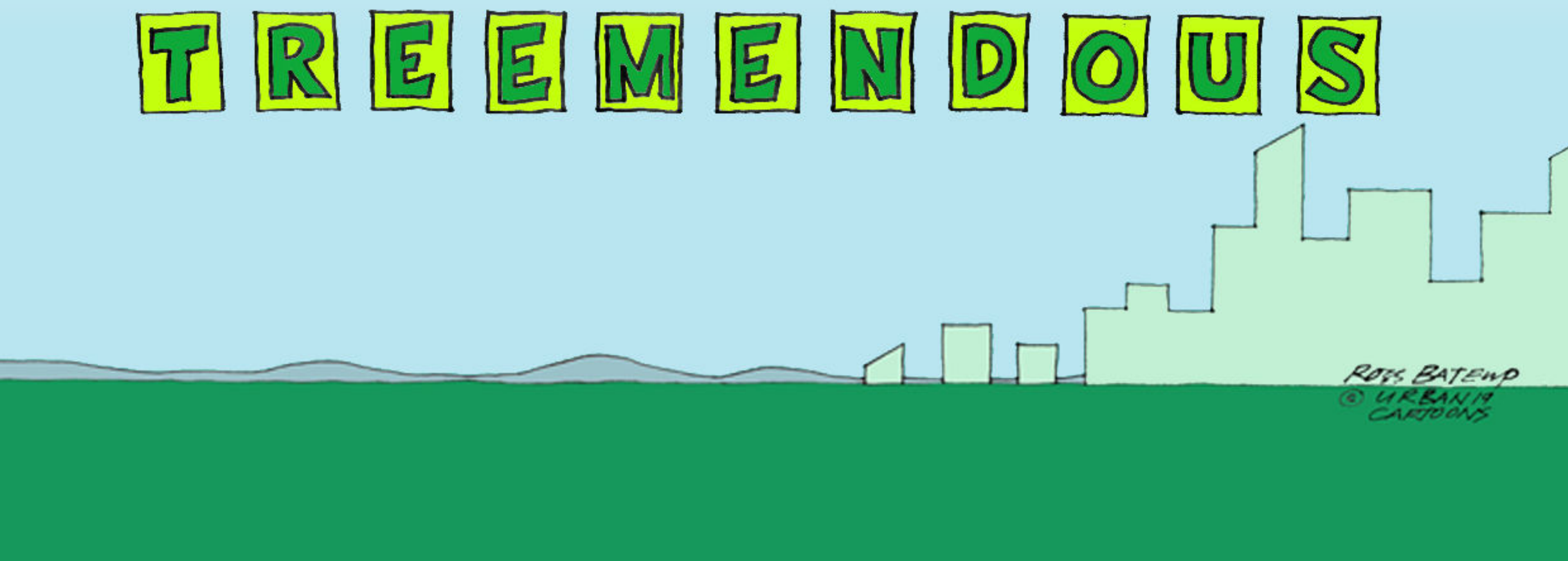
treenet

Proceedings of the

20th National Street Tree Symposium

5th and 6th September 2019

Urban Forest Huggers



ISBN: 978-0-9942149-6-6

TREENET Proceedings of the 20th National Street Tree Symposium 2019

Author/Contributor: Williams, Glenn (editor)

Date of Publication: August 2019

Contents

INSTITUTIONAL MEMBERS OF TREENET 2019

ASSOCIATIONS

Council Arboriculture Victoria

Institute of Australian Consulting Arboriculturists (IACA)

Local Government Tree Resources Association (NSW)

Nursery & Garden Industry SA Inc (NGISA)

Queensland Arboricultural Association Inc. (QAA)

Victorian Tree Industry Organisation (VTIO)

GOVERNMENT

Albury City Council

Berri Barmera Council

Campbelltown City Council

City of Adelaide

City of Belmont

City of Burnside

City of Charles Sturt

City of Glen Eira

City of Holdfast Bay

City of Melbourne

City of Melville

City of Mitcham

City of Norwood, Payneham and St Peters

City of Onkaparinga

City of Port Adelaide Enfield

City of Sydney

City of Unley

City of West Torrens

Inner West Council

Ipswich City Council

Georges River Council

Hume City Council

Lake Macquarie City Council

Moreland City Council

Mount Barker District Council

National Capital Authority

Office for Design & Architecture SA
(Dept of Planning, Transport & Infrastructure)

TAFE SA

Toowoomba Regional Council

Transport Canberra and City Services

Wagga Wagga City Council

Whyalla City Council

Yarra Ranges Council

CORPORATE

- Active Tree Services
- ArborCarbon
- Arbor Centre
- Arborgreen
- Arbor Operations QLD Pty Ltd
- Arbortrack Australasia Pty Ltd
- Austral Tree Services
- Bluegum Consultancy
- Botanix Plant Supply Pty Ltd
- Citygreen
- C&R Ryder Consulting
- Greenwood Consulting
- Greater Metropolitan Cemeteries Trust
- Homewood Consulting
- HR Products
- Metro Trees
- Mt William Advanced Tree Nursery
- Quantified Tree Risk Assessment Limited (QTRA)
- Remote Area Tree Services
- Sevron Environmental Contractors
- Space Down Under
- Speciality Trees Pty Ltd
- Terra Cottem Australasia Pty Ltd
- The Tree Company
- Tree Dimensions
- Tree Sales
- Treescape Australasia
- Urbanvirons Group Pty Ltd

Click here to visit the TREENET website to find out more about our Institutional Members

TREENET MANAGEMENT COMMITTEE AND ADVISORY BOARD 2019

TREENET MANAGEMENT COMMITTEE

Chairperson:	Dr Greg Moore OAM
Director:	Glenn Williams (ex officio)
Treasurer:	Darryl Gobbett *(ex officio)*
Members:	David Lawry OAM
	Dr Kate Delaporte
	Dr Tim Johnson
	Cameron Ryder
	Rob Bodenstaff
	Dr Lyndal Plant
	Geoffrey Nugent

TREENET ADVISORY BOARD

Glenn Williams	Director TREENET	SA
David Lawry OAM	Founder, TREENET & Avenues of Honour	SA
Darryl Gobbett	Honorary Treasurer TREENET / Avenues of Honour Project	SA

Educational and Research Institutions

Prof Chris Daniels	Director, Cleland Wildlife Park	SA
Dr Kate Delaporte	Curator, Waite Arboretum, TREENET Management Committee	SA
Dr Greg Moore OAM	Research Assoc. Burnley School of Resource Management & Geography, Chair, TREENET Management Committee	VIC
Dr Jennifer Gardner OAM	University of Adelaide	SA
Dr Dean Nicolle OAM	Director, Currency Creek Arboretum	SA
John Zwar	Australian Inland Botanic Garden	SA
Geoffrey Nugent	Senior Lecturer, Ryde TAFE	NSW

Nursery Industry

John Fitzgibbon	Metro Trees	VIC
Hamish Mitchell	Speciality Trees	VIC

Community

Spencer Brown	Avenues of Honour Project, France	France
Michael Rabbitt	Avenues of Honour Project, France	SA

Landscape Architects and Urban Planners

Michael Heath	Chair, National Trust SA Significant Tree Team	SA

Arboricultural, Horticultural, Media & Allied Professions

Dr Lyndal Plant	Lyndal Plant Urban Forester, TREENET Management Committee	QLD
Jan Allen	Terra Ark	QLD
Peter Bishop	Bunya Solutions	QLD
Rob Bodenstaff	Arbor Centre, TREENET Management Committee	WA
David Galwey	Tree Dimensions	VIC
Peter Lawton	Trentcom	VIC
Ben Kenyon	Homewood Consulting	VIC
Phillip Kenyon	Kenyon's Quality Tree Care	VIC
Cameron Ryder	C & R Ryder Consulting, TREENET Management Committee	VIC
Kym Knight	Tree Environs	SA
Mark Willcocks	Active Tree Services	NSW
Quentin Nicholls	Arbortrack	QLD
Sue Wylie	Tree Talk Arboricultural Consulting	NSW
James Smith	fauNature	SA
Dr Josh Byrne	Josh Byrne & Associates	WA
Sophie Thomson	Sophie's Patch	SA
Judy Fakes	former Commissioner (retired), Land & Environment Court NSW	NSW
Geoffrey Fuller	Nursery & Garden Industry SA	SA

Local Governments

Dr Tim Johnson	City of Mitcham	SA
Christopher Lawry	Mount Barker District Council	SA
Jason Summers	Hume City Council	VIC
Karen Sweeney	City of Sydney	NSW
Vic Bijl	City of Belmont	WA

TREENET INCORPORATED CONSTITUTION

1. NAME

The name of the Association is "TREENET Incorporated"

2. DEFINITIONS

2.1 "The Act" means the Associations Incorporations Act 1985.

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 broaden the body of knowledge that exists about street trees and foster research, distribute applicable information, facilitate cooperation and enlist community support concerning the protection, preservation and enhancement of the urban forest.

3.2.4 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

Directors & 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.

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 Organisations.

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 organisation'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.

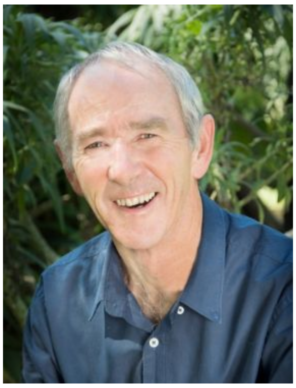
SPEAKER AND PANELIST PROFILES

Professor Peter Newman AO

Peter Newman began in 2008 as the Professor of Sustainability at Curtin University and Director of the Curtin University Sustainability Policy (CUSP) Institute. He started as an academic at Murdoch University in 1974 and retired in 2007, the last 20 years as the Director of the Institute for Sustainability and Technology Policy.

He sat on the Board of Infrastructure Australia and is a Lead Author for Transport on the IPCC. His books include 'Green Urbanism in Asia' (2013), 'Resilient Cities: Responding to Peak Oil and Climate Change'(2009), 'Green Urbanism Down Under' (2009) and 'Sustainability and Cities: Overcoming Automobile Dependence' with Jeff Kenworthy which was launched in the White House in 1999.
In 2001-3 Peter directed the production of Western Australia's Sustainability Strategy in the Department of the Premier and Cabinet.
In 2004-5 he was a Sustainability Commissioner in Sydney advising the government on planning and transport issues.
In 2006/7 he was a Fulbright Senior Scholar at the University of Virginia Charlottesville.
In 2011 Peter was awarded the Sidney Luker medal by the Planning Institute of Australia (NSW) for his contribution to the science and practice of town planning in Australia and in 2014 he was awarded an Order of Australia for his contributions to urban design and sustainable transport, particularly related to the saving and rebuilding of Perth's rail system. He was an elected Fremantle City Councillor from 1976-80 where he still lives.

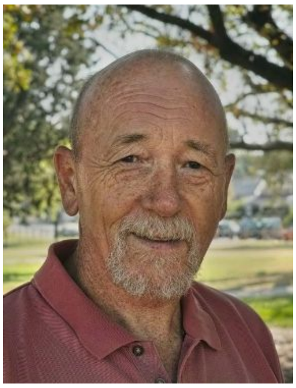
Dr Greg Moore OAM



Senior Research Associate of Burnley College, University of Melbourne Greg was Principal of Burnley from 1988 to 2007 and Head of the School of Resource Management at the University from 2002 to 2007.

With a general interest in horticultural plant science, revegetation and ecology, Greg is particularly interested in arboriculture. He was inaugural president of the International Society of Arboriculture, Australian Chapter, and has been a member of the National Trust's Register of Significant Trees since 1988 and chair since 1996.
He has served the Board of Greening Australia (Victoria) 1988-2012 and was a trustee of Trust for Nature, 2009-17.
He has chaired TREENET since 2005 and is on the board of Sustainable Gardening Australia. He has written two books, contributed to five others and has published over 165 scientific papers and articles.
Greg was awarded an OAM in 2017 for services to the environment, particularly arboriculture.

Dr Peter May



Peter May graduated with an honours degree in agricultural science from the University of Melbourne and completed a PhD in soil science at the same institution.
He was employed as an academic at Burnley Campus – The University of Melbourne for 30 years, developing expertise in soil science, urban soils and urban and landscape horticulture. At Burnley he taught undergraduate and post-graduate subjects, managed courses and supervised postgraduate students.
He was head of Campus on retirement in 2005.
On retiring he established a consultancy business (May Horticulture Services) and for about 12 years provided specialist advice in a range of areas including urban and landscape soils, landscape plant establishment, landscape plant selection and the management and maintenance of landscape plants, primarily to local government and landscape architecture firms.
He is now enjoying a proper retirement. He is an assistant editor of the journal Arboriculture and Urban Forestry.

Declan McDonald

Declan has over 30 years' experience in agricultural, horticultural, recreational and amenity soil management. In May 2014 he opened an office for SESL in Victoria.
He holds a B.Sc in Urban Horticulture (UTS) and a Master of Sustainable Agriculture (University of Sydney). He also holds Graduate Certificates in Climate Change (University of Melbourne) and Leisure Management (UTS) and an Associate Diploma in Horticulture (Nursery Mgt.).
He has a strong background in Urban Horticulture, Agricultural Production and Natural Resource Management through his work in Private Enterprise, State and Local Governments, and Catchment Management Authorities.
He has authored / co-authored a number of publications aimed at improving understanding and management of soil as a living realm.
In his current position of Senior Soil Scientist with SESL Australia he is responsible for high level technical input for design of tree soils, contaminated land assessment, major redevelopment work aimed at re-using site soils, and urban renewal projects including green walls and rooftop gardens, all while continuing to follow his passion for sustainable management of our soil resources.

Dr Rodney van der Ree

Dr Rodney van der Ree is the Australian National Technical Executive – Ecology, with WSP, a multi-national specialist engineering consultancy.
He is internationally recognised for his expertise in urban ecology and road ecology.
Rodney is also an Associate Professor at The University of Melbourne and continues to undertake research and supervise students in Australia and internationally, including Africa, Asia, Europe and the Americas.
He has published extensively, with over 70 refereed scientific publications, 120 conference and community presentations, 100 reports and popular articles and dozens of media presentations.
Rodney published the international award-winning "Handbook of Road Ecology" (Wiley, 2015), with 63 chapters by more than 100 authors from 25 countries.
He has advised the European Union on habitat fragmentation issues and sits on expert advisory committees for the Swedish Transport Administration and VicRoads. He has supported the development and growth of road ecology research and mitigation programs in South Africa, Singapore, India, Taiwan, China, Japan and South America.

Dr Steve Griffiths

Steve is a Research Fellow in the Department of Ecology, Environment & Evolution at La Trobe University, Melbourne. His current research is focused on quantifying the effectiveness of different types of artificial hollows in providing supplementary nest and den sites for hollow-dependent fauna in human-disturbed landscapes. Along with collaborators from The University of Melbourne and The Arthur Rylah Institute for Environmental Research, Steve is involved in several projects looking at the pros and cons of using traditional timber and plywood nest boxes, versus novel, largely untested types of artificial hollows, such as log hollows that are salvaged from felled tree limbs, and cavities carved with chainsaws directly into the trunks and branches of live trees.

Steve's other research interests include the ecology and sociobiology of tree-roosting insectivorous bats, and mitigating risks associated with wildlife interacting with polluted anthropogenic water bodies.

Ben Seamark

Ben Seamark is an Environmental Manager and Consulting Arborist and has spent the past 25 years working with trees. He studied at Flinders University the University of Adelaide and Brookway Park school of Horticulture.

Ben joined the City of Burnside as Coordinator of Environmental Assets in 2016 where he is responsible for the management of trees, waste and biodiversity. Ben's work and life experiences have generated a passion for trees and their role in society and community, his other areas of interest include Environmental Economics, Information technology and Horticultural Science. These interests have intersected to develop a drive to reconnect people to nature.

In 2018 Ben was awarded TREENET's Leadership in Urban Forestry for the development of Urban Forest Interactive, a website designed specifically to connect people to trees in their urban environment.

Heather Johnstone

Urban forests excite Heather, particularly working in the space that fosters multi-stakeholder partnerships to bring community outcomes such as improvements in social well-being and civic participation. She believes strongly that everyone has a skill they can share and that those in the community who choose to share their skills should be supported and valued appropriately, to build the capacity and resilience of the community as a whole.

During the last 2½ years Heather has volunteered her time in writing both the expression of interest and request for quote for the urban forest strategy, marketing and social media, developing content and running workshops for community consultation. Along with Dave Lindner from the Vic Park Collective and Millennium Kids Inc, Heather co-authored the Town of Victoria Park Urban Forest Strategy. Vicki Caulfield and Jim Mellor were also great contributors.

Heather coordinated the 40 volunteers that supported the project during its development and made numerous presentations to Town of Victoria Park staff as well as the World Forum on Urban Forests held last year in Italy.

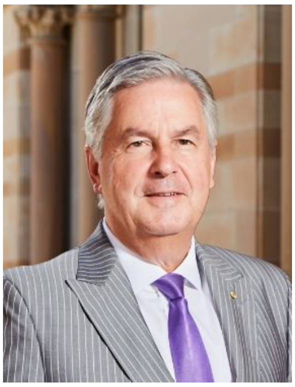
Heather is a current member of the Transition to Implementation Working Group who are working on the implementation Action Plan for the Town of Victoria Park's Urban Forest strategy.

She also currently volunteers with community groups Vic Park Urban Foresters in the core group; sits on the Vic Park Collective committee and she is also a member of the Millennium Kids Inc council, where she lends her skills to foster increased urban tree canopy and the building of stronger communities.

Associate Professor Andrew Butt

Andrew is Associate Professor in Sustainability and Urban Planning at RMIT University, Melbourne.
His research interests relate to land use planning systems and practice, with a focus on regional and peri-urban communities.
Recently, this has included issues associated with climate change adaptation with planning systems and local government through policy and material interventions in areas including active transport, food systems and urban shade.

Rear Admiral the Honourable Kevin Scarce AC CSC RAN (Rtd)



Kevin was born in Adelaide and educated at Elizabeth East Primary School and Elizabeth High School, was the 34th Governor of South Australia from 2007 to 2014. He served in the Royal Australian Navy from 1968, retiring in 2004. His appointments included service on HMAS Sydney during the Vietnam War, postings in Washington and London, Commanding Officer of HMAS Cerberus and Flag appointments as Naval Training and Naval Support Commander.

Kevin also specialised in military logistics and procurement, rising to the rank of Rear Admiral and Head of Maritime Systems at the Defence Materiel Organisation. After retirement, as Head of the South Australian Defence Unit, he led a government team that contributed to ASC winning the contract to build air warfare destroyers for the Australian Defence Force.

Kevin was awarded the Conspicuous Service Cross in 1994, the Knight of Grace in the Venerable Order of Saint John in 2007 and a Companion of the Order of Australia in 2008.

In addition to his role as 16th Chancellor of the University of Adelaide, Rear Admiral Scarce is Chair of the Adelaide Oval Stadium Management Authority, Chair of Cancer Council SA and President of Novita Children's Services. He is a Director of a number of public and private companies, a Governor of the Coopers Foundation and joint Patron, with his wife Liz, of Anglicare SA.

Dan Lambe

Dan is the president of the Arbor Day Foundation, founded in 1972, which has grown to become the largest nonprofit membership organisation dedicated to planting trees, with over one million members, supporters, and valued partners.

Dan leads the strategic development of programs and partnerships through which the Foundation strives to educate, recognise, and empower people to plant, nurture, and celebrate trees.

WE CAN'T FIX CLIMATE CHANGE WITHOUT PLANTING MORE TREES

Peter Newman AO

Professor of Sustainability, Curtin University
and a Coordinating Lead Author in the IPCC.

Abstract

The latest report from the IPCC on 1.5^{0}C shows that we need to do all we can to remove fossil fuels from our economy but we cannot make the necessary adjustment to reducing CO2 in the atmosphere unless we put much more carbon back into the landscape.

This needs more plant matter and more soil carbon – both mean more trees.

Globally there is still more carbon being depleted from the land rather than being regenerated.

This presentation will show how critical cities are to this agenda, both in the application of biophilic urbanism into every part of the city but also in ensuring the bioregion plants trees through carbon neutral programs. Carbon neutral can be a major source of funding for tree planting.

It is now clear how to remove coal and oil in power and urban transport through solar, wind, batteries and electric vehicles thus contributing to resolving the climate emergency in the next 12-15 years.
But what do we do with the unsolved issues such as natural gas used in industrial heat, and oil used in aviation, long distance trucking and shipping?
It is unlikely they will find a reasonable solution in this critical period. Perhaps all these need to become carbon neutral while they keep using fossil fuels, thus giving them the chance to contribute during the carbon emergency of the next 12-15 years, and planting millions of trees their multiple benefits.

The new IPCC Report on Land, called in full 'An IPCC Special Report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems' is available on this link:

https://www.ipcc.ch/site/assets/uploads/2019/08/4.-SPM_Approved_Microsite_FINAL.pdf

The Land Report has been summarised for easy communication in two articles in The Conversation:

UN climate change report: land clearing and farming contribute a third of the world's greenhouse gases

August 8, 2019 6.01pm AEST
Mark Howden – Director, Climate Change Institute, Australian National University

https://theconversation.com/un-climate-change-report-land-clearing-and-farming-contribute-a-third-of-the-worlds-greenhouse-gases-121551

New climate change report underscores the need to manage land for the short and long term

August 12, 2019 9.11pm AEST

Chris E. Forest - Professor of Climate Dynamics, Pennsylvania State University

https://theconversation.com/new-climate-change-report-underscores-the-need-to-manage-land-for-the-short-and-long-term-121716

STREET TREE PLANTING: SOME RECIPES FOR SUCCESS AND PRESCRIPTIONS FOR FIRST AID

G M Moore

School of Ecosystem and Forest Sciences, University of Melbourne, Burnley College, University of Melbourne, 500 Yarra Boulevard, RICHMOND, AUSTRALIA 3121

Abstract

After 20 years of TREENET symposia, there is a much better understanding of what makes a street tree planting successful. Proper tree selection and using the highest quality stock are a great start, but problems with planting technique are still too common. Trees are planted too deep or shallow and the process of planting can contribute to site compaction. Even the mulch and paving materials surrounding street trees can affect their success.

Street trees can benefit enormously from cost-effective formative pruning. However, this simple and efficient technique is still practised rarely in municipal horticulture. Even simple maintenance such as deadwooding canopies is often forgotten. Many street trees suffer damage and wounds from neglect or the human activity that takes place around them. Appropriate action such as bark grafting and the use of epicormic and lignotuberous shoots can quickly restore the amenity of a tree.

In an era when the use of drones and ground penetrating radar allows better inspection of tree canopies and root systems, it is disappointing that street tree plantings often fail through ignorance and the failure to apply basic arboricultural principles. This paper is a timely reminder of what can be done to make street trees great again.

Introduction

In Australia, a forest is defined by a tree canopy cover equal to or greater than 30%; less than this is woodland. So if the term urban forest is to be widely used then should canopy cover also be equal to or greater than 30% or if not, is it really an urban woodland? As we know, language and words matter as they connote concepts and meaning. When the term urban forest is used does it connote a canopy cover that is greater, and often far greater, than the reality of woody cover in Australian cities?

In general, to maximise the benefits that canopy can provide in terms of environmental services requires a canopy cover of about 30%. Once the figure exceeds 30%, the law of diminishing returns takes effect and there is relatively little extra benefit for the increased cover. In work on the effect of trees on Brisbane house sale prices, Plant (2017) found that while street trees nearby added up to a 3.7% premium on median house price, positive effects of trees growing on the property were capped at a threshold of no more than 20% tree cover, after which greater cover led to a decrease in value. The recurrence of a canopy cover figure around or approaching 30% prompts the rhetorical and tongue-in-cheek question, “Is 30% an arboricultural magic number?” It also prompts a conclusion that the target tree canopy cover for cities in Australia, under current climate change scenarios, should not be less than 30%.

The task of achieving acceptable levels of tree cover in Australia’s cities and suburbs is daunting. Reporting the work of Jacobs et al (2014) at TREENET in 2017, it was noted that over half the local government agencies in greater Sydney, Melbourne, Adelaide and Perth had less than 20% canopy cover, and that in Melbourne canopy cover was being lost at a rate of 1-1.5% per annum (Moore 2017). In its recent *Living Melbourne: Our Metropolitan Urban Forest* report, The Nature Conservancy (2019) reported the current tree canopy cover and the targets of cover proposed for different regions of Melbourne by 2050 (Table 1). It is pleasing to see that in some regions of Melbourne (Eastern, Inner South East and Southern) a 30% goal for canopy cover by 2050 has been set and that for two other regions and for Melbourne as a whole a target of over 27% has been listed. But for the west it remains at less than 20%, which raises the questions, “Why 27% in places and not 30%?”, “If the target is so close to 30%, why not aim just a little higher?” and “Why is the target for the west so different from the other regions and so low?” The canopy cover can be seen as an indirect index of sustainability, quality of life, human health and well-being and socio economic status, none of which are to be taken lightly as they directly affect peoples’ lives. Indeed they can be matters of life and death and certainly impact on peoples’ longevity.

Table 1 .Current and Targeted canopy cover for Metropolitan Melbourne by 2050 (The Nature Conservancy 2019).

Region	Current canopy cover (%)	Target canopy cover – 2050 (%)	Target Canopy increase (%)
Eastern	25.2	30.0	4.8
Inner	12.5	27.5	15
Inner South East	21.7	30.0	8.3
Northern	12.1	27.1	15
Southern	16.4	30.0	13.6
Western	4.2	19.2	15
Metro Melbourne	15.4		

Given the arboricultural magic number of 30%, it seems logical to suggest that all the regions have the same target of 30%. It may be argued that some regions with historically fewer trees should have lower targets. However, suburbs are suburbs regardless of their vegetation history and the issues being faced under climate change relate to urban development. It seems reasonable that given the regions are essentially similar suburban parts of Melbourne, the 19.2% target for the western region should be questioned. Such a low target would seem destined to entrench the lower socio-economic status of this part of the city rather than aiming for 30% which would play a part in redressing some of the imbalance. There is also concern that by not aspiring to a higher target, the opportunity for achieving a high cover will be lost permanently as planning and development will be so intense that there will be no space provided for tree planting. It might be argued that having lofty targets, where half of the regions would have to double their current canopy cover, is unrealistic, even daunting – why set a target that cannot be achieved! However, by having lower targets the desired cover of 30% and the multiple benefits that it confers on a region will never be achieved.

While it is commendable that there is an aspiration to achieve an increase in canopy cover by 2050, the truth is that in most regions, and despite the best efforts of local governments and programs like 20/20/20 Vision, canopy cover is declining at a rate of 1-1.5% per annum largely due to tree losses from private open space (front and back yards) (Moore 2017). At the 2019 Arboriculture Australia conference, McManus (2019) presented a fine case study on canopy cover in the suburb of North Sydney. With a traditionally high suburban canopy cover, it seemed that their goal of 30% canopy cover would be achieved relatively easily, especially when they had moved from 19% in 1997 to 33.9 % in 2008 (Table 2). However, by 2014 a decline in cover was becoming evident and by 2017 the cover had fallen to 28%.

Table 2 .Targeted canopy cover and changes in canopy cover in different parts of North Sydney from 1997 to 2017 (McManus 2019).

Description of land type	% of LGA	Canopy target	1997 %	2001 %	2008 %	2014 %	2017 %	Decline since 2008
Overall canopy cover	100	34.4%	19	24	33.9	30.7	28.2	5.7
CBD	10	15%			16.5	13.5	14.2	2.3
Urban	48.3	25%			32.4	28.8	26.9	5.6
Suburban	41.7	50%			39.8	37	33.0	6.8
Public Land	25.7				50.5	52.8	50.0	0.5
Private Land	58				31.6	26.4	24.0	7.5
Roads	16.3	30%			28.1	26.1	23.4	4.7

There is a recurring pattern in this declining canopy cover across Australia. Cover on public land is relatively stable and local governments have policies seeking to increase the tree canopy cover of their region, but despite this, overall canopy cover is falling. In some instances virtually every available space in public open space for tree planting is occupied but due to tree losses in urban and suburban private open space due to in-fill development, along roads and in heavily urbanised districts, the number of trees and their canopy cover declines (Table 2). Overall canopy decline in North Sydney has been 5.7% with the greatest contributors to loss being from suburban and private land. The imperative of retaining current tree cover and expanding it has never been greater. It is essential that when we plant street trees not only are we successful, but that the trees we plant need to persist and reach the full potential of their life spans.

After 20 years of TREENET symposia, there is a much better understanding of what makes a street tree planting successful. However, whole tree planting schemes still fail and multiple tree failures in an otherwise successful planting are common. Lack of success may be due to failure in the planning, implementation or management phase of a street tree planting project. These failures are costly to the authorities responsible for them and to society as a whole, but there are opportunity costs and the loss of environmental and ecological services associated with such failures. Amenity is diminished, time and resources are wasted and a future generation is deprived of an asset.

The long-term success of street tree planting relies upon early tree establishment and long-term performance, which are different aspects of street tree growth. Tree establishment relates to the extension of the recently planted root system into the backfill soil which increases the available resources to and stabilizes the tree. It also relates to adequate canopy health, structure and growth which allow successful street tree performance in the long term. Tree performance is assessed by how the tree grows within the landscape over time and is often characterised by measures such as growth rate, height increment, canopy spread and density and measurements of girth increase (Leers et al 2017). The term tree establishment is commonly used by urban tree managers but rarely defined. In this paper, establishment of street tree stock is defined as the tree being of an acceptable height for its species and age, having a good canopy spread and density and being stable in the ground two growing seasons after planting (Leers et al 2018).

In an era when ground penetrating radar and the use of drones allow better inspection of tree canopies and root systems, it is disappointing that street tree plantings often fail through ignorance and the failure to apply basic arboricultural principles. In any endeavour management can only be as good as the quality of the information that informs it. Urban street tree management requires accurate measurement and quality data that can inform the decisions made. This paper is a reminder of some of the things that can be done to make street trees great again.

Some Recipes for Success

Purpose, design and species selection

Before any tree is planted in a street, there should be a clear design intent that specifies what the planting is expected to achieve. While species' genetics and aesthetics may be components of the design intent and brief, other factors such as the provision of shade, water management, carbon fixation, and other environmental and ecological services have their place (Table 3). It is re-assuring that the list of benefits provided by trees has expanded significantly over the past couple of decades as multi-disciplinary research into urban trees has developed and increased the understanding of the benefits that trees provide, and the list continues to expand. Tree planting in public open space has always been multi-functional and many factors must be considered in the design and subsequent species selection. Proper tree selection and using the highest quality stock are a great start. The use of AS 2023: 2015 Tree Stock for Landscape Use has an important role to play but must be specified in tender documents and purchase contracts to be effective.

Table 3. Some of an expanding list of benefits provided to society by urban trees.

Biodiversity	Shade/thermal comfort	Human health - mental
Aesthetics	Human health - physical	Increase biodiversity
Air quality/pollution reduction	Increased employment	Flood mitigation
Air quality/humidification	Stormwater management	Food production
Moderation of wind	Recreation – active/passive	Tourism
Noise abatement	Increase property value	Increase biodiversity
Water quality management	Provide habitat	Noise abatement
Carbon sequestration	Reduced vandalism/graffiti	Reduction in sun glare
Soil Management	Reduced crime/violence	Human well-being
Urban heat island management	Pollination	Heritage conservation
Altered effective precipitation	Better education outcomes	Dust control

Tree establishment

Successful street trees require effective and efficient tree establishment which can be assessed using the criteria recommended by Leers et al (2018) such as, appropriate planting depth, whether trees exhibited trunk movement at or below the soil surface, damage to the trunk, whether there were co-dominant stems, and presence of epicormic shoots on the trunk/branches (Table 4). The Burnley test (Figure 1) proved a simple, effective and reliable indicator of tree stability and a test of root system establishment. Criteria such as these require measurement and management of the data acquired, but they effectively replace the subjective assessment of street tree establishment and performance that has so often been the hallmark of horticultural management with objective assessment and quantitative data.

Table 4. Practical criteria for assessing street tree establishment (Modified from Leers et al 2018).

CRITERIA	Implications for tree establishment
Whether trees had been planted too deeply or too shallow	Poor root system development
Trunk movement at or below the soil surface	Burnley test indicates root system development which can adversely affect establishment
Damage to the trunk	Reduced canopy growth and poor tree establishment
Trunk sunscald injury	Reduced canopy growth and poor tree establishment
Epicormic shoots on trunk/branches	Indicator of general tree stress
Co-dominant stems.	Poor form requiring structural pruning
Canopy dieback	Indicator of general tree stress and poor establishment
Shoot tip extension	Allows a quantitative measure of canopy growth

Reliable, accurate, objective and practical indicators of whether street trees have successfully established can inform decisions about irrigation, formative pruning, removal of supporting stakes and ties, the monetary value of an individual street tree, pest and disease management and whether poor performing trees should be removed and replaced. In some jurisdictions there are legal or regulatory implications that arise once a tree is established. AS 4970 - 2009 Protection of Trees on Development Sites, for example, stipulates that the standard only applies to established trees. In other situations, site plan agreements or requirements may stipulate that trees will be inspected to determine if they have successfully established, whether trees will be then accepted or removed and when, or if, final payments to contractors will be approved.

Figure 1. The Burnley test for investigating street tree stability and root development

Soils, compaction and tree selection

In a study of street trees growing in the Western region of Melbourne, it was shown that there were considerable differences in compaction and penetrative resistance on different sides of the same street tree (Fitzgerald 2012). This suggested that the insertion and levering of the mechanical spade used in creating the planting pits compacted the soil on one side. Specifying that the sides of the planting holes need to be decompacted after planting, or perhaps more proactively and simply, that the soil surrounding the planting hole must not be compacted in the process of planting should be written into street tree planting contracts. The use of good mulch, discussed later in this paper, is also an important part of successful tree planting.

In the same study, it was suggested that street trees growing in this soil type (basaltic clay) could be placed into three categories based on their growth in compacted and uncompacted urban soils (Fitzgerald 2012).

Category 1: trees increased growth in compacted soil, were more tolerant of soil compaction than other species and may not require soil amelioration prior to planting.

Category 2: tree growth was unaffected by compacted soil. Trees were tolerant of soil compaction, but may benefit from site amelioration to alleviate compaction for optimum growth. They will grow adequately if the soil remains compacted.

Category 3: trees had reduced growth in compacted soil. Trees did not tolerate soil compaction and site amelioration would be necessary for growth. These species may be unsuitable for compacted soils.

Categorising tree species in this way for other soil types and climates could be useful to urban tree managers in informing their approach to and procedures for street tree selection and planting.

Correct planting

Problems with planting technique are still common. Planting advanced stock too deeply (or more rarely too shallow) is still a regular occurrence, which can affect street tree establishment and performance. This has been a matter of concern for over forty years and something this simple should no longer be a problem. However, several recent studies have confirmed that up to 25% of some street tree plantings have-not been planted at the correct depth (Leers et al 2018). Planting depth specifications are usually quite clear, but too often they are not enforced.

Formative pruning

In their research on formative pruning, Ryder and Moore (2012) reported that only 22% of the young, newly-planted street trees surveyed were without structural defects and that species such as *Pyrus calleryana* were prone to such high rates of defects that their selection for street tree planting could be questioned. Structural defects were clearly defined (Table 5) in a way that would enable their identification and rectification to be part of routine street tree management. The defects can be counted and assessed giving quantitative data for use in future decision making. About a third of the trees surveyed had codominant stems with included bark which represented a significant risk of future failure. The results highlighted the issues of sound street tree selection and the importance of good quality planting stock.

Table 5. Definition of structural defects in street trees (Modified from Ryder and Moore 2012)

Fault	Description
Codominant stems	Stems equal in size and relative importance, usually associated with either the trunks or stems or scaffold limbs.
Included bark	Bark is turned inwards at branch junctions instead of being pushed out, which may result in the branch or stem being weakly attached and prone to fracturing
Low Branching	Branches low on the stem of a tree that has established or branches encroaching on the road or pathway that require a canopy lift. Removal of low branches earlier rather than later reduces the wound on the trunk.
Epicormic Shoots	Shoots which may not be well attached to the trunk or stem and can present a hazard when they get larger.
Suckers	Shoots arising from roots at or below the soil surface which are often from grafted rootstock. Suckers can be vigorous but may not be the desired cultivar
Broken Branches	Branch may not completely break off and continue to grow with a weak point becoming a danger.
Broken Stems	Main stem broken.
Deadwood	Dead wood in the canopy requiring removal. Often coincides with poor health.
Rubbing or Crossing Branches	Branches rubbing against each other wound, which may weaken the branch and provide an open wound for entry of pathogens.

The economic value of formative pruning is sound. The average cost of formatively pruning different species of trees that were in the range of 4-6.0m tall was estimated at $2.80 per tree (Ryder and Moore 2012). If the tree was not formatively pruned, then ten years later the cost of remedial structural pruning can be estimated at about $200.00 and at twenty years the costs will be $500-1000 per tree, and could be more depending on its position and accessibility. The economic benefits of formative pruning are clear, and if such work is undertaken, funds can be freed up in tight arboricultural budgets for more proactive work. However, formative pruning is still the exception rather than the rule for many large scale street tree planting projects around Australia.

Some First Aid Prescriptions

Mulching

In work on the effects of compaction on root growth and tree establishment, Fitzgerald (2012) showed that over a 20 month period, the bulk density of an uncompacted control soil remained constant while that of the compacted soil reduced. It is possible that root penetration may have reduced compaction, but it is well known that mulch is a cost-effective remedy to soil compaction over the medium to long term. While other studies have reported that it often takes several to many years before the mulch is effective in reducing compaction depending on soil type (Scharenbroch et al. 2005; Urban 2008), this research supported the view that mulch can significantly reduce soil compaction but over the shorter period of 20 months.

For years, a mixed-particle size organic mulch, 75-100mm deep has been recommended for placement around newly-planted street trees and in garden beds containing trees. Some of the many benefits of doing so include, better water infiltration, reduced evaporation of water from the soil, elimination of competition from other plants such as turf or weed species, easier weed control and better soil organic matter content and structure. To this list can be added the results of research showing that addition of biochar to soils was no better than mulch, and that there was no synergy between biochar and mulch, in improving growth in *Corymbia maculata* and *Eucalyptus torquata* (Somerville et al 2019). Ambient temperatures around street trees can also be impacted by mulch which is cooler than other surface materials that are often placed around trees (Leers et al. 2017). Good mulch sensibly applied really is marvellous!

Bark grafting

It is inevitable that from time to time, some established trees will suffer significant wounds to the trunk or major branches where the bark is dislodged or the tree ringbarked. Bark grafting may provide an effective first aid for some of this damage. In 1991, a bark patch was attached to an *Ulmus procera* growing at Burnley after the removal of a large branch (Figure 2) and remained intact and healthy until the removal of the tree in 2014. The wound had successfully grown over ("healed") very quickly (<2years) compared to an unpatched wound of such a size and had successfully compartmentalised.

Figure 2. A successful bark patch graft on an elm at Burnley Gardens

This successful bark patch graft precipitated experiments which investigated whether bark patches could be removed and then successfully replaced on the same tree, whether there were differences between tree species in their responses and whether the season when the damage and patch grafting was done had any effect of successful bark re-attachment (Moore and McGarry 2017). The experiments showed that the right orientation of bark tissue enhanced the potential of successful re-attachment in all seasons and that the greatest success was achieved when tissues were re-attached at their original orientation in spring. The work showed that grafts larger than 100mm in diameter may need to be secured in position and proposed a set of steps for successful bark re-attachment first aid (Table 6).

Table 6. Recommendation for bark replacement or bark grafting of wounded street trees (Moore and McGarry 2017)

Recommendation	Rationale
Bark patch grafts should be applied to a trunk wound, or branch stub, as soon as possible after wounding or pruning.	Prevents drying of tissues and further damage to cambial
The wound must be kept clean and moist while preparing the patch graft. The material for the patch may come from damaged bark, or fresh bark taken from a limb removed from the tree.	Basic plant hygiene to reduce the risks of infection. Moisture keeps cells and tissues from desiccating
The edges of the wound and the bark patch graft must be clean and neat to ensure good cambial contact and to minimize the risk of disease.	Basic plant hygiene to reduce the risks of infection and maximise cambial contact
The bark patch grafts should be placed in cambial contact that ensures the maximum amount of cambial alignment.	Maximise cambial contact between patch and cambium of tree
The orientation of the tissue should be as close as possible to the original	Retain tissue orientation and minimise stress
The bark patch should be well-covered with budding tape (or similar) for at least 2 and up to 4 weeks.	Secures patch, retains moisture and reduces the risk of pest attack
If the bark graft patch is not attached when the wound area is uncovered, remove the patch and allow natural callus growth to enclose the wound	Removes dead tissue that might harbour insect of fungal pests
Bark patch grafts are most successful in spring, so try to perform elective bark patch grafts during this season.	You may not have a choice of seasons, but sometimes you might

The use of bark patch grafts may mean that the removal of a tree limb could be less of an eyesore. Covering the wound with a bark patch graft conceals the fact that a limb has been removed and hides obvious scarring, while at the same time the risk of disease and stress to the tree may be reduced by closing the wound more quickly than would normally occur due to natural callusing. The use of bark patch grafts provides arborists with a method of dealing with tree trunk wounds caused by vandalism and accidents, and would be particularly useful if a tree was of special, historic, or environmental significance to the landscape.

Tree inspections and deadwooding

Tree risk inspections are a routine part of most local government tree management programs. While there is neither time nor space to discuss this aspect of urban tree management in detail, it is worth being aware or the Victorian coroner's recommendations in relation to tree risk inspections after a tree related fatality (Moore 2016). The eight recommendations (Table 7) are a strong incentive for undertaking inspections professionally using qualified arborists on a regular basis.

As part of a regular tree inspection and assessment program, there are good reasons - aesthetic, biological, economic or safety - for the deadwooding of tree canopies, but some are more compelling than others. The advantages of deadwooding as part of formative pruning for young and developing trees are manifold especially for reducing the incidence of and costs associated with the later management of trees with poor canopy structure. However, deadwooding is more commonplace in the management of mature and over-mature trees than young specimens.

The aesthetic argument for deadwooding urban forest trees is quite strong, especially for many eucalypts that produce copious amounts of relatively small deadwood as a consequence of the dynamic nature of their crowns (Moore 2018). The deadwood can look unsightly, is nearly always present, but is rarely large enough to be hazardous. This dynamic crown is quite different from the crowns of many exotic trees such as oaks or elms which tend to slowly expand once the tree is mature. The biological advantages of deadwooding not only relate to the development of a sound canopy, but also to compartmentalisation, wound closure and the minimisation of pest and disease attack. Wound closure can be obstructed and delayed by the presence of dead branches and stubs.

Table 7. Coroner's recommendation in relation to Tree risk Inspections (Abridged from Moore 2016)

Number	Recommendation
1	All local government agencies (LGAs) should have a computer-based inventory of all trees for which they are responsible, which identifies the species of the tree and its location.
2	All LGAs should have a computer maintenance program linked to the inventory which provides dates and details (what was done and why) of all maintenance and inspection operations undertaken on the trees.
3	All LGAs should have a computer-based risk assessment system that is applied to all trees within the tree inventory. Such a system may incorporate widely available systems such as QTRA or TRAQ, or other systems which embody the principles of risk assessment specified in the relevant Australian Standard.
4	All LGAs should have a formalized tree inspection protocol, which specifies the purpose of the inspection and what form the inspection takes (walk-by Visual Tree inspection, use of technological aids) and whether the inspection is ground-based, or from above. The inspection record should also indicate what arboricultural works, if any, are recommended for the tree and why these works are recommended.
5	All inspections must be undertaken by a qualified (Level 4 or above) arborist. A level 5 qualification or above is preferred, but may not be applicable to all council--based situations at present.
6	All inspection and assessment protocols should be dated and indicate a time line for the next inspection /assessment. The inspection/ assessment record should also indicate what further arboricultural works, if any, are recommended for the tree and by what date in the future these should be undertaken.
7	In any tree inspection or risk assessment, it should be noted that the anatomy of branches and epicormic shoots are different. The term "branch" should only be applied to structures that have branch anatomy and epicormic shoots should be clearly identified as such in assessment or inspection procedures.
8	All inspection protocols should assess trunk and canopy components (above-ground) and root system (below-ground) using criteria that allow assessment against these criteria at the time of inspection.

The most compelling reasons for deadwooding mature trees relate to safety. Leaves and higher order branches act as mass dampers when they were alive and they continued to do so for some time after they die (James 2003). Mass damping is part of the tree's responses to strong winds (Moore 2014), but on a windy day, small dead branches (less than 75mm in diameter) without leaves or lower order branches can begin to vibrate quite rapidly. Over time as tissues dry, weaken and decay, it becomes likely that on windy days these movements may lead the smaller dead branches to fail. This is one of the reasons why dead branches will often fail during windy weather. Any rapid vibration in a living branch is not usual and may be indicative of poor branch development, a lack of taper, internal structural problems or that the branch is in decline.

Arborists are told never to attach their ropes to a dead branch or to loop ropes around the main axis of a tree above a dead branch. These dead branches can be set vibrating simply by moving a rope which may be enough to cause them to fail, but if a climber's weight is added to the dead branches then significant vibration of the dead limb is unavoidable and the risk of failure is increased. As an arborist, if you feel vibrations or jerkiness when you are within, or attached to, a tree or branch, exercise greater caution. If there is no wind then the tree should be still. In a wind, the tree or branch may gently sway with the breeze, but if there is any jerkiness in the action, it can be a sign that the branch or whole tree is structurally compromised. In common high-risk situations that can exist with street trees, trees in public parks and trees growing near schools or public buildings, inspection and deadwooding of trees on a regular (annual) basis should be recommended.

Value of root and dormant bud systems

Over the past twenty years, a lot has been written to reinforce the recognition of the value of root systems, epicormic buds and lignotuberous shoots. Because they are essentially out of sight, their values as assets are often unrecognised. Too often stump grinders are used routinely, without thinking of the potential use of these assets that may allow the re-establishment of a badly damaged tree at a fraction of the cost and time that it takes to remove a damaged tree and re-establish it. A tree can be removed without the recognition of the value of its root system and lignotuber or a tree is removed because of canopy damage without consideration of reconfiguring a sound canopy from epicormic or lignotuberous shoots.

Adaptive management

Adaptive management (AM) strategies can be both effective and resource efficient in dealing with pest and diseases. The AM framework provides a context for practicing arborists to address the uncertainty in pest and disease management of urban forests during climate change (Moore 2018). The AM model consists of a loop that involves: knowledge of past infestation and management practices - monitoring the current pest or disease outbreak - learning from data collected in the field- evaluation of consequences - deciding on action - implementing action – monitoring consequences of action - learning from data collected - evaluation of consequences - deciding on action - implementing action and so the loop continues (Figure 3).

There is a strategic opportunity for urban tree managers to integrate AM control of mistletoe, elm leaf beetle, fig psyllid and other infestations of urban trees with climatic events (Moore 2018). Such an approach relies on monitoring of pest numbers to collect data on the level of infestation. The surveys provide hard data that trigger control programs when pest levels are above a certain point, but which also allow the suspension of control programs possibly for several years if numbers are low. This contrasts situations where routine control or spraying programs are undertaken regardless of pest numbers. It means that in situations where urban forest budgets are tight, funds can be freed up for other proactive arboricultural activities.

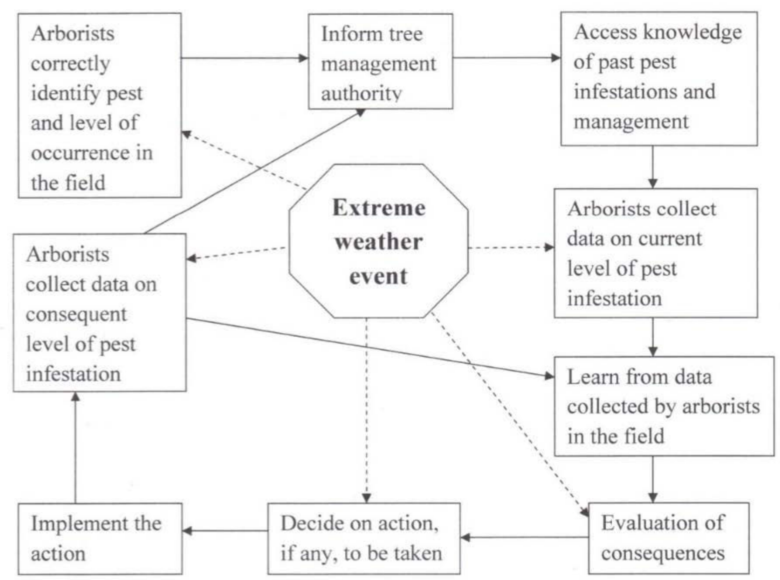


Figure 3. The role of arborists in the adaptive management of urban tree pest species showing the possible impact of extreme weather events on pest numbers and the consequences for tree management (from Moore 2018).

Conclusion

Trees are an essential part of urban infrastructure and are crucial to the liveability and economic and environmental sustainability of cities. In marking the twentieth TREENET Symposium, it is gratifying to see the progress that has been made in urban tree management and to see that so many, but by no means all local governments have street tree policies, urban canopy targets and significant tree protections. However, despite the support for and positive rhetoric surrounding trees in cities, the number of trees and the canopy cover they provide is continuing to decline in many cities and local government areas. As climate changes, it raises the questions as to what sort of urban environmental legacy will be left for future generations of Australians.

Urban trees are societal assets and every effort has to be made to ensure that street tree plantings are both efficient and effective. Once planted it is in society's general interest that the trees survive, thrive and reach their full potential life spans. Anything that TREENET and other relevant groups can do to facilitate such an outcome in the coming decades will prove to be worthwhile in cementing a better urban forest legacy for the future.

References

Fitzgerald. A. 2012. The root system and canopy relationships in urban trees: Doctoral Thesis, School of Land and Environment, University of Melbourne.

Jacobs, B., Mikhailovich, N. and Moy, C. 2014. Benchmarking Australia's urban tree canopy: an i-Tree assessment, prepared for Horticulture Australia Limited by the Institute for Sustainable Futures, University of Technology Sydney.

James, K. 2003. Dynamic loading of trees. Journal of Arboriculture, 29:163-171.

Leers, M., Moore, G. M. and May P.B. 2017. The effects of paving surfaces and planting orientation on street tree growth and trunk injury. Arboricultural Journal 39, (1), 24-38.

Leers, M., Moore, G.M. and P.B. May. 2018. Assessment of six indicators of street tree establishment in Melbourne, Australia. Journal of Arboriculture and Urban Forestry: 44**:**12-22.

McManus, M. 2019. The North Sydney Council Experience - Tracking canopy change over 20 years, the ups, the downs and taking a new approach. Conference Proceedings, 2019. Arboriculture Australia.

Moore, G.M. 2014. Windthrown Tree: Storms or Management? Journal of Arboriculture and Urban Forestry, 40: 53- 69.

Moore G.M. (2016) Drones will be Arboricultural Busy Bees. Arborist News 25 (1): 30-

Moore, G.M. and McGarry P.J. 2017 Investigation of the Potential for Bark Patch Grafting to Facilitate Tree Wound Closure in Arboricultural Management Practice, Journal of Arboriculture and Urban Forestry **43** 186-198**.**

Moore, G.M. 2017. "Taking it to the Streets" - Celebrating a Twenty Year History of TREENET - responding to the urban forest challenge*.* Williams G. Editor, Proceedings of the Eighteenth National Street Tree Symposium, 23-33, University of Adelaide/Waite Arboretum, Adelaide, ISBN 978-0-9942149-3-5.

Moore, G.M. 2018. Do Heat waves give us a glimpse of the future under climate change? Arborist News 27 (6), 24-28.

Moore, G.M. 2018. Deadwooding Tree canopies: Cosmetic or Safety Surgery? Arborist News 27 (1), 30-33.

Plant. L, Rambaldi A, and Sipe N. 2017. Evaluating Revealed Preferences for Street Tree Cover Targets: A Business Case for Collaborative Investment in Leafier Streetscapes in Brisbane, Australia. Ecological Economics 134: 238-249.

Ryder, C. and Moore G.M. 2013. The Arboricultural and Economic benefits of Formative Pruning Street Trees, Journal of Arboriculture and Urban Forestry **39** (1), 17- 23.

Scharenbroch, B.C, Lloyd J.E. and Johnson-Maynard J.L. 2005. Distinguishing urban soils with physical, chemical, and biological properties. Pedobiologia 49(4):283-296.

Somerville. P.D, Farrell C, May P.B. and Livesley S.J. 2019. Tree water use strategies and soil type determine growth responses to biochar and compost organic amendments. Soil and Tillage Research. 192: 12-21.

The Nature Conservancy. 2019. Living Melbourne:our metropolitan urban forest, The Nature Conservancy.

Urban, J. 2008. Up By Roots. Illinois: International Society of Arboriculture.

IS THERE ANYTHING NEW TO SAY ABOUT SOIL AND TREES?

Peter May

Retired. Faculty Associate, Faculty of Science, University of Melbourne.

Abstract

This paper presents some current thinking and experience regarding the relationship between soil quality and tree performance. It presents information on the restoration of soils damaged during construction work, and also provides a summary of current thinking on soil profile construction. It concludes with some thoughts on the future of providing quality soil environments for urban trees.

Introduction

In this presentation I will be discussing some recent research that relates to the ways in which soil affects tree growth. At the outset, it is important to clarify that this paper is primarily directed towards the role of soil in tree establishment. There is clear evidence that soil conditions affect successful tree establishment and that there are benefits to understanding and possibly modifying soil conditions as part of the planting process. While soil changes can affect mature trees, there is little clear evidence that in such a circumstance tree health can be recovered by addressing soil issues. Since urban development usually results in damaged soil, this paper will address some of the strategies that can be used to enhance tree performance in difficult environments. In general, the approaches taken to remediate damaged sites are either to rehabilitate the soil material that is left on site, or to build a new soil profile entirely. In the interests of sustainability, the former approach is preferable as it minimizes the amount of new soil material required for the project, however on some sites soil is either not present or is completely unsuitable for use and in those cases new profile construction is required.

Useful Resources

Finding specific reference material to solve problems of urban and landscape soil can be difficult, however four resources stand out. These are: Australian Standard AS4419 *Soils for garden and landscape use*; two books by Philip Craul (Craul (1999), Craul and Craul (2006)), Leake and Haege (2014), and the chapter by Bassuk and Day in Calkins (2012).

A4419 has been around for about 16 years and, while still useful, is in need of an update. It sets out a group of properties that a soil blend must meet to be considered as useful in landscape applications. The "soils" that are categorized in the standard are blends of mineral soil and organic matter. The testing procedures described in the standard are widely used in labs that evaluate soil mixes, however in my view, the major limitation of the standard is that it doesn't attempt, except in the most general way, to explain how various mixes could be used in landscape construction. So, as a consequence, one can't ask a supplier to provide a soil that meets AS4419 and necessarily expect to get a product that actually meets your needs. There is going to be "soil" material in the market place that meets the standard but will not be fit for purpose in some applications. The user has to be quite well informed about the standard to be able to use it effectively.

Philip Craul has written two books that can be used to provide a sound basis for planning soil improvement or replacement. These are *Urban soils: applications and practice* (1999) and *Soil design protocols* (2006) which was co-written with his son Timothy. Until recently these were, to the best of my knowledge, the only books in English that specifically addressed the quite unique situation of designing soils for landscape and other urban applications. They are valuable for two main reasons. The first of these is in the setting out of approaches to soil design and the provision of explanations of the relevant principles of soil behaviour. The other is in the use of templates for the soil requirements of different landscape components. Craul calls these components "landscape elements", and for each landscape element an outline of the soil profile requirements of that element are provided. For example, "Open trees in turf" will have a different profile to " Covered trees" which relates to trees planted in paving.

As an introduction to the design of soils these books are invaluable, however they are of limited immediate practical use, as Craul is careful to avoid making specific recommendations for soil use. However, in both books there are useful case study sections that show how these principles have been applied to actual projects.

Leake and Haege's *Soils for landscape development* (2014) is a very valuable source. It does two main things. The first of these is to provide good advice for soil problem solving in landscape situations. This includes discussion of the minimum soil requirements for various types of vegetation, and also a good discussion of landscape drainage. The second is to provide a series of template specifications for different soils for use in landscape projects. These can be cut and pasted to attach to landscape specifications to provide a set of properties that must be met for a soil to be regarded as fit for purpose for a particular application. For instance, there are six different topsoils described. Three of these are for turf and lawns with different levels of use, and three are for garden beds with different quality expectations. There are also a series of specialist profiles for applications such as trees and green roof construction. The information provided is based on the authors' decades long experience in the evaluation and specification of soil for landscape projects in Australia. As will always be the case with textbooks, the user has to understand the background to the advice in order to choose the most suitable set of specifications for a particular job. Having said that, I do think that Leake and Haege (2014) is one of the most directly useful publications provided for the landscape professional. I would hope that as the industry becomes more aware of this book and its contents, soil suppliers will be able to start thinking about the blends they are selling in terms of how they meet the different requirements of the template specifications.

Meg Calkins' *The sustainable sites handbook* is a guide to sustainable landscape development and contains an excellent chapter on soil, co-written by Nina Bassuk and Susan Day. This chapter is a source of advice and methods for consultants and practitioners who need guidance on how to evaluate soil properties for various landscape projects.

Soil resource evaluation

The start of any decision making about soil and tree planting has to be an audit of the soil resource at the planting location that allows the determination of what soil is on site, what its properties are, and whether any of these are limiting to tree growth. Sampling is best done by either collecting an undisturbed core (for example, using a Dig Stick®, or by inspecting an exposed profile in a trench dug with an excavator or back hoe. Both approaches allow clear observation of horizon boundaries. As a minimum, the following soil information is a suggestion (to at least a depth of 500 mm):

- texture (noting changes with depth)
- structure (friability, penetrability, bulk density)
- aggregate stability/dispersivity
- permeability to water (on site percolation test, not lab testing of saturated hydraulic conductivity)
- pH and salt content
- nutrient status
- general information on site such as previous history, annual cycle (eg waterlogging, cracking) can also be useful.

The process of conducting and interpreting an audit may require specialist input.

This process assumes that we know what properties are important. For agricultural and horticultural crops we often have quite good understanding of the minimum requirements for productivity, allowing land to be rated for potential use (eg Cockroft and Dillon, 2004). The complexity of the plant palette available in the urban context is both a hindrance and an opportunity in this respect: a hindrance because we are often are poorly-informed about plant tolerances; and an opportunity because where we do know tolerances, tree selection techniques can be used to allow planting on sites where conditions are potentially limiting.

Two recent studies from the USA (Scharenbroch and Catania (2012), and Scarenbroch et al. (2017) have used detailed site investigations to identify the most important properties of soils and sites in terms of tree performance.

In the first study, soil pH, salt content, bulk density, water stable aggregates and soil organic matter were the most important properties although this study was based in a relatively small urban area with limited soil variation. In the more recent study, most variation in tree growth in a number of sites across the NE USA could be explained by looking at the open surface area around the tree and the level of soil compaction. This latter work is interesting in as much as it suggests that complex soil amendment projects may not be required in many cases.

Remediation of site soil

One of the approaches to improving growing conditions where site soil has been physically degraded by development work is to work with the soil resource on site. By reducing the requirement for bringing new, "manufactured" soil to the project, this approach can improve project sustainability, as long as the soil meets the requirements of the planting. On disturbed, compacted sites, profile drainage may be a major limit to tree survival and growth. To get a feel for how well (or poorly) a site is drained, the most useful measure will be an on-site measurement of infiltration rate. One such test is the percolation test, where a hole is dug and filled with water and allowed to drain several times. The hole should have vertical sides and be as deep as the largest containers that are to be planted at the site. The hole is filled with water several times and allowed to drain before the final test where the time taken for the hole to empty is recorded (Bassuk and Day, 2012). Where a planting hole takes longer than 24 hours to drain the soil is likely to limit plant growth or force plant selection towards species that tolerate wetter soil conditions. Laboratory assessment of saturated hydraulic conductivity (a drainage rate surrogate test used for blended soils) is not useful in this circumstance unless it is proposed to harvest the site's soil, stockpile it, and then reuse it once the development process is complete.

At the end of the site evaluation a judgement can be made as to whether the site soil is suitable for the proposed planting without modification, whether it requires minor tweaking (adjustment of pH, application of fertilizer), whether it requires significant inputs (importing of new topsoil, soil loosening/decompaction), or whether the site requires the construction of an entirely new soil profile. To make these choices you must be able to compare the needs of the planting type being proposed with the conditions that the site is going to provide, based on the soil audit. Remember also that plant selection is cheaper than soil modification, especially where soil is poorly drained.

Decompaction

Loss of soil structure and soil compaction are common problems on development sites. Poor soil protection and traffic pressure are to blame. The industry standard treatment for soil compaction is soil loosening by cultivation (Rolf, 1994). How this is done will depend on the scale of the project and varies from hand digging, through ripping with tyned equipment, to the use of excavator buckets to lift and loosen soil. To get the best results from cultivation the soil should be relatively dry as the aim is to fracture the soil mass into smaller units, but not so dry as to cause dust formation. If soil testing has indicated a benefit from the use of gypsum this can be incorporated at the same time. The depth of cultivation required is dependent on the kind of vegetation being planted and the depth to which compaction can be detected. Over time, some of the benefits of cultivation will diminish as aggregates collapse and as the weight of soil bears down on deeper layers. That said however, cultivation is well regarded as a soil improvement method, is relatively simple to perform can result in improved tree growth (Cass (undated), Rolf (1994), Somerville et al, (2018). Where mechanical root injury is to be avoided, compressed air excavation is an alternative to mechanical disruption (Fite et al, 2011).

Decompaction with organic matter addition

Recently several authors have advocated including an organic component in this decompaction work, especially where the cultivation is being done using an excavator bucket. Much of this work has been published by two researchers in the USA; Professor Nina Bassuk at Cornell University and Dr Susan Day at Virginia Tech. Professor Bassuk calls her method "Scoop and dump" soil treatment and Dr Day calls her method Soil Profile Rebuilding. Details of websites where these approaches are set out are given in the reference section at the end of this paper.

At the heart of each is the spreading of a layer of compost over the soil and then roughly mixing that into the soil with a backhoe or excavator. One variant, if topsoil is available, is 100 mm of compost incorporated to a depth of 600 mm with the backhoe then 100 – 200 mm topsoil (stockpiled site topsoil or imported topsoil) applied over the surface. If there is no topsoil available for use, or if the landscape does not require it, then 200 mm of compost is incorporated to a depth 600 mm. In both cases mulch is applied after site preparation. This work is well documented and research has shown improved soil conditions (reduced bulk density, increased infiltration rates, increased soil aggregation) and increases in plant growth. The scoop and dump/soil profile rebuilding approach has two useful aspects. One of these is that the method can be used on relatively wet soils as it is not essential to finely blend the soil and organic matter. The other is that the presence of the organic addition will help to reduce the tendency of the soil to revert to its original condition following treatment. A recent study at the Burnley campus of the University of Melbourne has been investigating the scoop and dump/soil profile rebuilding approach under local conditions and has found the same improvements in soil properties that the US work has indicated (Somerville et al, 2018). However, plant responses have varied and depend to some extent on the site conditions. For example at one location in West Melbourne, there was no improvement in plant growth rates over the experimental period because the soil was saline and this was a more important limit to growth than poor physical soil conditions. At other sites in this and a subsequent study, plant growth responses to soil loosening have been demonstrated. Soil that has been severely degraded during development work can be rehabilitated. Where the damage is physical, cultivation/loosening is a valuable pre-planting treatment. In my opinion, the scoop and dump/soil profile rebuilding approach has a great deal to recommend it, especially in landscapes where the expectations are high enough to justify the additional cost.

Building new soil profiles from scratch (soil design for soilless sites)

Rationale

There will always be situations where soil has to be imported for successful landscape outcomes. In years past, this soil was often productive agricultural soil that was harvested for use in landscape applications. As good soil has become scarcer, and as limits are imposed on soil harvesting, the soils that are available in the market place are based on blends of various mineral and organic components. What is used in a particular place will reflect the nature of the feedstock that is available locally. These “soil replacements” are called variously, soil blends, or manufactured soils. The term, designed soil, is also used on occasion. In my opinion, that latter term should only be used where a blend has been formulated to meet a specific planned outcome. That is, the soil has been designed to meet specific performance outcomes.

For the landscape designer or consulting arborist, the process has two parts. The first is identifying what the soil functional requirements of the landscape are to be. The “design elements” approach (Craul and Craul, 2006) argues that most landscapes can be split up into a relatively small number of components and each of these components has a characteristic soil profile allocated to it. This profile can be based all, or in part, on site soil, or it can be based on the use of manufactured soil blends. The second part of the process is then to develop written specifications for the soil profiles that are required, to satisfy the needs of each design element. They offer only general guidance as to the detail of these specifications although they do provide case studies to illustrate the points they are making. Leake and Haege (2014) provide exemplar generic specifications that can be used to describe the properties of the soil blends required for different kinds of landscape design elements. They also provide suggested guidelines for depths of profile layers, such as topsoil or subsoil, and also provide guidance for calculating soil volumes for trees.

Desirable properties of soil blends

A soil specification will describe the essential properties of a soil blend for a particular landscape application. Some of these are fairly obvious, including pH, salt content and nutrient status. The amount of added organic matter content is important and will be discussed later in this paper. Texture and structure are, in my view, not critical in the sense that they have to be specified, although there will be circumstances where that is routinely done. High performance turf is probably the best example. What is critical though, is the specification of the properties that are affected by texture and structure, and drainage rate is probably the most critical of these, as a poorly-drained soil will almost certainly result in substandard landscape performance.

Drainage rate of soil blends

Current thinking is that the potential drainage rate of a soil blend should always be specified and any candidate material should be tested before installation. This potential drainage rate is a laboratory test (the test is called saturated hydraulic conductivity (SHC)) and confusingly, there are three methods in use in Australia. These are: the test described in AS4419 (for landscape soil blends); the ASTM1619 test method (for sports turf originally - this tests SHC under compaction); and the McIntyre and Jakobsen method (used in Leake & Haege's generic specifications) which tests at a series of compaction levels, the level used in the specification being determined by the application that the soil is being specified for.

AS4419 sets a lower limit of 20 mm/h for a soil blend to meet the standard. The soil is not mechanically compacted in this test. ASTM1619 does not have fixed minimum levels but high performance turf often requires 150-200 mm/h to ensure that drainage is retained under compaction. This method is useful in applications where the soil is likely to become compacted during installation or with use, and some prediction of the effects of this risk is needed. In Leake & Haege (2014) most landscape soil blends require a minimum of 30 mm/h under moderate compaction tested according to the McIntyre and Jakobsen method. To make this issue more complex, results from these tests cannot be easily compared with each other, or with on-site percolation tests. In most cases, to find blends that meet these rates, the blends will be reasonably sandy with textures in the range sand to sandy loam. However, stay tuned on this issue, as there are concerns that these methods are not providing reliable information. This may result in changes to standards, testing protocols, and the way specifications are written.

Organic matter in soil blends

Most commercial soil blends have organic matter added to them, often in the form of compost. Superficially this seems like a good thing as there is plenty of compost around, organic matter is seen as having useful ameliorative properties in soil management, and it is seen as environmentally responsible to be returning compost to soil and to find a valuable use for the compost generated from large-scale commercial composting operations. However, too much organic matter can be a problem in soil blends. At present, recommendations are that added organics are kept close to the soil surface (upper 200 mm of the profile only (AS4419)) as this can avoid anaerobic decomposition of compost deeper in the profile. A consequence of this is that where deeper profiles are being built, the lower, subsoil, layers must be mineral soil only. Secondly, compost and similar added organics are often only partly decomposed and so will break down further once the soil is installed, resulting in a loss of soil volume and possible changes in soil properties (Craul, 1999). Craul (1999) suggests that added organics greater than 20-25% by volume of a blend will result in shrinkage and soil volume loss. In some composts, nitrogen drawdown may also affect early tree growth.

Soil for trees in paving

This topic has been dealt with in a number of other locations and I do not propose to cover it in any detail. The approaches undertaken to enhance tree growth in pavement can be summarized as being either non-compacted soil systems (cantilever pavement (Craul,1999) and soil cell approaches (Urban, 2008)), or compaction tolerant systems (uniform coarse sand such as Amsterdam Tree Soil (Couenberg, 1994) and structural soil (Grabosky et al, 2002)).

Sustainable soils

Craul (1999) raises the issue of sustainable soils: soil blends and soil replacement materials that are not based on soil and sand resources that are being quarried elsewhere for use in landscape projects. He advocates that waste materials of various sorts could be used to replace quarried soil. These materials could include quarry waste, crushed masonry, crushed glass and properly managed waste site soil. Such an approach requires more evaluation but Sydney Environmental and Soil Labs have already used this approach at at least two sites, Homebush (Leake, 2001) and Barangaroo (Leake and Haege, 2014), using crushed sandstone as a major component of blended soils. Structural soil is another approach that could be used to value-add waste materials by converting them to soil substitutes. Tree subsoils based on crushed brick/site soil structural soil are quite feasible in my view.

I would like to also suggest that another issue of soil sustainability that must be addressed is the increasing pressure that urban soils are going to be exposed to as populations increase and green space decreases. In a recent study for City of Yarra I found surface soil bulk densities around 1.9 Mg. m^{-3} in lawn areas around trees. These extreme values were simply due to very heavy public use. Tree soils of the future will have to be able to still function as root zones under compaction and this will probably require some inventive thinking. Recent work in Europe with various synthetic topsoils for perennial plantings suggests that there are approaches that should be evaluated for trees. For example, Schmidt and Murer (2014) have successfully used blends of crushed tile and brick with compost to provide top soils for herbaceous plants. Subject to particle size distribution and responses to compaction, novel materials such as these may also be useful for supporting trees in heavily trafficked areas. For anyone interested in how one might approach formulating such blends and what their properties might be, Rokia et al (2014) describe an interesting evaluation of the properties of blends of various urban waste materials used to create what they call Technosols (analogous to Urbic anthroposols in the Australian Soil Classification).

Conclusions

Use site soil information to assist with planning of new tree planning. Try to work with site soil as much as possible, which will require a knowledge of important soil properties for predicting tree performance. Be careful when using soil blends – use good written specifications and enforce adherence to them by contractors. Ask for recent test results when seeking to match sample test results to specifications. The properties of the soil you are specifying must be provided in the specification. You can't just use a description. "Premium sandy loam" or "Premium garden soil blend" are meaningless terms and not reliable indicators of performance. These days reasonably good generic specifications are available to use. For important projects, seek professional help if you aren't certain. Considerable work has been done over the past few decades to provide approaches to tree growing in difficult locations and good advice and information is available to specify these soils. We still have to do more work to allow us to grow trees well in the increasingly heavily-used urban environment.

References

Websites

Dr. Susan Day's work at Virginia Tech: Urbanforestry.frec.vt.edu/SRES/

Dr. Nina Bassuk's work at Cornell University: https://blogs.cornell.edu/urbanhort/

Books

Bassuk, N and Day, S. 2012. Chapter 5, Site Design: Soils in *The Sustainable Sites Handbook: A Complete Guide to the Principles, Strategies, and Best Practices for Sustainable Landscapes.* M. Calkins (Ed.). Wiley

Craul, P. 1998 *Urban soils: Applications and practices.* Wiley

Craul, T. and Craul, P. 2006 *Soil design protocols*. Wiley

Leake, S. and Haege, E. 2014 *Soils for landscape development*. CSIRO Press

Scharenbroch, B. et al 2014. *Soil management for urban trees*. ISA Best Management Practices Series, ISA.

Standards Australia 2003 *Soils for garden and landscape use* Australian Standard AS4419-2003

Urban, J. 2008. *Up by roots*. ISA.

Papers

Cass, A. (undated) Gypsum application and deep ripping for vineyard development http://www.groguard.com/gypsum.html

Cass, A. et al. 1993 New approaches to vineyard and orchard soil preparation and management in *Proc. Vineyard Development and Redevelopment Seminar*, Mildura, 1993, pp 18-24.

Cass, A. et al. 1998 Soil assessment – sampling and testing. Aust. Grapegrower and Winemaker May: 13-16.

Cockroft, B. and Dillon, C. 2004 A soil survey method for productivity in irrigated agriculture. Agricultural Science 17(2):14-20.

Couenberg, E. 1994. The Amsterdam Tree Soil in *The Landscape Below Ground*. (eds. Watson, G. and Neely, D.) ISA.

Fite, K. et al. 2011. Evaluation of a soil decompaction and amendment process for urban trees. Arb. & Urban For. 37: 293–300

Grabosky, J. et al. 2002 Structural soils: a new medium to allow urban trees to grow in pavement. Landscape architecture technical information series (LATIS). Amer. Soc. Lsc. Arch. 636:20001-23736.

Leake, S. 2001. Soil landscape rehabilitation: an example. Landscape Australia 8: 62-63.

Rolf, K. 1994. Soil compaction and loosening effects on soil physics and tree growth in *The Landscape Below Ground*. (eds. Watson, G. and Neely, D.) ISA.

Rokia, S. et al. 2014. Modelling agronomic properties of Technosols constructed with urban wastes. Waste Mgt. 34:2155-2162.

Scharenbroch, B. and Catania, M. 2012 Soil quality attributes as indicators of urban tree performance. Arb. & Urban For. 38: 214–228

Scharenbroch, B. et al 2017 A rapid urban site index for assessing the quality of street tree planting sites. Urb For & Urb Greening 27:279-286

Schmidt,S. and Murer, E. 2014 Substrate für extensive Staudenmischpflanzungen.

Neue Landschaft 10:40-45.

Somerville, P. et al. 2018. Effects of deep tillage and municipal green waste compost amendments on soil properties and tree growth in compacted urban soils. J. Env. Mgt, 227:365-374

ESTABLISHING TREESCAPES
IN CHALLENGING URBAN IN-FILL DEVELOPMENTS

Declan McDonald

SESL

Background

The concept design for the redevelopment of a former paper mill in Alphington, Melbourne featured medium density housing with attractive streetscapes in an exclusive inner-city environment. The design promised superior amenity, and central to this was a green environment.

The landscape design included trees and garden beds. Feature trees of the development included *Corymbia citriodora* and *Corymbia maculata*, trees popular in Melbourne in view of their stately form, relative hardiness, and ability to cope with a wide temperature range.

Works commenced on site in 2017 with stripping of topsoil. Not untypical of in-fill developments, the project was characterised by spatial constraints including limits for stockpiling. As a result, all topsoil was removed off site and disposed of.

I was consulted in May 2018 with a request for guidance on structural soils. Structural soils had not been part of the original design; strata vaults had been specified. However, the pressure on space meant that root zones were shared with all services and any future maintenance, repair or replacement would be strongly impeded by strata vaults. As a result, structural soils were recommended.

Soil challenges

A review of the landscape design for the site showed that a number of different soils were required. Along with structural soils there was a strong emphasis on Water Sensitive Urban Design (WSUD) outcomes, raingardens and display garden beds. Soil specifications were developed for each of these different landscape elements which included high infiltration tree pit soils for the WSUD element.

However, the first site inspection revealed that the topsoil stripping had left the remnant tertiary basalt clay subsoil as the palette on which the green infrastructure would be developed (figures 1a & 1b).

Figures 1a and 1b. Dense clay subsoils excavated for tree pits. Note the smearing of the clay (right) by the excavator bucket.

Testing of the clay confirmed an extremely hostile medium, not only physically, (figures 1a & 1b) but also chemically (table 1 and figure 2).

Analyte	Target values for subsoils	Sample 1	Sample 2
pHw	5.5 – 7.5	8.49	8.13
EC (dS/m)	< 0.5	0.23	0.69
Sodium mg/kg	<300	1506	1696
Chloride mg/kg	<200	155	732
Sodium %CEC	<10	30.8	29.2
Calcium %CEC	>50	14.7	12.6
Magnesium %CEC	15 - 30	52.1	57.1
Potassium %CEC	2 - 7	2.2	1.2

Table 1. Subsoil chemistry at the Alphington site.

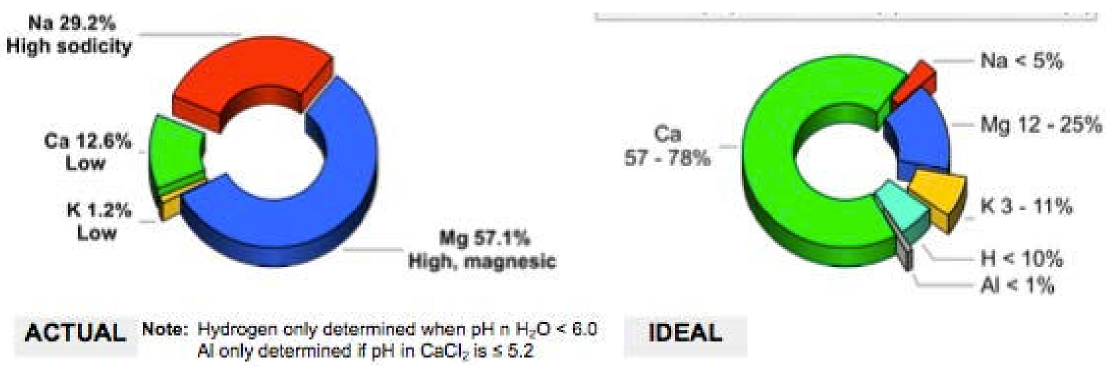


Figure 2. Graphical representation of tested vs. ideal cation balance (note ideal proportions are shown for topsoil – refer table 1).

Figure 2 is a reproduced graphic from the soil tests which shows the degree of imbalance between the tested soil (left) and the ideal soil (right). It is important to note that we do not generally expect subsoils to achieve 'ideal' status. However, the degree of departure from the ideal is what we assess and what determines potential remedial action.

When contrasted with the ideal cation balance it is immediately evident that the soils are completely unbalanced. In simple terms, plants will struggle to grow without amendment. A brief explanation follows.

The cations (calcium, magnesium, potassium, sodium) are – in addition to being important plant nutrients – central to soil structure. A dominance of calcium is necessary to support chemical flocculation and aggregation of soil particles. When magnesium and sodium dominate, flocculation and aggregation are extremely weak and this results in dispersive soils (soils which totally or partially 'dissolve' in fresh water) and loss of soil structure (the arrangement of solids and pores). In practice, and what happened on the Alphington site, is that soils effectively collapse on themselves and in the process lose their pore structure and their ability to breathe. Roots cannot grow in this medium. This is unfortunate because they can hold substantial stores of water during dry conditions.

The design featured trees at set intervals along each street in the development. It was initially assumed that individual pits would be excavated for each tree. Tree performance is substantially improved where root zones are shared. This is due to the fact that tree root exploitation of a given soil volume is not particularly 'efficient'. Enhanced growth is also likely due to the reported collaboration between trees growing together. Where trees can share a particular soil volume, roots can overlap and maximise the use of available topsoil without overly competing with each other. The initial recommendation therefore was that contiguous tree pits be constructed.

The trench shown in figure 1 became the standard for tree pits across the development. Options to increase the size of pits were explored but were rejected in view of spatial constraints. Tree pits were positioned under footpaths and laybacks and trees were confined to this narrow alignment.

Once it was determined that structural soils were the only acceptable medium for load-bearing structures, the issue of tree root volumes arose. It was immediately apparent that the competing demands of tree root volumes and available space between roadways, footpaths, services and private gardens represented significant challenges.

Tree root volumes

Calculation of soil volumes is determined by a number of factors including tree size and expected longevity, tree pit soil type, surrounding soil type, irrigation / passive watering, surrounding surface (i.e. natural soil or sealed concrete etc.), and climate. In the Alphington development, passive irrigation was planned and soil amelioration outside the tree pit was required.

On these bases, the recommended minimum soil volume in natural soil was $22m^3$ per tree for the selected species. Soil volumes were reduced by trees sharing the same tree pit. Soil volumes for shared rooting zones were calculated as follows:

- Three trees per pit – total soil volume of 45m3
- Six trees per pit – total soil volume of 77m3
- Seven trees per pit – total soil volume of 88m3
- Eight trees per pit – total soil volume of 100m3

The use of structural soil greatly increases the volume of soil required – by a factor of 5. Structural soils are comprised of a 5:1 blend of large (63mm) ballast and filler soil. Therefore the recommended structural soil volume was 110m3 per tree. In the case of shared root zones, this figure was adjusted downward as per the figures for natural soils above, times 5 (i.e. where the volume requirement for eight trees in natural soil is $100m^3$, the volume will be $500m^3$ for structural soil). Any shortfall from the required root volumes had to be met by soil outside the tree pit. In some situations, tree volumes were met by structural soils only; in others, soil volumes were met by a combination of structural soils and surrounding soils.

However, a review of figure 1 reminds us how hostile surrounding soils were and this included hostility to amelioration. The density of soils – and hardness when dry and plasticity when wet – meant that incorporation of ameliorants was extremely difficult.

Our prescription included application of gypsum as the primary chemical ameliorant, at rates of $1kg/m^2$.

This equates to 10t/ha, an extremely high application rate. Given that gypsum is poorly soluble – about 2g/L – the application rate meant that a supply of gypsum is available to continue working on these soils as trees grow and roots attempt to penetrate these dense soils. We also recommended that the glaze (figure 1b) on the sides and bottom of the tree pits be broken by the teeth of an excavator bucket. Shattering, or roughening the sides of the tree pits aimed to increase the soil surface area on which the gypsum could work. The importance of conditioning site soils ahead of works was emphasised to maximise the amount of site soil that could contribute to overall soil volume requirements.

Detailed investigation and design by the consulting engineers was successful in integrating the spatial requirements of tree root volumes in most locations. However, in some locations sufficient space was not available. Our recommendation in these locations was to allow the use of structural soils beneath carriageways. This would have provided ample root volume for the large trees but the proposal was met with caution by Council who would by default become the authority with responsibility for long-term maintenance of the road assets. They were concerned about the risk of differential settlement between sections of the road underpinned by structural soils and sections underpinned by conventional pavement sub-grade. Our argument was that structural soils could easily deliver a 98% Proctor compaction similar to conventional sub-grade design.

We researched the literature for evidence of structural soils being used under road carriageways and consulted with the City of Melbourne, the City of Greater Bendigo and Hume City Council, all of which have used structural soils extensively. We also contacted Professor Jason Grabosky, an urban tree expert from Rutgers University in New Jersey, USA.

Whilst all have used structural soils under parking and footpaths, none was able to cite an example of the use of structural soils under carriageways. SESL had previously designed structural soils for private internal roads in the Olympic Park in Sydney and while these roads are traversed by various levels of traffic including garbage trucks and service vehicles, they are not public roads and responsibility for their maintenance rests with the Olympic Park Authority. The recommendation to use structural soils under carriageways was rejected.

Soil handling and management

Our work on specifying structural soils, and agreement on soil preparation and tree root volumes, was temporarily settled. We proceeded to specify soil properties for the non-structural soil tree pits, garden beds, and biofiltration beds. The non-structural soil tree pits (hereafter referred to as 'tree pits') were part of the WSUD aspect of the design. These soils were designed to allow rapid infiltration while also ensuring sufficient water and nutrient holding capacity to sustain healthy tree growth.

Again, the pressure on space highlighted issues relating to the appropriateness of placing structural soils contiguous with tree pit soils or biofiltration soils. Concern was raised of the risk of particle migration from the tree pits or biofiltration beds into the coarser structural soils potentially creating 'wash-out' zones in tree pits and reducing the effectiveness of the structural soil. The use of geofabric to prevent migration of tree pit soil was proposed.

Tree pit soils are designed for high flow stormwater ingress. Stormwater can have high velocity due to low resistance of pavements. However, the design of the kerb invert aimed to reduce the energy of stormwater entering the tree pit. Rock mulch was proposed to absorb the energy of inflowing stormwater. This results in water diffusing down the soil profile at 100-200mm/hr as specified in the Specification for Tree Pit Filter Media. This rate is not high enough to carry soil particles and promote migration of tree pit soil into the structural soil.

It was recognised that some settling of the Tree Pit soil may be expected as the soil 'beds in' to the surrounding structural soils but further migration was considered highly unlikely. It was therefore recommended that Tree Pits were overfilled by 5-10% to allow for settling of Tree Pit soil against the abutting structural soil. Further controls to limit migration of tree pit soil into structural soils were not deemed necessary.

Tree stability

The next issue that arose concerned tree stability. While tree root volumes may be sufficient in a linear tree pit, we were asked to provide an opinion concerning the lateral stability of trees where radial spread of tree roots may be compromised. Whilst a lot of work has been done on lateral spread of tree roots, little work has been done to determine risks to tree stability where radial expansion is constrained.

We called on research we had completed for the Melbourne Quarter development in Docklands which examined the risk from tree roots on a heritage wall. From this and other researches, we recommended that trees should have a minimum radial root expansion of four times the mature bole diameter at ground level. For example, if the mature bole diameter of a mature tree is expected to be 800mm, the minimum distance from the base of the tree to a root impediment should be 3.2m.

In some particularly constrained locations, minimum distances could not be met. The only remaining option for these locations was a review of tree species. The trees were replaced with smaller-growing trees more suited to the available space.

Conclusion

This project was characterised by extensive research that included:

- soil specification for:
    - structural soils,
    - water sensitive urban design tree pit soils,
    - biofiltration soils,
    - garden bed soils,
- soil placement;
- tree root volumes;
- tree health, vigour and longevity, and;
- tree stability.

The project was also characterised by highly professional collaborations between the developer, consulting engineers, landscape architects, and Council. The developers recognised relatively early that substantial work was required to ensure realisation of the design intent. There were many meetings between the parties. Council were fully cognisant of the fact that they would have long-term carriage of site assets (trees, roads etc.) and were careful to ensure that decisions made were in the long-term interests of residents. The developer enjoys a very good reputation in residential and commercial developments in Melbourne and was keen to ensure delivery of quality outcomes. These drivers resulted in constructive engagements and a shared desire to achieve quality outcomes.

From the perspective of the soil scientist, it yet again highlighted the importance of early professional engagement of soil professionals to assess soil conditions to ensure compatibility of design intent with achievable outcomes.

MAXIMISING LEARNING OPPORTUNITIES WHILE REPLACING TREE-HOLLOWS FOR WILDLIFE

Dr Rodney van der Ree

National Technical Executive - Ecology, WSP Australia Pty Ltd

Associate Professor, School of BioSciences, The University of Melbourne

Introduction

Nest boxes have been used in Australia since at least the mid-1970s (Menkhorst 1984), with an enormous number of studies documenting patterns of occupancy and rates of use by a range of different species. Despite occasional debate about the efficacy of nest boxes in the scientific literature in the intervening years (e.g. Harley 2006; Harley and Spring 2003; Lindenmayer et al. 2002; Mckenney and Lindenmayer 1994), there is only now a realisation that nest boxes are deficient in many respects when compared to other types of hollows, particularly natural hollows (e.g. Griffiths et al. 2018; Griffiths et al. 2017). As a result, there is a widespread and rapidly growing movement towards the use of carved hollows in standing trees rather than the installation of nest boxes.

A pertinent question as momentum for carved hollows grows is 'why has it taken at least 40 years to understand that nest boxes are not a panacea to the loss of hollows?' And an even more important question is 'what do we need to do over the next few years to ensure that we aren't still debating the merits of carved hollows in 40 years' time?'

Background

Habitat clearing, logging and selective removal of 'high risk' trees has caused a massive decline in the abundance of large and dead trees, reducing the abundance of tree hollows in urban, agricultural and timber production landscapes globally (Le Roux et al. 2014; Lindenmayer et al. 2014; Stagoll 2012). Trees in urban areas are typically managed to maximise health and amenity whilst reducing risk to the public and property and dead or decaying limbs and trees are typically promptly removed. These dead or decaying trees and limbs often contain valuable hollows, resulting in a net decline in the abundance of hollows. Determining the most effective method to increase the number of hollows is a critically important topic because over 300 species of native Australian birds, mammals, reptiles, and amphibians rely on tree hollows (Gibbons and Lindenmayer 2002; Goldingay 2009). Hollows form naturally when the heartwood of the tree is exposed due to fire or wind damage, which then allows natural decay processes to create the hollow. The outer sapwood of the tree is resistant to decay and forms the structural walls of the hollow (Gibbons and Lindenmayer 2002). In natural systems, eucalypt trees typically need to be at least 100 – 120 years old before usable-hollows develop.

Land managers have been using nest boxes for the past few decades as an alternative denning resource to natural hollows for a range of reasons, including:

- to offset hollows removed during a development;
- to increase or supplement hollows in an area for wildlife; and
- as targeted actions to recover declining or vulnerable hollow-dependent species.

Despite being used for the past few decades, nest boxes have repeatedly come under scrutiny and criticism because they:

- often have a relatively short lifespan, ranging from <5 to 10 years;
- some designs are prone to overheating in summer;
- can harbour invasive species, including European bees, noisy miners or support already abundant common species; and
- sometimes have low rates of uptake, particularly of the target species.

In response, there is a growing groundswell of movement and support for the use of hollows carved directly into standing trees with a chainsaw or other tool. There is a diversity of types of carved hollows, including the faceplate method, false door method, simple plunge cuts, coronet cuts etc, with very little strong or peer-reviewed evidence to support one method over another. Furthermore, other types of replacement hollows, such as salvaged log hollows and standard nest boxes are still being installed, leaving land managers with a bewildering array of options.

The way forward

Unless carved hollows are installed according to a scientifically robust experimental study design and carefully monitored and evaluated, it is highly likely that we will still be debating the relative merits of nest boxes, carved hollows, log hollows and natural hollows in 40 years time.

Hundreds or possibly even thousands of carved hollows are being installed around Australia each year and each project is an incredible opportunity to 'learn while doing'. However, the current typical approach to hollow replacement is to simply install the hollows that the land manager requests or arborist recommends, possibly record some details about the hollow or the host tree, maybe do some ad-hoc monitoring/inspections for a short period of time, and then as interest wanes or funding runs out, move onto the next project. With this approach, it will at best take a long time and much effort to generate sufficient reliable data to be able to evaluate the effectiveness of carved hollows because of the enormous variation in:

- the type, size and construction technique of hollows installed;
- the species, health and size of the host trees;
- the prevailing weather and other environmental conditions among sites;
- different management regimes (e.g. risk assessments, pruning techniques and intensity); and
- the type and quality of data being recorded.

The solution to this problem is for land managers to adopt the principle that every hollow being installed is an opportunity to 'learn about the use and effectiveness of carved hollows', as well as be an opportunity to replace hollows. In effect, every hollow installed should be considered part of an experiment, and by considering and adopting a few guiding principles, the maximum amount of reliable and robust information can be learnt in the shortest amount of time, leading to more rapid adoption of evidence-based best-practice techniques.

What features of an 'experiment' should I consider?

The first consideration is that land managers must recognise that they have a role to play in ensuring that they don't just install hollows, but that they actually commit to learning while installing hollows. Once a commitment to maximise learning opportunities has been made, the next step is to formulate the question to be answered or hypothesis to test.

For example:

- Does species X prefer a nest box, carved hollow, log hollow or natural hollow?
- Does species X prefer entrance sizes that are 50 mm, 60 mm or 100 mm diameter?
- How much longer will a nest box (of design X) last compared to a carved hollow?
- Which construction method for carved hollows is better?
- What are the impacts of carved hollows on tree health?
- Which species of trees are more- or less-suited to carved hollows?
- How does the wildlife population and/or community of species respond to the installation of carved hollows?
- What is the optimal density of carved hollows in different forest types and/or landscapes?
- What is the optimal aspect, wall thickness, color, material, etc of replacement hollows to support wildlife year-round?
- ____(fill in your questions here!)

It may be possible to begin to answer some of these questions now by compiling data and results from numerous installations and/or conducting inspections of hollows that have been installed. While it is often difficult to collate and use unpublished data sets because necessary information may not have been recorded; the monitoring may have stopped suddenly; data or metadata has been lost; or the study was biased in some way that prevents a sensible analysis, we should at least try.

Once the questions or hypotheses have been formulated, it is time to consider the design of the study. There are various experimental designs possible, and the most powerful design that maximises inferential strength (i.e. the ability to detect an effect, if one exists) should be selected. It is not possible to exactly specify which design should be adopted for your particular question(s) and situation, but in general terms, the most powerful designs include:

- Replicated Before-After, Control-Impact (BACI): where a variable of interest is measured at numerous experimental units (e.g. nest boxes, carved hollows, study sites) 'Before' and 'After' an intervention is made at the 'Impact' sites, as well as at sites which are not treated (i.e. 'Control' sites). If the question is 'Are the number of hollows limiting the population of an endangered mammal', a BACI approach might be to install 5 hollows per ha at three sites, 10 hollows per ha at another three sites, and 15 hollows per ha at another three sites, and leave another three sites with no additional hollows (i.e. the control) The density of the target species would be measured for an appropriate length of time at all sites before adding the hollows, and again after adding the hollows.
- Variations on the BACI design include reducing the amount of replication (e.g. fewer study sites or hollows), excluding the before and after comparison and/or excluding the control and impact comparison, however each downgrading of the design reduces the ability to detect a significant difference in the results.
- The effect of carved hollows on tree health would ideally be tested using a BACI approach, with variation in perhaps the size of the hollow, the species of tree, etc. In this example, say 40 trees of the same species, approximate size and similar health condition are selected within the study area, and half are randomly selected to receive hollows and half not. Then, the health and condition of both cohorts of trees are assessed annually over the next 5 – 10 years and compared.
- Confirming whether a species of wildlife prefers one type or size of hollow over another could be investigated by conducting a choice experiment, where a small number of different types or sizes of hollow are installed in close proximity to each other and the species chooses which it prefers. For example, identifying the preferred type of hollow for an endangered arboreal mammal could be achieved by installing a similarly-sized nest box, log hollow and carved hollow within 25 – 50 m of each other (i.e. installed as a triplicate) and subsequent monitoring evaluates rates of use by the target species.

The various options for analysis of the data are too many to list here, but data analysis is critical to ensure that the conclusions drawn are accurate and reliable, and expert advice should be sought.

Collaboration is critical to success

Most arborists and local land managers are neither trained nor experienced in the nuances of scientific study design and furthermore, conducting scientifically robust experiments is typically not part of core business for them. Therefore, a key component to undertaking high quality hollow installation programs as experiments is collaboration between arborists, land managers and researchers/scientists/consultants. The nature of the collaboration can range from the three groups working as equal partners to develop and undertake the project to one where the project manager consults or commissions an appropriately qualified ecologist for advice on study design and/or data collection and analysis. Collaboration among adjacent land managers to increase the number of hollows (i.e. replication) in the study is also beneficial because the cost per hollow may be reduced, sample size increased and more questions can be asked. Overall, greater collaboration on hollow installation projects is absolutely fundamental to:

- identifying the most important and relevant questions;
- developing the optimal study design, increasing sample sizes and asking more complicated questions;
- reducing costs and obtaining funding from alternative sources;
- identifying which data to collect and the most appropriate data collection methods;
- analysing the data and writing up the results, ideally in a peer-reviewed journal; and
- making the raw data publicly available for others to use and/or to combine with other data sets.

Case Study: Replacing hollows on a major development project

A hypothetical major development project through a high-quality patch of forest will result in the removal of 200 trees with hollows. The project proponent and regulator have read a recent critique of the use of nest boxes as an offset on a highway project (Lindenmayer et al. 2017) and have decided that nest boxes will not be used as a replacement strategy on this project. Instead, a combination of carved hollows and log hollows will be used to replace the hollows being removed, and the project will be set up as an experiment to test the relative effectiveness of each approach. In addition to replacing each of the 200 hollow-bearing trees with either a carved hollow or log hollow, nest boxes will still be used to provide a comparison to the 'standard' technique, as well as monitor a natural hollow. In effect, 100 groups of four hollows (one carved hollow, one log hollow, one nest box and one existing natural hollow, each within 50 m of each other) will be established in the vicinity of the project to provide replacement hollows for hollow-dependent species, as well as answer critical questions in a seriously powerful approach. The questions being asked include:

- What is the rate of use and preferences for different hollow types by different species?
- What are the impacts to the health and survival of the host tree and how does it differ among species, with three species of *Eucalyptus* being carved into?
- What is the longevity of the different types of hollows and how much maintenance is required?
- What are the thermal properties of the different types of hollows?
- Extensive opportunities exist to value-add to the project by supporting and facilitating university student research projects, including studying changes in animal abundance and community composition as a result of manipulating hollows.

The value of a project of this nature is that it achieves multiple objectives at very little extra cost, namely meeting the conditions of approval to replace one hollow for each hollow-bearing tree removed, as well as to undertake a scientifically robust experiment that maximises the information learnt to guide future hollow replacement programs. In addition, by offering opportunities for collaboration with researchers or university students, the project will achieve far more than simply meeting the basic conditions of approval.

Smaller-scale projects can offer similarly important opportunities for learning while doing by scaling back the questions and work and by collaborating with adjacent land managers.

Conclusions

The loss of large old trees and the loss of trees with hollows is a significant problem globally and particularly in Australia where hollows form slowly due to decay, rather than through active excavation by wildlife. Carved hollows in standing trees and the installation of salvaged log hollows are increasingly being adopted as alternatives to nest boxes, yet there is still much to learn. Every installation of a carved hollow is a potential data point in a larger dataset, provided a series of standardised measurements are taken of each hollow. Furthermore, numerous development projects that remove trees with hollows are being required to offset or replace these at scales that are perfectly suited to undertaking scientifically robust experiments with minimal additional investment. The approach briefly outlined in this paper will allow us to learn as much as possible and as quickly as possible, in order to develop the evidence-base for best-practice decision making and conserving wildlife that rely on tree hollows. Through collaboration and innovation we can all contribute to ensuring that we are not still debating whether carved hollows are an effective approach in 20 or 30 years' time.

References

Gibbons, P., Lindenmayer, D.B., 2002. Tree hollows and wildlife conservation in Australia. CSIRO Publishing, Melbourne.

Goldingay, R.L., 2009. Characteristics of tree hollows used by Australian birds and bats. Wildlife Research 36, 394 - 409.

Griffiths, S.R., Lentini, P.E., Semmens, K., Watson, S.J., Lumsden, L.F., Robert, K.A., 2018. Chainsaw-carved cavities better mimic the thermal properties of natural tree hollows than nest boxes and log hollows. Forests 9, 235.

Griffiths, S.R., Rowland, J.A., Briscoe, N.J., Lentini, P.E., Handasyde, K.A., Lumsden, L.F., Robert, K.A., 2017. Surface reflectance drives nest box temperature profiles and thermal suitability for target wildlife. . PLoS One 12.

Harley, D.K.P., 2006. A role for nest boxes in the conservation of Leadbeater's possum (Gymnobelideus leadbeateri). Wildlife Research 33, 385-395.

Harley, D.K.P., Spring, D.A., 2003. Reply to the comment by Lindenmayer et al. on "Economics of a nest-box program for the conservation of an endangered species: a re-appraisal". Canadian Journal Of Forest Research-Revue Canadienne De Recherche Forestiere 33, 752-753.

Le Roux, D.S., Ikin, K., Lindenmayer, D.B., Manning, A.D., Gibbons, P., 2014. The future of large old trees in urban landscapes. PLoS One 9, e99403.

Lindenmayer, D.B., Crane, M., Evans, M.C., Maron, M., Gibbons, P., Bekessy, S., Blanchard, W., 2017. The anatomy of a failed offset. Biological Conservation 210, 286-292.

Lindenmayer, D.B., Laurance, W.F., Franklin, J.F., Likens, G.E., Banks, S.C., Blanchard, W., Gibbons, P., Ikin, K., Blair, D., McBurney, L., Manning, A.D., Stein, J.A.R., 2014. New Policies for Old Trees: Averting a Global Crisis in a Keystone Ecological Structure. Conservation Letters 7, 61-69.

Lindenmayer, D.B., MacGregor, C., Gibbons, P., 2002. Comment-Economics of a nest box program for the conservation of an endangered species, a re-appraisal. Canadian Journal of Forest Research 32, 2244-2247.

Mckenney, D.W., Lindenmayer, D.B., 1994. An economic assessment of a nest box strategy for the conservation of an endangered species. Canadian Journal of Forest Research, 2012-2019.

Menkhorst, P.W., 1984. The Application of nest boxes in research and management of possums and gliders, In Possums and Gliders. eds A.P. Smith, I.D. Hume, pp. 517-525. Australian Mammal Society, Sydney.

Stagoll, K., Lindenmayer, DB, Knight, E., Fischer, J & Manning, AD, 2012. Large trees are keystone structures in urban parks. Conservation Letters 5, 115 - 122.

PRELIMINARY INVESTIGATIONS INTO THE EFFECTIVENESS OF CHAINSAW-CARVED HOLLOWS

Dr Stephen Griffiths

Department of Ecology, Environment and Evolution

La Trobe University

Background

The ongoing loss, modification and fragmentation of natural habitats, and particularly mature hollow-bearing trees, presents a major threat to many species of cavity-dependent wildlife worldwide (Fischer and Lindenmayer 2007). Long-term management strategies to increase hollow availability are required to complement the revegetation and restoration of degraded areas, in conjunction with retaining the mature hollow-bearing trees that persist in human-disturbed landscapes (Lindenmayer *et al.* 2011)

One popular management action used to provide supplementary hollows for cavity-dependent fauna is the addition of nest boxes (Lindenmayer *et al.* 2017). Nest boxes can be effective in well-resourced programs, typically when a single species of conservation concern is targeted. For example, in Australia, nest box programs have generated positive conservation outcomes for the Gouldian finch *Erythrura gouldiae* (Brazill-Boast *et al.* 2013), squirrel glider *Petaurus norfolcensis* (Goldingay *et al.* 2015), and Leadbeater's possum *Gymnobelideus leadbeateri* (Harley 2016). However, more often nest boxes are used by only a few common species, and are generally less effective for the conservation of rare or threatened species (Lindenmayer *et al.* 2017). Hence, there is a real risk that limited conservation resources are being spent on the installation of artificial hollows that are ineffective for native species of conservation concern, or are providing resources for highly competitive invasive species, such as European honey bees *Apis mellifera*, and common mynas *Acridotheres tristis* (Grarock *et al.* 2012).

To improve their value for conserving hollow-dependent fauna, we need a clearer understanding of how the range of factors relating to nest box design and placement, which interact to drive temporal patterns in microclimate, affects their suitability to a range of taxa (Rowland *et al.* 2017). However, supplementary habitats may ultimately be more effective at mimicking the structural and thermal properties of tree hollows if they are mechanically carved directly into the trunk or branches (e.g. with a chainsaw), rather than attached to the outside of trees (Saenz *et al.* 2001).

Case study 1: Thermal properties of natural tree hollows compared to chainsaw hollows, salvaged log hollows, and nest boxes.

Naturally occurring tree hollows provide wildlife with protection from adverse weather conditions. Ideally, artificial hollows should provide the same (or better) protection, yet the thermal suitability of nest boxes for many wildlife species is unclear (Rowland *et al.* 2017). The few studies to date on this topic have shown that tree hollows and nest boxes vary significantly in their physical and thermal properties, with greater thermal fluctuations occurring in nest boxes compared to natural hollows (Maziarz *et al.* 2017). Consequently, nest boxes may provide thermal habitats that are unsuitable for target fauna (Rowland *et al.* 2017).

A recent survey conducted by the Department of Environment, Land, Water and Planning, Victoria, which attempted to quantify the number and location of nest boxes across the state of Vitoria, provides a good example of why thermal properties of nest boxes should be considered. Stakeholders from 94 different nest box programs provided data showing that approximately 10,000 boxes are currently installed across Victoria (Macack 2018). Many of these nest box programs are located in Mediterranean or semi-arid environments. These landscapes are characterised by relatively cold winter and hot summer conditions.

The combination of day-time ambient temperatures above 40°C and high levels of solar radiation, both of which can occur regularly in these environments during summer, can drive internal nest box temperatures well above critical thermal tolerance limits for endothermic birds and mammals using boxes (Rowland et al., 2017). However, these predominantly community-run nest box programs typically do not consider the thermal properties of the boxes they install, and these groups do not have the capacity to monitor internal box microclimates to determine their thermal suitability for the different species that use the boxes.

Here, we conducted a field experiment to investigate whether artificial hollows cut with chainsaws into live trees and felled logs could better approximate the thermal properties of naturally occurring hollows in mature trees (Griffiths *et al.* 2018). We compared the thermal profiles of natural hollows in large, mature trees (*Eucalyptus* spp.) with three types of artificial hollows designed for small marsupial gliders (*Petaurus* spp.: 100–600 g) and tree-roosting insectivorous bats (Chiroptera: 4–50 g): (1) chainsaw hollows cut directly into live tree trunks or branches, (2) chainsaw hollows cut into felled logs that were subsequently attached to tree trunks (henceforth 'log hollows'), and (3) nest boxes made from plywood.

Across the range of ambient conditions experienced during the study, mean hourly temperatures within nest boxes varied considerably more than natural hollows, chainsaw hollows or log hollows, with boxes experiencing both the hottest and the coldest extremes (Fig. 1).

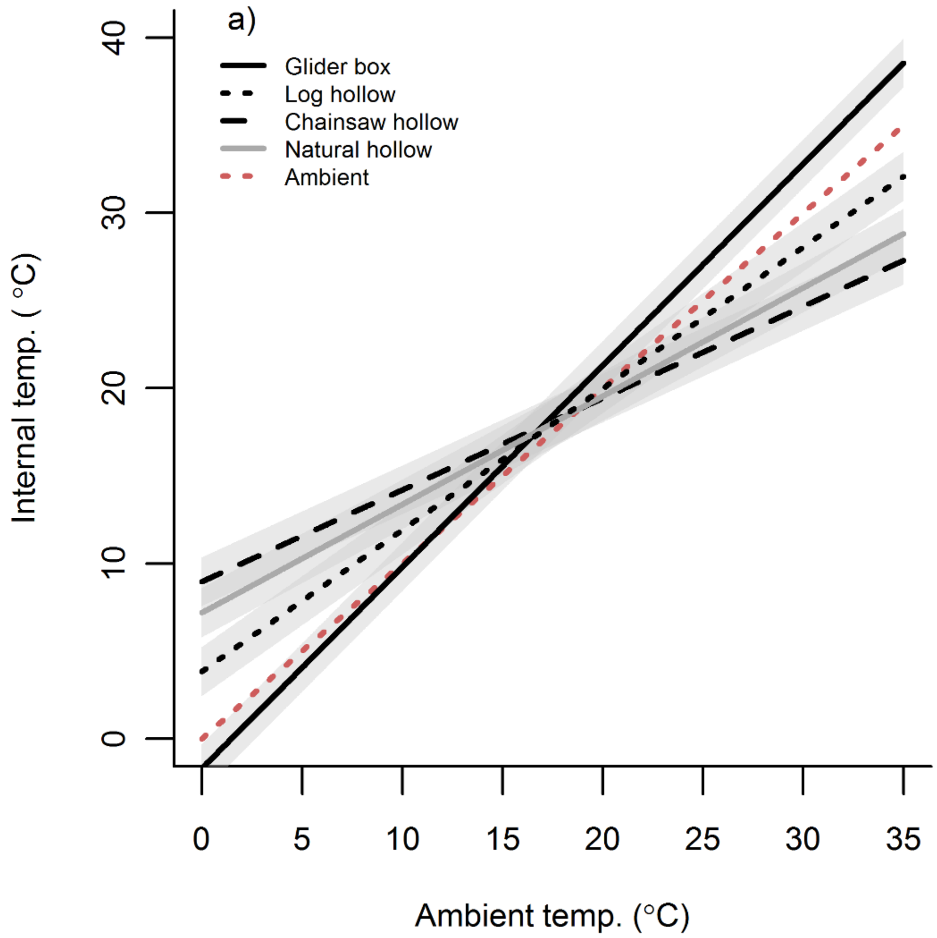


Fig. 1. Modelled data showing predicted mean internal cavity temperatures (°C) for all ambient temperatures experienced across the study. Temperatures were recorded hourly in glider boxes, log hollows, natural hollows, chainsaw hollows and outside under shaded ambient conditions over 50 days in spring (2 October to 20 November 2016) and 60 days in summer (23 December 2016 to 20 February 2017). Shaded areas represent 95% confidence intervals. Adapted from Griffiths et al. (2018).

Over the daily 24-hr cycle, mean hourly temperatures in chainsaw hollows were comparable to natural hollows: both were cooler than ambient during the day, and warmer than ambient during the night (Fig. 2). Mean hourly temperatures in log hollows were also cooler than ambient during the day and warmer than ambient at night, but fluctuated more than temperatures in chainsaw hollows and natural hollows. In contrast, the nest boxes exhibited the opposite pattern: they began warming rapidly in the morning, remained warmer than ambient throughout the day, and then quickly cooled in the early evening and either closely tracked or fell below ambient temperatures during the night. Natural hollows, chainsaw hollows and log hollows also followed ambient conditions but had a slower rate of heating and cooling than nest boxes, whereby daily cavity maxima and minima lagged 1–2 h behind the ambient (Fig. 2).

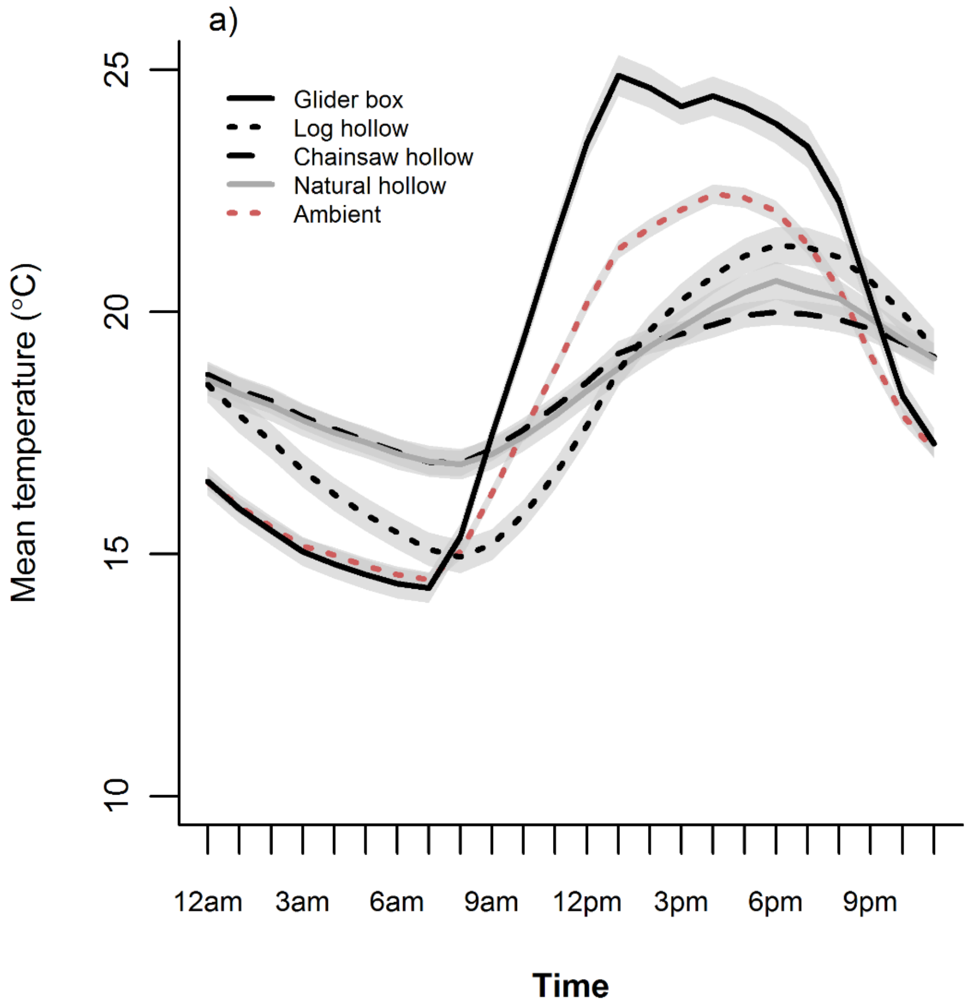


Fig. 2. Mean temperature (°C) calculated from raw data over 24 h inside natural and artificial hollows compared to external ambient conditions. Temperatures were recorded hourly in glider nest boxes, log hollows, natural hollows and chainsaw hollows over 50 days in spring (2 October to 20 November 2016) and 60 days in summer (23 December 2016 to 20 February 2017). Shaded areas represent 95% confidence intervals. Adapted from Griffiths et al. (2018).

The contrast in 24-h patterns of heating and cooling (relative to ambient conditions) that we recorded in nest boxes compared to natural hollows, chainsaw hollows and log hollows, raises the question – are temperature profiles a factor contributing to the dominant use of nest boxes by common, highly adaptable species? There is some evidence that the ability to tolerate a wide variety of climatic conditions helps exotic cavity-nesting bird species, such as rose-ringed parakeets *Psittacula krameri* in South Africa, to successfully invade novel environments (Thabethe *et al.* 2013). However, it is unclear whether this thermal flexibility specifically relates to invasive bird species, or applies more widely.

The link between the thermal profiles in nest boxes and their disproportionate level of use by widespread, highly adaptable species of birds and mammals, particularly in human-disturbed landscapes, warrants further investigation.

In summary, our results revealed that chainsaw hollows had thermal profiles that were similar to natural tree hollows, being consistently warmer than ambient conditions at night, while remaining cooler than ambient during the day. This daily pattern of heating and cooling could provide ecophysiological benefits to nocturnal mammals using cool chainsaw hollows (relative to external ambient conditions) during the day by decreasing the amount of heat loss required (via evapotranspiration) to maintain constant body temperature (Griffiths *et al.* 2017b; Rowland *et al.* 2017). It could also benefit diurnal hollow-nesting birds using warm (compared to ambient) chainsaw hollows at night by decreasing the amount of metabolic heat production required to maintain core body temperature (Ardia *et al.* 2006). In contrast, nest boxes had the opposite pattern of heating and cooling, being slightly colder than ambient at night and substantially hotter during the day. These findings provide the first empirical evidence that chainsaw hollows designed for target species could be used to deliver supplementary habitats with thermal conditions that closely mimic those in natural tree hollows, thereby addressing a significant shortcoming of timber or plywood nest boxes (Rowland *et al.* 2017; Maziarz *et al.* 2017).

Case study 2: Wildlife response to chainsaw hollow installation.

Growing awareness among policymakers, land managers and conservation professionals of potential limitations associated with nest boxes when used to offset the loss of hollow-bearing trees has lead to increased interest in the potential for novel designs of supplementary habitats (Le Roux *et al.* 2016). One such technique involves using chainsaws to carve out artificial hollows from the trunks and branches of live trees (Carey and Gill 1983), thereby avoiding the long time periods it takes for these keystone habitat features to form via natural processes (Gibbons *et al.* 2000). The creation of artificial tree hollows with the use of a chainsaw and wooden box inserts has proved to be effective in North America for providing supplementary nesting habitats for the endangered Red-cockaded woodpecker *Leuconotopicus borealis* (Cox and McCormick 2016). However, in Australia mechanical creation of cavities in trees is a relatively novel, unexplored technique, with the few studies conducted to date focusing primarily on documenting preliminary evidence of use of chainsaw hollows by wildlife (Hurley and Stark 2015; Lumsden *et al.* 2016; Rueegger 2017). Less attention has been paid to investigating whether the installation of these artificial hollows elicits changes in the behaviour of hollow-dependent birds and mammals.

Here, we investigated the behavioural response of hollow-dependent wildlife to the creation of chainsaw hollows in the trunks of live, developing trees located in urban and peri-urban parks and reserves across Greater Melbourne, Victoria. We created chainsaw hollows that were designed for small marsupial gliders (e.g. *Petaurus* spp.) or small hollow-nesting birds (e.g. musk lorikeet *Glossopsitta concinna*). However, minor variations to the entrance size and internal dimensions could make these supplementary habitats suitable for a range of other hollow-dependent arboreal mammals, tree-roosting insectivorous bats and secondary cavity-nesting passerines.

We posed the question: can the introduction of chainsaw hollows increase the visitation by hollow-dependent fauna to developing trees? We hypothesised that the addition of chainsaw hollows to developing trees would increase the activity of hollow-dependent fauna (measured as rates of visitation to trees), particularly immediately after hollow creation, as animals investigate these novel habitat structures as possible den or nest sites (Lumsden *et al.* 2016). To test this hypothesis, we conducted a before-after control-impact (BACI) chainsaw hollow addition experiment and used passive camera traps to monitor changes in visitations by hollow-dependent wildlife to (a) mature hollow-bearing trees, (b) developing trees without hollows (i.e. control trees), and (c) developing trees with newly installed chainsaw hollows (Semmens et al., 2019).

Over 3,951 camera-trap nights, we recorded 439 tree visitation events by hollow-dependent taxa. Of these, 385 visitations were identified to four species of nocturnal mammals: 141 common brushtail possum *Trichosurus vulpecula*, 127 sugar glider *Petaurus breviceps*, 106 common ringtail possum *Pseudocheirus peregrinus*, and 11 agile antechinus *Antechinus agilis*). While 113 visitations were identified to seven species of diurnal cavity-nesting birds: 24 crimson rosella *Platycercus elegans*, 73 eastern rosella *Platycercus eximius*, 7 rainbow lorikeet *Trichoglossus moluccanus*, 5 galah *Eolophus roseicapilla*, 1 laughing kookaburra *Dacelo novaeguineae*, 1 spotted pardalote *Pardalotus punctatus*, and 2 wood duck *Chenonetta jubata*) (Table 1).

Table 1. Summary of visitation records of hollow-dependent mammal and bird species to different tree treatments.

Hollow-dependent species	Control trees	Natural hollow trees	Chainsaw hollow trees
Mammals			
Common brushtail possum	40	66	35
Sugar glider	28	39	60
Common ringtail possum	38	25	45
Agile antechinus	2	2	6
Birds			
Crimson rosella	0	6	18
Eastern rosella	1	7	65
Rainbow lorikeet	0	1	6
Galah	0	0	5
Laughing kookaburra	0	0	1
Spotted pardalote	0	0	1
Wood duck	0	1	1

In summary, we found that installing chainsaw hollows in the trunks of developing trees resulted in increased rates of visitation by a range of native hollow-dependent birds and mammals, thereby providing support for our hypothesis. We predicted that the addition of chainsaw hollows to developing trees would lead to increased visitations by hollow-dependent wildlife. We found that, trees (that previously did not provide den or nest sites) that hollow-dependent animals were not detected visiting during pre-impact surveys were 100% likely to be visited and inspected after the installation of a chainsaw hollow.

Our preliminary findings suggest that chainsaw hollows designed to replicate the external physical characteristics of natural hollows could be effective in attracting target fauna to developing trees in regenerating and revegetated landscapes (Semmens et al., 2019). However, to empirically test the effectiveness of different habitat supplementation techniques in attracting target endemic species, further empirical studies are required that compare the use of natural and artificial hollows installed in a range of human-disturbed landscapes (Griffiths *et al.* 2018). Of particular interest would be studies comparing temporal patterns in wildlife use of natural tree hollows, nest boxes and chainsaw hollows, and testing whether occupancy of these different habitat structures, both natural and artificial, results in variation in the fitness of hollow-dependent birds and mammals.

Case study 3: Factors influencing occupancy of chainsaw hollows by sugar gliders.

In this study, we monitored chainsaw-carved hollows installed in live trees that were designed for sugar gliders *Petaurus breviceps* throughout urban and peri-urban Melbourne. We investigated spatial (hollow, tree and landscape) and temporal influences on the frequency of chainsaw hollow visitation, and the probability of chainsaw hollow occupancy by sugar gliders (Best et al., 2019).

During a 3-year survey period, 14 native hollow-using species were found to visit or occupy chainsaw hollows, including three species not previously recorded in prior chainsaw hollow studies: spotted pardalote *Pardalotus punctatus*, striated pardalote *Pardalotus striatus* and agile antechinus *Antechinus agilis*. Chainsaw hollows were occupied predominately by the target species, the sugar glider; however, they were also used intermittently by microbats and agile antechinus. Over 66% of chainsaw hollows were occupied at least once by sugar gliders throughout the survey period. This figure is high compared to many similar studies investigating occupancy rates of nest boxes by arboreal mammals.

Sugar glider visitations to chainsaw hollows was largely driven by the local density of a critical food resource, black wattle *Acacia mearnsii*. Occupancy of chainsaw hollows by gliders was also driven by the internal volume of the cavity, and structural complexity of the surrounding habitat, increasing with the density of black wattle, trees and hollow-bearing hollows.

We also recorded preliminary evidence suggesting that parrots may act to keep chainsaw hollows functionally available to other species by chewing at hollow entrances, thus preventing trees from totally closing entrances through the development of wound-wood.

Conclusion

The primary objective underlying biodiversity offset and habitat restoration programs targeting cavity-dependent wildlife is to replace natural tree hollows that have been removed from the landscape with equivalent artificial habitats (Miller *et al.* 2015). There is a growing body of evidence that traditional timber or plywood nest boxes do not provide equivalent structural or thermal microhabitats to those of natural tree hollows (Maziarz *et al.* 2017). Consequently, there is unlikely to be any scenario where timber or plywood nest boxes can adequately compensate for the loss of tree hollows for the community of wildlife that rely on these keystone structures (Griffiths *et al.* 2017a). There is a clear need for collaboration between policy makers, conservation practitioners, the arboriculture industry, and managers of biodiversity offset programs, to develop and implement protocols that incorporate the safe mechanical creation of artificial hollows as permanent structures within trees (Griffiths *et al.* 2018).

While research into the effectiveness of chainsaw hollows carved into live trees has generated some promising preliminary findings, it is very much early days and there are still many unanswered questions. Where novel methods of habitat supplementation are being used, such as carving chainsaw hollows into trees or re-attaching salvaged log hollows, it is critical that stakeholders endeavor to undertake some level of ongoing, systematic monitoring to document temporal patterns in wildlife use, plus the ongoing costs associated with maintenance and repair of these artificial hollows.

References

Ardia, D. R., Pérez, J. H., and Clotfelter, E. D. (2006). Nest box orientation affects internal temperature and nest site selection by Tree Swallows. *Journal of Field Ornithology* **77**, 339–344. doi:10.1111/j.1557-9263.2006.00064.x

Best, K., Haslem, A., and Griffiths, S.R. (2019). Factors influencing visitation and occupancy of chainsaw hollows by a hollow-dependent arboreal mammal, the Sugar Glider *Petaurus breviceps*. In Prep.

Brazill-Boast, J., Pryke, S. R., and Griffith, S. C. S. C. (2013). Provisioning habitat with custom-designed nest-boxes increases reproductive success in an endangered finch. *Austral Ecology* **38**, 405–412. doi:10.1111/j.1442-9993.2012.02424.x

Carey, A. B., and Gill, J. D. (1983). Direct habitat improvements - some recent advances. In 'Snag Habitat Management: Proceedings of a Symposium. US Forest Service Technical Report RM-99.' (Eds J. Davis, G. Goodwin, and R. Ockerfells.) pp. 80–87. (US Forest Service: Washington DC, USA.)

Cox, J. A., and McCormick, J. K. (2016). New insights from an attempt to reintroduce Red-cockaded Woodpeckers in northern Florida. *Journal of Field Ornithology* **87**, 360–370. doi:10.1111/jofo.12165

Fischer, J., and Lindenmayer, D. B. (2007). Landscape modification and habitat fragmentation: a synthesis. *Global Ecology and Biogeography* **16**, 265–280. doi:10.1111/j.1466-8238.2007.00287.x

Gibbons, P., Lindenmayer, D. B., Barry, S. C., and Tanton, M. T. (2000). Hollow formation in eucalypts from temperate forests in southeastern Australia. *Pacific Conservation Biology* **6**, 218–228. doi:10.1071/PC000217

Goldingay, R. L., Rueegger, N. N., Grimson, M. J., and Taylor, B. D. (2015). Specific nest box designs can improve habitat restoration for cavity-dependent arboreal mammals. *Restoration Ecology* **23**, 482–490. doi:10.1111/rec.12208

Grarock, K., Tidemann, C. R., Wood, J., and Lindenmayer, D. B. (2012). Is it benign or is it a pariah? Empirical evidence for the impact of the Common Myna (*Acridotheres tristis*) on Australian birds. *PLoS ONE* **7**, 1–12. doi:10.1371/journal.pone.0040622

Griffiths, S. R., Bender, R., Godinho, L. N., Lentini, P. E., Lumsden, L. F., and Robert, K. A. (2017a). Bat boxes are not a silver bullet conservation tool. *Mammal Review* **47**, 261–265. doi:10.1111/mam.12097

Griffiths, S. R., Lentini, P. E., Semmens, K., Watson, S. J., Lumsden, L. F., and Robert, K. A. (2018). Chainsaw-carved cavities better mimic the thermal properties of natural tree hollows than nest boxes and log hollows. *Forests* **9**, 235. doi:10.3390/f9050235

Griffiths, S. R., Rowland, J. A., Briscoe, N. J., Lentini, P. E., Handasyde, K. A., Lumsden, L. F., and Robert, K. A. (2017b). Surface reflectance drives nest box temperature profiles and thermal suitability for target wildlife. *PLoS ONE* **12**, e0176951. doi:10.1371/journal.pone.0176951

Harley, D. (2016). An overview of actions to conserve Leadbeater's Possum (*Gymnobelideus leadbeateri*). *Victorian Naturalist* **133**, 85–97.

Hurley, V. G., and Stark, E. M. (2015). Characteristics and uptake of simulated natural cavities for Major Mitchell's Cockatoo (*Lophochroa leadbeateri leadbeateri*) in Slender Cypress-pine. Department of Environment, Land, Water and Planning, Victoria', Melbourne, Australia.

Lindenmayer, D. B., Crane, M., Evans, M. C., Maron, M., Gibbons, P., Bekessy, S., and Blanchard, W. (2017). The anatomy of a failed offset. *Biological Conservation* **210**, 286–292. doi:10.1016/j.biocon.2017.04.022

Lindenmayer, D. B., Welsh, A., Donnelly, C., Crane, M., Michael, D., Macgregor, C., McBurney, L., Montague-Drake, R., and Gibbons, P. (2009). Are nest boxes a viable alternative source of cavities for hollow-dependent animals? Long-term monitoring of nest box occupancy, pest use and attrition. *Biological Conservation* **142**, 33–42. doi:10.1016/j.biocon.2008.09.026

Lindenmayer, D. B., Wood, J., McBurney, L., Michael, D., Crane, M., Macgregor, C., Montague-Drake, R., Gibbons, P., and Banks, S. C. (2011). Cross-sectional vs. longitudinal research: a case study of trees with hollows and marsupials in Australian forests. *Ecological Monographs* **81**, 557–580. doi:10.1890/11-0279.1

Lumsden, L. F., Powell, C., and Cashmore, M. (2016). Successfully creating new hollows for the Critically Endangered Leadbeater's Possum. In 'Abstracts from the Australian Mammal Society conference, Alice Springs, September 2016'.

Macack, P. V (2018). The Use of Nest Boxes in Victoria. Unpublished Client Report for the Regional Landscapes and Targeted Action program 2017-2018. Arthur Rylah Institute for Environmental Research, Department of Environment, Land, Water and Planning, Heidelberg, Victoria.

Maziarz, M., Broughton, R. K., and Wesołowski, T. (2017). Microclimate in tree cavities and nest-boxes: implications for hole-nesting birds. *Forest Ecology and Management* **389**, 306–313. doi:10.1016/j.foreco.2017.01.001

Miller, K. L., Trezise, J. A., Kraus, S., Dripps, K., Evans, M. C., Gibbons, P., Possingham, H. P., and Maron, M. (2015). The development of the Australian environmental offsets policy: from theory to practice. *Environmental Conservation* **42**, 306–314. doi:10.1017/S037689291400040X

Le Roux, D. S., Ikin, K., Lindenmayer, D. B., Bistricer, G., Manning, A. D., and Gibbons, P. (2016). Effects of entrance size, tree size and landscape context on nest box occupancy: considerations for management and biodiversity offsets. *Forest Ecology and Management* **366**, 135–142. doi:10.1016/j.foreco.2016.02.017

Rowland, J. A., Briscoe, N. J., and Handasyde, K. A. (2017). Comparing the thermal suitability of nest-boxes and tree-hollows for the conservation-management of arboreal marsupials. *Biological Conservation* **209**, 341–348. doi:10.1016/j.biocon.2017.02.006

Rueegger, N. (2017). Artificial tree hollow creation for cavity-using wildlife – trialling an alternative method to that of nest boxes. *Forest Ecology and Management* **405**, 404–412. doi:10.1016/j.foreco.2017.09.062

Saenz, D., Conner, R. N., Collins, C. S., and Rudolph, D. C. (2001). Initial and long-term use of inserts by Red-cockaded Woodpeckers. *Wildlife Society Bulletin* **29**, 165–170.

Semmens, K., Jones, C., Watson, S.J., and Griffiths, S.R. (2019). Chainsaw hollows carved into medium-sized, live trees increases rates of visitation by cavity-dependent fauna. Under Review.

Thabethe, V., Thompson, L. J., Hart, L. A., Brown, M., and Downs, C. T. (2013). Seasonal effects on the thermoregulation of invasive rose-ringed parakeets (*Psittacula krameri*). *Journal of Thermal Biology* **38**, 553–559. doi:10.1016/j.jtherbio.2013.09.006

PERSONALITY OF TREES
Using Data to Connect Community to the Urban Forest

Ben Seamark
Coordinator of Environmental Assets, City of Burnside

Introduction

The urban forest provides a range of social, economic and environment benefits to the community. These benefits include, but are not limited to: climate change resilience, improved health outcomes, reducing traffic speed, improved academic performance, attracting investment, increasing property values, providing habitat and benefiting biodiversity (Li & Sullivan, 2016, National Heart Foundation, 2019, Alvey, 2006). The need to connect the community to urban forestry is critical if the social, economic and environmental utility provided is to be considered commensurate to other urban planning products, like roads or footpaths.

The City of Burnside has undertaken a number of initiatives to promote its urban forest, including the development of an online tool called "*Urban Forest Interactive*" which has become a catalyst to promoting the city's urban forest and making tree data accessible to the public; allowing for informed decisions to be made.

As Philip Hewett (2002) said over 10 years ago, when discussing the importance of marketing the urban forest;

"…few products ever get marketplace and establish market share without an effective marketing strategy'. "

This paper discusses why promoting the urban forest is important, some of the Key features of *Urban Forest Interactive* and how the personality of trees helped shape an idea to connect community with nature.

Background

The urban forest provides a range of benefits and these reflected in the adoption of canopy cover targets in the recently released South Australian 30 Year Plan for Greater Adelaide (SA Government, 2017). This plan now includes the following relevant canopy targets across the metropolitan area:

1) For council areas with less than 30% tree canopy cover currently, cover should be increased by 20% by 2045

2) For council areas with more than 30% tree canopy cover currently, this should be maintained to ensure no net loss by 2045

The delivery of these targets on ground however, is dependent on public support.

In 2016 the City of Burnside undertook a benchmark study of its canopy cover (SEED, 2016). This study showed that between 2010 and 2015 canopy cover had declined across all three study areas selected. A Canopy Action Plan (CAP) was developed in response to these finding and endorsed in 2017. The CAP was based on the following objectives: 1) *Education, 2) Protection 3) Planning.*

In 2018 the City of Burnside undertook a benchmark study to measure its community's understanding and attitudes towards the urban forest (City of Burnside, 2018a). A total of 376 people participated in the survey and 337 (90%) of those surveyed valued the conservation of the urban forest highly, however only 54% were aware of the rate of canopy loss.

The CAP and benchmark study led to the development of promotional materials; including an interactive online tool (*Urban Forest Interactive*) to promote and educate the community on the importance of the urban forest. Since the launch of *Urban Forest Interactive* in 2018, this initiative has won a number of awards and recognition in both Local Government innovation, urban forestry management and public health.

Change and urban forestry

At the 1933 Census, 37.4 per cent of Australians lived in rural areas, but by 1976 this has changed to 13.9 per cent (Hugo, 2002). Australia is now one of the world's more urbanised countries with about 90% of Australians living in towns and cities. With a trend towards more people born and living in cities, there is a recognised disconnect between people and nature (Taylor, 2014). This estrangement from nature, as Taylor argues, necessitates a need to promote and educate the community to the benefits of nature and the urban forest.

Like many cities, the City of Burnside is experiencing consolidated housing pressures through planning reform, which in turn provides less room for trees and increases the likelihood of conflict between trees services, people and property. The City of Burnside is concurrently experiencing a change in demographics with rapid growth in overseas born residents. Trends in the nursery industry have, and will continue to influence the type and quality of species planted. The city of Burnside has a number of its tree population now reaching the end of their useful life expectancy and it is anticipated that 10% will need to be replaced over the next 10 years. Climate change is also bringing new challenges most notably by introduction of new pest and disease and risk to species adaptability. There is also the diverging and varying attitudes towards trees as recognised by Kirkpatrick and Davison (2017) with public either strongly advocating for, or against, and those whom are indifferent. How these attitudes may change in a society increasingly estranged from nature is concerning for the future of urban forestry management.

Managing the urban forest is therefore multifaceted and dynamic, and if a community becomes disconnected with the natural environment, implementing policies to address these challenges will become more difficult. The City of Burnside Urban Tree Strategy recognises the need to: *Promote and educate the community on the value of trees and their biodiversity*. This need is also reflected in a number of urban forest strategies globally. Promoting the urban forest is therefore becoming a recognised necessity in urban forestry management to address change and this is arguably more important now than ever before.

We Love Trees

The City of Burnside is recognized and valued by its community as a green and leafy city (City of Burnside, 2016b). This recognition is in part due to its established tree lined streets, grassed verges and being home to some of the largest remnant Blue (*E. leucoxylon*) and Red (*E. camaldulensis*) Gums growing in any City within Australia.

Figure 1 – The City of Burnside love of tree is best evident by its corporate Logo

The city of Burnside's commitment to trees is evidenced in the corporate logo which prominently features a centralized image of a tree, employment of arborists since 1936 (The Advertiser, p.21, 1936), and being one of the first cities to implement an urban tree strategy.

Tree protection efforts can be traced back to 1912, where the Council objected to the removal of trees in Kensington Gardens, by what was then known as the Tramways Trust (The Advertiser, p.11, 1912), and have continued to develop policies and carefully manage and endeavor to preserve the Urban Forest. It would be reasonable to presume there is ongoing support for proactively managing trees and increasing canopy coverage in a city whose community highly values these assets. But the city is changing and will this love of trees continue into the future?

Personality and connection

When pitching the idea to promote the urban forest, we demonstrated the City of Melbourne's marvelous initiative Urban Forest Visual (2019) which allows users to email trees. When explaining this function one wag asked "What would the tree say back?" And although this was asked in jest it did provide an insight into a gap that exists between urban forestry management and community perception. It raised the question of whether there was a way to forge communication and understanding between species.

It is well accepted that human relationships are formed, at least in part, on an understanding of personality. We subconsciously, or maybe consciously, assign others by a personality type, sometimes even before we meet them. This helps us understand and predict others, and therefore manage our interactions. As arborists we intuitively recognize personalities of trees, through understanding species individual form, habit, response to environmental conditions, preferences to soil types and aspect, but others may see trees as inanimate objects We have a unique perspective and knowledge that allows us to recognize how trees display similar personality traits to humans. There are those trees whom are caring or form symbiotic relationships with other species, those trees that are social, living in mixed woodland communities and are sharing resources, those trees that are overbearing, such as invasive weed species that dominate landscapes. The more we know about tree personalities, the more this helps us to connect; the more we learn the more we have an ability to understand and manage. Learning about personality helps us recognize and value diversity; not all people or trees are the same.

Connecting people to the urban forest, may help the public learn more about a tree's personality and form deeper connections. Bill Gamage's book "The Biggest Estate on Earth: How Aborigines Made Australia"(Gammage, 2012) describes the relationship traditional land managers had to land and how they promoted the importance and understanding of land through ceremony and storytelling. This deep connection allowed for the sustainable management of the land for over 60 thousand years. Connecting people to trees today, not only supports policy and helps deliver on ground activities, but research suggests makes people happier, fitter, improves learning and makes communities feel safer (Heart Foundation, Unknown) . In an endeavor to achieve these outcomes a review of global initiatives was undertaken to identify promotion tools that would work in our community.

Promoting the Urban Forest

Over the past few years the City of Burnside has undertaken a number of initiatives to promote the Urban Forest. These include graphic devices, placed on Council vehicles and waste trucks, i-tree eco assessment of one of its major reserves (City of Burnside, 2018c), internal workshops and public surveys to benchmark the relationship between trees and the public, internal stakeholder workshops and a citizen science based project 'Urban Foresters' where the public help to monitor the urban forest.

Figure 2- Example of promotional material used by the City of Burnside (2019)

Urban Forest Interactive

A number of large cities around the world now provide their tree data to the public. Cities that have undertaken these projects include, but is not limited to, the City of Melbourne, City of New York and the City of London. In 2013 the City of Burnside undertook a city-wide tree audit, capturing 37,000 public trees. This tree data was then used to drive a risk-based approach to urban tree management. Many other councils have undertaken similar audits capturing information on trees and mapping these using global positioning systems (GPS). Having this data allows cities to not only manage their trees, but provide information on their trees to the public.

Urban forest Interactive was launched in 2018 and allows the public to learn about those trees around them and, the benefits the trees provide and some of the challenges facing the urban forest.

Some of the key features of *Urban Forest Interactive* include:

- **Species Identification** – Users can select trees around them using a mobile device connected to the internet. Users are provided with information such as botanical and common name. Links to Wikipedia provide more information on species.

- **Ecosystem services values** - For the top 10% of most common species, detail is provided on some of the ecosystem services these individual trees provide. These ecosystem services include carbon stored, storm water intercepted, air pollution removed and oxygen produced.

- **Canopy Performance** – The 'Performance Index' (Figure, 3) ranks suburbs or wards performance by calculating the number of trees per 100 square meters with the number of tree vacancies and compares this to other suburbs within the City. This helps to inform tree planting and allows residents and Councilors to advocate for more tree planting in their local area.

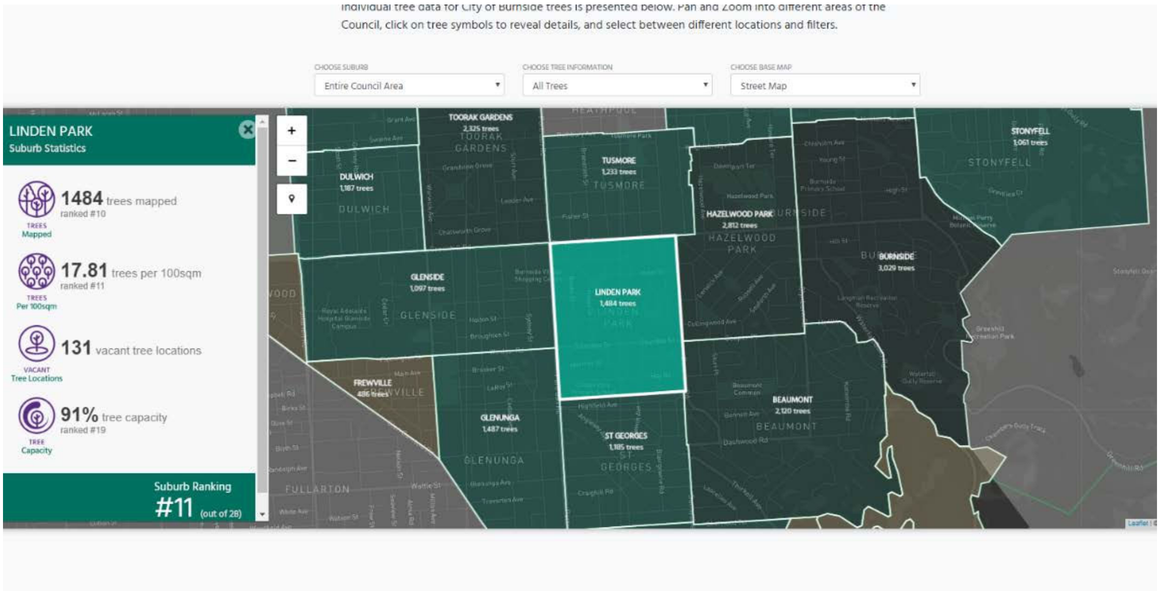


Figure 3. Screenshot of Urban Forest Interactive Performance Index ranking suburb tree performance

Heat Island - The heat map layer allows users to see the effects of Heat Islands and how areas with high populations of trees and open space help reduce the heat island effect locally (Figure 4).

Figure 4. Screenshot of Urban Forest Interactive Heat Island tool

Since the launch of *Urban Forest Interactive* in 2018, residents have used this online tool to advocate for the protection of trees and or increased tree plantings. Residents use it to communicate directly with Council by quoting the unique identification number given to each tree. This not only saves time for the City's arborists when trying to identify a tree, but allows Council to keep accurate records on the history of trees and in turn the relationship members of the public have with trees.

Urban Forest Interactive was built entirely on open source software to keep operating cost down. There is a risk when developing systems like this that the data becomes redundant quickly, but using open source resources like Google Street View and Wikipedia reduces this risk.

Since the launch of *Urban Forest Interactive*, this initiative has won a number of awards and recognition in both Local Government innovation, urban forestry management and public health.

Conclusion

Maintaining and increasing the canopy in urban environments is increasingly crucial for environmental, social and emotional wellbeing of the resident human and fauna population. The promotion of a city's Urban Forest is now recognized as an important tool in the effective management of the urban forest. The City of Burnside has developed an exciting initiative with *Urban Forest Interactive* which allows promotion of the urban forest using data. This relatively new platform presents a number of opportunities to deepen the connection between community and trees. The use of graphic devices, citizen science projects and other future initiatives are all underpinned by this core project.

Arborists are uniquely positioned, through their deep knowledge of trees and instinctive understanding of the personalities of trees to broaden and amplify the community connection to the urban forest. Working in conjunction with real time data driven tools like *Urban Forest Interactive* positions arborists to help foster and develop community values to help manage the urban forest into the future.

References

Alvey, A. (2006) Promoting and preserving biodiversity in the urban forest. Urban Forestry & Urban Greening, Volume 5, Issue 4, Dec 2006, Pages 195-201

Arborists and Argument in the Urban Forest: A synthesis (2017) Available (online) https://treenet.org/wp-content/uploads/2017/10/TREENET-2017-Symposium-Proceedings_FINAL.pdf TREENET, Accessed July 2019

City of Burnside, 2018a Community engagement results, Community Tree Survey (Unpublished)

City of Burnside, 2016b, Be the Future of Burnside Our Strategic Community Plan 2016-2026 (p,6) Available (Online) https://www.burnside.sa.gov.au/files/assets/public/about-council/plans-amp-reports/council-strategies/strategic-community-plan/be-the-future-of-burnside-2016-2026.pdf Accessed July 2019

City of Burnside, 2018c, valuing the Trees of Hazelwood Park, an i-tree Eco Assessment, 31 August 2018 available (online) https://www.burnside.sa.gov.au/files/assets/public/environment-amp-sustainability/trees/hazelwood-park-tree-assessment/attachment-b-hp-eco-assessment-web.pdf Accessed 31 July 2019

Li, Dongying & Sullivan,W. (2016) Impact of views to school landscapes on recovery from stress and mental fatigue, Available (Online) https://www.researchgate.net/profile/William_Sullivan6/publication/291148332_Impact_of_views_to_school_landscapes_on_recovery_from_stress_and_mental_fatigue/links/59f48471aca272607e2a8058/Impact-of-views-to-school-landscapes-on-recovery-from-stress-and-mental-fatigue.pdf?origin=publication_detail

Landscape and Urban Planning 148 (2016) 149-158

SA Heart Foundation (Unknown), Making the case for investment in street trees and landscaping in urban environments, Available (Online) https://www.heartfoundation.org.au/images/uploads/main/Programs/South_Australia/TreesLandscaping.pdf Accessed August 2019

Hewett, P. (2007) What's Marketing & Branding got to do with urban Forest, Available (Online) https://treenet.org/resources/whats-marketing-branding-got-to-do-with-urban-forest/ TREENET, Accessed, August 2019

Hugo, G.(2002) Changing Patterns of population Distributions in Australia. Available (Online) https://www.accc.gov.au/system/files/Fn%20118%20-%20Hugo%2C%20Changing%20patterns%20of%20population%20and%20distribution.pdf. University of Adelaide Accessed August 2019

Kirkpatrick J & Davison A, Arborists and Argument in the Urban Forest: A synthesis (2017) Available (online) https://treenet.org/wp-content/uploads/2017/10/TREENET-2017-Symposium-Proceedings_FINAL.pdf TREENET, Accessed July 2019

National Heart Foundation of Australia, (2019) Blueprint for an active Australia: National Heart Foundation of Australia AVAILABLE (Online) https://www.heartfoundation.org.au/images/uploads/publications/Blueprint/Blueprint_For_An_Active_Australia_Third_Edition.pdf Accessed August 2019

SA Government, THE 30-YEAR PLAN FOR GREATER ADELAIDE, Available (Online) https://livingadelaide.sa.gov.au/__data/assets/pdf_file/0003/319809/The_30-Year_Plan_for_Greater_Adelaide.pdf Accessed, July 2019.

SEED Consulting Services. (2016), Tree Canopy Cover in the City of Burnside, Benchmark Assessment, Sep 2016. Available (Online) https://www.burnside.sa.gov.au/files/assets/public/environment-amp-sustainability/trees/tree-canopy-report/657_report_final_230916.pdf Accessed, July 2019

Taylor, S. Green Space in Grey Places: Are Green Roofs and Walls Enough? TREENET Available (Online) https://treenet.org/wp-content/uploads/2017/04/a_Sandra-Taylor_TREENET-2014-Symposium-ProceedingsWEB.pdf accessed August 2019

The Advertiser, 1936, p26, Street Gardens in Suburbs, Council Ready to Aid Property Owners EXTENT OF WORK, Available (Online) https://trove.nla.gov.au/newspaper/article/48153045?searchTerm=tree%20oak%20%22burnside%20council%22&searchLimits= Accessed July 2019.

The Advertiser, 1912, p.11, Burnside District Council, Available (Online) https://trove.nla.gov.au/newspaper/article/5347396?searchTerm=tree%20burnside&searchLimits= Accessed July 2019.

Urban Forest Visual, 2019. City of Melbourne. [ONLINE] Available at: http://melbourneurbanforestvisual.com.au/ , Available (Online) Accessed August 2019].

Gammage, B. 2012, 'The Biggest Estate on Earth', How Aborigines made Australia, Allen & Unwin, Australia

DEVELOPMENT OF AN URBAN FOREST STRATEGY – COMMUNITY LED INITIATIVE

Heather Johnstone

Vic Park Trees / Vic Park Collective

The delivery of the Urban Forest Strategy in collaboration with the Town of Victoria Park (https://www.victoriapark.wa.gov.au/Home) directly involved a number or organisations:

Vic Park Collective: https://www.vicparkcollective.com

Vic Park Trees: https://www.vicparktrees.com

AUDRC: https://www.audrc.org/

Millennium kids: https://www.millenniumkids.com.au

Urban Forest Strategy

https://www.victoriapark.wa.gov.au/Around-town/Environment/Urban-Forest-Strategy

Abstract from presentation at the World Forum on Urban Forests 2018: Pge 116

https://www.wfuf2018.com/public/file/WFUFBookofAbstracts-26025.pdf

Presentation from the World Forum on Urban Forests 2018:

PS 4.2: Changing People – Chaired by Andrej Verlic:

https://www.wfuf2018.com/public/file/PS42JohnstonUK-25856-25857.pdf

*Please note that the file name PS42Johnston_UK has the incorrect country of origin, it should read AUS not UK (the presentation is for Victoria Park in Perth)

PLANNING SHADEWAYS IN BENDIGO: AN EXAMPLE OF DIGITAL PLANNING TO ADAPT TO EXTREME HEAT

Andrew Butt and Marco Amati
Centre for Urban Research, RMIT University, Melbourne

Abstract

Addressing extreme urban heat is rapidly becoming a core planning issue. For example, this year the Red Cross presented the UN with a guide for coping with extreme urban heat. Under climate change, green and 'grey' shade infrastructure has a vital role in protecting vulnerable populations and allowing the active use of public spaces. This concern has become particularly acute in Australia's inland cities where evidence of heat stress on people and urban vegetation is gaining broader community recognition. *Shadeways* is a digital solution designed for the city of Bendigo, Australia – a city where climate change, ageing and community disadvantage are evident. This paper describes the project's innovative approach to utilizing and triangulating geospatial data, community perspectives on urban greening and community shade mapping activities to develop a shade mapping and (walking) route comfort model for the city. The project addresses the challenge of providing up to date heat information for planning active travel on a mobile platform. In general, the project also supports initiatives to engage communities in strategies for urban greening and heat responses through localised temperature sensors. The research findings provide a guide for similar communities to replicate heat mapping in urban suburban and peri-urban areas, as well as demonstrating levels of community interest and capacity to utilize data and recognise shade benefits.

Key words: *Urban Heat, Green Infrastructure, Urban Analytics.*

Introduction

Urban heat management is an increasing planning issue internationally and in Australian cities. The intersection of climate change, population ageing, public health concerns and urban design for active transport coalesce in this issue – focusing in initiatives aimed at urban greening. It is also evident that community perspectives of the value of urban shade, urban greening and the amelioration of urban heat are contested, and in flux in many places.

Planning for enhanced green infrastructure needs both evidence of benefits and high levels of community support. Mapping the heat, comfort and shade in cities and neighborhoods offers the capacity to consider issues of public investment, planning regulation and to engage with communities about green infrastructure.

This paper explores these issues through the case study of the Shadeways Project, conducted in Bendigo, Victoria during 2017-2019[1]. The project utilized remote sensing, street level data collection and community engagement to consider how to both increasingly operationalize shade and green infrastructure as a strategic issue locally and at the city-scale, and also how to offer communities a perspective on the value and utility of shade in daily life. This program is coupled with a broader policy agenda of addressing heat and shade in Bendigo from local government, Bureau of Meteorology and community organizations.

The paper concludes with a set of considerations to guide the way that data and its analysis perform in process of public decision-making about shade infrastructure, and the challenges presented by an increasing variety of open data sources, including that collected and collated by broad processes of public, digital interaction.

[1] This project was funded by the Commonwealth Department of Infrastructure, Regional Development and Cities and supported by funding from RMIT, La Trobe University, City of Greater Bendigo and Spatial Vision

Shade as Urban Infrastructure

Interest has emerged in policy and public discourse focusing on urban shade infrastructure in Australian cities during a period that includes, globally, the warmest decade on record. Concern about the direct, indirect and cumulative impacts of heat and sunlight on human health have become a critical policy concern at the local level in the design of parks and schools (Dobbinson et al., 2009; Buller et al., 2017). However clear and meaningful infrastructure solutions in the public realm are often less advanced, and subject to tensions with other objectives in urban spaces, relating to design, natural habitat and risk management, for example.

High temperature events create varied impact within communities, however, it is broadly recognized that urban residents form the frontline of this threat (Estrada, Botzen et al. 2017), particularly in larger cities where these impacts are clearly evident through the amplification effects of an urban heat 'island' and of urban air pollution on temperature (Moriarty and Honnery 2015). Consequently, urban planners are recognizing the imperative to increase adaptation strategies for excess urban heat (Inayatullah 2011). This includes the clear recognition of urban heat impacts in public health planning for Australian state and local governments (DHHS, 2018). High temperatures and unsuitable public realms also result in reduced outdoor recreation activities, with consequences for chronic diseases and broader public health outcomes (Kjellstrom, Butler et al. 2010). Additionally, and particularly in Australia, the increased risk of exposure to UV radiation from low-shade urban environments is considered to contribute to the rate of skin cancer (Tracey, et al. 2010; Lefevre, de Bruin et al. 2015).

Natural or built shading is the oldest and most evident solution to urban heat and comforts in the public realm (Moll 1989), however, Australian cities exhibit many unequal and poorly-suited shade solutions in public and private realms. Different populations (for example older aged cohorts) may need, and utilise, more urban shade compared to others – different groups perceive outdoor thermal comfort differently. The urban context matters too, surfaces, built form, and of course local climate. The challenges of provision then relates to context of community and place, often resulting in poorly suited solutions (Boumaraf & Tacherift 2012). It is also evident that in Australian cities the distribution of *green* and of *shade* infrastructure is spatially and socio-economically uneven. Communities experiencing disadvantage are known to have poorer shade (and green) infrastructure quality and quantity (Anderson et al., 2012) and these reflect the broader issues of spatial inequality in urban design outcomes.

To explore these outcomes in a specific setting, the Shadeways project was developed in 2018, supported by a Commonwealth Government *Smart Cities and Suburbs* grant with application in urban Bendigo and investment from industry partners (www.shadeways.net). The concept of a 'shadeway', has been in use in the City of Brisbane since 2006 (Lyndal Plant, personal communication, 2019) as a corridor (particularly a walking route) through the urban environment with a relatively higher amount of natural and built shading, providing increased thermal comfort. In the Brisbane example, the City of Brisbane assigned two goals for its shadeways including an increase in shade from 35% (in 2010) to 50% (by 2031) for footpaths and bikeways in residential areas, the promotion of resident satisfaction with shade cover on footpaths in their suburb (Brisbane City Council, 2017).

Our conception of an effective *Shadeway* is multifaceted feature meeting the needs and the expectation of different population and user groups. It includes urban greening and the maintenance and preservation of tall trees (>10 m height) and the valorization of heritage shade infrastructure such as verandas. It also considers urban morphology: while Australian cities do not have citadels with narrow roadwidths to guarantee shade for most hours of the day, the laneway comprises a niche and serendipitous solution.

At the same time from local to National levels, governments that commission studies are being encouraged to share data (for example, https://data.vic.gov.au). We contend that the focus of planning should be on the design of the mobile interfaces that are used by people to access this data as well as the design of spaces and cities. In the context of Shadeways such a design should be based on various criteria, including community preferences for mobility and seasonal comfort in active transport. This suggests a people-place-information triad is necessary to gather the data required for planning and for the provision of meaningful insights for decision-makers (Fisher, Landry et al. 2007). The aim of this article is to highlight the frontiers of a pilot study to use modern technologies (a GIS-cloud platform) and understand the community expectation and policy-making possibilities of the Shadeways concept.

The Bendigo *Shadeways* Project

Shadeways Project involved key three areas of activity:

1. The development of an urban heat/thermal comfort mapping program;
2. Support for an enhanced network of localized temperature sensors; and,
3. A process of testing and research on issues of shade and active transport with community members

The outcomes of the project are ongoing, but include:

- Testing and synthesizing a series of heat comfort maps utilising a variety of available datasets from satellite/remote sensing sources, local government datasets and sources drawn from ground level observation;
- A prototype route mapping tool aimed at enabling heat/thermal comfort considerations for user-designing walking and cycling routes;
- Preliminary testing of attitudes, awareness and preferences for shade and green infrastructure in the setting of this small regional city.

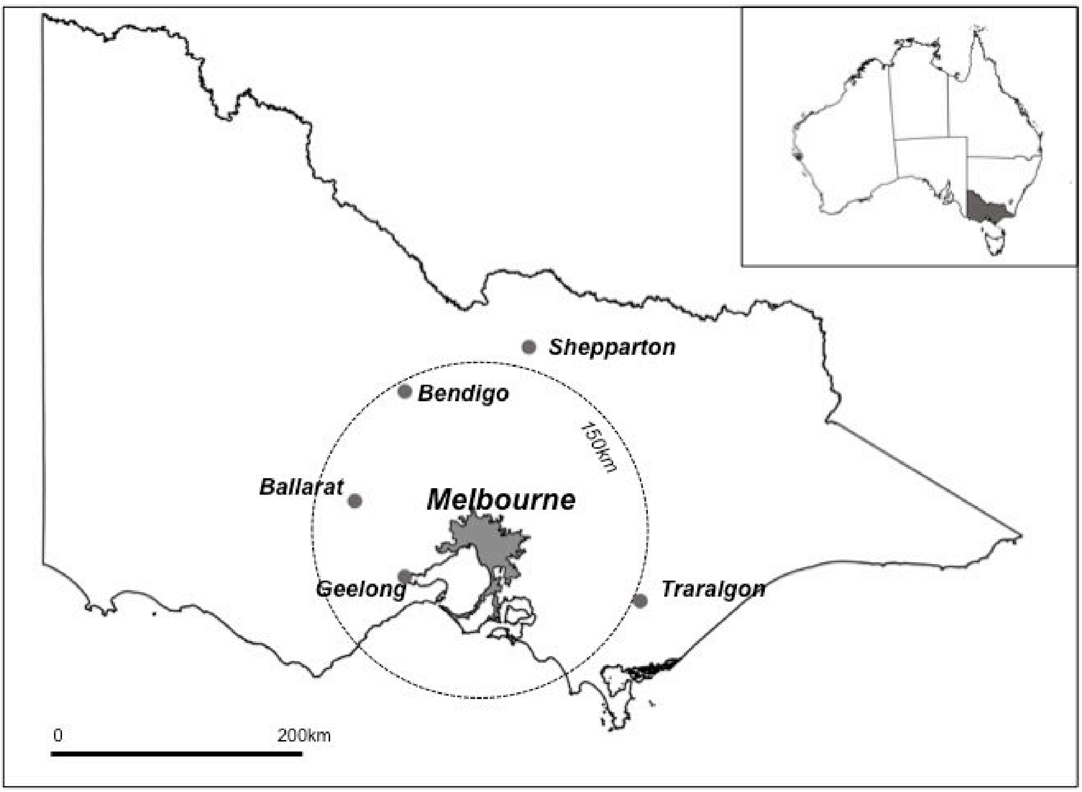
The context of the activity is significant. This relates not only the climate and community in a small, regional city, but also to the quality and availability of data, including GIS data, which is better than many small rural areas, but lacks the breadth and quality of many larger metropolitan areas. The process and contextual issues are outlined below.

The Context of Bendigo

Bendigo is a small to mid-sized Australian city with an urban population of just under 100,000 people (ABS, 2019). Bendigo is located 150 kilometres north west of metropolitan Melbourne and is experiencing population growth driven by various factors including metropolitan 'spill-over', regional (rural) population centralisation and broad economic restructure. Bendigo city features built heritage and urban landscapes drawn from a 19th century European imaginary that are superimposed onto a landscape of dry forest, intermittent waterways and abandoned gold mining sites. It has a relatively low rainfall (510 mm/year) and relatively high summer temperatures and a high annual proportion of clear, sunny days (BoM, 2019)

Despite a gold mining urban history, by the beginning of the 20th century gold became harder to extract, mining declined and the city stagnated. In 1901 the population was 39,400, declining until the 1950s. From the early 1970s the population began to grow due to industrial investment, the decentralisation of government functions and the establishment of higher education institutions.

Over the last twenty years population growth has been sustained, averaging over 1.5% per year, which is high in comparison to many urban areas, but it also exhibits an ageing population, and high levels of socio-economic disadvantage when compared to metropolitan Australia.



Map 1: Bendigo in the context of cities in Victoria, Australia

The urban morphology of the city is atypical for an Australian urban centre, and it is driven by three distinct patterns;

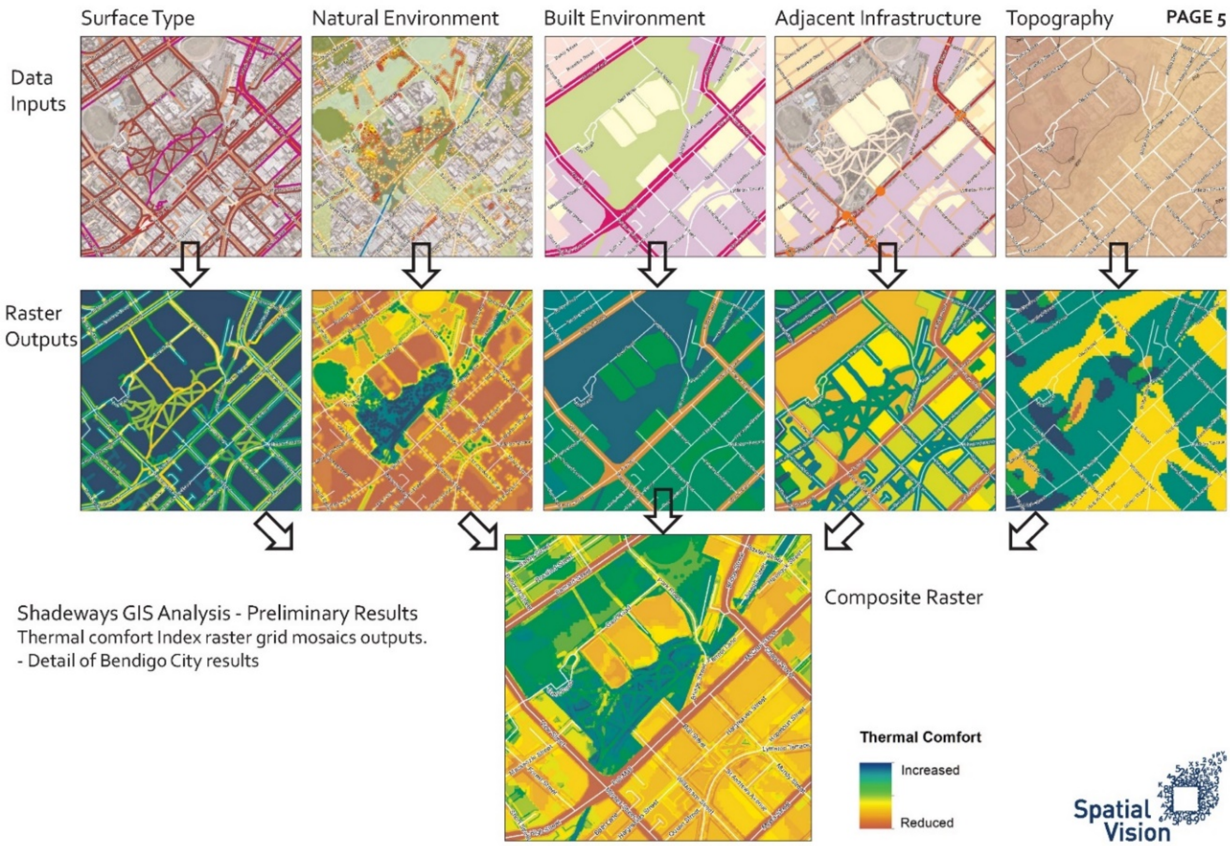
1. a formal, ordered Victorian era layout including wide, grid streets and formal urban plantings on streets and parks, in common with many Australian cities. The city centre also includes traditional areas of 'hard' shade in the form of verandahs, but only limited multi-storey development.
2. Beyond this a more scattered morphology following the gold mining activities and communities along the creeks and gullies which includes limited formal and structures streetscape planting, haphazard public open space provision and areas of unused (and often contaminated) former mining sites within the urban footprint that constrain development and are predominately in lower socio-economic suburban area
3. A car-based suburban form established since the mid 20th century which includes areas with and without formal pedestrian pathways and varied street planting including domestic and introduced species. Unlike metropolitan Australia, this suburban development includes many areas of informal road and pedestrian infrastructure, more consistent with peri-urban regions. The morphology of Bendigo is also substantially shaped by the forest (public land) that virtually encircles the urban area. In many places urban development is located hard up against extensive native vegetation and public land which serves as a recreational space. The city has a highly centralized employment pattern, low rates of active transport and few of the diseconomies of scale experienced in larger metropolitan regions that would typically lead to transport choices beyond the car. For many, reliance on active transport is challenging in summer months due to climate.

The distinctive social context and urban morphology of Bendigo matter in this project. An older population, a car-based transport preference and a sprawling, scattered urban form shape the experience of using the public realm. Similarly, the existing urban green infrastructure is subject to strong community opinions with the contest most typically framed between formal planting and indigenous vegetation and with urban planting and tree management often controversial (Jones, 2014).

Mapping Thermal Comfort – A Heat Vulnerability Index (HVI)

The explorative mapping process was an iterative activity which utilised several sources. Initial mapping utilised data available from the City of Greater Bendigo (CoGB) GIS dataset including road and footpath data to determine land use (especially road surfaces). This was combined with satellite imagery from Landsat and MODIS data to develop a Thermal Comfort Composite map which identified and scored areas of lower and higher relative heat and consequently scored heat comfort on the public road network in collaboration with the industry partner, Spatial Vision (see Figure 1).

Figure 1: Schematic of Data Inputs to the Thermal Comfort Index



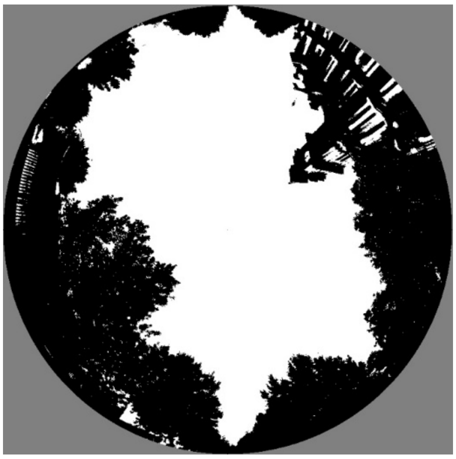
Temperature data derived from satellite thermal image are usually limited in spatial-temporal scales, for example, Landsat data is only available for morning surface temperature, while MODIS temperature data has low spatial resolution at 1000m but has available images at multiple times a day including morning and afternoon times. The resulting temperature dataset contains afternoon land surface temperature at 30m resolution (Figure 1). An assumed afternoon temperature was created using techniques adapted from previous studies (Hazaymeh & Hassan, 2015; Ping, Meng, & Su, 2018). This enabled the identification of likely 'hot' and 'cool' routes between key urban locations.

Figure 2. Calculating sky view factors along travel routes using Google Street View images

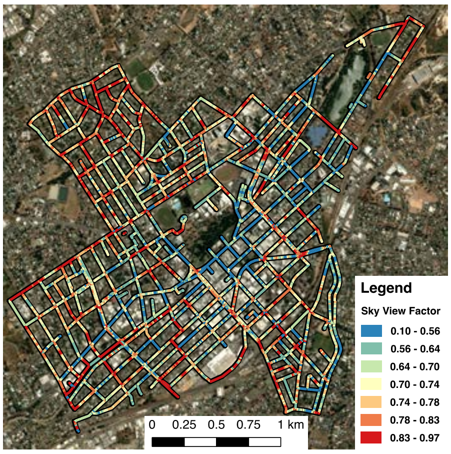
a. Example panorama image

b. Transformed fisheye image

c. Mean shifted image



d. Classified image

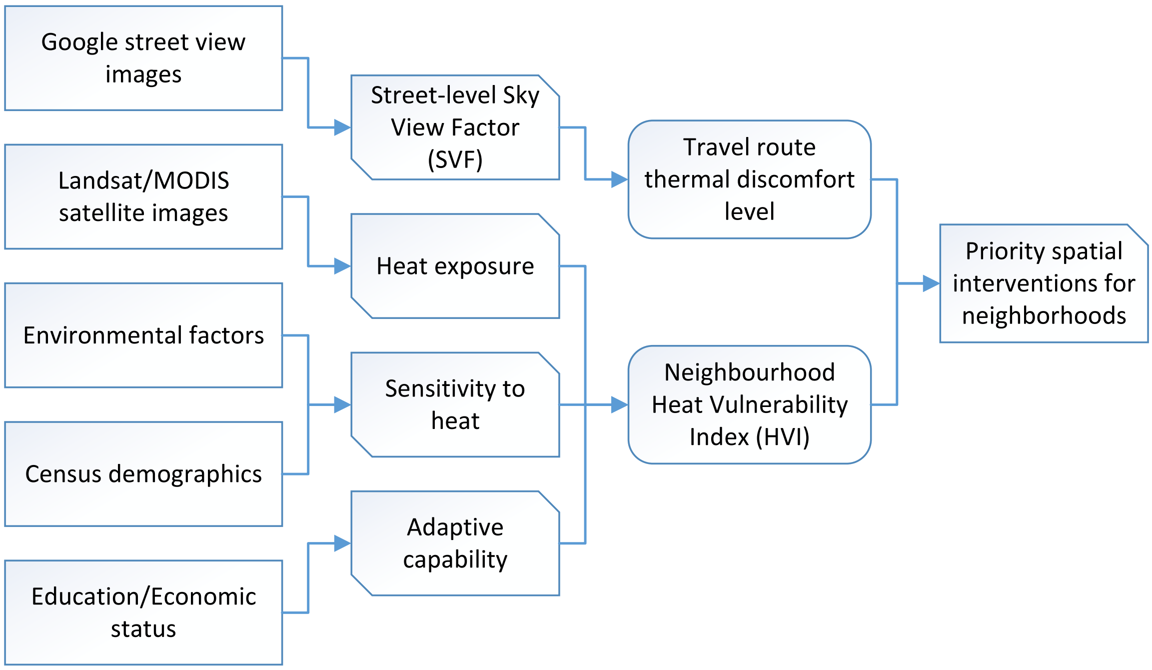


e. SVF map of Metropolitan Bendigo

The second stage involved creating a composite of these results with ABS Census data at meshblock level for indicators of socio-economic disadvantage and vulnerability – a Heat Vulnerability Index (HVI). This included measure of Heat Sensitivity (urban density, tree density) and Adaptive Capacity (prevalence of old and young people, levels of education and economic disadvantage). The purpose of this stage was to recognise the links between exposure, localised urban character and population type and also to establish those areas where improved shade was a critical issue for urban mobility.

Satellite data is unlikely to fully recognise the shade experience at street-level. Consequently a subsequent stage was undertaken to establish a 'sky view' factor. This utilised Google Street View imagery extracted at 10 metre intervals across the Bendigo street network. Once downloaded, the top half of each Street View panorama (Figure 2c) was transformed it into a 'fisheye' image (Figure 2.b), classified into 'shade' and 'sky' and the proportion of street-visible 'sky' calculated from a model proposed by Li et al. (2018).

Figure 3: *Flowchart* of work program for HVI and Travel Route Mapping



Perceptions of Shade

The Shadeways project involved two pilot activities seeking user input. Each was limited in scope, and intended to offer insight to approaches that have potential for application with a broader process of community research and aimed to:

1. understand likely pedestrian user perspectives and attitudes to concepts of urban shade and how this relates to habits in daily activities

2. test and 'ground truth' assumptions made about heat and comfort drawn from the various mapping processes undertaken as the core of the project

The form of engagement at this stage involved a series of focus groups and an activity using hand-held mobile devices in urban streets

The focus group process involved two stages:

1. Firstly a broad discussion of habits and perspectives on views and habits in relation to shade, walking and urban greening.

2. A second stage sought views on a series of prepared photographs of various intersections in Bendigo.

Focus Group - Discussions

Most participants showed habitual awareness of heat in daily (summer) activities. In each group, participants revealed regular behaviours that avoid hot weather, but also a desire to continue daily practices of walking, both for leisure/fitness and for daily activities (such as work or shopping).

I am conscious of the heat, particularly for gardening, like I'll put that off as an activity into the evening so… I garden a lot I feel like I'm always aware of the heat because I'm always thinking about it in relation to the plants

Walking the dog, you've got to do that early… before lunch

if there's an activity I want to go to whether it's work or something with my children, and it's too close not to walk…just have to walk, and just manage that in carrying water and hats and things

Conversely, participants also recognised the limits of coping through changes.

I like to walk, I, I prefer to park on the periphery and walk, but when it's hot, it… you've got to think all that through even clearer

I drive a bit too I must say, if it's a hot day, yeah, I just get in the car and drive

In relation to route choice, discussions were mixed. Some respondents described making clear choices to select routes, while others recognised limitations in this regard.

I've taken a few different like, side streets and bits that are like, off Google Maps, that I've just been able to kind of sus out on my way home, when I have a little bit of extra time to explore

…it's more comfortable isn't it, when you're cooler, so choose the shady routes. Unless you are running late

Sites such as a local reservoir were recognised for the comfort provided by shade

(The Reservoir) is attractive because you can run around and you're in shade most of the way around. Unless you do the boardwalk bit, but if you do the full circle there's very little sunshine

In relation to urban greening as shade infrastructure, responses were mixed. Participants typically understood the challenges and competing objectives of urban greening in the public realm. In this regard views were mixed about how urban street planting should be undertaken and managed. Discussion also involved question of native vs introduced species and their shade value.

that entry to Bendigo is so beautiful, years ago all the native gums down the middle… was just stunning

they provide an incredible amount of shade, [but], if we start doing more plantings for streets, you know so people can have shady areas, we're looking at a 20 year turnover

I love the bush tracks as well but they always, it's complicated because it's not, you see they're dryness in a way, so they, they always feel hotter

Discussion also involved consideration of the value of 'hard' versus 'green' infrastructure as a solution. Infrastructure variations (such as path surfaces) were also discussed

If you go to Mildura, it's shade, shade… all the car parks have them everywhere, Mildura's really onto it

you go out to Kangaroo Flat and all the parking in that area is all under shade

you look for that shade…shopping centres…you know that should be compulsory if they're going to build anymore of the damn things

we're now getting heat like Cairns used to get, and you go up there, and everything's under shade, and I'm talking about artificial shade - I don't care what the shade is… and that's the way it'll go

Some days you can handle the heat because the glare's not as strong

Focus Group - Route Preference

Participants were shown a selection of six (6) set of photographs taken in November 2018 at intersections in Bendigo (see examples below). The locations formed routes with options at various points and included an alignment along Bridge St and Lucan St, and a second route along Reservoir Rd and Harley St. Through the photo elicitation, respondents were asked to express a ranked preference for a route direction. The selection of sites was intended to offer examples of established deciduous plantings as well as native species, and older and newer streetscapes.

Outcomes of the route selection activity included:

- Preferences for older, established introduced species
- Preferences for green shading over 'hard' shade
- Recognition of ground surfaces, including perceptions of glare
- An understanding of the limited value of ornamental street planting (particularly *prunus* species)

From a methodological standpoint, the process of photo elicitation provided two outcomes:

- The concept of route choice and visualising aspects of preference has potential (with an increased dataset) to explore "machine reading" of features include shade, glare and shade quality (see also discussions on the use of Google Street View)
- Capacity for verification of the results of 'remote' thermal comfort mapping (aerial and street view). For example the perception of pedestrian experience in Lucan St (where shady footpaths are dominant) required recalibration of the thermal comfort mapping that was heavily influenced by the width of the asphalt road area.

Handheld Device Exercise

In February-March 2019 a pilot exercise in route selection and preferencing was undertaken using handheld mobile devices. Participants used a proprietary GIS software package (GISCloud). This was *not* a purpose built app as the exercise was designed to test the user experience of such an activity.

The users were asked to walk in the selected neighbourhoods on warm, sunny days and, when at intersections, photograph their preferred direction and answer a series of questions about why that route is preferred. Images and survey responses were geo-tagged and mapped.

From a methodological standpoint, the process of mobile review provided similar outcomes to the photo elicitation, albeit with an *in situ* activity:

- The concept of route choice and visualising
- Capacity for verification of the results of 'remote' thermal comfort mapping

The exercise also provided input to the route mapping app design.

Collectively, the participants recorded the data from 226 routes. Table 1 shows the descriptive statistics derived from the collected data. As shown in Table 3a, overall, 52.3% of the routes visited by participants suffered from either no or poor amount of shading. Also, 51% of respondents indicated that they would cycle or walk along a specific route if it has more shading. (The result implies the significance role of shadiness to promote physical activity among city residents. We also found that, overall, 44.2% of participants were not comfortable (disagree, somewhat disagree and strongly disagree) with the temperature of the visited routes. Moreover, the obtained results can provide a better picture about the traffic and directness of the visited routes. Collectively, 69% of the routes suffered from traffic fair, somewhat or heavy traffic. This study also applied cross-tabulation analysis to examine the traffic status of the routes and their related shadiness. This is key information for a stakeholder due to the fact that commuters may avoid specific routes despite having sufficient shadiness. This may have a negative impact on the rate of return of related infrastructures (e.g. sidewalks).

It was found that 53 of shaded areas (acceptable, good and excellent) located in the routes with somewhat and heavy traffic. This almost represents 24% of visited routes.

Table 1: Cross- tabulation results between shadiness and traffic of the routes.

		Assess the amount of shading					Total
		No shade	Poor shade	Acceptable shade	Good shade	Excellent shade	
Assess the amount of traffic	Heavy traffic	16	10	6	12	11	55
	Somewhat traffic	13	9	12	8	4	46
	Fair traffic	20	11	8	9	5	53
	Poor traffic	12	11	3	12	8	46
	No traffic	10	4	2	2	4	22
Total		71	45	31	43	32	222

Evidence, planning and mobilising community

In this project we present some preliminary results from the Shadeways project. While the results serve as a snapshot of the actions of a local government in the face of extreme heat, one of Australia's most significant urban challenges, we argue that the challenges we faced in this project are of wider significance for planning for green infrastructure and for shading in a changing climate. This includes the issues related to how local government and community engage in deliberations about strategy and costs in refitting urban areas for enhanced shade, as well as how these issues become visible in public discourse.

Data generated either through satellites and Google Street View (a tenuous and difficult to use data source, especially for replicable or publicly available uses) is not easily translated into meaningful information from a human point of view (Hoene at al. 2018). Our focus groups illustrate how subjective the sensations of heat are, and that although timely information may be desirable, it may not be possible to achieve this – even with the biggest data set.

In Bendigo the project relied on mixed sources of data, many of which are of varied quality, such as the footpath network GIS layer, and this needs work before a fully effective 'cool' route app can be developed. Other issues in this example relate to the particular nature of travel behaviours and drivers of change in a regional city, and the specific urban morphology of a post-mining landscape and streetscape However, this is a city seeking to innovate and increasingly move to a new era of open data and the use of a range of data sources to inform decision-making about public investment, while recognising the ongoing challenges of this task.

References

ABS (2019) Regional Population Growth, Australia, 2017-18, (Catalogue Number 3218.0), Australian Bureau of Statistics, Canberra

Anderson, C., Jackson, K., Egger, S., Chapman, K., & Rock, V. (2014). Shade in urban playgrounds in Sydney and inequities in availability for those living in lower socioeconomic areas. *Australian and New Zealand Journal of Public Health*, 38(1), pp. 49-53

BoM (2019) Climate Statistics for Australian Locations: Bendigo, Bureau of Meteorology, Canberra <Online at http://www.bom.gov.au/climate/averages/tables/cw_081123.shtml>

Boumaraf, H. and A. Tacherift (2012). "Thermal comfort in outdoor urban spaces." *Studies in* Mathematical Sciences 6, pp. 279-283.

Brisbane City Council (2017). Brisbane: Clean, Green, Sustainable 2017–2031.

Buller DB, English DR, Klein Buller MK, Simmons J, Chamberlain JA, Wakefield M, Dobbinson S. Shade (2017) Sails and passive recreation in public parks of Melbourne and Denver: A randomized intervention. *American Journal of Public Health*, 107(12) pp. 1869-1875.

DHHS (2018) Heat Health Plan for Victoria: Protecting Health and Reducing Harm from Extreme Heat and Heatwave, Department of Health and Human Services, Melbourne. Available online: https://www2.health.vic.gov.au/public-health/environmental-health/climate-weather-and-public-health/heatwaves-and-extreme-heat (accessed on 27 July 2019)

Dobbinson, S., White, V., Wakefield, M., Jamsen, K., White, V., Livingston, P., English D. and Simpson, J. (2009), Adolescents' use of purpose-built shade in secondary schools: cluster randomised trial. *British Medical Journal*, pp. 338–395

Estrada, F., W. W. Botzen and R. S. Tol (2017). "A global economic assessment of city policies to reduce climate change impacts." Nature Climate Change 7(6) p. 403

Fisher, K., Landry, C. and Naumer, C. (2007). "Social spaces, casual interactions, meaningful exchanges:'information ground'characteristics based on the college student experience." *Information Research* 12(2) pp. 12-12.

Hazaymeh, K., and Hassan, Q. (2015) Fusion of MODIS and Landsat-8 surface temperature images: a new approach. *PLOS ONE*, 10(3), e0117755.

Hoehne, C., D. M. Hondula, M. Chester, D. P. Eisenman, A. Middel, A. Fraser, L. E. Watkins and K. Gerster. 2018. Heat exposure during outdoor activities in the US varies significantly by city, demography, and activity. Health & Place 54(Nov):1-10. DOI: 10.1016/J.HEALTHPLACE.2018.08.014. (link)

Inayatullah, S. (2011) City futures in transformation: Emerging issues and case studies, Futures 43(7), pp. 654-661.

Jones, A. (2014) Bendigo, the town that became scared of trees (audio), ABC Radio <online at https://www.abc.net.au/radionational/programs/offtrack/the-town-that-became-scared-of-trees/5367286>

Kjellstrom, T., Butler, A., Lucas, R., and Bonita R. (2010). "Public health impact of global heating due to climate change: potential effects on chronic non-communicable diseases." *International Journal of Public Health* 55(2) pp. 97-103.

Lefevre, C., de Bruin, W., Taylor, A. Dessai, S., Kovats S., and Fischhoff, B. (2015). "Heat protection behaviors and positive affect about heat during the 2013 heat wave in the United Kingdom." *Social Science & Medicine* 128(2) pp. 282-289.

Li, X., Ratti, C., & Seiferling, I. (2018) Quantifying the shade provision of street trees in urban landscape: A case study in Boston, USA, using Google Street View. *Landscape and Urban Planning*, 169, pp. 81-91.

Moll, G. (1989) Shading our cities: a resource guide for urban and community forests, Island Press, NY

Moriarty, P. and D. Honnery (2015). "Future cities in a warming world." Futures 66: 45-53.

Napoli, M., L. Massetti, G. Brandani, M. Petralli and S. Orlandini (2016). "Modeling Tree Shade Effect on Urban Ground Surface Temperature." Journal of Environmental Quality 45(1): 146-156.

Ping, B., Meng, Y., & Su, F. (2018). An Enhanced Linear Spatio-Temporal Fusion Method for Blending Landsat and MODIS Data to Synthesize Landsat-Like Imagery. Remote Sensing, 10(6), pp. 881-893

Tracey, E., Kerr, T., Dobrovic, A., & Currow, D. (2010). *Cancer in NSW: incidence and mortality report 2008*. Sydney: Cancer Institute NSW

AVENUES OF HONOUR PROJECT

Hon Kevin Scarce

Chancellor, University of Adelaide
Patron, Avenues of Honour

I am delighted to join you this afternoon at the 20th National TREENET Symposium, and equally delighted to join as Patron of the Avenues of Honour Project.

It's perhaps not unsurprising for an ex-military man to accept a role that seeks to create a living memory for the Australians who paid the supreme sacrifice in serving this nation.

Having toured through the western front on a couple occasions, and particularly the Australian remembrance trail, I continue to marvel at the manner in which our serviceman are remembered by the local population more than 100 years after the end of the war.

Whether in a school at Dernancourt, the nightly service at Menin gate or at one of the many cemeteries, the French and Belgian communities remain steadfast in their appreciation of the efforts of Australian servicemen.

The next major project of the Avenues of Honour will be to create a Centennial Anzac Memorial Avenue along a public road in the Somme, to commemorate Australians who died on this front in France during WW1. What could be better than a living avenue of majestic trees to replicate what was there at the time of the start of the twentieth century. This will complement the wonderful avenues already established in Australia.

The avenue will represent a significant affirmation of the historic alliance between France and Australia after WW1 and will commemorate the centennial of the end of the conflict.

I commend Glenn and David on this next venture to set up an Avenue of Honour across on the Western Front, to honour the service, suffering and sacrifice of the 46,000 Australian's still lying in French soil. It is vital that future generations of Australians have an opportunity to remember our fallen servicemen and women. To do so in a manner which benefits the environment is an added bonus.

There is a crowd funding site that has been established to help raise funds for the French project. I hope you can join me in supporting this important program.

https://avenuesofhonour.org/

https://chuffed.org/project/centennial-australian-memorial-avenue-at-western-front-france

TREE CITIES OF THE WORLD

Dan Lambe

President, Arbor Day Foundation
August 1, 2019

At the Arbor Day Foundation, planting trees is at the heart of our mission "to inspire people to plant, nurture, and celebrate trees." We are now in our fifth decade of planting trees and forests, in rural areas, in cities and towns, across our country and around the globe. We know that trees can change people's lives and that trees, in fact, provide the necessities of life itself. We all need clean air to breathe and healthy water to drink. We all need a climate that's tolerable and communities that ensure personal health and wellbeing. These are global issues that demand an urgent global response, at an unprecedented scale. If ever there was a time for trees, now is that time.

Partnerships and positive reinforcement are cornerstones of every endeavor, and every program, at the Arbor Day Foundation. We know that to achieve our vision of "being a trusted leader in creating worldwide recognition and use of trees as a solution to global issues," we must engage citizens, community leaders, and like-minded partners to have a lasting effect. Our Tree City USA program—started in 1976 with the support of state foresters and the USDA Forest Service—has provided a framework for community forestry management in the United States. Using core standards, we help the managers of community trees gain recognition for their work, knowing that there is always room to grow, to learn, to improve. But achieving recognition from the Arbor Day Foundation has long been that positive first step towards urban forest sustainability.

Our experience with recognition programs in the U.S. has taught us that citizens and community leaders increasingly value community trees. They know, as we do, that trees and forests are vital components of healthy, livable, and sustainable communities. Urban forests define a sense of place and well-being where people live, work, play, and learn. And we all know that the need for healthy trees in urban spaces is great: cities are hotter than ever, air and water pollution affect millions of people, and the frequency and intensity of storms is growing. Insects, diseases, storms, and the constant pressures of urban growth claim more trees every year. City budgets are tight. The need for management of our urban and community forests has never been greater, all around the globe.

That's why we are launching a new program—with support from the United Nations Food & Agriculture Organization (FAO)—called **Tree Cities of the World**. From the largest mega-cities to the smallest villages, this program is meant to recognize communities that commit to ensuring that their urban forests and trees are properly maintained, sustainably managed, and duly celebrated. Our shared goal is to foster a robust and diverse network of communities, practitioners, advocates, and scientists that will lead to sustainable urban forests across the globe. This initiative is key to FAO's role in supporting the development of urban and peri-urban forestry projects and planning tools that promote a sustainable and resilient model for cities around the world.

Following the pattern of our recognition programs in the U.S., we have established basic eligibility criteria and standards that will guide this new program. At the end of calendar year 2019, any municipal government with the authority over city-owned or managed trees can apply to join Tree Cities of the World. Applications will be renewed annually to continue recognition.

That government entity—be it a city, a town, or a village—must document that it meets the five core standards that show a commitment to caring for its trees and forests:

STANDARD 1: ESTABLISH RESPONSIBILITY

The community has a written statement by city leaders delegating responsibility for the care of trees within the municipal boundary to a staff member, a city department, or a group of citizens—often called a "tree board."

Our intent is to set the stage for professional management of community trees and forests. While interested citizens often play a part in holding city leaders accountable and filling necessary management roles in the smallest towns, we know that trained arborists and urban foresters are best suited to deliver a safe, healthy, and growing urban forest to residents.

STANDARD 2: SET THE RULES

The community adopts policies, best practices, or industry standards for managing urban trees and forests. These rules describe how work must be performed, where and when they apply, and penalties for noncompliance.

In the U.S., we have a legal system for adopting local laws and regulations, but we know that other systems may be in place internationally. The U.S. legal system is also underpinned by a fundamental separation of public and private property that may not exist elsewhere in the world. Therefore, we have chosen a highly flexible standard that includes the adoption of professional standards for safety and conduct, or the adoption of ISA Best Management Practices as ways to meet this standard.

STANDARD 3: KNOW WHAT YOU HAVE

The community has an updated inventory or assessment of the local tree resource so that an effective long-term plan for planting, care, and removal of city trees can be established.

It is a time-honored saying that you must know what you have in order to manage it, so we have included this concept as a core standard. The manager must be able to report at least one of two key metrics: the total number of trees under city management, or the percent canopy cover for the municipality. Of course, those numbers should drive the goals of the city tree plan but having such counts of trees is the foundation of an effective tree plan. With the worldwide availability of free software tools, such as i-Tree Canopy, local leaders should be able to meet this standard without difficulty.

STANDARD 4: ALLOCATE THE RESOURCES

The community has a dedicated annual budget for the routine implementation of the tree management plan.

Annual budgeting by cities is hard, but it forces a discussion of priorities. By allocating any amount to community trees, city leaders have chosen the relative importance of this work. But we also know that some planting and tending tasks can be performed by residents, stretching budgeted resources to accomplish more. There are few other public works programs with a similar participatory component.

STANDARD 5: CELEBRATE ACHIEVEMENTS

The community holds an annual celebration of trees to raise awareness among residents and to acknowledge citizens and staff members who carry out the city tree program.

Celebrating accomplishments annually has been a hallmark of recognition programs offered by the Arbor Day Foundation since the very beginning. Positive reinforcement puts city trees and tree managers in the limelight for a moment, helping to raise awareness among both residents and political leaders of the importance of city trees and forests.

Local leaders may ask, “What do we get from this new recognition program?” One likely outcome of joining Tree Cities of the World is simply the benefits that healthy city trees and forests provide to the residents they serve, including reduced costs for energy, stormwater management, and erosion control. But annual celebrations such as Arbor Day or other festivals provide leaders a chance to show citizens that they care about the environment, and participation in the network builds connections to like-minded cities all around the globe.

As we look to spread the word about this new opportunity, we are actively seeking individuals and organizations, such as TREENET, to help communities of all sizes across Australia work towards meeting the five standards in 2019. At TreeCitiesoftheWorld.org you can learn more about the program and find ways to spread the word to communities in your country.

This is an exciting moment for the practice of urban and community forestry. With most of the world’s population now living in cities, our profession is needed more than ever. The essentials of life are at risk. We must ensure that people have clean air to breathe, clean water to drink, and a livable climate. We need to create resilient cities that can quickly restore tree cover following storms that are increasingly damaging. We must integrate trees and forests into the very fabric of our growing cities, so that all residents can share in the benefits that community trees provide. Now is the time for trees. And we need your help to achieve this vision. Join us in our effort to create a new global network of cities dedicated to the sustainable practice of urban and community forestry and grow the profession worldwide.