised about this training, which include:

• Councils may not be engaging staff and contractors with the skills and qualifications commensurate with the tasks and activities required to properly manage trees.
• Arborist training in South Australia follows the National Training Package curriculum, which has been criticised as being open to broad interpretation that allows for lower training effort and
standards. A further criticism is that it does not set specific training requirements for South Australian species and conditions, so that arborists receive general training and are uninformed about the tree management issues they are likely to encounter in South Australia.

It is beyond the scope of this Inquiry to make detailed recommendations for tertiary education in relation to arboriculture. However, this has been reported strongly and consistently from both the training and professional sectors as a major issue in the quality of tree failure management and in tree management generally in South Australia.

Work Crews and contractors undertaking pruning and excavation

Recommendation 16: The Board recommends the Local Government Association work with councils to identify the skills and qualifications required by employees and contractors undertaking arboriculture work for councils.

Recommendation 17: The Board recommends that private contractors who prune trees or excavate near trees on public land be required to comply with contractual requirements to notify councils of the potential impact of their activities on trees, and excavation practices that can avoid damage to trees.

Pruning, line-clearance and shaping of trees is undertaken by council work crews, ETSA work crews or their external contractors. In many cases, the work crews’ pruning practices are considered to be poor. Such practices may actually create defects that generate future failure risks and unnecessarily compromise the aesthetic, biodiversity and other values of trees.

In many cases work crews only have training in chainsaw operations and maintenance. Tree managers have suggested that additional training for work crews would greatly improve tree outcomes. Training in tree pruning practices for the work crews or contractors could be set as a requirement by councils. Such training could be provided by senior arborists as an in-service course arranged by the Local Government Association in South Australia or through an external service provider.

Similarly an important tree failure hazard is root severance, which destabilises trees and makes them prone to failure. Roots are frequently severed when underground services are installed or repaired. Trees may remain in good health even though their anchorage has been compromised, and failure may not occur until some time later. After the works are completed and the surface has been filled and finished, it is impossible to assess whether any root damage has taken place.

Contractors who excavate near council trees are generally required to notify council staff so that the potential for damage can be identified and protective measures can be put in place. In practice, however, council staff generally has limited time to visit sites and contractors frequently fail to notify councils.

It is proposed that the LGA Mutual Liability Scheme consider reviewing its ‘model contract’ documentation to require notification of councils and to provide guidelines that can be provided to contractors to assist them to determine when notification is required.

2.8 Significant trees

Recommendation 18: The Board recommends the Minister for Urban Development and Planning consider the matters raised in this report which impinge on ‘regulated’ and ‘significant’ trees in the current consultation on the draft Development (Regulated Trees) Variation Regulations 2010 and introduce regulations which require an applicant seeking to have a significant tree removed or pruned because of concerns about safety to obtain an assessment from an experienced and independent arborist (i.e. independent of tree removal contractors).

The Development Act provides for the protection of significant trees within certain parts of the state that are either nominated as significant or meet particular size criteria. The Act requires that development approval is given for actions that remove or substantially damage the tree, but that permission for pruning or removal may be given where trees pose a threat to safety or property.

Problems around significant tree assessments relate mostly to private land where landholders apply to remove trees, so that the issue is outside the scope of this Inquiry. However, it is possible for landholders to apply for the removal of significant trees on land adjacent to their property, which may be public land.
The quality of professional assessments of significant trees has been questioned. There is concern among council staff, planners and professional arborists that some arborists may be poorly qualified, and that tree assessments can sometimes be biased.

The potential of tree failure is frequently used as the basis of tree removal applications. Such assessments should be made by qualified arborists, however the criteria to determine these qualifications are not clear. In light of the concern over arborist training (see Section 0), the reliability of arborist opinion has been questioned.

Applicants seeking to remove significant trees have an interest in the tree’s removal and will take steps to increase the success of their application. This could include seeking an arborist who is more likely to provide a favourable opinion or seeking opinions from additional arborists until a favourable opinion is provided. Concern has been expressed that arborists may not act independently if the applicant has also engaged them to remove the tree or if there is a close relationship or understanding between the applicant and developer in favour of tree removal.

These conflicts have been acknowledged in other states, where some councils will only accept recommendations to remove significant trees that have been prepared by independent arborists who are not associated with contractors that undertake tree removal work.

At the time of writing of this report the Board noted that the Minister for Urban Development and Planning was consulting on draft regulations to the Development Act regarding regulated and significant trees which included reference to the matters identified by the Board.

2.9 Coordination with utilities

Recommendation 19: The Board recommends the Local Government Association, having regard to the specific obligations of councils under Regulations 4 and 10 of the Electricity Act 1996, redouble its efforts on working arrangements with ETSA Utilities to develop alternative approaches to manage tree selection and pruning which respect the value of trees and minimise failure risks.

The Board is aware that the LGA has existing mechanisms to liaise with ETSA Utilities on the management of trees adjacent to their infrastructure (especially regarding pruning practices) and this mechanism should be used to progress the additional matters identified by the Board.

ETSA has a legal obligation to manage trees in specified clearance envelopes to maintain electricity supply and minimise fire risk. Councils manage trees for the purposes of promoting tree health, achieving tree objectives in the landscape and minimising ongoing maintenance costs. These objectives result in conflict where tree pruning undermines tree health and stability or where the trees planted under powerlines inevitably grow to a height where they increase the line-clearance burden on ETSA.

Some measures are available to manage the conflicting objectives and establish cooperative arrangements between ETSA and councils. However, these measures have had limited success. Councils can arrange to pay ETSA to prune trees to a higher standard where tree form and health is better protected. Alternatively they can maintain the clearance envelope around powerlines under their own pruning programs, with the objective of reducing threats to tree health. ETSA also provides a list of species that are approved under the Electricity Act for planting in the vicinity of powerlines.

However, councils have expressed limited confidence in the pruning standards that ETSA applies and ETSA has expressed dissatisfaction with the line clearance performed by councils. Councils are also reluctant to plant species approved under the Electricity Act, which do not provide the form required of street trees.

Recommendation 20: The Board recommends the Local Government Association establish a working party to review how below and above ground activities by utilities affect trees, how councils are notified of work, the capacity of councils to respond to notification and the expertise available in councils to provide advice on the protection of trees.

The differing objectives of utility providers (e.g. telecommunications, electricity, gas and water utilities) and councils are an ongoing source of conflict that can result in poor tree condition, increased risk of failure and friction between these groups.
Council tree managers require the time and expertise to advise utility providers of how to avoid damage to trees. They also depend on utility providers on advising of them of upcoming work with sufficient time to respond. Both of these matters are deficient in many cases.

## 2.10 Summary of recommendations

<table>
<thead>
<tr>
<th>Topic</th>
<th>Recommendation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tree Management Policy</td>
<td>1 All councils develop and adopt a formal Tree Management Policy with appropriate linkages to the council’s strategic management plans.</td>
</tr>
<tr>
<td></td>
<td>2 Tree Management Policies be developed through consultation and include procedures to keep the community informed of tree values (including community education programs), the adopted objectives of tree management and how they are being achieved.</td>
</tr>
<tr>
<td></td>
<td>3 The Local Government Association develop a template Tree Management Policy that councils can use to develop their own specific policy.</td>
</tr>
<tr>
<td>Proactive management of tree risks</td>
<td>4 All councils adopt a proactive approach to managing the risks in existing trees.</td>
</tr>
<tr>
<td></td>
<td>5 All councils have a tree register which is an essential component in the proactive management of tree risks.</td>
</tr>
<tr>
<td></td>
<td>6 The Local Government Association develop a tree register template, and identify possible technology options to simplify, integrate and coordinate relevant information for decision making. The tree register template can be modified by councils according to their own resources and objectives.</td>
</tr>
<tr>
<td></td>
<td>7 A standard approach be used for collecting data on tree and limb failure across councils in South Australia.</td>
</tr>
<tr>
<td></td>
<td>8 All councils adopt the preliminary screening assessment methodology developed by the Botanic Gardens of Adelaide.</td>
</tr>
<tr>
<td></td>
<td>9 The Local Government Association explores the development of a South Australian standard or standards for risk assessment and in the interim each council adopt one detailed risk assessment methodology that is well-regarded and ensure relevant staff have been properly trained in its application.</td>
</tr>
<tr>
<td></td>
<td>10 Councils should be aware of and consider the merits of alternative options to manage risk, where the last resort option would be to remove the tree.</td>
</tr>
<tr>
<td>Measures to prevent the development of defects in new plantings</td>
<td>11 Councils develop protocols for site and species selection, nursery stock selection, and planting and establishment techniques.</td>
</tr>
<tr>
<td>Land use planning</td>
<td>12 The LGA approach the Minister for Urban Development and Planning to propose that Development Plans should specifically ensure there is space for trees and that these areas are sufficient to cater for the needs of trees throughout their entire lifespan.</td>
</tr>
<tr>
<td>Supervision of developments</td>
<td>13 Councils supervise new developments more closely in relation to trees, with similar performance expectations as for other infrastructure.</td>
</tr>
<tr>
<td></td>
<td>14 The Local Government Association approach the Minister for Urban Development and Planning to investigate the feasibility of using bonds paid by developers or land owners to reduce the incidence of tree damaging activities associated with development.</td>
</tr>
</tbody>
</table>
### Training and qualifications

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>The Local Government Association engage with the Primary Industry Skills Council, in consultation with relevant industry associations and professional bodies, to review the training standards and practices, and independent quality control for arborist training in South Australia, especially as they compare to other states.</td>
</tr>
<tr>
<td>16</td>
<td>The Local Government Association work with councils to identify the skills and qualifications required by employees and contractors undertaking arboriculture work for councils.</td>
</tr>
<tr>
<td>17</td>
<td>Private contractors who prune trees or excavate near trees on public land be required to comply with contractual requirements to notify councils of the potential impact of their activities on trees, and excavation practices that can avoid damage to trees.</td>
</tr>
</tbody>
</table>

### Significant trees

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>18</td>
<td>The Minister for Urban Development and Planning consider the matters raised in this report which impinge on ‘regulated’ and ‘significant’ trees in the current consultation on the draft Development (Regulated Trees) Variation Regulations 2010 and introduce regulations which require an applicant seeking to have a significant tree removed or pruned because of concerns about safety to obtain an assessment from an experienced and independent arborist (i.e. independent of tree removal contractors).</td>
</tr>
</tbody>
</table>

### Coordination with utilities

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>19</td>
<td>The Local Government Association, having regard to the specific obligations of councils under Regulations 4 and 10 of the Electricity Act 1996, redouble its efforts on working arrangements with ETSA Utilities to develop alternative approaches to manage tree selection and pruning which respect the value of trees and minimise failure risks.</td>
</tr>
<tr>
<td>20</td>
<td>The Local Government Association establish a working party to review how below and above ground activities by other utilities (i.e. other than ETSA) affect trees, how councils are notified of work, the capacity of councils to respond to notification and the expertise available in councils to provide advice on the protection of trees.</td>
</tr>
</tbody>
</table>

### References


120. McInnes K.L., R. Suppiah, P.H. Whetton, K.J. Hennessy, and R.N. Jones (2003). Climate Change in South Australia. CSIRO Atmospheric Research, Canberra, ACT.


Culturally significant trees review

David Cooney
Senior Policy Planner
District Council of Mount Barker

Introduction
Local Government recognises the importance of trees in the urban and rural landscape. Trees are an important community asset, providing a number of benefits.

Most communities have planted trees or gardens to commemorate a person or important event. These plantings help define communities and are a living reminder of significant local history. Many native plantings have significance for local Aboriginal communities, some of these trees are obvious, such as shield or canoe trees, but others may be less visible.

From a local government perspective many of these important trees are located on public land or road sides, and may either be at risk from adjacent development or maintenance activities, or may through age, proximity to other structures or neglect, be a hazard themselves.

Because of their potential significance to the local and broader community these plantings should be given special consideration and pro-actively managed, and potentially replaced or relocated.

Why manage culturally significant trees?
The primary driver for managing any infrastructure on land under the care and control of Council and accessible by the public is risk minimisation. Trees have been subject to a review by the Local Government Association with the Final Report of the Independent Enquiry into Management of Trees on Public Land being released for consultation in October 2010.

A recommendation of this report (Recommendation 1) is that The Board recommends that all Councils develop and adopt a formal Tree Management Policy with appropriate linkages to the Council’s strategic management plans.

Recommendation 2 states that, The Board recommends that tree management policies be developed through consultation and include procedures to keep the community informed of tree values (including community education programs), the adopted objectives of tree management and how they are being achieved.

Recommendation 3 states that, The Board recommends that all Council’s adopt a pro active approach to managing the risk in existing trees.

The development of detailed guidelines and policies relating to the management of culturally significant trees provides a more specific suite of management tools to assist Council’s in addressing the complexity of managing these trees.

Policy objectives
- To enhance Local Government’s reputation within the community, as a steward and manager of trees.
- To maintain and improve a quality tree canopy within their areas.
- To increase awareness and to educate the community, developers and Council staff on the value of all trees, and specifically culturally significant trees in the landscape.
- To identify and preserve culturally significant, valuable trees based on historic, visual, cultural, social and ecological criteria.
- To broaden the emphasis from tree planting and preservation to an overall approach of urban tree management with a specific acknowledgement of culturally important trees and plantings.
- To document and standardise process and procedure to ensure consistency in the management of culturally significant trees and plantings.
- To maintain culturally important trees over time by planning for logical, orderly and agreed replacement to prevent senescent trees from posing increased risk.
Mount Barker Council, in partnership with TREENET, and with funding support from the LGA has undertaken a project to develop a suite of management policies and guidelines to enable these objectives to be met. Sam Cassar from Symatree has been engaged to develop the guidelines, and through close collaboration with the project steering committee has accurately reflected our project objectives.

These guidelines will be available to all Councils to use, through the LGA.
Literature Review - Culturally Significant Tree Project
Version 1

Sam Cassar

Introduction
Historic (culturally significant) trees, streetscapes and avenues form significant landscape features and have a large impact on the landscape, both visually and environmentally. Historical trees are known as heritage or as it has been colloquially described ‘the things we want to keep’ (Dr Olsen 2006).

The tangible and visual history of our State, (South Australia) in the form of man-made monuments, will take us back no more than 150 years. But trees are living monuments capable of transporting us 400 years back into the past. (Ivens R 1980).

The aim of this report is to provide a theoretical background from the available literature. The report will review current approaches, ideas and considerations and investigate potential problems for the protection, care and management of this class of special-merit trees. It is the intention that this information will be used:

- To provide the tools necessary to systematically record and protect outstanding trees, native and exotic, under the care and control of local councils within South Australia;
- To create an awareness of the contribution that culturally significant trees make to aesthetic, cultural and historic fabric of the state; and
- To promote awareness of the value of culturally significant trees to the community, including local councils.

The review discusses the relevant charters and conventions, lists the fundamental standards and language, details identified assessment processes and discusses the issues of managing and maintaining this important group of urban trees.

Heritage charters and conventions
A number of heritage charters and conventions exist to help professionals and others to define and manage these items of cultural significance for present and future communities.

Heritage charters and conventions act as frameworks to help the decision making process when dealing with culturally significant items. From a review of the heritage charters it was determined to use the Australian ICOMOS, Burra Charter (Australian ICOMOS 1999) and the Australian Natural Heritage Charter for the places of natural heritage significance (Natural Heritage Charter 2002) as the primary charters with supporting reference to the Florence Charter for Historic Gardens (ICOMOS-IFLA 1982).

These charters appear to be the most applicable to trees. The Burra Charter provides guidance for the conservation and management of places of cultural significance (cultural heritage places), and is based on the knowledge and experience of Australia ICOMOS members (Australian ICOMOS 1999). The Burra Charter is the favoured Charter used by Australian professionals.

Trees create a unique challenge when one applies an architecturally driven approach to what is in essence a biological system. Trees have vastly different management needs to buildings.

Tree biology is dynamic, changing as the tree ages. Age-related changes to trees include decreased rates of net carbon assimilation, decreased rates of growth in all organs, increased susceptibility to disease, insect and other stresses and altered patterns of dry matter partitioning (Clark and Matheny 1991).

Heritage has often been perceived as a don’t touch affair, so that to do “as little as possible, as much as necessary” translates as doing nothing at all. Arborists and related professionals know to do this is suicidal as a management practise. The principle purpose of planting and maintaining trees, streetscapes and avenues is at the very least to provide a better environment for human habitation. In contrast, heritage practitioners know it is suicidal as a management practice to ignore the abstract values, associations and meaning that we as humans bring to these environments” (Dr Olsen 2006).
Melding of these approaches will provide the best possible methodology to conserve and manage culturally significant trees. The conservation of trees and avenues really means the best appropriate care for the enjoyment of present and future communities. Conservation means all the processes of looking after a place so as to retain its cultural significance (Burra Charter Article 1.4).

The Burra Charter provides the fundamental standards and language for the practical management of cultural items. A major criticism of the Burra Charter has been its application to the management of vegetation and historical landscapes (Parker M 1988).

The Burra Charter lacks the recognition of natural processes that define what a tree is and how it grows. For these conservation processes to clearly be applicable to urban tree management certain terms and guidelines must reflect trees as biological (living) systems.

By adapting Article 2 from the Florence Charter, the unique characteristics of trees and other plants can be defined as: Trees are living, which means they are perishable and renewable. Thus their health and stability reflects the perpetual balance between the cycle of the seasons, the growth and decay of nature and the desire of the arborist/horticulturalist to keep them permanently unchanged once maturity has been reached.

Successful application of these Charters revolves around a clear understanding of the principles and terms used and if they can be applied to culturally significant trees.

**Terms and guidelines**

The Australian ICOMOS, Burra Charter uses the concept of cultural significance to justify the conserving of places, including trees. Cultural significance means aesthetic, historic, scientific or social value for past, present and future generations (Australian ICOMOS, Burra Charter Article 1.2 1981). The Charter describes the four values used in the definition as encompassing all other values.

Trees and avenues can be described and analysed as one of more than one of these values. These values vary from community to community, as well as having the potential to change within the same community over time. (Dr Olsen 2006)

A listing of the relevant conservation processes and terminology from the Burra Charter 1999, the Natural Heritage Charter 2002 and Florence Charter for Historic Gardens (1982) is provided below. Where appropriate, these processes and terminology have been adapted to culturally significant trees, therefore building on accepted conservation principles and practices.

**Place:** means site, area, land, landscape, building or other work, group of buildings or other works, and may include components, contents, spaces and views. The concept of place should be broadly interpreted. The elements described in Article 1.1 may include memorials, trees, gardens, parks, places of historical events, urban areas, towns, industrial places, archaeological sites and spiritual and religious places (Burra Charter Article 1.1).

**Fabric:** means all the physical material of the place including components, fixtures, contents, and objects (Burra Charter Article 1.3). Fabric may define spaces and these may be important elements of the significance of the place. Species, age, location, biology, growing zone are considered to be the fabric of a tree.

**Protection:** may include conservation management measures that are either direct or indirect. The aim of protection is to prevent or minimise impacts that may degrade the natural significance and to facilitate regeneration (Natural Heritage Charter Article 16). Any alteration to the physical environment which will endanger the ecological equilibrium must be prohibited. These applications are applicable to all aspects of the infrastructure, whether internal or external e.g. drainage works, irrigation systems, road, car parks, fences etc (Florence Charter 1982 Article 14).

**Conservation:** means all the processes of looking after a place so as to retain its cultural significance (Burra Charter Article 1.4). Conservation should include the provision for its security, its maintenance and its future Conservation is based on a respect for the existing fabric, use, associations and meanings (Burra Charter Article 2.2). It requires a cautious approach of changing as much as necessary but as little as possible (Burra Charter Article 3.1).
Maintenance: means the continuous protective care of the fabric, contents and settings of a place. For a tree this may include minor pruning, weeding, mulching, fertilising and watering undertaken to prolong the vigour and life expectancy of a tree (Burra Charter Article 1.5). Culturally significant trees must be preserved in appropriate surroundings.

Reinstatement: is appropriate only if (Natural Heritage Charter Article 20):

- There is evidence that the tree or tree avenue that is to be reintroduced has existed there at a previous time.
- Returning the tree contributes to the cultural significance of that place.
- Processes that may threaten their existence at that place have been discontinued.

Restoration: is appropriate only if there is sufficient evidence of an earlier state to guide the conservation process and if returning an avenue of trees or an individual tree planting is consistent with a previous time (Burra Charter Article 13). An illustration of restoration for a culturally significant tree is major pruning to regain a tree’s structural integrity or the interplanting of new trees of the dominant species to complete an avenue planting.

Reconstruction: is appropriate only where a place is incomplete through damage or alteration, and only where there is sufficient evidence to reproduce an earlier state of fabric (Burra Charter Article 20). This is the most applicable of the conservation terms for culturally significant trees, along with the idea of maintenance (Olsen 2001). Reconstruction most accurately reflects the ongoing nature of scheduled arboricultural practices given the ongoing continually changing nature of living trees. Tree replacement most readily approximates this process (Olsen 2001). It can include the introduction of a new species to replace the old if sufficient justification exists and no or minimal impact to the significance of the place occurs.

Use: While any culturally significant tree is designed to be seen, access to it must be restricted to the extent demanded by its size and vulnerability, so that its physical fabric and cultural message may be preserved (Florence Charter 1982 Article 18). The application of a fenced tree protection zone would illustrate best the intention of this term.

Cultural significance

Part of the assessment for cultural significance includes understanding historical and other evidence according to a range of values of significance (Dr Olsen 2001).

The concept of cultural significance in the context of culturally significant trees has been adapted from a publication by the NSW, Dept of Planning 1990, guidelines for the conservation and management of street trees in NSW:

Cultural/social/health value: Trees play an important role in elements of towns and cities such as approach roads, showgrounds, transport links, residential areas, important buildings, access roads, parks and strips. The definition distinguishes between country towns and metropolitan areas by planting styles, locations and associations with various built form. Trees help recognize special places. Trees contribute to society’s health and physical wellbeing.

Historical value: Trees are often of historical significance when associated with important eras, buildings, events or people. Trees/gardens may reflect specific epochs in garden design/landscape architecture.

Scientific/environmental value: Trees are often valuable for a range of scientific reasons. Species which are rare, vulnerable or endangered, of a great age or provide important habitat for wildlife can be considered under this definition.

Aesthetic value: Trees are of aesthetic value if they reflect important features in townscape, screen unattractive buildings or are exceptionally beautiful, provide shade, or act as a wind breaks.

Also needed for heritage is a range of detailed management approaches which are specific to each value of significance, so that heritage value itself, rather than just the physical specimen, is maintained and continued appropriately over time (Dr Olsen 2006).
Defining a culturally significant tree
A number of definitions have been proposed to describe what a culturally significant tree is. In most cases the term ‘significant tree’ has been used to describe this class of trees.

The Significant Tree Steering Committee for the National Trust of South Australia (Heath and Tamblyn 2008) defines culturally or heritage trees as a class of special-merit trees. Heritage trees are classes of trees which warrant special consideration. They provide a wide range of historical, cultural and scientific benefits over and above the accepted values of everyday trees as such their extraordinary values need to be retained for as long as possible.

City of Rydes has adopted the following definition:

Trees can be either a single tree or a larger grouping of trees that may possess values relating to their visual, historic, botanical, cultural, commemorative or other significances as defined in their approved category list.

The City of Sydney defines culturally significant trees in the following way (Significant trees register, part 1 of 4 2005):

Significant (culturally) trees are commonly the last vestiges of former natural and cultural landscapes. These trees retain exceptional values in terms of their contribution to our urban environment. They have a recognisable range of values—natural, cultural, aesthetic, visual, social and historic. These trees can be symbols of great spiritual power, they may have associations with individual people and communities or tell stories of other times and places, or the historic development of a place, trade routes, connections and communications. Significant trees often visually dominate a place by their sheer size, scale and visual impact. Remnant trees from former natural ecological communities may retain valuable habitat and faunal corridors for other endangered and dependent species. These trees also offer a valuable gene pool for future scientific research, conservation and restoration.

In recognising the significant trees within a local area, greater meaning can be brought to the past, allowing a richer understanding of the present. This in turn can provide the basis for better methods of protection, care and management for the future. The assessment of heritage significance is a dynamic process, changing with the passage of time and reflecting the way people interact and perceive the relative importance of places and items, particularly as parts of this collective heritage are lost.

The Victorian Planning Department in its planning bulletin ‘Vegetation Protection in Urban Areas’ (August 1999) defines significant vegetation including trees as follows:

Vegetation can make an important contribution to the urban environment. It may be of botanical or scientific significance or have environmental, historical, aesthetic or cultural value. Vegetation may also be important to the community in defining and contributing to the character of a city, suburb or township.

Avenues are a unique landscape feature requiring a slightly different approach when defining their characteristics. Tree avenues are a double row of regularly spaced trees, usually lining an entrance or road, creating a walkway or vista. Generally an avenue consists of only one or a limited number of species (Dickins 1985).

Avenues as a group can have a recognisable range of values including natural, cultural, aesthetic, visual, social and historic. Avenues can be categorised as either a town or street avenue, private avenue and memorial or commemorative.

Therefore, trees and avenue plantings can be culturally significant and worthy of conserving. Their value can be, historic, aesthetic, scientific, or social; generally they are a combination of some of these values.

Assessment criteria
Generally the criteria used to evaluate culturally significant trees reflects the values expressed in the definition of cultural significance; aesthetics, historic, scientific or social.

Dr Greg Moore (n.d.) states in his paper ‘Ancient and Significant Trees - Protecting Community Assets and Heritage’:
There is no simple approach to identifying significant trees and selecting criteria that are objective, meaningful and broadly understood, which has been essential to the success of the Victoria Register of Significant Trees. In general, nominations can be made and assessed under one or more of the categories listed below.

- Horticultural and/or Genetic Value
- Rare or Localised Distribution
- Outstanding Size (Girth, Height or Spread)
- Curious Growth Habit
- Connection To Aboriginal Culture
- Unique Location or Context
- Particularly Old Specimen
- Aesthetic Value
- Historical Significance
- Outstanding Example of Species

For each of these categories a number of sub-categories exist to assist in making decisions about the worthiness of specimens for classification. Some of these sub-categories are listed below:

<table>
<thead>
<tr>
<th>Outstanding Size</th>
<th>Historic Value</th>
<th>Rare or Localised</th>
</tr>
</thead>
<tbody>
<tr>
<td>Height</td>
<td>Cultural Group</td>
<td>Only Known Specimen</td>
</tr>
<tr>
<td>Circumference (Girth)</td>
<td>Public Feature</td>
<td>1-10 Known Specimens</td>
</tr>
<tr>
<td>Canopy Spread</td>
<td>World War I</td>
<td>10-50 Known Specimens</td>
</tr>
<tr>
<td>Height x Girth</td>
<td>World War II</td>
<td>In the Wild</td>
</tr>
<tr>
<td>Spread x Girth</td>
<td>British Royalty</td>
<td>End of Natural Range</td>
</tr>
<tr>
<td>Height x Girth x Spread</td>
<td>Other Royalty</td>
<td>Disjunct Community</td>
</tr>
<tr>
<td></td>
<td>Visiting Dignitary</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Australian Public Figure</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Victorian (South Australian) Public Figure</td>
<td></td>
</tr>
</tbody>
</table>

Note: There are no sub-categories for the horticultural, aesthetic, age or outstanding specimen categories. A key to the above criteria for classification has been provided in Appendix A.

Dr Moore then goes on to highlight the categories used for the nomination form for Registering Significant Trees for the Victorian National Trust Tree register. These categories include:

- Any tree which is of horticultural or genetic value and could be an important source of propagating stock, including specimens that are particularly resistant to disease or exposure.
- Any tree which occurs in a unique location or context and so provides a contribution to the landscape, including remnant native vegetation, important landmarks, and trees which form part of an historic garden, park or town.
- Any tree of a species or variety that is rare or a very localised distribution.
- Any tree that is particularly old or venerable.
- Any tree outstanding for its large height, trunk circumference or canopy spread.
- Any tree of outstanding aesthetic significance.
- Any tree which exhibits a curious growth form or physical feature such as abnormal outgrowths, natural fusion of branches, severe lightning damage or unusually pruned forms.
- Any tree commemorating a particular occasion (including plantings by Royalty) or having associated with an important historical event.
- Any tree associated with Aboriginal activities.

The City of Sydney (Significant Trees, part 1 of 4 2005) has adapted criteria from The Register of the National Estate, in accordance with the Burra Charter. These criteria are applied to all types of heritage places and items including natural, cultural and Indigenous. The collected tree data is evaluated on the basis of each tree’s contextual relationship to other similar trees and its relative importance in terms of the following criteria:
Historic and/or natural value (i.e. indigenous/ cultivated origin)

- Determination of origin as a component of natural ecological community or cultivated/planted as part of historic development of the place; including influences by historic figures, events and patterns of development.

Botanic/ scientific value

- Associated with research and educational values, based on integrity, rarity and representative values.

Social, cultural and commemorative value

- Focusing on qualities such as the spiritual, political, national and cultural sentiment reflected by the broader population or smaller community groups; including commemorative events.

Visual and aesthetic value

- Must be based on existing physical fabric: its health and structural integrity.
- Relates to qualities of bulk, scale and contribution to defining local character and the ‘spirit’ or sense of place.

The heritage values for each listed tree or group of trees is encapsulated in a Statement of Significance which involves interpretation and analysis of comparative points of importance as follows:

- rarity value;
- biodiversity value;
- individual and/or group value;
- landmark value;
- representative value;
- integrity value;
- research, teaching and understanding;
- social, cultural or spiritual associations; and
- associations with significant individuals.

The criteria relate to both cultural and natural significance of an item and place. Some have a specific cultural or natural bias. Nevertheless, the heritage values of a significant tree or group of trees are almost always multi-layered.

The National Trust of South Australia has adopted the following criteria to assess the cultural/heritage significance of trees. The nominated tree(s) should be significant for one or more of the following reasons:

1. Natural value (remnant vegetation, habitat, maintain biodiversity)

   (R) - An isolated remnant of native vegetation or is a species or variety that is rated Rare, Endangered or Vulnerable

   (F) - Provides valuable fauna habitat (e.g. hollows suitable for possums or a range of bird species)

   (X) - Other (please describe)

2. Historic/cultural value (Aboriginal, colonial, post-colonial, association with person or event, ethnic, community)

   (H) - Commemorates or has associations with an important historical event

   (V) - Significantly associated with a VIP or well known public figure, (eg planted by Royalty or prominent person)

   (E) - Significantly associated with an aboriginal or ethnic group

   (P) - Part of a private or public historic garden or park or town

   (C) - Is or has been of importance in the life of the local community

   (X) - Other (please describe)
3. Aesthetic value (dimensions, age, character, physical features, landmark/landscape qualities)

(B) - Outstanding aesthetic beauty
(D) - Outstanding dimensions in height, or trunk circumference, or canopy spread
(O) - Very old or venerable
(L) - Occurs in a unique location or context, and thus provides a special contribution to the landscape, or is a landmark
(T) - Excellent example of topiary
(Q) - Curious growth forms or physical features either from natural causes, or pruning
(X) - Other (please describe)

4. Endangered/rare (International, national, state, local, horticultural)

(R) - Isolated remnant of native vegetation or is a species or variety that is rated Rare, Endangered or Vulnerable, or is of very localised distribution
(G) - Horticultural or genetic value, possibly important as propagating stock, or cultivars particularly resistant to disease or exposure
(J) - Preserves the genetic stock of a listed tree (eg a seedling or cutting of a tree which is nearing the end of its lifespan), a juvenile of possible future significance
(X) - Other (please describe)

City of Ryde has adopted similar criteria to assess the cultural/heritage significance of trees.

Primary selection categories are to be listed as:

- Heritage
- Botanical/Horticultural
- Urban Forest Community
- Other

Sub categories will be used for a more detailed assessment either supported by Council searches or as supplementary information provided by the nominee or other interested persons.

**Heritage Planting**

- Aboriginal significance
- European significance
- Historical significance
- Commemorative significance

**Botanic/Horticultural**

- Significant contribution to a flora/fauna habitat or corridor
- Rare or uncommon species
- Unusual growth form
- Visual or aesthetic qualities

**Urban Forest Community**

- Local and/or verge groupings

**Other category that may apply**

- Landmark importance
- Scientific values
- Potential future heritage value
The City of Prahran in its study ‘Significant tree and garden study’ (Looker and Hubbard 1992) adopted the following criteria adapted from the Significant Trees Register prepared by the Royal Melbourne Botanic Gardens and the National Trust.

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>L Landscape</td>
<td>An important individual feature or group, frames or screens view, or acts as a landmark</td>
</tr>
<tr>
<td>S Size</td>
<td>Outstanding dimensions measured by the height, diameter (referred to as the DBH – diameter of trunk at 1.4 metres) and spread</td>
</tr>
<tr>
<td>A Age</td>
<td>The relative age of the tree, especially if the tree is old for its species or venerable</td>
</tr>
<tr>
<td>Rw Rare</td>
<td>A tree which is rarely found in the wild</td>
</tr>
<tr>
<td>Rc Rare</td>
<td>A tree which is rarely found in cultivation</td>
</tr>
<tr>
<td>H Historic</td>
<td>A tree with specific historic association such as a commemorative planting</td>
</tr>
<tr>
<td>F Form</td>
<td>A tree with outstanding or unusual form compared with others of its species</td>
</tr>
<tr>
<td>V Remnant</td>
<td>Vegetation which survives from the pre-European period</td>
</tr>
</tbody>
</table>

A tree may be significant according one or several of these criteria.

Criteria provide a guide to help the user identify what could be considered valuable. Criteria can be used as a standard against which a place can be evaluated. (Johnston 1987).

The Process

Cultural significance is understood and assessed through a series of steps often summarised by a document called a conservation analysis/plan. The Burra Charter provides a clear & concise process which can be used as a guide when assessing culturally significant trees. The stages of this process have been reproduced in Appendix B.

The Burra Charter defines conservation as all the processes of looking after a place so as to retain its cultural significance (Burra Charter Article 1.4). The relevant processes suitable for culturally significant trees are: maintenance, protection, reinstatement, restoration, and reconstruction.

Other processes listed as part of this charter have limited application to protection, care and management of culturally significant trees and are better suited to architectural conservation practices. These processes include change, new works, preservation, adaptation and compatibility.

The key conservation principles identified by Planning Victoria (Planning Bulletin 1999) in the process of assessing and listing these trees includes:

- Identify the value of vegetation to the community and the factors that contribute to its value.
- Establish a reliable and consistent methodology to evaluate vegetation.
- Identify criteria for assessing vegetation for its natural and cultural value.
- Protect vegetation for its contribution to the character of an area.
- Identify the best methods of protecting vegetation.
- Balance the protection of vegetation with the practical considerations of vegetation.
- Management and safety.
- manage change in the urban environment where increases in development densities result in the cumulative loss of vegetation.
- Control vegetation removal before development approval is granted.

The stages in conserving culturally significant trees can be summarised in four key verbs: identify, assess, manage and monitor. These form and inform the process outlined in both the Burra and Natural Heritage charters. The key is to gather all the relevant information before taking a decision or action so that the right one is taken for the actual place, tree, or collection of trees, and they survive and thrive (Reed 2005).
The City of Sydney (Significant Trees, part 1 of 4 2005) has summarised the conservation steps as significant trees are assessed through systematic research, field work and documentation. A thorough physical examination of trees in relation to their natural occurrence or cultural history is conducted and supported through reports, photographs, archival material and oral evidence.

The following sequence has been adapted from Planning Victoria (Planning Bulletin 1999):

1. Undertake a vegetation survey
2. Determine vegetation significance
3. Prepare a local policy (MSS and local policy)
4. Apply overlay provisions, where appropriate
5. Enforce the planning scheme where necessary
6. Monitor outcomes

Depending on the circumstances and the level of detail sought, the analysis of physical evidence and development of supporting strategies, may involve (Planning Bulletin 1999):

1. Gathering information
   - Undertake a broad survey to identify areas likely to contain important or significant trees. A number of information sources are available to assist in this process.
   - Check if any trees have been formally recognised on the Register of the National Estate, National Trust Register or listed under specific local government or state registers.
   - Focus on specific areas or sites of interest.
   - Undertake a vegetation survey of specific areas or sites. Vegetation surveys must be undertaken by suitably qualified arboricultural consultants, botanists, landscape architects or other experienced environmental scientists.
   - Involve the public in the survey and assessment process, whether the assessment method has an objective (scientific) or subjective (aesthetic) basis.

   Useful sources of information have been listed by Hawker J (1992). These sources include: the National Trust, historical societies, public libraries, local government and conservation groups. Local histories, conservation studies, student theses, photographs, journals, books and other archives are also useful. Oral histories from elderly members of the community and part owners may also be able to provide valuable information.

   Once the historical information, physical description and features of the tree are collated an assessment as to the tree’s significance can be conducted (Hawker J 1992).

2. Assessing significance

   Assessment methods must be rigorous as they provide strategic justification for protection through the planning scheme and will be the basis of decisions. Recognised assessment criteria should be used.

   Useful criteria include:
   - National Trust (Victoria), Register of Significant Trees of Victoria criteria. This has been developed to be applied to trees or a group of trees.
   - Australian Natural Heritage Charter (Australian Committee for IUCN 1997). This contains standards and principles for the conservation of places of natural heritage significance.
   - Other criteria have been developed for individual studies, for example, the NEROC study may be acceptable.

   These criteria may also provide a framework to assess the aesthetic or cultural value of vegetation.

3. Statement of significance

   A statement of significance is a succinct statement expressing what vegetation is significant or important and why. It should be written with reference to the assessment criteria and based on the survey results and, if relevant, reliable secondary data.

   It should not restate the survey or documentary evidence but be cross-referenced to it. The level of significance will enable the development of appropriate policies. Statements of significance may be prepared for individual trees or groups of trees.

The 12th National Street Tree Symposium 2011  
106
4. Developing a strategic vision

If it is proposed to protect a tree/s via a planning scheme, this must be supported by strategic justification and identified within Council’s strategic policies and strategies. These policies should clearly articulate objectives for protecting trees, strategies for achieving the objectives and practical implementation measures. The objectives should state why these trees should be protected, what level of protection is being sought and what the desired outcomes are for protecting trees drawing on strategic work.

The community should have ownership of the objective by being involved in formulating the strategic vision. If the community is involved, there is a greater likelihood that the outcomes sought by the planning scheme will be understood and supported.

Objectives for protecting trees may be related to other objectives such as protecting significant landscapes, valuable habitats or the character of a place or area and the Significant Tree Legislation 1991.

Local policies should explain and inform planning decisions. They should reinforce and emphasise broader strategic objectives.

In some areas, where tree protection is important to Council’s broader planning objectives, the preparation of a specific policy for vegetation protection may be preferred (such as a land management agreement). Typical local policies may reinforce the need to protect remnant vegetation, emphasise the significance of mature vegetation or the need to actively eradicate environmental weeds. In some instances, a local policy may be all that is required to achieve a particular objective.

5. Enforcement

Protecting significant vegetation using the planning scheme places an obligation on councils to carry out enforcement. Gaining support for the principle of vegetation protection and improving knowledge of the planning provisions, their objectives and how they work should assist in reducing the need for formal enforcement action. Enforcement strategies should, therefore, focus on community education and participation in order to gain broad support for vegetation and management policies rather than relying only on enforcement measures under the Planning and Environment Act.

The availability of advice and assistance and the efficient handling of applications may also minimise cases of unlawful vegetation clearance. Enforcement methods can be supported by:

- Periodic review of the vegetation inventory as part of the normal planning process.
- The appraisal of the effectiveness of the vegetation provisions and permit conditions in practice.
- Regular inspections of work sites.
- Enforceable permit conditions and agreements.

A list of various relevant South Australian legislative requirements and regulations that relate to trees under the care and control of councils has been provided as part of Appendix C.

6. Monitoring

Ongoing monitoring is a key feature of the tree protection program. To determine whether planning policy and provisions are successfully protecting vegetation, Council must develop a monitoring program. Monitoring is critical as it can provide information that enables current practices to be reviewed. In developing a monitoring program for vegetation protection, Council should:

- Be clear about what key elements of the planning scheme and planning system it wants to monitor.
- Identify indicators of Council’s performance in relation to these key elements.
- Establish performance targets for particular indicators to guide the assessment of success.

An obvious glaring omission is the on-going management and maintenance trees typically require.
Mcphee (1999) includes in her approach in the management of historical gardens which includes trees two additional steps:

- The preparation of an implementation program which identifies and prioritises what works are required to conserve the trees; and
- Implement the program in stages as funds are made available.

In summary, the conservation of culturally significant trees falls naturally into two stages. The first covers the gathering and analysis of evidence and the assessment of significance. The second is concerned with developing policies and setting out strategies to maintain, monitor, protect and as required replace these important trees.

### Data Requirements

The City of Sydney collects the following data for each tree or group of trees that is listed within its register:

#### Summary Data:

- Precinct number and description.
- Digital photographic record and precinct map references.
- Date, location and full property description, ownership/management, control/responsibilities and references to other listings where applicable.
- Origin (cultural planting or indigenous remnant).
- Cultural type (e.g. single specimen, row plantation, group planting, etc).
- Level of significance (e.g. LOCAL, CITY/ LGA or REGIONAL levels).
- Number of scheduled items for property description.
- Summary of other tree and palm components/associates (i.e. important contextual elements within the property description).

#### Tree Attributes (as applicable):

- Full botanical description including botanical and common names, other local/historic names, if applicable.
- Significance attributes of scheduled item; origin (e.g. ornamental/cultivated – geographic place of origin/cultivars).
- Location – detailed description of site location within property listing.
- Extent of influence – reference to canopy cover and possible extent of root zone.
- Estimated age, height, canopy spread and trunk diameter @ 1.0 metre above ground level/extent of any buttressing, etc.
- Visual tree assessment including condition, status, health, evidence of any physical or structural damage, insect attack and pathogens (refer to notes).
- Comments on existing or potential threats and other relevant issues affecting the status of the tree(s) and recommendations for management and/or remedial treatment (including priority scheduling).
- Statement of Significance – description outlining the reasons for significance of scheduled items.
The National Trust of Victoria collects the following data for each tree. The following is the assessment form used by the Trust:

<table>
<thead>
<tr>
<th>Family</th>
<th>Category (s) recommended:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Botanical name:</td>
<td></td>
</tr>
<tr>
<td>Common name:</td>
<td></td>
</tr>
<tr>
<td>Number of trees:</td>
<td></td>
</tr>
<tr>
<td>Location:</td>
<td>Condition:</td>
</tr>
<tr>
<td>Municipality:</td>
<td>Classified:</td>
</tr>
<tr>
<td>Ownership:</td>
<td>State / Regional</td>
</tr>
<tr>
<td>Circumference: m</td>
<td>height: (m)</td>
</tr>
<tr>
<td>Spread: m</td>
<td>estimated age: (yrs)</td>
</tr>
<tr>
<td>Date measured:</td>
<td>Latitude:</td>
</tr>
<tr>
<td>Description &amp; background:</td>
<td></td>
</tr>
</tbody>
</table>

Also included is any potential or immediate threat to the specimen. Citations are prepared for each tree considered worthy of retention. National Trust of Victoria conducts comparative assessments using photographs of the tree which are evaluated by a Committee of selected experts. Each nominated tree is then assessed in comparison to know specimens in similar categories. The importance of individual trees or stands is also considered.

The City of Ryde collects similar data. The City of Ryde within its register includes the following verifiable assessment details for each tree listing:

- Date, tree location (preferably by GPS co-ordinates) and a full property description (public or private lands), ownership/management and references to other listings (e.g. National Trust of NSW), where applicable.
- Photographic record linked to an appropriate scaled map reference.
- Detailed description of location, with references to tree canopy extent and root zone in relation to neighbouring properties especially where development on adjoining property could affect the tree.
- Number of listed trees and significance attributes.
- Full botanical description including botanical and common names.
- Local names if applicable.
- Origin, height, canopy spread and trunk diameter.
- Horticultural condition/health report and estimated age.

Also to be included is a Statement of Significance. This is a description outlining the reasons for significance which is a brief summary and should, where possible include:

- Identification of possible threats and problems; (e.g. road widening, ETSA overhead line clearance), and
- Recommendations for management and/or remedial treatment.

The City of Prahran in its study of significant trees (Looker and Hubbard 1992) collected the following information: Location, Species and Diameter at Breast Height, Height, Spread, Age, Condition, Life Expectancy and Statement of Significance.

Management programming and action
The best conservation studies are extended to provide management guidelines to ensure the long term significance is safeguarded. Management plans assure a continuity of direction throughout a period of time, although they should be seen as dynamic rather than a static instrument, responding to new information as it becomes available (Hitchmough J 1994).
The cultural significance of a place, including its value and level of significance should play a pivotal role in what management programming and action is chosen (Olsen 2001). This would help determine the level of protection and therefore maintenance input and other conservation measures a particular tree/s requires.

The tree’s fabric - species, age and biology will determine the selection of a particular conservation action/s. Such programs or plans commonly include a combination of general aims or objectives and/or specific strategies and detailed actions.

These works have various labels including schedule of conservation works, a works program, implementation program etc. The whole of the process, often including a conservation analysis, will also be called the conservation management plan (Olsen 2001).

Good tree management programs/plans integrate species and site differences into both general approaches and specific actions. These actions must be clear, logical and straightforward.

Having a basic knowledge of species history, an arborist may approach the care and management of aging trees by focusing preventative care on two objectives: avoiding entry into mortality spiral and preventing death from acute causes. Arborists play an active role in optimising tree longevity, using two strategies: developing a stable physical structure and developing a stable environment (Clark and Matheny 1991).

arboretural maintenance

The management of mature trees involves the application of cultural treatments in the context of tree biology which change with time. Since the biology of a tree changes overtime, so must its management. Arborists can play a central role in the maintenance of mature, stable conditions. They identify routine and remedial treatments, as well as assess the ability of a tree to respond to such treatments. However the capacity of an arborist to restore a declining tree to a stable condition is questionable (Clark and Matheny 1991).

The Burra Charter defines maintenance as the continuous protective care of a place. For trees this may include minor pruning, weeding, mulching, fertilising and watering undertaken to prolong the vigour and life expectancy of a tree (Burra Charter Article 1.5, Draper D and Richards P 2009).

The growth, development, appearance and success of a plant (including a tree) on any site will be dependent on three factors (Parker M 1998):

- The first is the physiological make up of the species which includes its tolerance of environmental conditions e.g. drought and its response to physiological stimuli, for example, day length or extended periods of cold.
- The second is the environmental conditions of the site, which range from pH to wind patterns.
- The third factor being the maintenance or horticultural (arboretural) inputs which aims to strike a balance between the other influences and to produce an attractive and healthy specimen.

There are arboretural practices that can help with maintaining the health of a tree and to slow its decline, although one must question how much tree work is acceptable (Taylor 1990). The form and reasons for significance need to be considered when contemplating tree surgery (Parker M 1998).

The maintenance procedures involved must be clearly identified and scheduled as part of an overall, management plan. It must be viewed in the long term with preventative maintenance being the main focus.

A few of the important maintenance techniques that will create a strong, stable tree structure, minimise unfavourable environmental changes and minimise insect and disease attack for culturally significant trees includes (Clark and Matheny 1991):

- Prune mature trees conservatively to avoid excessive thinning and wounding.
- Observe target pruning to minimise decay development.
- Irrigate and fertilise judiciously considering the trees natural environment and part culture.
- Protect the tree from environmental degradation, such as soil compaction, root damage, mechanical damage etc.
• Develop species-appropriate programs for pest management.

Maintenance programs for aging trees need to be considered carefully with a focus on preventative not reactive maintenance. As a tree matures it becomes increasingly affected by stress and responds slowly to treatment. Problems observed must be treated quickly.

The tree’s growing environment must be maintained to protect it from undue stress and the structural integrity of the tree in public locations must be maintained to ensure public safety.

**Tree replacement**

Tree replacement is one of the most complex, emotive and pressing issues of managing culturally significant trees.

Tree death and stress can be attributed to a number external factors including unforeseen damage from extreme weather events, infections from fungi, bacteria, virus-like organisms, insect attack, root damage and irreparable changes to the tree’s growing environment. Trees are living organisms and have a finite life span and senescence and death is inevitable.

Over-mature trees can represent a risk should they be in decline or stressed. The potential hazard of older trees, and in particular those that start to drop branches, demand that managers ask the questions (Parker M 1999):

• When are trees too hazardous to be tolerated?
• When should they be removed?

The difficulty for managers comes as culturally significant trees age and decline and decisions need to be made on their future (Parker M 1999).

Hitchmough (1990) compares the aesthetic return with that of the management inputs for the life of a tree. Aesthetic returns increase with age, levelling off at maturity and then falling as the tree declines. Management costs on the other hand increase as the tree ages. Tree removal before the completion of the tree’s natural life span can be justified on the grounds of decreasing aesthetics and increasing management cost, although determining where a particular tree lies on the hypothetical curves is no easy task. However, aesthetic costs are not the only consideration; the historical and social significance of the tree both individually and as a component of the entire landscape needs to assessed and taken into account. Hitchmough (1990) goes on to pose the following question: Should a tree be sustained for as long as possible because there is significance in the planting?

I believe the response to this question generally is yes. It may be necessary to retain a tree beyond its peak aesthetics because of its age, dimensions, rarity or association with a particular historical event or person. However this is subject to risk, historical and social significance, aesthetics and cost.

Should it be decided to replace the tree the problem then lies in continuing the significance with a new tree. Hitchmough (1990) suggests the following approach: Is this significance undone when the tree is replaced if the replacement is of identical genetic constitution to the original, as is the case if the new tree has been derived from the original by vegetative propagation?

In this respect the replacement tree would simply be a smaller version of the original. Should this technique become acceptable then cyclic renewal of plants would be possible and the only constraints being aesthetics and management costs (Hitchmough 1990). However, not all trees can be propagated vegetatively. This then raises the question on how these trees would be replaced.

The emphasis throughout the whole replacement process should be on planning. Any tree removal or replacement needs to be planned to ensure a staged process that does not detract from the quality of the place (Parker M 1999).

Layering, coppicing and self-seeding are some of the common methods that can be used to regenerate trees. However these are subject to tree health and species response to these techniques.

Should these techniques not be possible then it may be necessary to clear fell and replant with a young tree (Hitchmough 1990). The decision then needs to be made at what stage in a tree’s life cycle they should be replaced.
A number of tree replacement approaches have been identified and are summarised below.

- **Single tree rotation** – Clear fell and replace before or as the tree enters decline.
- **Prop up for as long as possible then fell when the tree is no longer safe or attractive and replace.** It is necessary to consider that arboricultural techniques aimed at prolonging the life of trees will improve vigour and slow the rate of senescence by providing an ideal growing environment, however they cannot halt or reverse decline.
- **Dual tree rotation** – Plant a young replacement tree adjacent to the existing tree as close as practical a number of years prior to removal. If successful this will allow one to soften both the aesthetics and functional blow of mature tree replacement.
- **Continuous tree rotation** – The process is applicable for extensive features such as woodlands, it may be possible to develop a mix classes by carrying out a continual replacement program.
- **Identify external factors that may be contributing to a tree’s slow decline, such as compaction and then attempt to eliminate these factors via management.**

Depending on the specifics of the tree, its level of significance, location and resources will determine the method of replacement that can be applied to a specific situation.

Culturally significant trees in public places are managed by Council’s on behalf of the community and are recognised as important living assets. As such the community should be consulted (in accordance with the Local Government Act) in all major tree replacement projects.

**Avenues and rows**

The aesthetic effect of avenues and rows is created by the symmetry of equal aged, sized trees of the same species. The problem is created when a single tree dies or requires removal, as a gap forms. If a replacement tree is introduced it will be at a different stage of maturity drastically altering the avenue (Parker M 1999).

There are a number of approaches that be applied to avenues and rows of trees if replacement is required. These approaches are summarised below.

- Clear fell and replant the entire avenue.
- Clear fell and replace sections at a time.
- Replace each tree as it dies.
- Remove and replace every second or third tree.
- Planting a new row of trees either side of the existing.

Each of these methods has positive and negative implications and is not always suited to all planting situations.

No matter what method of replacement is selected it is important that the chosen method retains the fundamental characteristics of an avenue-symmetry created by consistency of age, species and size and key stakeholders are consultant and encouraged to participate.

**Storage of information**

Once individual trees have been assessed and required information collected it needs to be stored and maintained. This should be achieved through computerised database.

Key requirements of these systems include:

- Storage of information,
- Data manipulation – generating lists, summarising data,
- Computer Mapping (GIS) – visually display the location of the tree, useful for future referencing.

The system should be user friendly, have good documentation and support and permit easy updating of data. General or specific software packages are available to fulfil these requirements.

**Conclusion**

This report has been prepared to summarise the available literature that is intended to be used to develop a series of clear concise (policy statements) principles and supporting guidelines that will assist South Australian councils to identify and manage culturally significant trees in an urban or rural setting.
References

- City of Ryde – Significant Tree Register – 25 March 2003
- City of Sydney 2005. Register of Significant Trees, Part 1 of 4, Significant Trees in Public Parks and Reserves
- Dickins J (1985), Avenues of Victoria, Melbourne, Horticultural Project, Burnley College.
- Dr GM Moore n.d Ancient and Significant Trees: Protecting Community Assets and Heritage, (date unknown)
- Ivens R (1980) Historic Trees of South Australia. The Island Press Kingscote, Kangaroo Island South Australia
- Olsen Dr K. 2006 Reality Bites Both Ways: Heritage Values and Urban Tree Management (Treenet Symposia, fifth annual national conference) Adelaide South Australia
- Parker M (1999), Analysis of Plant Replacement on Historic Sites, Melbourne, Horticultural Project, Burnley College.
- Street Trees in NSW – Guidelines for Conservation and Management, Dept of Planning 1990
- The National Trust of South Australia Register of Significant Trees Nomination Form
- Vegetation Protection in Urban Areas, Dept of Planning Victoria, August 1999
Appendix A

The 12th National Street Tree Symposium 2011

10. Outlining Example of Species

- 9. Conference Tree
- 8. Annual or Biennial
- 7. Non-Resident
- 6. Resident
- 5. Permanent
- 4. Community
- 3. Local
- 2. State
- 1. Federal

11. Conclusion

12. References

- 12.1 - 12.5

11.1 - 11.9

11.10 - 11.15
Appendix B

The Build Order Process
Sequence of investigations, decisions and actions

1. **Identify Place and Associations**
   Secure the place and make it safe

2. **Gather and Record Information about the Place**
   Sufficient to understand significance
   - Documentary
   - Oral
   - Physical

3. **Assess Significance**

4. **Prepare a Statement of Significance**

5. **Identify Obligations Arising from Significance**

6. **Gather Information about Other Factors Affecting the Future of the Place**
   - Owner/manager's needs and resources
   - External factors
   - Physical condition

7. **Develop Policy**
   - Identify options
   - Consider options and test their impact on significance

8. **Prepare a Statement of Policy**

9. **Manage Place in Accordance with Policy**
   - Develop strategies
   - Implement strategies through a management plan
   - Record place prior to any change

10. **Monitor and Review**

The whole process is iterative. Parts of it may need to be repeated.

Further research and consultation may be necessary.
Appendix C

Legislative Requirements
The management and care of Urban Trees is subject to various Legislative requirements and regulations.

Local Government Act 1999
- Sections 196 to 199 Community land management plans
- Section 213 Recovery of costs of roadwork
- Section 221 Alteration of road
- Section 232 Trees
- Section 233 Damage
- Section 244 Liability for injury, damage or loss on community land
- Section 245 Liability for injury, damage or loss by certain trees
- Section 299 Vegetation clearance
- Councils existing Policies including Public Consultation which reflects the requirements of the Local Government Act 1999

State and Federal Acts
- Development Act 1993
- Commonwealth Environment Protection and Biodiversity Conservation Act 1999
- Electricity Act 1996
- Heritage Act 1993
- Water Resources Act 1997
- Environment Protection Act 1993
- Animal and Pest plant Control (Agricultural Protection and Other Purposes) Act 1986
- Sewerage Act 1929.
- Aboriginal Heritage Act 1988
Culturally significant trees: A brief TREENET case study

Greg M Moore
Burnley College, University of Melbourne
500 Yarra Boulevard, Richmond, Australia 3121

Introduction
The recognition of trees as important parts of our history and heritage is well documented. Ivens (1981) commented in relation to the historic trees of South Australia:

‘The tangible and visible history of our State, in the form of man-made monuments will take us back no more than 150 years, but trees are living monuments capable of transporting us 400 years into the past’.

The need for the recognition and protection of trees of heritage, landscape and biological significance in Australia has been an urgent matter in all Australian States for over 30 years (Moore 2001). It is both surprising and disappointing that over that time the long term preservation of such trees has not been guaranteed in any State despite the best efforts of organizations, such as the National Trust of Australia or the various attempts by State and Local governments to provide legislative protection.

The National Trust of Australia, Victoria has an active State register of significant trees, which utilises a set of criteria (Table 1) for registering trees. None of the trees registered as heritage, notable or significant has any legal standing that affords them legislative protection. Some can be linked to local government regulation or parliamentary statute, however, the real protection and value of such schemes is that they bring specimens to public attention and raise the public profile and interest in the future management of the trees.

Table 1: Guidelines to the categories used for nomination of significant trees

<table>
<thead>
<tr>
<th>Categories</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Any tree which is of horticultural or genetic value and could be an important source of propagating stock, including specimens that are particularly resistant to disease or exposure.</td>
</tr>
<tr>
<td>2. Any tree which occurs in a unique location or context and so provides a contribution to the landscape, including remnant native vegetation, important landmarks, and trees which form part of an historic garden, park or town.</td>
</tr>
<tr>
<td>3. Any tree of a species or variety that is rare or of very localised distribution.</td>
</tr>
<tr>
<td>4. Any tree that is particularly old or venerable.</td>
</tr>
<tr>
<td>5. Any tree outstanding for its large height, trunk circumference or canopy spread.</td>
</tr>
<tr>
<td>6. Any tree of outstanding aesthetic significance.</td>
</tr>
<tr>
<td>7. Any tree which exhibits a curious growth form or physical feature such as abnormal outgrowths, natural fusion of branches, severe lightning damage or unusually pruned forms.</td>
</tr>
<tr>
<td>8. Any tree commemorating a particular occasion (including plantings by Royalty) or having associated with an important historical event.</td>
</tr>
<tr>
<td>9. Any tree associated with Aboriginal activities.</td>
</tr>
</tbody>
</table>
The case study

The tree
The Separation Tree in the Royal Botanic Gardens in Melbourne is an old and significant river red gum, under which the separation of Victoria from New South Wales was celebrated in 1850. The tree was already mature at the time, and has long been registered by the National Trust of Australia as it meets many of the criteria listed in Table 1.

In August 2010 the tree was badly vandalised by someone who tried to kill it through ringbarking. Fortunately, the perpetrator(s) did not understand what they were doing:

- ring barking is a very slow killing process
- they probably meant to girdle but cutting the wood was too hard to do
- the tree did not wilt immediately as they had probably hoped
- there was the opportunity for remedial action

The tree was special in that it was or pre-European settlement age, historic, well-documented and growing in an ideal place for its future management. It was always going to get special treatment that would not be available, or even considered for other trees

Some tree anatomy and physiology
A proper understanding of the xylem and phloem transport systems is useful to a practicing arborist. Ringbarking is the removal of the bark to the cambium. It blocks phloem but not xylem transport. Water and nutrients get to the canopy from the roots, but if the break is wide enough for the tree not to grow over the wound then sugars and hormones do not get to the roots. The root system gradually starves and eventually the tree dies after 3-5 years.

Girdling is the removal of bark, cambium and xylem (usually the sap wood and some heart wood). Water transport is blocked and the canopy often wilts within 24-48 hours and the canopy above the cut dies

If bark is removed from a tree:

- to kill over the longer term a complete ring has to be removed so assess how much bark and cambium is intact (in this case about 20% was left)
- often as little as 10% of the circumference of bark is required for a tree to remain healthy
- replace any bark that you can immediately (in this case it took 3 days to replace the bark and some had dried)

Arboricultural management
A few days after the attack, all of the removed bark was put back in place and it was hoped that some of it might re-attach if the tree produced callus. The bark was held in place with nylon strapping. The damaged area was shaded, kept moist and protected. The tree was mulched and the soil moisture was monitored and maintained.

Unfortunately the tree did not produced callus that would have allowed the retention of the replaced bark and after about 6 months it fell off. However it was anticipated that much, if not all, of the bark that had been re-attached would be shed, and so this did not cause too much concern

The summer was mild and wet, and the tree remained healthy despite heavy insect grazing. It produced at least two flushes of new growth over the spring and summer after the damage. A thin band of callus has grown around the damaged surface, which gives some hope for the future. The spring of 2011 will be crucial in determining the future of the tree

So far things have gone as well as can be expected with the mild summer being a great benefit. It will be concerning if there is no evidence of greater callus production by the end of 2011, but old, large trees often take a few seasons to respond to damage. Humans want quick responses, but large, old trees move to their own rhythms of time and they are often much slower than ours.
The tree will be monitored regularly over the next few years. There is hope that there will be greater callus produced in the 2011 spring flush of growth. Once again care will be exercised with irrigation regimes and pest and disease protection, particularly over the coming summer.

**Conclusion**
The garden management, staff and contractors have been magnificent in their care and concern for the tree. While the long term prognosis is still uncertain, everything has gone as well as could be hoped. There is genuine reason to hope that the tree will still be making its historic contribution for many years to come.

**References**
Ivens R (1981), Historic Trees of South Australia, Island Press, Kingscote, King Island

A short history of tree planting and a summary of content from key documents posted on the Newcastle City Council website on investigations into the Laman Street Hills Fig trees

Philip Hewett
Arborist (Casual) City of Newcastle

The Newcastle City Council Tree Asset Management System (TAMS) records 109,000 street and park trees of which 1217 are the Hills Fig (*Ficus microcarpa var Hilli*). The Hills Fig public tree population comprises 832 semi-mature trees and 374 mature trees. The majority of the mature trees were planted between 1930 and 1950 as street trees to create avenues or as single rows in centre road medians. The remainder were planted to the perimeters of public parks and reserves. Most if not all the mature Hills Figs in Newcastle were propagated by the Royal Botanic Gardens Sydney from material collected by Walter Hill (1820-1904) the first Superintendent of the Brisbane Botanic Gardens.

In its heyday BHP made extensive plantings of Hills Fig throughout Newcastle to screen its industrial facilities and in response to demands to improve the amenity of the city that was characterised at the time as a barren industrial landscape. As a result the number of mature Hills Fig’s on private land might exceed the number on public land.

The Newcastle draft Street Tree Master Plan recently exhibited, gives a fascinating account of the history of amenity planting in Australia’s premier industrial city. An extract from the draft plan is included here in order to bring some context to the current debate about the future of 14 Hills Fig trees in Laman Street.

The world of today is a far cry from the 1930s when tree lopping was a routine practice and road shoulders were unsealed so that trees had a modicum of space and access to air and water. But catering to the demands of vehicles, new development and utilities led to Newcastle’s street grown figs being repeatedly wounded above and especially below ground.

It is the legacy of wounding and increasing confinement of the critical root spread of what are now very large mature street trees that has led to the situation in Laman Street where the future of the remaining 14 trees is in question following storm induced tree failures and a case history of similar failures in the city.

Before turning to the key documents for Laman Street, it might help to put today’s Laman Street tree issues into some context by reading an extract on Newcastle tree planting from the recently exhibited draft Street Tree Master Plan.

**A Short History of Tree Planting in Newcastle**

Street trees form an important part of the cultural and historic landscape of Newcastle. The type of trees chosen, their location and grouping provide an insight into the past. Tree planting was undertaken to mark events, to celebrate and remember people and as a functional response to land use. Collectively the street tree population in Newcastle exhibits distinctive characteristics of a culture, a way of life and signifies a particular response of people to a place over time.

By the 1930s it was evident that industrialisation had created a landscape that was devoid of vegetation, with Newcastle often referred to as ‘Coaly Town’ and as being ‘drab’ in appearance. In 1931 Alderman Parker, the Lord Mayor, commented in response to this industrialised landscape, ‘It is on all sides admitted that the city streets sadly lack the beauty and picturesque appearance which well ordered and suitably planted avenues of trees would afford’.

In response, an extensive policy of tree planting and a five year city beautification program was initiated. Alderman Shedden spoke of an intention to create a ‘tree sense’ in the public, the best way to nurture this being to provide trees for private citizens to plant and attend.

Newcastle’s intent to overcome its bleak industrial character has been closely aligned with tree planting programs implemented over time. The 12 individual councils, which were amalgamated to form the Greater Newcastle Council in 1938, had been active in beautifying their areas. The
Newcastle Herald on the 5th of August 1937 reported that ‘The suburban councils have planted hundreds of trees,... and it is expected that in a short time the suburbs will do much to explode the belief that Newcastle is a treeless city’.

The historically significant stand of Moreton Bay Fig trees along Islington Park’s boundary with the Pacific Highway was first planted in 1880 by Wickham Municipal Council. A group of protesters gathered in 1935 to protect the Figs in Islington Park when they were under threat. The original planting was supplemented circa 1937 to commemorate the golden jubilee of Islington School. In 1941 E.G.Waterhouse, a prominent professor from Sydney University was invited by the Newcastle Tree Planting and Preservation League to inspect the trees in Islington Park. He commented that the grove of figs is ‘one mass of greenery, the one landmark on which the eye dwells with pleasure in the otherwise uninspiring city landscape’.

A dense planting of Hills Fig trees along Port Waratah’s boundary with Industrial Drive is a prime example of tree planting in response to the industrial environment. When steel was being produced at BHP these figs assisted in absorbing airborne particulates and providing an effective visual screen to the vast industrial complex. As these fig canopies have matured they have merged to form a massive hedge that has outlived BHP and still enhances Industrial Drive today.

Inspired by a trip abroad Alderman Armstrong, President of Newcastle Rotary Club, stated ‘Trees planted on main traffic routes into overseas cities gave one a tremendous first impression’. An Avenue of Remembrance first planned in 1961 in association with the Rotary Club was implemented along the Pacific Highway from Hexham Bridge to the abattoir at Mayfield. The avenue had a dual objective to beautify the northern approach to the city and commemorate the early pioneers of Newcastle. In addition Council commenced planting of Hills Figs along the Pacific Highway west of Mayfield. Tree planting along these routes was instrumental in improving Newcastle’s presentation to visitors.

Over the years, Newcastle’s citizens have been divided on the importance of trees in Newcastle. A negative attitude to trees was expressed in an article in the Newcastle Herald March 1941 from a ratepayer in Wickham complaining about the fig trees that lined Albert Street in Wickham Park, ‘They are dirty, and make our homes look like rubbish tips. We are always cleaning up the mess they make.’ Council’s Park Superintendent Mr Richard H Patterson countered, stating the importance of trees for four reasons first their ‘beauty’, second for their ‘sanitary and hygienic value’, then for the ‘convenience in keeping the city cool’; and lastly for ‘their architectural value in creating harmony where non-uniform buildings exist’. Patterson continues, recognising key environmental benefits identified in today’s urban forest; ‘Who would believe that trees absorbed the surplus carbon dioxide in the air and that they prevented much dust from flying over the city’.

The benefits of trees recognised by Patterson back in 1941 are still relevant today. Council’s Urban Forest Policy recognises that quality tree canopy cover across the city provides aesthetic, health, environmental and monetary benefits, helping to offset the negative effects of increasing urbanisation, the heat island effect and climate change.

Newcastle currently benefits from the canopy of trees planted from the 1930s onward, however this canopy has a limited lifespan and there are many parts of the city that still lack trees. The Urban Forest Policy requires that the current canopy is properly managed with due regard for the principles and goals of intergenerational equity, so residents of Newcastle can continue to enjoy the benefits of trees.

Key documents relating to investigations and reporting on the Laman Street Hills Fig trees

December 2006 - Review of the Root Plate Architecture of Hills Figs in Laman Street (12.3 MB PDF)- To inform Art Gallery redevelopment proposals.

Summary – The report describes exploratory trenching in the road pavement to 8 trees adjacent to the Art Gallery and identified eccentric root plates. It was found that roots have been wounded and structural roots severed near the base of the trees. The trees are confined to small rectangular cut outs. Branch systems are weakened from past lopping resulting in ‘cluster wedge’ branch formations and branch inclusions.
June 2007 - Wind loading in Laman Street (7.1MB) – This report focuses on the effects the removal of the Art Gallery can have on the trees on Laman Street and the possible consequence of the wind load on the trees in Civic Park.

Summary - In the absence of the Gallery, the Laman Street trees would experience an increased wind load.

11 July 2007 - Investigation into stability of three Hill’s Weeping Figs along Laman Street, Newcastle (1.1 MB PDF) – This applies to Hills Figs on the western end of Laman Street and one inside the Civic Precinct

Summary – The Hills Fig outside No 41 Laman Street was destabilised by the June 2007 storm and was in the process of gradual whole tree failure. Removal was recommended. Tree 4797 on the northern footpath opposite the Gallery was at risk due to severe crown imbalance and removal was recommended.

7 August 2009 - Assessment of Hill’s Weeping Figs in the Civic Cultural Precinct, Laman Street (2.3 MB PDF) – This brings all the previous case studies and a detailed investigation into one report and estimates a useful life expectancy for all 14 trees.

Summary – This report identified root-plate architecture as the main structural weakness of the Laman Street trees, with trees on the southern side more vulnerable to wind-throw because of mechanical damage to roots. The report also identified crown asymmetry as a contributing structural weakness. Conducted a review of risk mitigation options by way of pruning, cabling and site isolation and concluded they were unsuitable or impractical and that removal and replacement of the trees as a group would secure the best long term outcome.

2 September 2009 - QTRA Fig Trees Risk Assessment of Fig Trees in Laman Street, Cooks Hill (608KB PDF) – The QTRA is a risk assessment methodology used to determine risk thresholds and assist in determining tree management options. The outcome of this QTRA was 1/19.8 for the 2007 storm event, well below the accepted threshold of 1/10,000.

Summary – Based on the assumption that the trees have a similar probability of failure because of their size, condition, age and growing environment, the probability of failure for the 2007 calendar year is 1/19.8. To achieve the QTRA threshold of 1/10,000 the probability of failure would need to equal 1/3788 and this was considered an unreasonable figure given the case history and detailed reports on the trees. The report reviews all previous reports and management options and concludes that the future of the trees is limited by the likelihood that some of the trees require removal soon if not immediately.

10 December 2009 - Peer review of Marsden Report by Integrated Vegetation Management (89KB) – This report was commissioned to review of the findings of Dennis Marsden’s assessment of the Hills Fig trees.

Summary – The reviewer concludes that the Marsden (2009) report has appropriately used known examples of failure of the same species within the site and near by sites, and related these to the subject trees. The reviewer agrees that pruning and cabling are not appropriate management approaches and that whole of street removal is the most effective method to remove and replant the trees. The visual tree assessment outlined in the Marsden (2009) report has been undertaken in accordance with the internationally recognised VTA method.

11 December 2009 - Peer review of Marsden Report by Arboreport (86KB PDF) – This report was commissioned to review of the findings of Dennis Marsden’s assessment of the Hills Fig trees.

Summary – The review concludes that the Marsden (2009) report demonstrates clearly, through the use of established arboricultural conventions and the analysis of casebook history, that the trees should be removed in order to minimise the risk of failure.

8 March 2010 - Social Impact Assessment Stage 1 - Hills Figs Trees, Laman Street, Newcastle (244KB PDF) – This report undertakes a literature survey to inform the benefits of trees to the community. It proposes a Social Impact matrix that would be informed by the consultation process.
9 March 2010 - Laman Street Hills Figs QTRA and Review (269KB PDF) – This QTRA was conducted following implementation of Council’s risk abatement strategy for Laman Street. The outcome of this QTRA was a risk of harm of 1/14,400. This is within an acceptable limit subject to the continued implementation of the risk management strategy.

9 March 2010 - Heritage Assessment and Recommendations (1.5MB PDF) – The report is an assessment of heritage significance for the stand of fig trees in Laman Street between Darby and Dawson Streets.

12 March 2010 - Quantified Tree Risk Assessment (QTRA), Root Investigation Report and Memo (1.2MB PDF) – A collation of the revised QTRA report taking into account the implementation of the risk abatement strategy, the root plate structure investigation using ground penetrating radar technology and trenching and social and heritage assessments.

Summary – The review finds that:

- The Simonsen (2009) QTRA risk of harm of 1/19.8 for the 2007 storm event provides a reasonable assessment of the quantified risk of harm associated with the trees.
- The ground penetrating radar does not correlate with actual root distribution as found in previous excavations.
- The Laman Street Traffic Control Plan of 23/12/09 is appropriate.
- The risk management strategy as implemented leads to a calculated risk of harm of 1/14,400 subject to the continued implementation of the current risk management strategy.

16 March 2010 - Heritage Assessment and Recommendations (1.6MB PDF) – This report is the final assessment of the heritage significance of the fig trees (amended 9 March version).

19 March 2010 - Independent Arborist Presentation – Earthscape Horticultural Services Laman Street Community Workshop (from page 37).

Summary – The arborist agrees that the methodologies applied for assessing the trees, the findings, assumptions and conclusions on root and crown architecture, tree stability and recommendations for management are appropriate. He concludes that given the age and nature of the trees, failures are expected to continue and that as more failures occur there will be an increase in the risk of failure in adjacent trees.

1 July 2010 - Quantified Tree Risk Assessment and Review (288KB) – The revised Laman Street QTRA report of July 2010 was assessed based on information compiled by Council’s asset management staff and compliance section. The information revealed that the road closure measures and parking restrictions were not effective and that cars were parking in the street and pedestrians were traversing across the closed off area. The QTRA as revised was 1/400 which equates to high risk. The acceptable minimum is 1/10,000.

9 July 2010 - Feasibility Study - Tree Restraint (183KB) – The THS report is in relation to the feasibility of using physical structures to restrain the trees in the event of a failure. The author was keen to find a solution however when calculations were completed it became evident that this was not feasible. The determination took into account the cost, size of structures required and the logistics of installation that would require large drilling equipment.

12 August 2010 – Trenching Investigation of Hills Fig (927KB) – A report on the implications of Hunter Water pipe repairs that severed a 110 mm diameter root on the south-east side of tree 12025 adjacent to the library entrance.

Summary - The investigation found that the tree, like others in Laman Street did not have a radial root plate. The report concluded that on balance, it was unlikely that the root severance had increased the likelihood of whole-tree failure during normal day to day conditions.

13 September 2010 - Fauna Habitat Assessment – An assessment of the habitat values of the Hills Fig trees in Laman Street and an assessment of the impacts of their removal on native fauna.

11 November 2010 - Court Judgement on Parks and Playgrounds Movement Inc's application to stop the removal of the fig trees from Laman Street. Read a short synopsis of the court findings.
December 2010 - Report on the feasibility of a pull test on the Laman Street trees (333KB) – Prepared by Total Height Safety Pty Ltd.

Summary – The review concluded that pull testing was possible but unlikely to provide accurate data to assess the trees future stability. It was found that the indicated forces required to test the stability of the trees would likely result in the loss of some of the trees and the community would need to be prepared for stem and tree failure should the tests proceed.

July 2011 - Memo to Councillors on Laman Street Risk Identification and Management (90KB PDF) – A summary of Council’s approach to risk management of the Laman Street trees.

July 2011 - Branch Failure in Laman Street (30KB) – A memo dated 15 July 2011 of recent branch failures in Laman Street.

Summary – On 16 June 2011 a maximum wind gust of 70km/hr was recorded from the south-east. At that time three branches failed, two exceeding six metres in length, fell to the footpath on the northern side of Laman Street and one of three metres length fell from a tree on the southern side. Expert reports to Council as confirmed by Dr Ken James of ENSPEC warn that branch failure is an increasingly likely occurrence due to increased wind exposure following removal of adjacent trees.
What is required of an expert witness?

Judy Fakes
Commissioner, NSW Land & Environment Court
225 Macquarie Street, Sydney, NSW 2000

Abstract
Arborists, whether they are council employees or consultants, are increasingly engaged as expert witnesses in many courts and tribunals throughout the country. This paper discusses the role of the expert and their reports in the courts. It considers the nature of evidence, the admissibility of expert evidence and Court procedures.

Introduction
In all jurisdictions in Australia, experts are part of the litigation process. Depending on the court or tribunal and the matter under consideration, expert evidence may be required of medical practitioners, acoustic engineers, valuers, planners, heritage consultants, surveyors, ecologists or arborists.

The primary function of a technical/scientific expert witness is to explain the application of their relevant field of expertise to the question or matter before the court or tribunal. This must be done in a way that the decision maker (judge, commissioner, member) and the lawyers can make sense of it. Even though many decision makers develop some level of expertise in some areas, it is unlikely that experience will enable them to deal with conflicting technical evidence, particularly in highly specialised areas, without assistance from experts.

Arborists may be required as expert witnesses in a range of matters in a range of jurisdictions. Typically arborists are involved in planning appeals and the issues of trees on proposed development sites. They might be involved in civil actions involving injury caused by tree failures; these might be heard in a District Court or possibly the Supreme Court. Similarly, arborists may be called to give evidence in criminal matters such as prosecutions in OH&S cases or illegal damage to vegetation. In NSW, arborists may be involved in applications made under the Trees (Disputes Between Neighbours) Act 2006. Arborists may be private consultants or tree management officers employed by councils.

Regardless of the jurisdiction in which arborists may appear, they, and all other experts, will be bound by certain Rules of the Court. These rules will be Rules of Evidence and Procedural Rules.

All Australian courts and tribunals operate under over-riding State Acts, Regulations and Rules that govern criminal and civil procedures. In NSW the Civil Procedure Act 2005 specifies how Courts must operate in civil proceedings. More specifically, the Uniform Civil Procedure Rules 2005 (UCPR) set more detailed operational and procedural guidelines. Within these Rules and Regulations, most if not all courts and tribunals have an Expert Witness Code of Conduct. In addition, courts and tribunals may operate under their own specific Acts and Regulations. Some professional associations whose members may regularly appear in court as experts may have their own Code of Conduct. Courts and tribunals may have Practice Directions that refer specifically to expert witnesses.

1 In NSW this is found in Schedule 7 of the UCPR.
2 The NSW Land & Environment Court operates in accordance with the Land & Environment Court Act 2005.
4 The NSW Land & Environment Court has Practice Directions relevant to the classes of matters heard by the Court. Most arborists appear in Class 1 proceedings. The Practice Directions for these matters include specific information on the engagement and duties of experts.


The 12th National Street Tree Symposium 2011
125
Appointment of experts

There are several ways in which experts might be engaged. Firstly, each party in a matter may engage their own expert. In many instances, especially in planning matters, the developer will have engaged a number of professionals to produce the reports required by council for a development application. These specialists and their reports may end up in court if council does not approve the development.

If a matter does come to court on appeal, the first step is a ‘directions hearing’, usually before a Registrar of the Court/Tribunal. At this stage, the parties will be required to consider whether expert witnesses are required. If so, they may be directed to engage their own witnesses to prepare an individual report or sometimes a joint report on the ‘facts and contentions’ relevant to their expertise. Joint reports are discussed elsewhere in this paper.) In some instances, a party may engage more than one expert in a particular area if they consider that the issues are such that no one person has the experience or specialised knowledge to deal with everything5.

Alternatively, the parties may be directed to engage a ‘single parties’ expert’ to prepare a report and attend court. This is someone acceptable to both parties and renumerated by them. Another alternative is a ‘court-appointed expert’. This person is appointed at the court’s discretion and paid by the parties. This may occur because the parties do not wish to use a single expert, but in the circumstances of the matter, or in an effort to keep costs down, the court finds that a single expert would be appropriate6. In the NSW Land & Environment Court, the use of court-appointed experts has declined dramatically7.

At the directions hearing, the parties will be given a timetable for the production of and, if necessary, the exchange of reports, the timing of joint conferencing, and a date for the hearing. In the NSW Land & Environment Court (and presumably in most courts and tribunals), apart from details provided in the UPCR, there are detailed Practice Directions as to the how, what and when of expert reports and conferencing.

If you are approached by a party to be an expert witness or to prepare a report that may end up in court, you should think about the following:

- What is the scope of the brief? Is it in your area of expertise? Is the brief specific enough for you to understand what is required of you?
- What is the time frame? This is not just how long have you got to visit the site and write a report but it may require the viewing of plans and feedback to others. You need to consider time for joint conferencing with other experts, attending court (which may include site views or on-site hearings as well as time in the court room), and time before and after court for further discussions with other experts.
- What is the fee? Time blowouts and extra work will need to be considered.
- Any ethical issues? Do you have any material interest in the matter or any other relationships/work history etc that you should disclose?

---

5 Hinset Pty Ltd v Lane Cove Council [2011] NSWLEC 20 at [20]-[28]
6 Justice Rachel Pepper 2010 Experts, Parties’ Single Experts and Court-appointed Experts. A paper presented on 8 June 2010 for the Australian Property Institute and the University of Sydney.
7 According to the NSW Attorney General’s Law Reform Commission, 2005 Report 109 Expert Witnesses, in the period between March 2004 and April 2005 there were 171 court-appointed experts in the NSW LEC. According to Justice Pepper in her 2011 paper Expert Evidence in the Land & Environment Court, in 2010 there were only 5 parties’ single experts and no court-appointed experts. Justice Pepper considers that this change may in part reflect perceptions of fairness concerning court-appointed experts and the decision by the Court to appoint Commissioners and Acting Commissioners with expertise in specific areas. This is an excellent paper that provides a very good understanding of matters pertaining to expert witnesses.

Remembering your duty is primarily to the court, if you get a brief that in your professional opinion you think is unsupportable, you should say so and not accept it. This does no harm to your credibility.

As Justice Lloyd (2000) said:

*Experts who give evidence on a regular basis also have their own reputations to consider. Their reputations as reliable experts *are* … often hard won and can be easily lost. Experts who tend to be partisan toward their client’s cause can be caught out*.8

**Expert witness code of conduct**

Common to all Codes of Conduct are the following general duties of the expert to the court9:

1. An expert witness has an overriding duty to assist the court impartially on matters relevant to the expert witness’s area of expertise.
2. An expert witness’s paramount duty is to the court and not to any party to the proceedings (including the person retaining the expert witness).
3. An expert witness is not an advocate for a party.

In NSW (and elsewhere), other duties include an obligation to follow Directions of the Court, to work co-operatively with other experts, and to prepare expert reports in accordance with the requirements set down in the Code and the UCPR.

**How does an expert witness differ from any other witness?**

As stated above, expert witnesses play a particular role in court proceedings and are under special obligations. Some obligations are common to all witnesses such as a duty “to tell the whole truth and nothing but the truth”.

Evidence is all the information given directly to the court by a witness. The court will only take note of evidence that complies with certain rules known as the Rules of Evidence. Most courts are bound by the rules of evidence that are set out in State and Federal Evidence Acts10. Even those courts and tribunals that are not bound by the rules of evidence11, generally do so because of the good sense and utility of the rules, particularly as they have been developed, tested and refined over many years in order to ‘prevent error and elicit truth’12.

Evidence must be relevant to the particular issue being tried or appealed. Of importance is what’s known as ‘hearsay’. For example, in criminal matters, a witness is asked to tell the court only what they saw or heard, not what someone else told them occurred (i.e. hearsay evidence)13. This is why in expert reports it is essential to differentiate between what you saw and what you were told by whom and when. This must be made clear to the reader.

In general, the opinion of a witness is not admissible in court unless the witness is an expert in the field on which the opinion is given. Section 79 of the Evidence Act (Cth) 1995 permits the use of opinion evidence from a person having ‘a specialised knowledge based on the person’s training, study or experience’14.

---


9 Clause 2, Schedule 7 NSW UCPR 2005


11 such as the NSW Land & Environment Court and the Administrative Appeals Tribunal


14 Preston, BJ (undated) The Role of the Expert: Duties and Responsibilities in Giving Evidence EXPLAW
According to Preston (2002) opinion evidence will not be reliable if its subject matter is not generated by and in accordance with a body of knowledge or expertise that is sufficiently organised or recognised to be accepted as a reliable body of knowledge or experience. It has been held by various courts that if evidence tendered as expert opinion evidence is to be admissible, the following factors must be present:

- It must be agreed or demonstrated that there is a field of specialised knowledge [for example ‘astrology’ is not such a field];
- There must be an identified aspect of that field in which the witness demonstrates that by reason of specialised training, study, or experience, the witness has become an expert [hence the requirement to include a CV in an expert report];
- The opinion proffered must be wholly or substantially based on the witness’s expert knowledge [that is, keep within your area of expertise];
- So far as the opinion is based on facts observed by the expert, they must be identified and admissibly proved by the expert, and so far as the opinion is based on assumed or accepted facts, they must be proved in some other way [facts v assumptions; peer-reviewed literature/standards];
- It must be established that the facts on which the opinion is based form a proper foundation for it [relevance]; and
- The expert must explain how the field of specialised knowledge in which the witness is expert, and on which the opinion is wholly or substantially based, applies to the facts assumed or observed so as to produce the opinion or conclusion propounded.

**Expert reports**

Anyone engaged as an expert for a court matter should be advised by whoever engaged them as to the requirements of an expert report. However, it is prudent to check the rules and requirements yourself. As previously mentioned, the Uniform Civil Procedure Rules that operate in each state or federal jurisdiction will have something to say on the contents of an expert report. The following example comes from the NSW UPCR as described by Pepper 2011.

The expert report should start with an acknowledgment that the expert has read the Expert Witness Code of Conduct and agrees to be bound by it. Failure to do this may render the report inadmissible unless the court grants leave. The purpose of the acknowledgment is to ensure that the expert has approached the task responsibly and mindful of the importance the expression of opinion will have as part of a body of evidence placed before the court.

The report must also include details of the expert’s qualifications. It is essential that this is accurate and up-to-date. It is entirely reasonable for an advocate for a party to question your expertise or for a judge to check your curriculum vitae. If information is inaccurate it will certainly affect your credibility as a witness. In general, your CV should be reasonably concise and relevant to the matter for which you have been engaged.

---


16 These factors are given by Heydon JA in *Makita (Australia) Pty Ltd v Sprowles* [2001] NSWCA 305, NSWLR 705 at [85] cited by Biscoe J in *Scientific Experts in the Land and Environment Court – A paper delivered to Environmental Forensics Law students, UTS 2009.*

17 Pepper, R, above n 6, pp 34-36

18 Tim Barr Pty Ltd v Narui Gold Coast Pty Ltd [2009] NSWSC 49 at [46] in ibid p 32 at [101].

19 Hinset Pty Ltd v Lane Cove Council [2011] NSWLEC 20 at [23]
Whatever evidence would be required in oral evidence must be in the report. In special circumstances, the court may grant leave for additional information to be added if it simply updates the report or clarifies matters already in the report.

An expert report must set out the facts and assumptions that the findings of the report are based on. [Further discussion of this below.] This will normally require the expert to identify and to prove or assume the specific facts on which their opinion is based. However, the expert is not required to prove the contents of the texts or journals to which reference may be made. Similarly, a witness is also able to draw on a body of knowledge that is unpublished (but reliably collected). This is essential as the court may not be able to determine how the expert has applied their specialised knowledge to the facts. This may result in the report being inadmissible or being given very little weight [see footnote 14]. Each opinion expressed by the expert must be supported by the reasons for that opinion.

If you have been requested to comment on something that is beyond your expertise, or there is insufficient data to support the conclusions reached (maybe because of insufficient time to collect the data), this should be stated in the report. Similarly, if you believe that your report may be incomplete or inaccurate without some qualification, the qualification must be stated in the report.

You must set out any tests, examinations or other investigations that you have relied upon or that you undertook. This may include investigations by someone else that you engaged to carry out specialised testing. Your report must note all materials, plans, and literature that have been used to support your opinions. In my experience, the methodology section of a report is essential when trying to understand how an expert formed their opinion. The references to literature must be relevant, reliable and correctly cited.

Expert reports should be as clear and transparent as possible. If its use as evidence is outweighed by the report being confusing or misleading, it can be thrown out. Reports must also be written in plain English with numbered headings for ease of referencing. Long and complex reports should include an Executive Summary.

Apart from clarification of the scope of the report and the issues to be reported on, and what is required for admissibility, lawyers should not be involved with the preparation of an expert report.

If something happens, after you have provided your report, that makes you change your opinion about something of importance to the matter, you must notify whoever has engaged you and provide them with a supplementary report.

**Joint reports and conferences**

It is common practice in many jurisdictions for a direction to be given for a joint conference between experts in a particular field of knowledge and the production of a joint report.

Depending on the type of appeal, the relevant party prepares a ‘Statement of Facts and Contentions’. Each contention generally contains a number of ‘particulars’. The aim of the joint conference is to identify and narrow the issues in the proceedings that are relevant to the area of expertise. This in turn helps to bring about the just, quick and cost effective determination/settlement of the matter by reducing time spent in cross-examination to matters disagreed by the experts.

The joint report should concisely set out what is agreed, what is not agreed and the reasons for disagreement, and the relative importance of the matters that are disagreed.

---


21 That person’s report and cv should be annexured to your report.

22 Do not use references from Wikipedia!! Use refereed or peer reviewed journals/ widely accepted textbooks; Australian Standards and Codes/ government policies etc. Whoever is reading your report should be able to verify your information by going to the source document; therefore page numbers are important for book references; material from the internet should include the actual link and the date you accessed it. Unpublished material may be acceptable if it can be determined that it is sound.

23 [http://infolink/lawlink/lec/ll_lec.nsf/pages/LEC_practicedirections](http://infolink/lawlink/lec/ll_lec.nsf/pages/LEC_practicedirections) accessed 9 August 2011. This link gives the practice directions for the various classes of cases heard by the NSW LEC. Each practice direction includes information on expert witnesses including directions for the production of joint reports.
It is very important that the joint conference is undertaken in a co-operative and constructive manner. Each expert should keep an open mind and be prepared to consider the other person’s point of view. Each expert must exercise his or her independent, professional judgment and must not act on instruction or request from the client/solicitor to withhold information or avoid agreement. It may be that a compromise is reached; this must be something that is professionally appropriate and supportable. The issues raised in a joint conference may influence conditions of consent. The discussion between the experts may identify other questions or issues they believe would be useful for them to consider.

It is considered that the advantages of an expert conference include: any extreme or biased views that one expert holds may be moderated when that person has to justify their position before their peer; factual concessions are easier to make in private than in court where there is pressure in front of the client for the expert to stick to their original opinion; experts often disclose facts and or relevant information not always known or appreciated by the other expert; and, as already mentioned, significant points of disagreement can be identified more quickly and then dealt with in more detail.

Legal representatives are not to attend joint conferences or be involved in the preparation of reports unless the court grants leave. The joint conference can be held anywhere and may also involve a site visit.

The expert in court

As an expert you may be required to attend court. Depending on the jurisdiction, the matter may start as a ‘without prejudice’ conciliation conference between the parties on site; it may move to hearing; the hearing may be on site or in court.

On a site view or an on-site hearing, you may be asked to point out various things to the court and you might be asked to explain what it means. The other party’s witness is likely to be asked their view on the matter and for their interpretation of what is being shown or discussed. Even though matters on site are relatively informal, they are still part of a hearing and rules apply…for example you can’t have a private chat with the judge/commissioner/member.

In court, if you are called to give evidence you will be sworn in by taking an oath or affirmation – that is, you agree to tell the truth and nothing but the truth. You will be asked by your solicitor/barrister to give your full name and your address (usually your business address); you will be asked if you prepared a report/joint report.

Some jurisdictions are still based on the traditional adversarial system of giving evidence and then cross-examination of each witness on their own. In an adversarial system, the parties have the responsibility and control over defining the issues in dispute and for investigating and advocating their particular case. In this system, questions can be very specific and often an expert doesn’t always get a chance to explain their opinion. The hardest part for an expert giving evidence isn’t responding to the questions that have been asked, it is often what can’t be said because the question wasn’t asked. Under cross-examination, the court may only get a very disjointed version of the expert’s opinion. This system has been criticised due to issues of cost, delays, efficiency and access to the justice system.

In contrast is the use of concurrent evidence (sometimes referred to as “hot-tubbing”). That is, all of the experts in a particular field are put into the witness box at the same time. This is very common in NSW. Young (2010) considers the objective of concurrent evidence is to achieve greater efficiency and expedition, by reduced emphasis on cross-examination and increased emphasis on professional dialogue, and swifter identification of the critical areas of disagreement between the experts.

---

24 Pepper R above n 6 p20
27 Preston B. J above n 14 p 5.
28 Neil Young QC Expert Witnesses: On the stand or in the hot tub – how when and why? Formulating the questions for opinion and cross-examining the experts. Commercial Court Seminar 27 October 2010
According to Wright (2010), a well-run process of concurrent evidence can allow experts to fully express their opinions in their own words. The environment is less confrontational, and therefore more conducive to a constructive debate. This may also uncover a ‘flawed analysis’ in an expert’s argument. Experts can’t hide behind their instructions or unreasonable assumptions as these can be picked up by the other expert and debated more openly.\(^\text{29}\)

Questions will generally be limited to the points of disagreement and a list of topics will be made up. The advocates will direct questions to their own expert and may cross-examine the other witness. The judge/commissioner can also ask the experts questions. The experts can interact and discuss points. During the process refinements may be made to plans/setbacks from trees etc. Issues raised in the hearing of evidence from other experts may be put to the arborists if it may have an impact on trees. During the hearing, the experts may be directed to go off and discuss an issue/ review a plan/ prepare conditions of consent.

The extent to which concurrent evidence is useful depends on how well it is managed by the judge/commissioner, the advocates and the experts themselves.

Regardless of how evidence is given in court, there are a few things you must consider. Never forget that your duty is to the court and not to your client. Be honest; if you say something that on later reflection you think was wrong, bring it to the court’s attention. It is very easy to get a bit confused and overwhelmed by ‘lawyer speak’. Pay attention and listen carefully to the question. If you don’t understand what you are being asked, ask it to be repeated. Take your time to answer the question. Keep your answers concise, clear and simple without a lot of jargon.\(^\text{30}\)

Do not be a smart arse and try to take on a barrister or solicitor; don’t be too strident in your language or manner if you disagree with your fellow expert; however, if you are a quiet person you may have to be assertive if you think your point of view has not been understood. Try to relax and stay calm. The best preparation for court is to know your report/joint report inside out and be confident in your knowledge.

Other issues relating to expert witnesses

According to Morris (2006), some judges still have some anxiety over the use of expert evidence in court. The reasons for this include: levels of competence, lack of training and accreditation of so-called experts; and, the independence and neutrality of the expert because their client pays them. The following paragraphs summarise some of the common concerns.

\textit{It is difficult to avoid a conclusion that a witness who is paid by a party will not have a tendency to please that party, at least if this is consistent with the views and integrity of the witness. Further, the very fact that experts can have strongly held and contradicting opinions on the same point of fact sometimes raises a question mark over the reliability of such evidence. There is also the problem of “expert shopping” – where a party engages a series of experts to provide advice until they find the particular expert who will support their client’s case. This witness is brought to the witness box to espouse their form of expertise without any reference to the fact that the client may have engaged a long line of potential witnesses and discarded their opinions before finally settling on the most advantageous opinion available.}

\textit{The imposition of a theory of neutrality on experts is also questionable with the emergence of a breed of expert witnesses who have a long standing professional relationship with the client who hires them. Some expert witnesses appear time and time again in litigation for a particular client; a situation in which the allegation of being a “hired gun” could be levelled...}  \(^\text{31}\)


\(^{29}\) Wright D above n 25

\(^{30}\) Purcell, D 1997 Giving Evidence: A Guide for Witnesses Phillips Fox

\(^{31}\) Justice Stuart Morris Getting Real about expert Evidence A paper presented at a seminar hosted by the Victorian Planning and Environmental Law Association, 16 November 2006.
In such a relatively specialised field as arboriculture, it is inevitable that there is a relatively small pool of consultants who appear as experts in court. If you are on the record as having advanced an opinion in a particular matter, if you vary widely in your opinion in another, but very similar case, the opposing counsel might bring it up. For example, Justice David Lloyd, a retired judge of the NSW Land and Environment Court writes about his own experience when he was at the Bar:

For example, some years ago I was appearing in a case which involved some scientific evidence. It was decided that we would call evidence from an eminent biophysicist, being a professor of biophysics at a United States university. His evidence in chief was supportive of the client’s case. The other side, however, had obtained transcripts of all the evidence the witness had given in other cases. After answering, in cross-examination, a particular question, the cross-examiner would then ask: “Professor, when you were asked that very same question in the case of Brown v The State of New York, your answer was...” (which was clearly a different answer to that which had just been given); “Was your answer wrong then, or wrong now?” It was clear that the witness’s evidence varied depending upon the interest of his client. After a series of such questions, the expert’s credibility was lost.

Arboricultural evidence - Fact v assumption

Take for an example a reported branch failure. If you saw the branch fail, that is first hand evidence and fact. If it was reported to you that a branch failed, that is hearsay and something that must be verified and, at the very least, noted. If you are called to investigate the failure after the event, is there any evidence that may prove that it failed? For example, does the branch still exist? Is the point of failure obvious? Does the end of the failed branch appear to be consistent with the area from which it appeared to fail? How did you determine that? Did you observe a photograph of the failed branch? Could you be certain that the branch in the photograph came from the tree in question? Who took the photograph and when was it taken? This is information that must be conveyed in your report.

In supporting an opinion you may have about the failure of a branch or tree, is it relevant that a tree, or parts of a tree, located somewhere else on the planet, failed? What may be relevant, by way on demonstrating a particular characteristic of a species, are documented examples of failure of many trees. This information won’t prove an actual or potential failure of the tree in question but it might add weight to an opinion regarding the management of the tree. The theoretical propensity of something to fail must be related to the particular circumstances of the tree in its actual environment.

Much arboricultural opinion is based on theories developed by researchers in various parts of the world. By necessity, research involves the use of local tree species under the environmental conditions prevailing at the time and place in which the research was conducted. Alternatively, experiments may be undertaken in contrived or simulated situations. The results of an experiment will vary according to how it was conducted, i.e. the methodology. As we know, the variables in any growing environment are immense and constantly changing. Therefore changing one variable in an experiment may result in a very different outcome.

The area of tree dynamics, load testing and the mechanics of tree failure is a classic example of a wide variety of theories. Therefore, the applicability of that research to other species and environmental conditions must be carefully considered and not taken as fact but may be the assumption on which an opinion is based. You must consider the limitations of the theory or the principle it produces. It is essential that arborists who appear as experts have an understanding of the way in which the theories have evolved. Unfortunately this is often difficult to extract from some texts and references. When using examples of findings from peer reviewed research articles, always critically consider the method that was used and determine its applicability to the situation at hand.

32 Justice D H Lloyd – A paper presented to the Australian Property Institute, 11 February 2000.
33 The Macquarie Dictionary defines the word ‘theory’ as : a coherent group of general propositions used as principles of explanation for a class of phenomena; a proposed explanation whose status is still conjectural, in contrast to well-established propositions that are regarded as reporting matters of actual fact;...
The court does not expect that any scientific or technical evidence must be ‘known to a certainty; arguably there are no certainties in science. But in order to qualify as ‘scientific knowledge’, an inference or assertion must be derived by the scientific method. Proposed testimony must be supported by appropriate validation – ie, ‘good grounds’, based on what is known...’ 34.

In essence, what an expert is required to do is find the facts (observation and testing), apply the laws and theories (the assumptions) to the facts, and deduce an opinion.

In a practical sense, determining and recording the facts involves visual tree assessment to the level stated in the report. Do not just trot out...I undertook a Visual Tree Assessment. What does that mean? If it does not involve an investigation of the internal condition of the tree that must be stated. If Resistograph® tests are undertaken, the graphs should be included with a report. In my opinion, Chapter 5 in Lonsdale35 should be compulsory reading as it is a very measured approach to tree inspection and reporting procedures. The methodology used by each expert can be scrutinised closely36.

Similarly, the site details and characteristics must be observed, recorded and tested if required. Clear photographs are important. If you see displacement of paving or a crack in a building near a tree, how can you be sure that the displacement or crack is due to the tree. This is an extremely common assumption in many arborist’s and engineer’s reports. It is amazing in cases of determining whether a tree may have caused damage to infrastructure how little digging is undertaken to prove/disprove the causation. Similarly, in determining if roots may be affected by building works how rarely exploratory trenching is undertaken. In some cases, even when a trench has uncovered a root that could not be the cause of damage, opinions may still vary37.

In negligence cases involving branch failure, the way in which data is collected and the qualifications of those responsible for tree management can be put under the microscope. Great slabs of reports/evidence of arborists and others may be reproduced in the judgment for all to see38.

**Conclusions**

If you are a council employee or a self-employed consultant, you could end up in court as an expert witness. Anything you write may become evidence. Always remember that the best policy is honesty. Your integrity as a professional is put under the microscope in court. You must justify your opinion on the facts and substantiated assumptions relevant to the particular circumstances of the situation under consideration. Clarify precisely what you have to do and whether you have the time or expertise to take on the job. Remember, your duty is to the court and not to your client.

---


38 Yun Hee Choi v City of Sydney Council and 4 others [2007] NSWSC 65