THE UNIVERSITY of ADELAIDE

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ASSOCIATIONS

Arboriculture Australia Ltd
Council Arboriculture Victoria
Institute of Australian Consulting Arboriculturists (IACA)
Local Government Tree Resources Association (NSW)
Nursery & Garden Industry SA Inc (NGISA) Queensland Association of Arboriculture (QAA)
Victorian Tree Industry Organisation (VTIO)

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CORPORATE

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Arborman Tree Solutions Arbortrack
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Terra Cottem Australasia Pty Ltd
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Trentcom APS Pty Ltd

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

TREENET MANAGEMENT COMMITTEE AND ADVISORY BOARD 2014

TREENET MANAGEMENT COMMITTEE

Chairperson:	Dr Greg Moore
Director:	Glenn Williams *(ex officio)*
Director:	David Lawry OAM (*ex officio)*
Treasurer:	Darryl Gobbett *(ex officio)*
Members:	Judy Fakes
	Dr Jennifer Gardner
	Tim Johnson
	Cameron Ryder
	Hon Dr Bob Such MP
	John Zwar

TREENET ADVISORY BOARD

Glenn Williams	Director TREENET	SA
David Lawry OAM	Director, Avenues of Honour	SA
Darryl Gobbett	Director, Prescott Securities, Honorary Treasurer TREENET / 1915- 2015 Avenues of Honour Project	SA

Educational and Research Institutions

Prof Chris Daniels	Professor of Urban Ecology University SA	SA
Dr Jennifer Gardner	Director, Waite Arboretum, TREENET Management Committee	SA
Dr Greg Moore	Research Assoc. Burnley School of Resource Management and Geography, Chair, TREENET Management Committee	VIC
Dr Dean Nicolle	Director, Currency Creek Arboretum	SA
John Zwar	TAFESA Urrbrae Campus, TREENET Management Committee	SA

Nursery Industry

John Fitzgibbon	Metropolitan Trees	VIC
Geoffrey Fuller	CEO, Nursery & Garden Industry of South Australia	SA
Hamish Mitchell	Specialty Trees	VIC

Community

Hon Dr Bob Such	Independent Member for Fisher	SA
Hon Michelle Lensink	Liberal Member Legislative Assembly	SA

Arboricultural & Allied Professions

Jan Allen	Terra Ark	QLD
Peter Bishop	Bunya Solutions	QLD
Rob Bodenstaff	Arbor Centre	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	Homewood Consulting, TREENET Management Committee	VIC
Kym Knight	Tree Environs	SA
Mark Willcocks	Active Tree Services	NSW
Quentin Nicholls	Arbortrack	QLD

Landscape Architects and Urban Planners

Michael Heath	Chair National Trust SA Significant Tree Committee	SA

Local Governments

Tim Johnson	City of Mitcham	SA
Christopher Lawry	The District Council of Mt Barker	SA
Lyndal Plant	Brisbane City Council	QLD
Phillip Hewett	Newcastle City Council	NSW
Jason Summers	Hume City Council	VIC
Karen Sweeney	City of Sydney	NSW
Vic Bijl	City of Belmont	WA

State Governments

Judy Fakes	Commissioner, Land & Environment Court NSW, TREENET Committee	NSW
Henry Polec	Department of Planning Transport and Infrastructure	SA

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 organization's environmental purpose.

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

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

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

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

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

22.7 A committee of management of no fewer than three persons will administer the fund. The committee will be appointed by the organisation. A majority of the members of the committee are required to be 'responsible persons' as defined by the Guidelines to the Register of Environmental Organizations.

SPEAKER AND PANELLIST PROFILES

Dr Sandra Taylor

Sandra is an environmental scientist. Since retiring from the University of Adelaide, where she lectured in Environmental Studies for more than 30 years, she has been an Adjunct Senior Lecturer in Urban Ecology in the School of Natural and Built Environments and an Adjunct Researcher in the Barbara Hardy Institute at the University of South Australia.

Stephen Forbes

As Executive Director of the Botanic Gardens of Adelaide since 2001 Stephen has utilised the Gardens and diverse partnerships to contribute plant-based solutions to urban environmental and social issues through programs including sustainable landscapes, green infrastructure and community gardens.

Stephen is currently Chair of the Council of Heads of Australian Botanic Gardens and has published widely in the cultural history of plants, biodiversity conservation and urban landscape management. Stephen holds MPhil from Bath University exploring ecological approaches to landscape management and an MBA from Newcastle University and has worked widely in biodiversity conservation and botanic gardens in Australia and internationally.

Dr Nick Williams

Nick is an ecologist who works predominantly in urban areas because although he realises cities cause of many of the world's environmental problems they offer one of humanity's best hopes for a sustainable future. Nick seeks to understand urban biodiversity patterns and ecosystem processes and develop applied solutions to reduce negative impacts of urbanization such as biodiversity loss, excess urban heat, stormwater runoff and CO2 emissions.

Together with colleagues Steve Livesley and John Rayner, Nick leads the Green Infrastructure Research Group (GIRG) which is studying how we can maximise the benefits plants provide to the urban environment. He has published over 40 scientific papers and regularly presents his work at national and international conferences.

Dr Sharolyn Anderson

Sharolyn's area of research is covered under the broad umbrella of Geographic Information Science; incorporating urban remote sensing, GIS development, Volunteered Geographic Information and internet mapping. Her work has led to areas of ecosystem service valuation projects at local, national, and global scales.

Sharolyn's latest studies involve modelling urban ecological processes from micro to macro scales in Adelaide. As a collaborative project through multi-disciplinary research teams, Sharolyn's particular focus through her publication record covers a variety of topical areas, linked with the integration of remote sensing, GIS, GPS and socio-demographic data, to better understand the world.

Adam Burgess

Adam is the Horticultural Manager, National Arboretum Canberra a position he has held since 2007.

Adam has worked with Mark Richardson, a botanical consultant and the two have visited the Waite Arboretum in Adelaide to understand pruning techniques and management of trees planted there, particularly the dragon trees of which there is now a forest at the National Arboretum Canberra.

Mark Richardson

Mark is a botanical consultant based in Adelaide, Australia. He is working in Australia, the Middle East and Asia on a wide range of horticultural and conservation projects. His work includes the development, management and review of botanical displays and urban tree plantings, the conservation of threatened plant species, the facilitation of work and training programs and policy development.

Michael Rogers

Michael is the Coordinator Arboriculture & Streetscapes at the City of Yarra in the inner suburbs of Melbourne.
Michael's passion for trees has nurtured a culture within Council and the broader community that view trees as an essential community asset that needs to be protected, maintained and increased. Over his time he has had to adapt and hone his arboricultural and communication skills in response to an ever changing diverse and sometimes political environment.

GREEN SPACES IN GREY PLACES: ARE GREEN ROOFS AND WALLS ENOUGH?

Sandra Taylor
Barbara Hardy Institute, University of South Australia

Abstract

This paper explores the causes and consequences of the fact that many of the people living in cities no longer value nature and no longer see it as relevant to their lives. The paper suggests ways to ensure that the experience of urban nature will foster understanding and appreciation of nature in general, so that more people will be willing to invest in biodiversity conservation both in and beyond the urban environment.

Introduction

A variety of geologic processes and events have caused five mass extinctions in history of animal life on our planet. During each of these mass extinctions, there has been a catastrophic decline in the Earth's biodiversity as a significant proportion (more than 50%) of animal species has become extinct in a geologically insignificant period of time (Hallam & Wignall 1997).

It appears that we are now experiencing a sixth mass extinction (Kolbert 2014). The *Red List of Threatened Species* maintained by the International Union for the Conservation of Nature (2014)estimates that 26% (21-36%) of the world's mammals pecies, 13% (13-14%)of its bird species and 41% (31-56%) of its amphibian species are currently threatened with extinction. Barnosky et al. (2011) concluded that if all of these species and the other animal and plant species listed as threatened on the *Red List* were lost during this century, and if the current rate of extinction were to continue, we could lose three-quarters or more of all species within a few centuries, 'a state of mass extinction that has previously been seen only five times in about 540 million years' (Barnosky et al. 2011, p. 56).

Global biodiversity reached a maximum, in the present geologic period, about 30 000 years ago. Global biodiversity has declined since this maximum, primarily due to human impact on natural ecosystems. These impacts include:

- overexploitation, mainly through hunting, fishing and forestry
- habitat loss, through native vegetation clearance for agriculture and, to a lesser extent, urban development
- introduction of invasive species, which has had a devastating impact on Australia's biodiversity
- spread of diseases (e.g., the chytrid fungi affecting frogs)
- pollution, particularly fresh water pollution
- and the knockout blow, climate change (Chapin III et al. 2000).

The magnitude of the current extinction crisis, its causes and its consequences for humanity are not news to those of us interested in environmental issues. As Richard Hobbs (2013, p. 146) has noted, we grieve for a natural world that is mostly 'characterised by loss':

> Whether it is a local and personal loss such as the destruction of a piece of local woodland or a species that was once abundant now being scarce or non-existent, or whether it is loss on a grander and more general scale, such as the destruction of rainforest, the extinction of Australian marsupials, or the decline of the Arctic ice sheet, people with an interest in species, ecosystems, and the environment in general are constantly assailed with accounts of past or impending loss.

The grief we experience, consciously or unconsciously, as environmental scientists, educators and activists is compounded by anger and frustration that we have conspicuously failed to convey the relevance and the urgent need for biodiversity conservation to the general public (Miller 2005).

The reasons for this failure are complex, but one reason is undoubtedly the fact that many people no longer value nature and no longer see it as relevant to their lives. The increasing estrangement of people from nature engenders ignorance about natural processes. This decline in ecological literacy encourages each generation to accept increasingly degraded natural environments as the norm, a process that has been termed 'the extinction of experience' (Pyle 1993, p. xiii).The current rate of biodiversity loss is catastrophic, but it continues largely unnoticed by the majority of people who react with scepticism, apathy or in differenceto predictions of a biologically impoverished future.

Estrangement from Nature

Urbanisation is one of the main factors responsible for the increasing estrangement of people from nature. More and more people are living in towns and cities. More and more towns are becoming cities. More and more cities are becoming mega-cities.
Since 2011, the world's urban population has exceeded its rural population. By 2050, it is expected that 70% the world's people will live in towns and cities (Figure 1) (United Nations 2011).

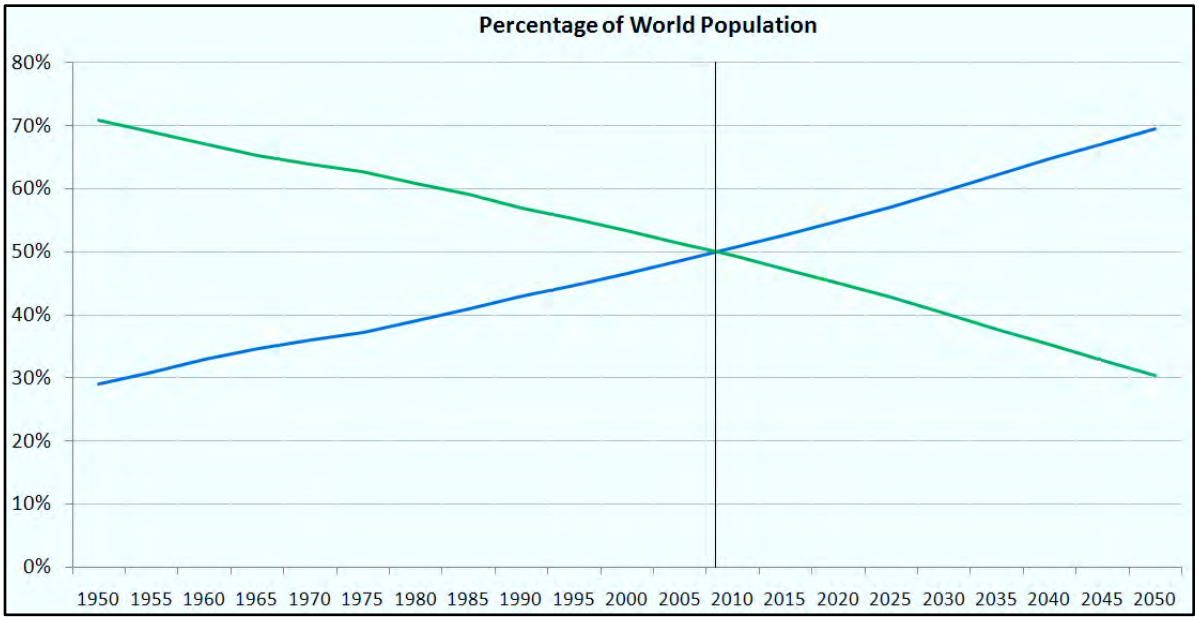

Figure 1 World Urban and Rural Population Percentages. Source: United Nations 2011.

Australia is one of the world's most urbanised countries. About 90% of Australians currently live in towns and cities and about 40% of all Australians live in the Greater Sydney and Melbourne Statistical Areas. Although South Australia is not Australia's most highly urbanised State, it is highly urbanised. About 78% of South Australians live in the urban and peri-urban environments of the Greater Adelaide Statistical Area; the area that used to be known as Metropolitan Adelaide and Outer Adelaide (Australian Bureau of Statistics 2014). We tend to think of Australian towns and cities as green and leafy places, at least during the winters of La Nina years, but we are rapidly losing urban greenspace. We are also making less use of the urban greenspace that we have. This is true of both private urban greenspace, particularly the residential backyard, and public urban greenspace, mainly urban parks.

Private Urban Greenspace

GIS-based research has shown that private greenspace forms a very significant component of the total greenspace of our cities and towns, greater than 60% in some suburbs. However, the contribution of private greenspace to urban biodiversity and the ecosystem services provided by private greenspace have been largely unrecognised and undervalued (Barnett, Beaty & Doherty 2005).

In many cases, the traditional Australian backyard is considerably more biodiverse than the local urban park on the other side of the back fence (Taylor, Murray-Leach & Smith 2005). Unfortunately, as Tony Hall (2010) has demonstrated, the traditional Australian backyard is becoming almost as much a relic of the past as the traditional Hills Hoist.

According to Hall (2010, p.41), during the early 1990s, 'a dramatic change in Australian suburban form began. Houses with large backyards ceased to be built. Dwellings built since then now extend to within a few metres of the side and rear boundaries of the lot.' New suburban developments also commonly lack sidewalks, street verges and, therefore, street trees (Figure 2).

Figure 2 Older Residential Area Versus New Residential Area. Source: Google Earth.

Public Urban Greenspace

Most of Adelaide's urban parks date from the post-WWII period of population growth and suburban sprawl. Earlier parks in the city centre, known as aesthetic or pleasure parks, were generally large and elaborately landscaped. The new urban parks were created mainly to provide active and passive recreational opportunities for the inhabitants of the suburbs. So the post WWII urban parks were downsized and their landscaping was simplified to more closely resemble playing fields than parklands(Nankervis 1998).

The City of Charles Sturt illustrates the development of urban parks following WWII. Charles Sturt has 390 hectares of public open space and 113 parks. Some of these are large regional parks, but most are small local recreation parks, generally less than two hectares in area (Figure 3). Children's playgrounds have been constructed in 110 of the parks (City of Charles Sturt 2006).

Figure 3 Open Space in the City of Charles Sturt. Source: City of Charles Stuart (2006).

Recreation parks generally contain large expanses of grass and tree shaded places for people to sit and have picnics. They tend to lack ornamental vegetation, beyond a few flowering shrubs, and have minimal biodiversity value. The larger recreation parks may also have team clubrooms and facilities like goal posts, basketball hoops, tennis courts, netball courts, bowling greens and cricket pitches.

In the post WWII period of immigration and the 'baby boom', children were recognised as significant urban park users, and play grounds were installed in most suburban parks(Nankervis 1998). The provision of facilities for children has continued with the installation of skate and BMX parks. Modern recreational trends have attempted to attract adult park users by including dog parks, exercise equipment and fitness trails. The loss of the traditional backyard has also created a demand, in many suburbs, for the inclusion of community gardens in larger urban parks.

Beginning in the 1970s, urban parks were increasingly required to perform ecological functions: cooling the urban heat island, storm water interception and retention, providing wildlife habitat, restoring watercourses and wetlands(Nankervis 1998).In many cases, this 'bush garden' trend in urban park design sacrificed social value for enhanced ecological value as recreational facilities were replaced by dense plantings of Australian shrubs.
More recently, there has been an emphasis on sustainability in urban park design, particularly in terms of water use, and also a reemphasis on making new urban parks attractive to people as well as wildlife; with limited success (Wright 2013).

While the ecological and social value of many of the new and redeveloped 'showcase' urban parks is very high, financial constraints have meant that the quality of many urban parks in the older suburbs has deteriorated. This is particularly true of the numerous small local urban parks that were established to provide recreational opportunities within walking distance for people living in the suburbs.

There is one of these local urban parks near my home. It is, typically, very small, about the size of a normal house block in my neighbourhood. It has a few trees and shrubs over lawn, a seat and some play equipment. It is reasonably well maintained, but during the 20 years I have been driving past this urban park, I've never seen anyone in it. Wright (2013, p. 312) tells a similar story about a small urban park near her home in Brisbane.

There are a number of reasons why people don't use their local urban parks:

- the decline in recreational use of urban parks in favour of indoor leisure and social activities
- the decline in unsupervised, unstructured outdoor children's play
- increasing vandalism and other anti-social activities
- increasing maintenance costs (security costs, labour costs, irrigation costs, insurance costs etc.)
- declining maintenance standards as a result of increasing maintenance costs
- deterioration and removal of facilities
- concerns about safety, particularly the safety of children, in urban parks.

Children's Outdoor Play

Two recent reports on children's activities have noted with alarm the low level of unsupervised, unstructured outdoor children's play in Australia:

- *Missing Trees: the Inside Story of an Outdoor Nation* (Planet Ark 2013)
- *Is Sport Enough?: 2014 Report Card on Physical Activity for Children and Young People*(Active Healthy Kids Australia 2014).

The first of these reports found that …'1 in 4 Australian children under 16 years spend, on average, less than 2 hours of their spare time per week playing in natural outdoor environments' (Planet Ark 2013, p. 5). The second report found that Australian children are among the least active in the world and that 'the majority of Australian children and young people are not meeting the daily Australian physical activity guidelines' (Active Healthy Kids Australia 2014, p. 8).

Young children (2-4 year olds) are the most likely to be physically active and to play outdoors, while older children (5-17 year olds) are generally inactive and unlikely to engage in outdoor play (Active Healthy Kids Australia 2014).

Kellert (1996) notes that attitudes towards nature are mostly formed in childhood, particularly between the ages of nine and twelve years when children may acquire an interest in nature and the way that it functions, and between the ages of thirteen and seventeen when teenagers often become concerned with wildlife conservation and the ethical treatment of animals. However, the development of curiosity about and concern for nature depends on experience of the natural world, even if this experience is limited to mucking about in back yards and urban parks.

Richard Louv (2006), in his book *Last Child in the Woods: Saving our Children from Nature Deficit Disorder*, argues that direct exposure to nature is also essential for healthy childhood development. Louv directly links estrangement from nature to some of the most disturbing recent childhood trends, such as the rises in obesity, attention disorders and depression.

Reconnecting People with Nature

In our increasingly urbanised world, contact with urban nature will be the only direct experience of nature that most people have. This begs the question, how can we ensure that the experience of urban nature will foster understanding and appreciation of nature, in general, so that people will be willing to invest in biodiversity conservation both in and beyond the urban environment?

Miller (2005) has suggested that we need a new biodiversity management strategy that will put nature back into the places where people live, work and spend their leisure time. This new strategy is intended to complement biodiversity conservation and restoration, but to go beyond these strategies in urban environments by consciously designing urban places to reconnect people with nature.

Future Park: Imagining Tomorrow's Urban Parks by Amalie Wright (2013) contains numerous, lavishly illustrated examples,in a wide range of countries, of urban parks and other urban places that have been designed to reconnect people with nature, often incorporating the latest trend in landscape architecture, green roofs and walls. The First Creek Wetland, located in the Adelaide Botanic Garden and the Goods Line Project in Sydney are Australian examples of the reconnection strategy.

Unfortunately, the design ideas illustrated by *Future Park* are expensive and mainly relevant to major urban development or redevelopment projects. Small local urban parks are unlikely to receive a *Future Park* makeover and will continue to decline without community intervention. So if you have a needy local urban park in your neighbourhood, consider adopting it.

The Adopt-a-Park movement for urban parks began in North America, but has been implemented by a few Australian City Councils. Adopt-a-Park volunteers participate in urban park maintenance and form Park Watch groups to increase urban park safety. Even more importantly, some Adopt-a-Park groups also organise events with a nature-focus (e.g., BioBlitzes) to encourage the use of urban parks as oasis of nature in the built environment and not just as venues for weddings and rock concerts.

However, to connect children with nature, all an urban park needs to provide is a safe green space where they can look and listen, dig and splash, chase and catch, explore and discover. A young child's curiosity about nature may foster a teenager's concern and an adult's action, but 'what is the extinction of a condor or an albatross to a child who has never known a wren?'(Pyle, 2003, p. 207).

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TREES & ECONOMICS

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Department of Environment, Water & Natural Resources

The *eco* in economics has the same root as in ecology. While ecology is the study of our home, economics derives from the administration of the household. In its original (Aristotelian) sense economics was about the minimisation of waste and the effective utilisation of scarce resources. The so-called father of taxonomic botany, Carl Linnaeus wrote at length on *The Economy of Nature*– essentially a theological version of James Lovelock's Gaia theory that sees stewardship of Nature as core. The view of economics as something to do with financial markets has only established in the twentieth century. Economics is ultimately about the long run and, in the long run, certainly dependent on the contribution of as trees as the drivers of Earth's life systems. Trees drive food, climate and water security, underpin ecosystem services and support our health &well-being. Trees are indeed good!
Bill Clinton's famous campaign slogan perhaps should have been (It's) *The economy of trees, stupid*!

As rich and complex treescapes, botanic gardens are unrivalled as visitor attractions. The challenge for botanic gardens is to see the genetic and intellectual resources within the botanic gardens harnessed outside the botanic gardens. The green infrastructure and sustainable landscapes projects at the Botanic Gardens of South Australia illustrate the potential for utilising the institutional architecture of botanic gardens beyond the botanic gardens. The Green Infrastructure Working Paper prepared through a collaboration evolving in the Botanic Gardens of South Australia that's won state and national awards with the Australian Institute of Landscape Architects, the Planning Institute of Australia and the Urban Development Institute of Australia provides a good place to begin an exploration of trees and economics.

The escalating emphasis on cost and risk management in urban open space and parks & gardens has in significant measure been at the expense of a focus on the benefits and opportunities they provide. A reframing of urban open space as *green infrastructure* accords green infrastructure an equivalent status to grey infrastructure (- pipes & wires, roads & parking) and built infrastructure where benefits and opportunities are better understood by the community. The reframing also endeavours to shift thinking from an area-based approach focussed on 'open space' or 'parks & gardens' to a values & services-based approach. The values & services provided by green infrastructure underpin liveability. Indeed, green infrastructure should be seen as central to environment, social capital, health &well-being, innovation and livelihoods in cities.

While we're inclined to focus on the environmental benefits of trees, including their beauty, the key benefits in cities are likely their contribution to the physical, psychological and social attributes that comprise health and well-being.

While green infrastructure as a frame works well with greenspace practitioners to help in framing of benefits and opportunities it's an unlikely candidate as the right frame and narrative for the community. Nationally and internationally there are exciting projects and programs that can contribute to our thinking about the benefits and opportunities provided by green infrastructure and the framing and narratives that do connect with decision makers and community. Poster children include Singapore, Paris & Bogota where vision, governance and capacity align in greenspace development, management and maintenance. There's a lot to learn here and great opportunities for Australian cities.

For more information and the evidence base for the value of green infrastructure visit
www.botanicgardens.sa.gov.au/greeninfrastructure

RESPONDING TO THE URBAN HEAT ISLAND: OPTIMISING THE IMPLEMENTATION OF GREEN INFRASTRUCTURE

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Warming associated with urban development will be exacerbated in future years by temperature increases due to climate change. The strategic implementation of urban green infrastructure (UGI) e.g. street trees, parks, green roofs and facades can help achieve temperature reductions in urban areas by providing shade and evapotranspirative cooling whilst reducing heat storage. It can also deliver diverse additional benefits such as pollution reduction and biodiversity habitat. Although the greatest thermal benefits of UGI are achieved in climates with hot, dry summers, there is comparatively little information available for land managers to determine an appropriate strategy for UGI implementation under these climatic conditions. We present a 5-step framework for prioritisation and selection of UGI for cooling. This is:

- Identify priority urban neighbourhoods based on people exposure, vulnerability and activity
- Characterise UGI and grey infrastructure
- Maximise the cooling benefit from existing UGI using water sensitive urban design and other strategies to maintain vegetation health.
- Develop a hierarchy of streets for new UGI integration
- Select new UGI based on site characteristics and cooling potential

The framework was developed following a review of the scientific literature examining the relationships between urban geometry, UGI and temperature mitigation which we used to develop guidelines for UGI implementation that maximises urban surface temperature cooling. We focus particularly on quantifying the cooling benefits of four types of UGI: green open spaces (primarily public parks), shade trees; green roofs; and vertical greening systems (green walls and facades) and demonstrate how the framework can be applied in the City of Port Phillip.
For further information and downloadable reports from our Victorian Centre for Climate Change Adaptation Research project seehttp://www.vcccar.org.au/responding-to-urban-heat-island-optimising-implementation-green-infrastructure

PROJECT BASED LEARNING: A CASE STUDY IN MAPPING THE GREEN INFRASTRUCTURE IN ADELAIDE

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Abstract
In Autumn 2014, the UniSA Environmental Informatics master's course took on the project of mapping Green Infrastructure in Adelaide. This was a natural progression from the report on the Evidence Base for Green Infrastructure in South Australia which was presented last year and the interactive companion version launched in June 2014. The question raised by the students was: "Where is the Green Infrastructure?" This was a logical question in light of the evidence presented in the report that demonstrated how important Green Infrastructure is to the economy, human well-being, and the environment. This presentation summarizes the process of creating a Green Infrastructure map of the Adelaide metropolitan area.

Introduction
Universities are under fire for failing to prepare students for life after university (Arum, R and Josipa R 2011). This has prompted a number of innovative teaching styles and research on the effectiveness of different pedagogies. The University of South Australia has embraced this challenge by encouraging faculty to explore alternative teaching methods. In the Masters of Natural Resource Management and Sustainability at UniSA we have adopted project based learning (PBL) for the Environmental Informatics course (ENVT5024). PBL is a teaching method that incorporates knowing and doing (Markham 2011). Blumenfeld & Krajcik (2006) cite numerous studies demonstrating that students applying their knowledge to real world problems have better outcomes than students who are taught using traditional methods.

In 2014, the problem selected for the course was "Mapping Green Infrastructure for the Adelaide Greater Capital City Statistical Area"(figure 1). Sheryn Pitman, Green Infrastructure & Sustainable Landscapes Project Officer at the Botanic Gardens of Adelaide, presented information to the students summarizing the work on the Green Infrastructure Evidence Base project. Students who reviewed the report which provided evidence demonstrating the benefits of Green Infrastructure raised the following questions: 1)Where is it? 2)What are the best methods of quantifying the areal extent of the Green Infrastructure? and 3) How might one go about mapping Green Infrastructure? The Green Infrastructure Project's Working Group recognized that mapping Green Infrastructure in all of its diversity would be highly desirable for characterizing, publicizing, improving and sustaining Green Infrastructure in Adelaide. With the support of the Green Infrastructure Working Group, this real world problem was presented for the class to solve.

Project: Mapping the Green Infrastructure of Adelaide Greater Capital City Statistical Area (GCCSA).

Background
The aim of this course is to explore, evaluate, and appreciate sources of environmental information and measurement. This was certain to be covered in the course given that mapping Green Infrastructure entails identifying, assessing, and acquiring multiple sets of geographic information pertaining to the environment. However, answering the question "What is Green Infrastructure?" was a new challenge for this particular course.

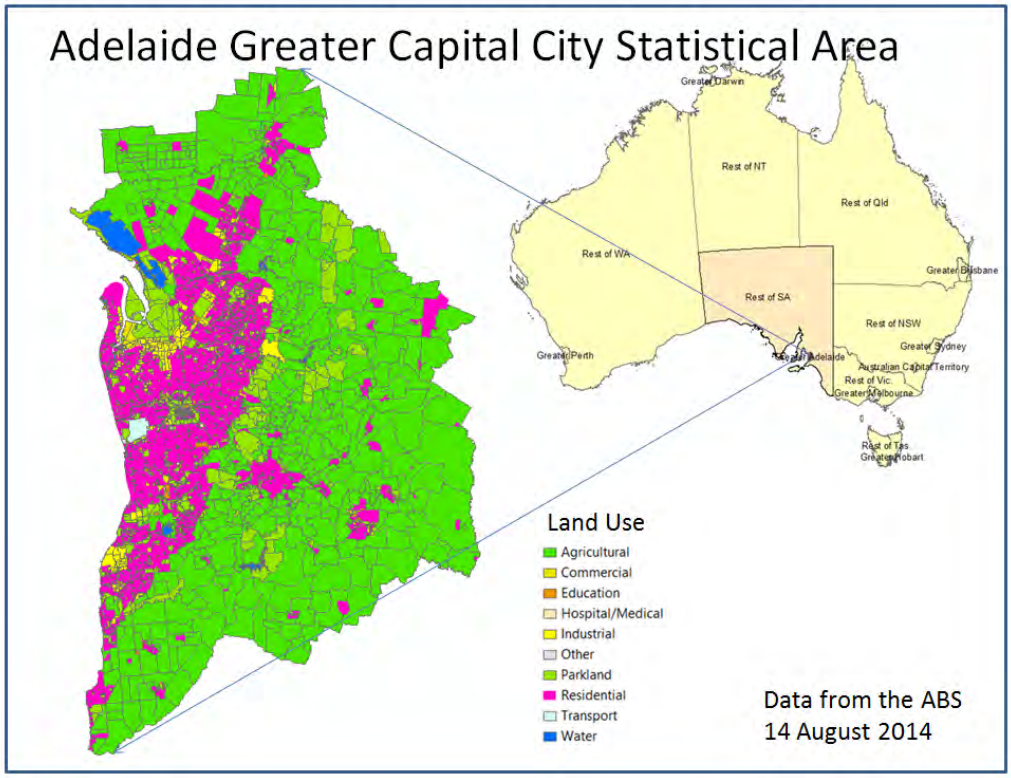

Figure 1: Overview map of land use in the Adelaide GCCSA

One of the issues with PBL is the lack of knowledge surrounding the selected problem, thus during the first few weeks of the course the students undertook a literature review which included reading the evidence base report, "Green Infrastructure: Life support for human habitats" by Ely and Pitman (2012). In addition, they expanded their GIS skills in preparation for solving the problem. This groundwork provided students with the awareness of the importance of mapping Green Infrastructure. The class accepted and used the definition of Green Infrastructure in the evidence based report. This is perhaps more expansive than some others and is provided below:

> *Green Infrastructure is the network of green spaces and water systems that delivers multiple environmental, social, and economic values and services to urban communities. This network includes parks and reserves, backyards and gardens, waterways and wetlands, streets and transport corridors, pathways and greenways, farms and orchards, squares and plazas, roof gardens and living walls, sports fields and cemeteries.*

A search of the 'Web of Science' (a comprehensive interdisciplinary and bibliographic database), for 'Green Infrastructure' returns 1,359 articles yet 'mapping Green Infrastructure' returns only 53 articles. In Google Scholar, the search for 'Green Infrastructure' alone returned about 1,060,000 results and for'mapping Green Infrastructure' reduced it to about 117,000 results. Although these are not extensive searches, they do provide perspective on the need for research and application development in the area of identifying, quantifying and mapping Green Infrastructure.

A consensus approach was developed through individual research, class discussions, and group work to proceed using a modified methodology based on the Liverpool and Mersey Forest reports. For an extensive explanation, please see Appendix A in the Liverpool Green Infrastructure Technical Document (Home link: http://www.merseyforest.org.uk/our-work/green-infrastructure/liverpool-city-region-green-infrastructure-framework/).

Mapping Methodology

The two methods adopted from the Liverpool report for the mapping were typology and functionality. Typology is an exercise in classification to get the standardized surface types (type of land cover, or land use, or both) for Adelaide GCCSA (most of these data were acquired from South Australian Government Data

Directory (data.sa.gov.au)). The functionality of Green Infrastructure is the nature of the services or values provided by the Green Infrastructure which can be a function of spatial context, land cover type, proximity to population, or other factors. We elected to use the most accessible datasets due to the time constraints of a one semester course. The new and interesting part of the mapping project was to decide on and create six functional surfaces appropriate to the Adelaide area. We used the 28 functional surfaces of the Mersey Forest research to generate our six; however, not all of the Mersey surfaces were appropriate for the Adelaide area (e.g. Biofuels production). We created six novel Adelaide specific functional surfaces. The functional surfaces selected by the student groups were: Water Recreation, Flood Mitigation, Native Bird Habitat, Non-Motorized Transport, Social Events, and Community Gardening. A discussion of the importance of each of the function follows.

Water Recreation

Water recreation is part of Green Infrastructure because water is an incredibly important physical and aesthetic landscape element (Völker & Kistemann 2011). Water is one of the essential ingredients to life, and has features and qualities that associate with health, wellbeing, leisure and tourism. These qualities are consistent with the project's definition of Green Infrastructure in that a space needs to be 'beneficial to its inhabitants'. Water recreation is beneficial to its inhabitants because water recreation areas encourage popular activities such as swimming, boating, nature study, walking, and picnicking by water bodies (Collins & Osmanski 1986). Recent studies have found that natural scenes that include lakes and creeks can have a higher restorative effect than grey urban environments. It has also been documented that nature scenes with water can have a positive influence on the psycho-physiological state as well as a positive impact on emotional states (Velarde, Fry &Tveit 2007).

Flood Mitigation (Water Ways for Flood Mitigation)

Even though Adelaide experiences relatively low rain fall flood events do occur and many people who live in Adelaide are often unaware of the risks of flooding. Flooding in Adelaide generally occurs during storm events and mostly around creek and former creek areas. Many creeks and watercourses in Adelaide are treated and have been altered to be used as storm water drains rather than as carriers of floodwaters (Wright 2010). The flood mitigation surface is essential to the mapping of Green Infrastructure in Adelaide because it identifies vegetated waterways that have the potential for flood mitigation. Councils can monitor these water bodies and their performances during flooding events. Vegetated waterways also have other benefits that include ecological benefits and aesthetic values which can be substantial when compared to concrete lined channels or other grey infrastructure.

Native Bird Habitat

Wildlife habitat is an important part of Green Infrastructure as it forms the basis for understanding the networks of natural greenspace in the urban environment and its environmental, social and economic value. In Adelaide, natural greenspace is made up of small parks and reserves, Conservation and Recreation Parks, as well as 'greenways' made up of rivers and creek systems (Ely & Pitman 2012). The native vegetation cover of Adelaide is an indicator of biodiversity health and reveals potential habitat sources for native birds and mammals in the urban environment. Important water systems including; the Barker Inlet- St Kilda Wetlands and the Onkaparinga Estuary are important environments for a variety of native and migratory bird species found in the metropolitan region of Adelaide. To further understand the biodiversity and conservation value of greenspaces and for the protection and planning of corridors and wildlife linkages between these spaces, bird habitat is an essential functional surface to include when mapping the Green Infrastructure of Adelaide.

Non-Motorised Transport

Non-motorised transport is an important part of the Green Infrastructure of Adelaide as it provides an alternative to the traditional reliance on motorised transport. The positive consequences of this are a range of environmental and human benefits including: increased physical activity and improved health and wellbeing; increased use of public and natural spaces; livelier and more pleasant suburbs and cities; reductions in greenhouse gas emissions; and reductions in noise, air and water pollution. Motor vehicle use results in air, noise and water pollution which can harm people and the natural environment (Chester and Horvath, 2008). Many pollutants, such as noise, carbon monoxide, and oxides of nitrogen and sulphur have local impacts, while others such as ozone, hydrocarbons, methane and carbon dioxide have regional and global impacts (Litman, 2009). Walking and cycling produces relatively no pollution.

Non-motorised transport promotes physical activity, which is incredibly important in Australia due to increasing rates of sedentary lifestyles and chronic disease (Paffenbarger et al, 1986). Walking and cycling are among the most practical and effective ways to incorporate regular exercise in peoples' lives (Rabl and Nazelle, 2012). We defined non-motorised transport as purpose-built and repurposed routes reserved for cyclists and pedestrians. This definition does not include normal footpaths or roads with or without bike lanes, unless they include specialist cyclist infrastructure.

Social Events

The parklands and gardens of Adelaide provide space for social events and represent vital aspects of the Green Infrastructure. The majority of social events in Adelaide are held on or adjacent to parks, reserves or gardens. This direct link is irrefutable evidence of the relationship between social events and Green Infrastructure along with why they are relevant to this project. We included our social event functional surface to areas that support the following: Leisure day, Carnival Spring Regatta, Carols by Candlelight, Gorgeous Festival, Schutzenfest, Harvest Festival, Australia Day Parade, Brighton Jetty classic, WOMADelaide, Willunga Almond Blossom Festival, Blues in the Barossa, St. Peter's Fair, Prospect Fair, French Market, Cheesefest, Beachside Food & Wine Festival, Glendi Greek Festival, Semaphore Greek Cultural Festival, Garden of Unearthly Delights, Tomato Festival, Town Picnic, Latin American Fiesta, and Indofest. The benefits of these greenspaces that host these events meet the definition of Green Infrastructure and provide tangible economic benefits with many of these "festivals generating income and contributing to sustainable local economic development" (O'Sullivan & Jackson, 2010).

Community Gardening

Community Gardens hold many of the key components of Green Infrastructure, from human collaboration with the environment, to investments into increased environmental sustainability and increased resilience in the form of increased food security. It is because of these major issues that community gardens are such vital parts of Adelaide's Green Infrastructure. Community gardens have the potential to reduce our need for processed food and our carbon footprint, as well as providing aesthetically pleasing environment which also hold key benefits for education and social collaboration. Community gardens are greenspaces which produce healthy fresh food and provide a model for improving food security, human health, local ecology, and social capital, along with creating opportunities for community development through education, skills and training (Wakefield, 2007).

Conclusion

This project was an excellent experience for the students and myself. Engaging students with the community in ways to serve the public good is exactly what UniSA hopes to continue to achieve. These spatial data sets comprise the proto type for the Green Infrastructure Geodatabase of the Adelaide greater capital city statistical area. The GCCSA is a useful regional concept developed by the Australian Census Bureau. However, at the local level this region is comprised of numerous independent local councils which could benefit from a larger regional and comprehensive geographic information system. A spatial database of this nature would enable a more holistic approach to many social, economic, and environmental initiatives that serve the public good.

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FOREST MANAGEMENT OF A NEW ARBORETUM

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Abstract
The National Arboretum Canberra (NAC) was opened in February 2013. With planting having started in 2007, there are now 94 forests on a site of 250 ha representing rare, threatened or otherwise significant trees from around the world. To date, about 40,000 trees have been planted. Although the collection has been planted predominantly in small one or two species forests, the management regime has had to include horticulture as well as silviculture to highlight the different features of each species planted and provide for outcomes such as soil amelioration and fire hazard reduction. The NAC has a valuable role in improving knowledge through attempting to manage several species that were previously poorly known in Canberra. The presentation will touch on a range of operational aspects at the individual tree and whole of forest level, including irrigation, formative pruning, thinning, pests and disease and weed control.

Introduction
In 2003 the bushfire that ravaged Canberra was the catalyst for the creation of an arboretum originally envisaged by the designer of the city of Canberra, Walter Burley Griffin. It provided an opportunity to promote and in some cases conserve threatened species, and provides a valuable future resource in Canberra for ongoing education and research and a place for community recreation. The goal is to create a place of outstanding beauty, of international standard and interest.

In December 2003 the ACT Government agreed that the burnt-out pine forest area known as Green Hills is to be preserved as an international arboretum. It is being developed on a 250-hectare site near Lake Burley Griffin about six kilometres from the centre of Canberra. The site incorporates existing stands of Himalayan Cedar (*Cedrus deodara*) and Cork Oak (*Quercus suber*) much of which was planted about 80 years ago. It was seen that the design would make provision for a wide range of commercial and community activities which could bring more activity to the area and support the development of the arboretum.

A national design competition for what was then called the Canberra International Arboretum commenced in September 2004, and on 31 May 2005 the ACT Chief Minister, Jon Stanhope MLA, announced the landscape architects Taylor Cullity and Lethlean, with the architects Tonkin Zulaikha Greer, as the winners with the "100 Forests 100 Gardens" entry. As the name suggests, the design includes a series of forests, such as the existing ones of cedars and oaks, instead of the usual wider arboretum collection of individual trees or small clumps. Further information about the competition and the design can be seen at http://www.nationalarboretum.act.gov.au/.

As a part of the early development of the Arboretum, the inclusion of a research forest connected to the Australian National University was discussed, and there is now a forest in which grow stands of *Eucalyptus tricarpa* and *Corymbia maculata*. The forest has been established to look at how these two different species will respond to the drier climate and longer droughts likely to occur in Australia as a result of climate change. Since the development of the Arboretum commenced, another one of the forests has been used for the establishment of the Southern Tablelands Ecosystems Park by a Canberra community group, in which grows stands of all of the ACT's *Eucalyptus* species.

Site Preparation
The Arboretum site had been originally used as a commercial radiata pine forest since the 1920's and contained large amounts of pine regrowth, exotic weeds, woody weeds, surface rocks, old irrigation lines, and compacted forestry tracks. The initial thought to bulldoze the 100 forests free from rocks and pine trees, quickly became a major cost and management issue. It became obvious that it was not possible to just bury the rubbish under the forests growing in neat and tidy fields of lucerne .

To address this, a 5 tone excavator was introduced to the project with rock grabs attached. It would simply pull the trees out and bypass the sites rocky outcrops, leaving them as future hubs for local native vegetation. The pines were put in wind-rows and tub ground to supply mulch for the future plantings.

The basic plan after the trees were removed was as follows:

1. Deep rip the forest planting areas and adjacent allees to 600mm deep at 1m centres.
2. Back blade lots to pick up all rock brought to the surface larger that 100mm in size.
3. Rock pick the forest lot and adjacent allee.
4. Bore tree holes to 800mm in depth using a 600mm diameter toothed auger.
5. Trench and install irrigation sub-mains, feeder lines and dripper lines on a bed of sand.
6. Over sow the entire forest and adjacent allees with a lucerne mix.

Scope of the Living Collection

Since the planning started for the National Arboretum Canberra, there has been a strong emphasis on plant conservation and just over 40% of the 90 forests planted to date represent a rare or threatened species. However, since the commencement of the species selection the number of principal themes has expanded to include:

- conservation
- plant use
- symbolism

In addition, an effort has been made to represent trees from:

- a wide range of countries around the world
- a wide range of habitats, with an emphasis on drier climates
- a wide range of botanical families, including
    - evergreen and deciduous species
    - broadleaved trees and conifers

As a part of the species selection process, there was obviously a strong desire for the species selected to have the potential to perform well on the NAC site. However, several of the species selected are new to Canberra and for some they could be close to their climatic boundaries, with the main issue being frost tolerance. The few species likely to be on a 'climatic cusp' will not only test the species survival over time, but also be possible indicators of climate changes in the Canberra region.

The conservation theme has provided the Arboretum with an excellent opportunity to highlight the fact that many of the world's trees, sometimes common in cultivation, are in fact threatened in the wild. For several of the species, it could also help to protect them through *ex situ* conservation.

While the conservation of our flora must be seen as the priority for conservation programs in Australia, the nature of the collections at the NAC takes into account its role to promote the importance of trees in a world-wide sense. By being the diplomatic capital of Australia, Canberra is well placed to fulfil such a role. As a part of this, it is intended to look at telling these stories using interpretation in languages other than English that are particularly relevant to the where the trees occur naturally. This would include an indigenous language where English is the national language – including for the Australian species.
At the individual species level, the Arboretum has already worked with in-country and international conservationists. One such species is *Cedrus libani*. While the species is already in Australia and is reasonably easy to acquire, a closer link with the natural stands in Lebanon was sought. A contact was made in Lebanon with the Lebanese Agricultural Research Institute who collected the seed at the Al Chouf Cedar Nature Reserve. The seed was passed on to the Arboretum via the Millennium Seed Bank in Kew. By doing so it not has only made other conservationists aware of the Arboretum but will also be an opportunity to promote the conservation of the species and the Al Chouf Cedar Nature Reserve through the Arboretum and the Lebanese Embassy in Canberra.

The selection of plant use as a theme was, in many ways, an expansion of the conservation theme. It has meant that in addition to those species that are threatened in the wild and require conservation, species that have been important for human use, have also been highlighted as worthy of conservation. This includes species with a broad range of uses like *Brachychiton rupestris* (Bottle Tree), *Maclura pomifera* (Osage Orange), *Eucommia ulmoides* (Chinese Rubber Tree) and *Cercis canadensis* (Eastern Red Bud).

The highlighting of the symbolism theme was in part driven by the interest that was being shown by embassies in Canberra. With the NAC collection representing just over 100 countries some of the species symbolic of those countries include: the national tree of Chile (Monkey Puzzle or *Araucaria araucana*); the national tree of Pakistan (Himalayan Cedar or *Cedrus deodar*); the State tree of Louisiana and Mississippi (Southern Magnolia or *Magnolia grandiflora*); the national tree of the Czech and Slovak Republics (Small leaved lime or *Tilia cordata*), and; the symbolic flower of Kiev, (Horse Chestnut or *Aesculus hippocastrum*).As a part of this, one section of the Arboretum is devoted to single plantings by national leaders from around the world.

Some of the species chosen are also regarded as being sacred in different countries and these include: the Parana Pine*(Araucaria angustifolia*) revered by several Brazilian tribes; the Yunnan Cypress (*Cupressus dulouxiana*) considered holyby Buddists in China, and; the Bunya pine *(Araucaria bidwillii*) held sacred by several aboriginal tribes.

Provenance

Although it was initially intended that all proposed seed collections or plants were to be characterised by credible provenance, the speed at which the arboretum was established and the number of trees required for the forests made this very difficult. It resulted in there often being an insufficient number of plants for the threatened species at the time of planting.

While this was partly overcome by introducing the plant use theme, the majority of the non-conservation related forests came with no provenance and it was still desirable to maintain the use of the threatened species that had already been acquired and grown. This was addressed by the use of a host species. For example, the few threatened Spanish Birch (*Betulapendula* ssp. *fontqueri*) the NAC had propagated from provenance seed have been planted with the host species Silver Birch(*Betula pendula* ssp. *pendula*) with the intention of slowly removing the Silver Birch and replacing it with Spanish Birch over time. These new trees would come from both cuttings from the original planting and more seed obtained from Spain. While it was easy to obtain approval to thin eucalypt and pine plantings there was difficulty in getting approval to thin the birches! The eventual achievement of having a forest of just the Spanish birch may now take a little longer.

WEEDINESS

One of the important issues that had to be taken into account when selecting the NAC species was the possible or recorded weediness of the species and the CRC for Australian Weed Management's weed status list (Randall, 2007) played an important role in plant selection. As a result, several species meeting numerous of other requirements for the Arboretum have been rejected because of likely weed issues.
This has not been an easy task as the variation in the localities that plants have become weedy is substantial and as a result trees known to have been weedy in areas thought different to Canberra have sometimes been accepted. For example, although the California fan palm, *Washingtonia filifera,* is considered to be a serious weed in central Australia it was still seen as a suitable planting for the NAC. However, the previous records must not be ignored and it is noted in NAC management plans that if a newly introduced species commences to show a weediness that could lead to it becoming naturalised, it should be removed.

Uses for the NAC forest species:

Research

As with all significant arboreta the management of the NAC will encourage and support research studies, including all avenues of scientific enquiry concerning the forests and their associated biodiversity. Arboricultural and silvicultural research as well as basic research (e.g. carbon flux and tree physiology) will be encouraged. The potential for social and cultural research associated with the amenity, educational and recreational values of the NAC is also acknowledged.

Given the significant themes underpinning the arboretum design, research priorities may be directed towards a better understanding of:

- Rare and endangered plant species;
- Climate change and adaptation;
- Species suited to the Canberra environment
- Understanding Urban forests interfaces and values

Particular strengths of the NAC as a site for research are: i) the potential longevity of research activities to build valuable long term data sets and studies; ii) the proximity of the site to major research Canberra-based institutions, including CSIRO and the Australian National University; iii) its strong connection with a likely user of the research results, that is, the ACT government, and iv) the significant community profile of and support for the site as a significant cultural asset. A major contributor to the latter is the Friends of the National Arboretum Canberra. This includes their involvement in regular growth measurements in all of the forests over the past 4 years.

Species Trials:
Although the introduction of poorly known tree species can be a risk, the trialling of them will undoubtedly help to identify species suitable for planting in Canberra's urban forest in the future. It is not only an opportunity to learn more about the trees that are already adapted to the Canberra climate but also trees that may be affected by climate change over time.

The trials that have already commenced are for those species expected to survive in Canberra but are still poorly known in the city's urban forest. These include species that have not been known to have been planted in Canberra before, such as Toromiro *Sophoratoromiro*, and species that had only been grown to very limited extent, such as the monkey puzzle tree *Araucaria araucana* and the Wollemi pine *Wollemianobilis*. Both species have been used to form forests with the latter having been reduced in size.

Prior to the planting of the Wollemi Pines at the Arboretum, the number growing in the ACT was still very small, with the species having not long been discovered or being freely available for horticulture. Since the first planting at the Arboretum, much has been learned about growing this species in Canberra. While the genetic diversity in the species is exceptionally small (Peakall et al, 2003), there is considerable landscape variation across the site where the trees are growing and the impact of those differences is already showing strongly. As a result of the experience to date it is likely that another Wollemi pine planting will be done in another area of the NAC that best provides the conditions in which the species has grown most successfully to date.

Although using the planting of whole forests as a part of these trials has a greater risk in terms of the number of trees lost, it has been found that the plantings have not only benefitted from the various growing conditions across the forest site but also, in some species, from the genetic variation in the planting.
If for example only 10 Wollemi pines had have been originally planted it is highly likely that it would have been declared as unsuitable in Canberra, given that nearly 2/3 of the forest planting have died over the past seven years. It is only because it was planted as a forest that the opportunities have been identified.

The second trials will be carried out in two forests that have considerably different growing conditions. Neither of these trial lots has yet been planted. Unlike the main forests, the main aim for these trials will only be to grow the trees long enough to determine whether they are in fact suited to the Canberra conditions and what maintenance issues might exist. There will only be 10-12 trees per species and the length of time each of the species is kept on trial will depend very much on the success of the tree. The more successful or unsuccessful the tree is, the faster will be the removal and replacement.

Tree Management

Although the trees have been planted as monocultures, it does not mean that they are to be managed as timber forests. It is the aim of the Arboretum to provide visitors with a feeling for each of the species that has been planted. Although there will be some formative pruning for most of the species, this will still involve giving the trees some freedom to express themselves. There will also be others within the individual forests that need to be treated differently from one another to fit in with original landscape design.

Of course, there is still going to have to be an appreciation that the areas around the trees will need to be maintained and so consideration will have to be given to people and the likes of mowers and other vehicles being able to pass through under the trees.

For all of the forests, the retaining of information has been important. This information has included details of the species' provenances, their propagation, their growth, flowering and fruiting and will also include information about pests and diseases and any tree loses and replacements. The information is currently still held as basic files and maps but the Arboretum is currently reviewing possible options for a botanic gardens style database.

Maintenance Guidelines

While the Arboretum's general maintenance directions are viewed as the expected standards across the site there are also particular guidelines which apply to every forest and associated tree species. A very important aspect of the Arboretum's guidelines is that it they are still evolving as we learn more about the species planted. Some of the issues that have had to be addressed are as follows:

Irrigation

It has always been the intention of the ACT government that the tree plantings of the Arboretum will not be watered with potable water. Instead, the irrigation water will be obtained from the dams and bores or will be trucked-in recycled water.

However, the provision of non-potable water for the rapidly expanding arboretum has been a particularly difficult task with the issues of environmental conditions, site topography, filtration, water security and irrigation maintenance. These have all been consistently monitored and adjusted to suit the current conditions where and when possible. The current water sources available to date are as follows.

1. Bore # 1 = 10ML
2. Front Dam = 30ML
3. Bore #2 = 37 ML
4. Other (Lower Molonglo surface water) = 50 ML

To assist the effective use of the water available, the Arboretum has developed a thresh hold for soil moisture in each forest. The measurements are done at 3 random locations within each forest and during the peak seasons weekly readings are collected indicating where the water is required.

To date the Arboretum has been successful in only using potable water, even during the extreme conditions in January 2014. Although this will be tested with more trees to be planted and the possibility of drier conditions, a significant number of the forests will survive in the future on very limited irrigation.

Weed Control

Weeds that were already well established on the site are another significant issue that the Arboretum has had to manage over its entire 250Ha site, although it was it was quickly learnt that not all weeds are nasty but can in fact aid in soil retention.

To assist ensuring effective weed management, a listing of the most problematic weeds recorded on site has been prepared and each is targeted in individual programs across the whole site. Of all the weeds being controlled, blackberry has required the most time to date. It was throughout the 250ha site when the development of the Arboretum was started and it is still present in many areas of the Arboretum, including the areas of remnant pine forest that surround the Arboretum.

However, as time allows the site to recover from the pine forest, fire and disturbance during re-planting, the weeds will become controllable through consistent mowing and the weed management programs.

Pruning and thinning

As the arboretum is a living collection of forests rather than a park or forest for timber, the formative pruning is being done in a somewhat different way than the typical Australian stands of urban or timber forests.

Of course, the general rules still apply to try and obtain a safe form or structure, but as a forest of 200 or more trees will eventually form a canopy connecting with each other, the form of the forest can be as important as the individual tree's form. This has opened the potential problem of having to produce a specification to prune forests which if not well supervised could possibly have devastating and long-term results. The conclusion was for the Arboretum's senior horticulturist to take on the responsibility for formative pruning across the whole site.

Thinning has also been driven by a number of issues. As mentioned earlier, the thinning of a radiata pine or eucalypt forest has raised little comment, but the proposal to thin a forest of what is viewed to be an 'ornamental' species can produce far more resistance. However, throughout the Arboretum there will be whole forests that will need to be thinned – both for the benefit of trees around them or to enable the expanding of the planting of the threatened for which the forest was originally established.

Pests and diseases

It is generally held that the treatment of pests and disease in the Arboretum should be restricted to those trees that are being seriously affected and that spraying of pests should be avoided. While several trees have been lost across the Arboretum as a result of pest and disease attacks, it has only affected an entire forest on one occasion.

The most serious pest attack to date has been on the Buchan blue forest (*Acacia caerulescens*) which has suffered from splitting of the bark, weeping of sap, weakening and loses of tree limbs and the death of a substantial number of trees. It is likely that this has primarily been caused by the jewel beetle *Agrilushypoleucus* although it is not recorded as a threat to the species where it grows naturally in Victoria. A possible result of this is that the forest will be replaced with another species, but this is yet to be decided.

When *Phytophthoracinamomi* was first discovered on the site during what were relatively dry years it was not occurring in areas that were a threat to the forests.

However, during a very wet summer in 2010, it was identified in at least six forests, including the Wollemi pine (*Wollemianobilis*), maidenhair Tree (*Ginkgo biloba*), giant sequoia (*Sequoiadendron giganteum)*, Japanese flowering dogwood (*Cornuskousa),* European beech (*Fagus sylvatica*) and eastern redbud (*Cercissiliquastrum*). Although the prolonged periods of rainfall in the summer of 2010 and 2011 provided perfect conditions for *Phytophthora* to survive, all of the forests seen to be at risk have been drenched with phosphate and potassium and the losses across the Arboretum have not been as significant as expected.

A disease which is becoming a considerable concern is the cypress or Seiridium canker with likely outbreaks already recorded on pencil pine, (*Cupressussempervirens)*, Lawson cypress (*Chamaecyparislawsoniana), Saharan cypress (Cupressusdupreziana)* and giant sequoia (*Sequoiadendron giganteum).* Although Seiridium is essentially a weak pathogen requiring some defect by which to enter, it is over time, becoming more evident in the Canberra region and there are perhaps four more tree species in the Arboretum that are vulnerable. Removal of dead and dying limbs and the application of a copper based fungicide is the current action being taken but it may be a significant issue to be addressed in the future.

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ENDEMIC PESTS, CURRENT THREATS AND FUTURE RISKS TO AUSTRALIAN URBAN FORESTS.

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Introduction

There are many threats to Australia's Urban Forests from a combination of native and established introduced insects and pathogens (together defined as pests), and overseas exotic incursions (Tables 1 and 2). Exotic pests that have become naturalised (established or endemic), have resulted in increased costs for tree management and in some cases placed doubts on their use as shade trees in parks and gardens. Established introduced pests have also adversely impacted on biodiversity values (e.g. *Phytophthora cinnamomi* Table 1), and continue to pose a significant threat to the economic and ecological viability of forests in Australia. Native pests have also caused significant damage in parks and gardens (e.g. *Armillaria luteobubalina* Table 1). Due to their proximity to ports, urban forests potentially play a role in the pathway for the introduction of new exotic pests into the Australian landscape.

In the past, Australia has relied on its geographical isolation to provide a degree of natural protection from exotic threats. However, because of rapid transport of imports and exports into and out of Australia, quarantine measures alone are insufficient to protect our urban forests, unique ecology and the productivity of plant industries (PHA 2007).Australia's reduced isolation in the modern world has been highlighted recently by an increased number of pest interceptions at border entry points (Table2). Whilst a pest interception at our border does not usually result in the establishment of a pest, and reflects the diligence of quarantine staff and current procedures, it demonstrates potential pathways exist for their introduction, and the need for continued vigilance and support by tree management agencies, industry and the general public to detect those that may escape detection.

Recent trends in climate change also have potential adverse impacts, not only in potentially increasing the area affected and rate of spread of exotic incursions, but also adding to the range of pest species not currently considered as potential threats. A robust and effective biosecurity system is therefore essential to minimise the impacts such exotic pest incursions pose to trees in Australia.
Biosecurity in general can be described as the protection of the economy, environment and public health from the adverse negative impacts of exotic infectious pathogens, insects and other biological organisms (e.g. weeds). It can be achieved by:

(a) implementing measures that prevent new pests from entering Australia that potentially could become established (quarantine: pre-border and border)
(b) establishing trapping and surveillance networks for pests so as to ensure early detection for those that break quarantine barriers(surveillance), and
(c) preparing a response plan and capacity through appropriate preparedness to act swiftly and accurately to manage incursions with the aim of eradiation where possible, or containment to lessen their impact (response).

Urban forest biosecurity may be achieved through systems that aim to detect and prevent pest introductions or spread, or mitigate an outbreak if it occurs. It is reliant on national and international policies and plans for dealing with a pest incursion, supportive tree management agencies, vigilant trained staff working in the arboriculture industry and an informed general public.
Stopping the entry, establishment and spread of unwanted pests is vital for protecting our urban landscapes, plant biodiversity and forest industries. This paper describes past, present and futures threats to urban trees in Victoria, Australia and highlights the importance of early detection and response.

Table 1. Native and endemic*introduced pests of concern to urban forests in Victoria, Australia

Common Name	Scientific name/s	Biotic agent/damage	Potential hosts	Potential risk to Urban Trees	Origin Native/Introduced
Armillaria root disease	*Armillaria luteobubalina*	Pathogen/root and butt rot	Gymnosperms and angiosperms	High	Native
Autumn Gum Moth	*Mnesampela privata*	Insect/defoliator	Eucalypts	Seasonal	Native
Chrysomelid Leaf Beetles	*Chrysophtharta, Paropsis spp. Anoplognathus spp*	Insect/defoliator	Eucalypts	Seasonal	Native
Cypress Canker	*Seridium* spp	Pathogen/branch and stem canker	Cupressaceae species	High	Introduced
Diplodia	*Diplodia pinea*	Pathogen/shoot blight and stem canker	Pines and other conifers	High/ stressed trees	Introduced
Myrtle Rust (Eucalyptus rust,Guava rust)	*Puccinia psidii*	Pathogen/shoot and leaf death	Myrtacae spp.	Moderate, restricted by climate	Introduced, under local containment
Five-spined Bark Beetle	*Ips grandicollis*	Insect/wood borer	Eucalypts	Moderate/ stressed trees	Native
Palm Fusarium Wilt	*Fusarium oxysporum f. sp. canariensis*	Pathogen/vascular wilt	*Phoenix canariensis and other palms*	High	Introduced, under local containment
Gum Leaf Skeletoniser	*Uraba lugens*	Insect/defoliator	Eucalypts	Seasonal	Native
Light Brown Apple Moth	*Epiphyas postvittana*	Insect/defoliator	Wide host range	Seasonal	Native
Longicorn beetles	*Phoracantha* spp.	Insect/ wood borer	Eucalypts and other native species	Moderate	Native
Monterey Pine Aphid	*Essigella californica*	Insect/defoliator	Pine species	Seasonal	Introduced
Phytophthora dieback	*Phytophthora cinnamomi* and some other species	Pathogen/root and collar rot	Wide host range	High	Introduced
Pine Longhorned Beetle	*Arhopalus rusticus*	Insect/wood borer	Pine species	Low/stressed trees	Introduced
Psyllids	*Psyllid* species	Insect/defoliator	Eucalypts and other native species	Seasonal	Native
Sawflies	*Perga* species and *Phylacteophaga froggatti*	Insect/defoliator	Eucalypts and other trees	Seasonal	Native
Sirex Wasp	*Sirex noctilio associated with fungal pathogen*	Insect/wood borer	Pine species	Low	Introduced, under biological control
Sycamore Lace Bug	*Corythucha ciliate*	Insect/defoliator	*Platanus* species	High	Introduced, not yet in Melbourne
Velvet-top Fungus	*Phaeolus schweinitzii*	Pathogen/butt rot	Conifers	Low/old age related	Introduced

* Exotic pests that have become naturalised (established) are considered endemic pests.

Table 2. Exotic pests of concern to urban forests in Victoria, Australia (*border interceptions occurred)

Common Name	Scientific name	Biotic agent/damage	Potential hosts	Potential risk to Urban Trees
Annosus root and butt rot	*Heterobasidion annosum*	Pathogen/root and butt rot	Gymnosperms and angiosperms	High
Armillaria root disease	*Armillaria* spp. incl *A.ostoyae* and *A. mellea*	Pathogen/root and butt rot	Gymnosperms and angiosperms	High
Asian gypsy moth*	*Lymantria dispar*	Insect/defoliator	Wide host range	High
Asian Longhorned beetle*	*Anoplophora glabriqennis*	Insect/wood borer	Wide host range	High
Brown mulberry longhorn beetle*	*Aprona germari*	Insect/wood borer	Wide host range	High
Chalara dieback	*Chalara fraxinea*	Pathogen/crown dieback	*Fraxinus* species	High
Chestnut Blight	Cryphonectria parasitica	Pathogen/ branch and stem canker	Chestnut, oak, red maple, shagbark hickory, and eucalypts	High
Coniothyrium eucalypt canker	*Colletogloeopsis zulensis* and *C. gauchensis*	Pathogen/stem and branch canker	Eucalypts	Moderate, restricted by climate
Dutch Elm Disease	*Ophiostoma* spp.*i*	Pathogen with insect vector/ vascular wilt	Elms	High
Eucalyptus canker	*Chrysoporthecubensis*	Pathogen/branch and stem canker	Eucalypts	High
Emerald Ash Borer	*Agrilus planipennis*	Insect/wood borer	*Fraxinus* species	High
Eucalyptus leaf blight	*Phaeophleospora destructans*	Pathogen/defoliator	Eucalypts	Moderate, restricted by climate
Eucalyptus (guava) rust (other strains)	*Puccinia psidii*	Pathogen/shoot and leaf death	Myrtacae species	Moderate, restricted by climate
Japanese pine sawyer beetle*	*Monochamus alternatus*	Insect carries Pinewood nematode	Pine species	High
Mountain pine beetle	*Dendroctonus pondersoae*	Insect/wood borer	Pine species	High
Nectria canker	*Nectria fuckeliana*	Pathogen/stem canker	Conifers	Moderate
Nun moth	*Lymantria monacha*	Insect/defoliator	Conifers	High
Pitch canker	*Fusarium circinatum*	Pathogen/branch and stem canker	Pine species	High
Pinewood nematode	*Bursaphelenchus xylophilus*	Nematode/wilt	Pine species	High
Sycamore Lace Bug	*Corythucha ciliate*	Insect/defoliator	*Platanus* species	High
Ramorum dieback (Sudden oak death)	*Phytophthora ramorum*	Pathogen/shoot blight, stem canker	Wide host range	High
Phytophthora kernoviae	*Phytophthora kernoviae*	Pathogen/shoot blight, stem canker	Wide host range	High
Western gall rust	*Endocronartium harknessii*	Pathogen/stem galls	Pine species	High
White Spotted Tussock Moth	*Orgyia thyellina*	Insect/defoliator	Rosaceae species	High

Past threats

Pine nematode

The importance of early detection and eradication is shown by an incursion of a pine nematode (*Bursaphelenchus hunanensis*) within Melbourne in late 1999 (Hodda *et al* 2008, Smith *et al* 2008). Local council officers reported a rapid decline of a mature pine tree (*Pinus halepensis*) in the botanic gardens at Williamstown, near Melbourne's main port (Figure 1). It is believed that the nematodes were introduced with wood boring insects that subsequently failed to establish. The early detection and identification by council officers and DEPI diagnostic staff rapidly led to a nationally coordinated response to undertake surveys and remove all infested trees.

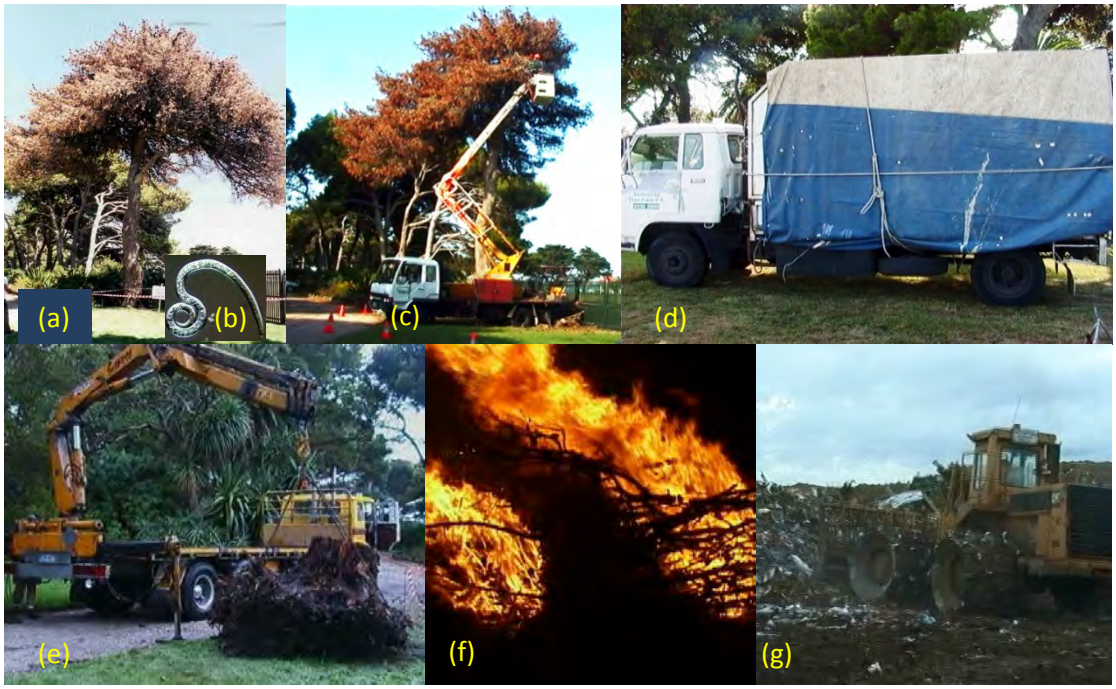


Figure 1. (a) Dying *Pinus halepensis*, (b) nematode extracted from wood, (c) Tree removal (d) load covered to prevent any insect escape (e) stump removal and disposal by either (f)burning or (g) deep burial

The rapid response prevented nematode establishment and potential spread into other urban trees and plantations. In this case, the trees in the gardens close to the ports acted as 'Sentinel Trees' and the diligence of the local officers provided an early warning of the pest introduction enabling the successful response and eradication.

The pathway for the introduction for pine nematodes (*Bursa phelenchus* spp. and in particular *B. xylophilus*) still exists, and in 2009 and 2014, two more interceptions of the wood boring insect vectors occurred in Melbourne (and Australia) when containers from abroad were opened near the ports (AQIS Nov/Dec 2009, DA 2014). However, in theses later interceptions the insects were destroyed and no reports of dying trees were received.

Present threats

Myrtle rust

In April 2010 myrtle rust, initially described as *Uredo rangelii*, a member of the eucalyptus/guava rust complex of *Puccinia psidii*, was detected on a myrtaceous host *Agonis flexusosa* 'After Dark' by a cut flower grower on the central NSW coast. For many years *P. psidii* has been considered a high priority quarantine fungus. Myrtle rust spread rapidly, and was detected in south east Queensland in late December 2010, and in Victoria in late December 2011.

The incursion into Victoria was human assisted through transport of nursery plants. So far myrtle rust has only been detected in nurseries, private gardens and amenity plantings in Victoria, but is widely distributed in native forests along the east coast from Batemans Bay in southern NSW to the Daintree in far north Queensland. The host range has expanded rapidly to over 240 species from 34 genera of Myrtaceae. Several species are highly susceptible with potentially severe consequences for native fauna.
The fungus was first described on guava in Brazil in 1884 where it rarely caused damage, but by 1912 it had expanded its host range and was observed on *Eucalyptus citriodora*. Epidemics have occurred on *Eucalyptus* species planted in Brazil, on allspice in Jamaica (1938), on *Melaleuca quinquenervia* in Florida (1979) and on *Metrosideros polymorpha* in Hawaii (2005). It was reported in Japan in 2009 and China in 2011.
Symptoms vary between hosts and may consist of round lesions up to 1 centimetre in diameter, purple to brown in colour, which develop through the leaf to express on both the upper and lower leaf surfaces. The fungus produces bright yellow asexual spores and dark red-brown sexual spores often found together in pustules (Figure 2). Lesions turn dark brown to grey with age. Disease only affect young shoots, flowers, fruits and leaves, causing curling, buckling and distortion of tissues. Heavy infection causes shoot dieback and defoliation. Repeated infection may reduce vigour and result in plant death.

Figure 2. Symptoms and signs of myrtle rust (a) fungal spores, (b) yellow spores on the bottom of the leaf, (c) infected shoots with yellow spores.

Spores are dispersed by wind, rain-splash, animals and humans. Infection requires conditions of high relative humidity greater than 70 per cent, or a 6-8 hour period of leaf wetness, during low light or darkness. The optimum temperature for infection is 15-25 ^{o}C with a range of 2-40 ^{o}C. Lesions appear within 5-7 days and spores are produced up to 14 days or more after infection. Spores may survive for a week under field conditions. Studies conducted in Brazil on Eucalyptus show infection is favoured by a microclimate found from ground level up to a height of 4 metres. In laboratory studies exposure to light during the initial stage of infection reportedly inhibits infection.
Control of myrtle rust depends on maintaining good hygiene practises, fungicide application and plant resistance and breeding. Glasshouse studies in Australia have identified susceptible and tolerant Myrtaceae genera and species, and only a few resistant native plants. Currently two fungicides are registered for disease control, while nine are permitted as is one surface sterilizing agent.

Asian longhorn beetle
The Asian longhorn beetle (*Anolpophora glabripennis* ALB) is a a polyphagous cerambycid native to China, Hong Kong, Korea and Japan where it causes widespread mortality to many tree species including elms, willow, poplar, maple and apple. Unlike many cerambycid species, ALB has enormous destructive potential because it attacks healthy trees and spends most of its life as a larva, boring inside tree trunks and large branches. This boring activity by the larva compromises the tree's vascular system, causes severe damage to the wood's structural properties, and eventually leads to the death of the attacked trees (Cavey et al ., 1998).The adults can also cause defoliation and damage by feeding on leaves, petioles and bark.
In 1996, the beetle was first discovered in the United States, as well as Canada, Trinidad, and several European countries including Austria, France, Germany, Italy and the UK. The species is believed to have been accidentally introduced into these countries in solid wood packaging material (dunnage).

ALB poses a significant threat to a range of deciduous hardwood species, including chestnut, ash and birch species and is the subject of costly eradication programs in many of these countries. The full range of potential host species is yet to be elucidated. Due to extensive trade links with Asia, the risk of ALB interception within Australia is high, with the most likely means of entry being through imported timber and wood products, including packing materials at major seaports.

An adult beetle is approximately 20 to 35 mm long and 7 to 12 mm wide. Its body is jet black in colour with white spots (Figure 3). The antennae are black with whitish-blue rings and can be up to two and a half times the body length (males have longer antennae). Beetle eggs (5 to 7 mm long) are laid under the bark within small oval pits that the female chews. A single female beetle can chew between 35 to 90 individual depressions. Once the eggs hatch, the larvae tunnel through the tree's sap layers, effectively ringbarking the trees if enough larvae are present. The larvae can grow up to 50 mm long and can take up to 3 years to emerge as beetles. Adults emerge in summer, mate and subsequently lay eggs in a host tree's bark. Adult beetles can live for up to 50 days. Because of the length of time that adult beetles may take to emerge, potential resources for surveillance is significant.

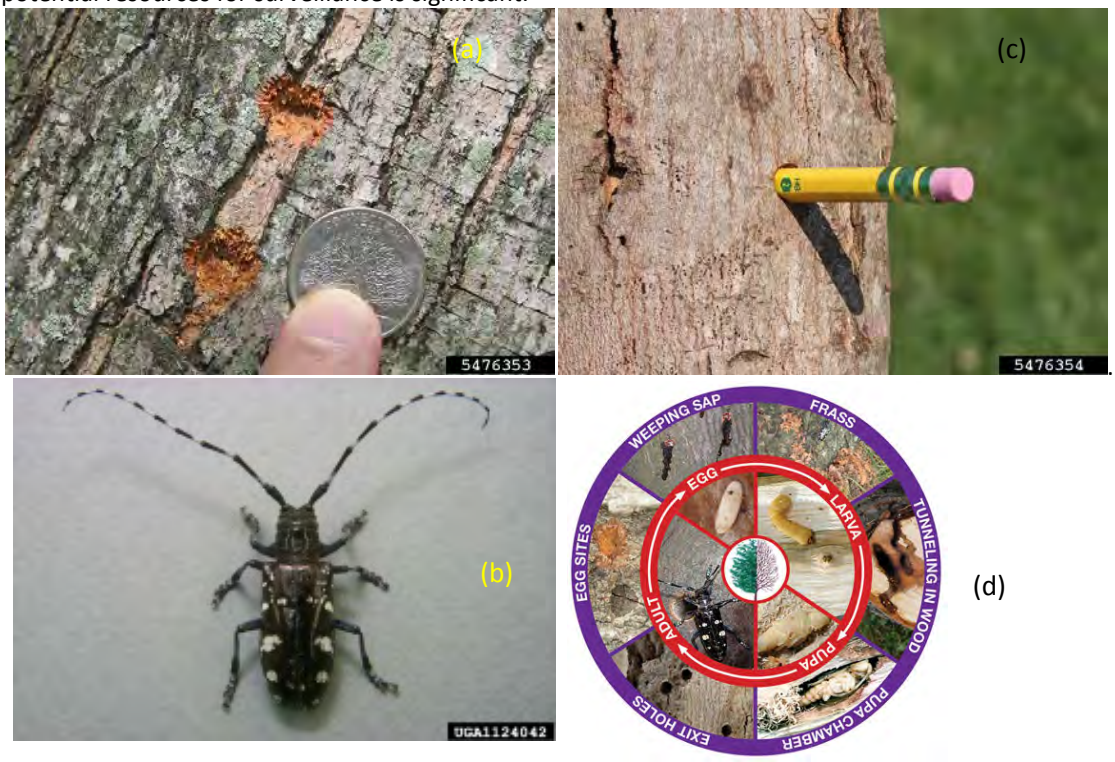


Figure 4. Asian longhorn beetle: (a) depressions chewed by a female beetle during egg laying (Donald Duerr, USDA Forest Service, Bugwood.org) (b) adult beetle (c) life cycle. (Joe Boggs, Bugwood.org) (d) life-cycle(http://asianlonghornedbeetle.com/spot-it/)

Brown mulberry longhorn beetle

Brown mulberry longhorn beetle (*Aprona germari*,BMLB) is a polyphagus wood-boring insect, recorded as feeding on 65 known host plants, including a large number of hardwood trees such as apple, elm, fig, mulberry, poplar, pear, citrus, rosewood, hawthorn, lagerstroemia, mulberry, walnut, and willow (CABI, 2014). BMLB occurs naturally in the Asian region, including Myanmar, China, Japan, Korea, Indochina (Vietnam, Laos and Cambodia), Malaysia, West Pakistan, North India, Taiwan, Thailand, and Nepal (NMA, 2010). It is reportedly a major pest of *Morus spp., Populus spp., Pyrus spp. and Salix spp*. with particularly severe damage in India and China on mulberry and poplar plantations (NMA, 2010, DA,2014, Huang, 1996 in Shui *et al.*, 2009, Huang et al., 1994, Ma *et al*. 1997, Huang *et al*., 1997).Brown mulberry longhorn beetle is particularly damaging in arid situations (Ji *et al*., 2011).The potential impact of brown mulberry longhorn beetle on Australian native plants is not known.

An adult beetle is large being about 26 to 50 mm long. Its body is black and covered with tawny brown to slightly greenish hairs (Figure 4). The antennae are brownish black with whitish grey rings and can be up to one third longer than the body.

BMLB attacks only living trees. Like other longhorn beetles, brown mulberry longhorn adults lay eggs under the bark on host trees. The eggs are about 8 to 9 mm long, with a brown tinge and are laid in slits made in the bark by the female adult beetle. After eggs hatch, the developing larvae feed under the bark forming tunnels or "galleries". Later larval stages also bore into the woody tissue and can grow up to 70 mm long. Over time, the feeding activity of the larvae can cause a decline in the health of trees and ultimately death.

Figure 4. Adult brown mulberry longhorn beetles (http://www.timesofmalta.com/articles/view/20121031/environment/An-unfriendly-squeaking-beetle.443379)(http://sinobug.aminus3.com/image/2011-08-01.html).

Japanese Pine Sawyer Beetle / Pine Wilt Nematode

The genus *Monochamus* contains several species of cerambycid beetles commonly known as longhorn beetles or pine sawyer beetles, which are native to temperate regions of North America, Asia, Africa and Europe. Adult pine sawyer beetles are secondary invaders of recently cut timber and felled, stressed, dying or dead coniferous trees. While they damage freshly cut timber by feeding and creating tunnels in the wood, *Monochamus* spp. in their own right are not generally considered to be serious forest pests. Their significance as a pest lies primarily due to their role as a vector of the pine wilt nematode *Bursaphelenchus xylophilus*, the causal agent of pine wilt disease. The beetle carries the nematode from an infested tree to a new host tree either when it feeds on the bark and phloem of twigs of susceptible live trees, or when the female beetle lays eggs (oviposits) in freshly cut timber or dying trees (Plant Health Australia 2007).

Pinewood nematodes, and in particular *Bursaphelenchus xylophilus*, are members of the pinewood nematode species complex (PWNSC) that are associated with pine wilt disease. Pine wilt disease manifests as a rapid wilt of susceptible pine species and causes extensive mortality in softwood plantations and forest environments(Figure 5). *Bursaphelenchus xylophilus*is pathogenic on a number of pines, as well as larch, spruce and fir. While other species of *Bursaphelenchus* have also been associated with death of pines, many are thought to be saprophytic.

*Bursaphelenchus xylophilus*is native to North America. It is an introduced pest in China, Japan, South Korea, Taiwan and Portugal where it has caused extensive mortality in pine plantations and forests. (Plant Health Australia, 2007). The likely pathway into Australia is via insect vectors introduced in bark, lumber and wood packaging material including dunnage.

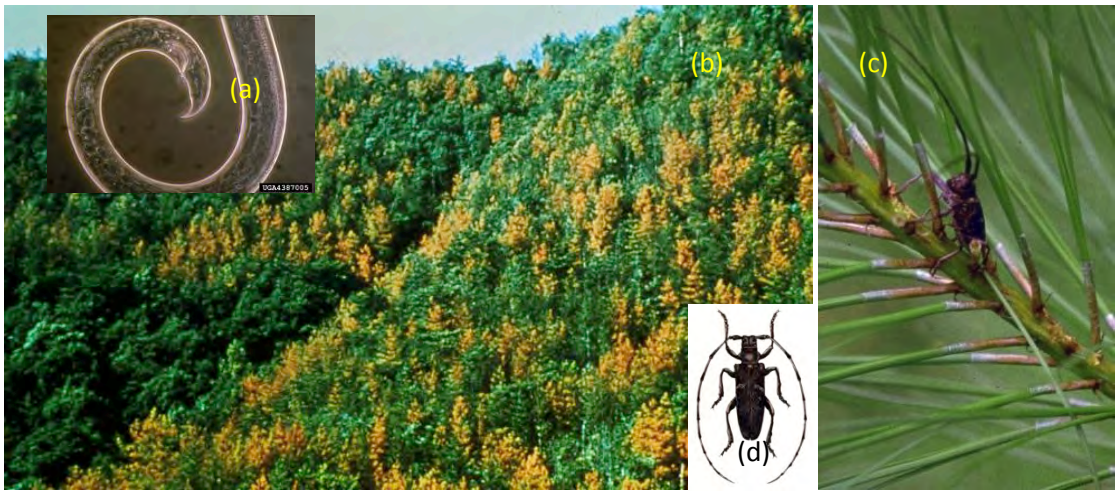


Figure 5. (a) Pine wood nematode (L.D. Dwinell, USDA Forest Service, Bugwood.org), (b) damage and (c& d) *Monochamus* beetle vector (Christopher Pierce, USDA APHIS PPQ, Bugwood.org).

Detection of longhorn beetles in Australia 2014.

In early 2014, the Department of Agriculture investigated consignments of timber pallets imported from China that were associated with non-timber building material (Figure 6). Some of the timber pallets were found to contain exotic timber pests. The pests of biosecurity concern included the Asian longhorn beetle, the Brown Mulberry longhorn beetle and the Japanese sawyer beetle. Nematodes species were also detected in one of the Japanese sawyer beetles (DA 2014).

These beetles could cause serious damage to our forestry industry, natural environment and urban parks and gardens. Ongoing surveillance continues to demonstrate that the beetles were confined to the immediate site of the infestation and have not entered the environment. To date no evidence that any of the beetles or nematode species have become established in Australia. All infested pallets were fumigated and tracing activities were used to account for all timber pallets imported. Fumigation kills any beetles present, as well as any eggs, larvae or pupae inside the timber.

Figure 6. Timber pallet showing damage and longhorn larvae in situ and galleries within the wood (DA 2014)

Future threats

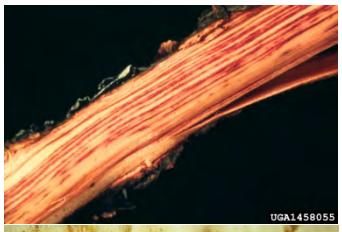
Dutch Elm Disease

Dutch elm disease (DED) is one of the most serious threats to elms within Australia. DED has killed tens of millions of elms in Europe and North America over the past 50 years. It is caused by the fungal pathogen *Ophiostoma ulmi* that infects and grows through the water conducting system of elm trees blocking the flow of water. Symptoms of DED include yellowing, curling, wilting, death of leaves (flagging) and brown longitudinal streaks in the sapwood of infected branches (Figure 7). The pathogen can be vectored from tree to tree through spores adhering to Elm bark beetles(Figure 7),and infects through wounds created during their feeding within the branches. The fungus can then spread through the branches into the main trunk and root systems of a tree and infect other trees in close proximity through root grafting.

One of the bark beetle vectors of the pathogen is the smaller European elm bark beetle (*Scolytus multistriatus*) This beetle vector is already well established in Australia, and could rapidly spread the fungus throughout the elm population. The detection of the disease in New Zealand in 1989 is of particular concern to Australia due to its geographic proximity to Australia and their inability to eradicate the pathogen (http://www.biosecurity.govt.nz/pests/dutch-elm-disease). While eradication was unsuccessful, the containment program initiated through the removal of all known infected trees reduces the possibility of an infected beetle accidentally being introduced to Australia. In 2012, about 50 elm trees were removed due to a DED outbreak on private properties in the Whitford area of Auckland.

A National DED contingency plan has been developed and includes pre-introduction measures to reduce the impact of the pathogen should it be introduced. This includes a surveillance program to pick up early symptoms of disease, improvement in the current health of elms and removal of any unwanted elms so as to reduce potential beetle breeding sites.

(a)



(b)

(c)

(d)

Future 7. Dutch elm disease symptoms in USA including (a) flagging (Petr Kapitola, State Phytosanitary Administration, Bugwood.org), (b) streaking in wood (North Carolina Forest Service Archive, Bugwood.org), (c) galleries of beetle vector (Beat Forster, Swiss Federal Institute for Forest, Snow and Landscape Research, Bugwood.org)and (d) adult beetle vector *Scolytus multistriatus* (Pest and Diseases Image Library, Bugwood.org).

Asian gypsy moth

Asian gypsy moth (AGM) (*Lymantria dispar* (Linnaeus)) is an exotic lepidopterous defoliating pest that is native to the Russian Far East and is found throughout China, Korea, Japan, as well as being detected in the United States, Canada and New Zealand (Pitt *et al*. 2007). AGM underwent a successful eradication program in New Zealand.

AGM is one of the most significant exotic insect pest species of concern to Australia as it has an extensive host range (over 650 tree and plant species), enabling the potential for rapid establishment and long distance spread. It poses a significant threat to commercial and native forests, parklands and trees in other public use areas. Examples of trees at risk in the moth's larval phase include pine, apples, oaks, elms, cherries, acacias and eucalypts. Feeding trials have indicated that important commercial and amenity species including *Corymbia maculata*, *Pinus radiata*, *Eucalyptus grandis* and *E. camaldulensis* are at potential risk from AGM defoliation (Matsuki *et al*. 2000, Commonwealth of Australia, 2001). In North America, gypsy moth (European form) has caused considerable damage to several important tree species in the 120 years since its initial introduction (Figure 8a). While single defoliations do not usually result in tree mortality, repeated events have the potential to severely weaken trees leading to eventual death.

Adult moths (Figure 8c) emerge in summer where they mate, with the females laying egg masses on tree bark, cliff faces or on infrastructure such as metal containers and ships superstructure (Canadian Food Inspection Agency 2006). The eggs hatch and the larvae (Figure 8b) that emerge form a fine silken thread that may be picked up on the wind allowing the tiny larvae to spread to new potential hosts. Larvae grow as they consume foliage prior to pupating and recommencing the lifecycle as an adult.
Since 1980, the US has spent in excess of US$30 million annually on gypsy moth control with a further US$34 million spent so far on an eradication of an AGM incursion from Russia (Matsuki *et al*. 2000). In the 1990's, incursions of the European and Asian forms (including hybrids of both race) have been intercepted along the east coast of the United States and over the past 25 years, repeated incursions of the Asian form have been detected along the west coast of Canada and the United States. Although these incursions have not led to establishment, they indicate the ongoing detection and eradication effort required over sometimes prolonged periods to ensure areas remain pest free. In early 2002, quarantine inspectors at the Port of Brisbane intercepted an AGM egg mass on machinery imported from Japan. While in March 2003, an adult female AGM was trapped in Hamilton, New Zealand resulting in an extensive monitoring and eradication program in late 2003 at an estimated cost of $11 million. As part of a Federal Government initiative in 1996, monitoring traps were located at major shipping ports around Australia as these were considered the most likely point of entry for AGM. The program serves as an 'early warning system' to detect and identify incursions of exotic Lymantrid species entering through Australian ports.

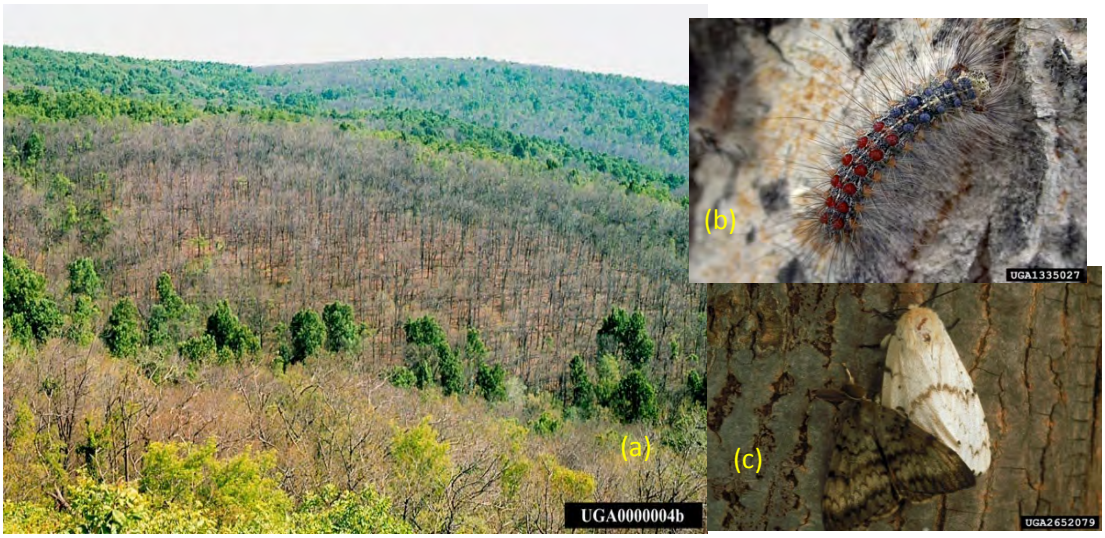


Figure 8. Asian Gypsy Moth (a) defoliation (Robinson, M.E. - USDA Forest Service), (b) caterpillars (Ghent, 2014) and (c) adults (USDA APHIS PPQ Archive, USDA APHIS PPQ, Bugwood.org).

Sentinel Tree Plantings

Sentinel tree plantings are a monitoring and surveillance technique that uses specific tree species to keep watch for anticipated pest events either within the country of potential threat, or in the country of the pest's origin. Thus there are two main uses of sentinel tree plantings:

1. **Post-Border surveillance:** tree species known to be susceptible to exotic pests may be planted surrounding high hazard sites (e.g. ports and their environs), to provide early detection of pests entering a country. Trees already established in gardens surrounding hazard sites may also be used (e.g. as with the Williamstown Botanic Gardens for detection of pine nematode). It is important in quarantine biosecurity situations such as with pine nematode, that the local flora be well sited, described and monitored. Established and well-mapped trees across a city may also be used in the response phase of an incursion to rapidly survey the spread and extent of an incursion. The monitoring may be as simple as arranging for regular and routine reporting of damage by botanic garden, council and professional arborists.

2. **Pre-Border surveillance:** tree species of unknown susceptibility may be planted and monitored in an exotic region to assess the potential that native pests of that region may have to the species under investigation. For example Australian native species may be planted amongst native forest in North America to assess the potential of North American pests (both native and established exotics), to Australia's forests. Existing gardens and arboreta may also be used for this purpose. For example the extensive arboretum of Australian native species planted in Santa Cruz in California (UC Santa Cruz), could provide an opportunity to monitor for potential exotic pests to Australia. These plantings were used to assess Australian tree species for their susceptibility to *Phytophthora ramorum* (Ireland *et al.* 2012a & b). In this manner the susceptibility of the different tree species can be determined, and potential pathways for their introduction closed and/or monitored. Alternatively the extensive planting of eucalypts across the world if monitored, could provide Australian authorities with an early warning of potential new incursions (e.g. Eucalypt rust in South America).Conversely, Australia's extensive plantings of exotic trees can equally provide an important early warning system for countries of their origin, should Australian species become pests. Individual countries could enter into agreements to monitor and report on the trees on their behalf. The monitoring may be as simple as arranging for regular and routine reporting of damage by botanic garden, council and professional arborists, and the current forest health surveillance activities carried out in each State.

In developing a sentinel plant network for the production of an early warning system for exotic pests, it was identified that linking with local councils that maintain detailed Geographic Information System tree information around high risk areas such as Melbourne ports and airports, to be key to a quick response system. A pilot sentinel plant program has been with four Melbourne councils (City of Melbourne (COM), City of Port Phillip Council (COPP), Hobsons Bay City Council (HBCC) and Hume City Council (HCC)). All councils are enthusiastic about the program and have provided their tree databases for examination.

During the program, known pest host interactions are examined to provide a list of the tree species that are at risk from the 24 exotic pests of known concern to Victorian Forestry. This investigation required a thorough literature search that identified 77 tree genera and over 100 species of trees that are at risk from an exotic pest incursion. Tree databases around the Melbourne port and airport and the local councils were supplied in ArcGIS format (geo-reference database) and analysis of the COM tree data has been initially investigated to test its feasibility. Each tree within the databases has a latitude and longitude so tree distribution can be displayed. The database provided by COM contains 49,818 trees with 55 genera. Within these 55 genera there are over 100 tree species that are susceptible to the 24 exotic pests of concern.

The benefit of geo-referenced tree databases is that risk modelling that can be performed showing the distribution of the trees that are most at risk to a specific pest and maps produced quickly for incursion surveillance. This strategy was tested in 2010 and again in 2014 when exotic pests were detected in Australia (as previously described). The data enabled the Department of Environment and Primary Industries and Councils to analyse their risk and prioritise the emergency response. Tree data can also be used to prove area freedom.

Conclusions:

Protection of our valuable urban trees and plant industries is a joint responsibility of government (Federal, State and Local), industry and the general public. The increased number of pest interceptions with increased trade has highlighted the need for continued vigilance and support by tree management agencies, industry and the general public to detect those that may escape detection at border entry points.

The supply of geo-referenced tree databases by local councils to agencies responsible for surveillance activities, has greatly improved the ability to detect pests and rapidly respond to incursions. However, this is dependent on the maintenance of these databases, provision of good identification material and training of those who are at the front line of detection, and the allocation of sufficient resources to adequately cover detection and response activities.

This paper has highlighted the threats to urban trees in Australia from exotic pests, and the importance of early detection and a rapid response.

Reporting suspect pests

http://www.planthealthaustralia.com.au/biosecurity/emergency-plant-pests/reporting-suspect-pests
Any unusual plant pest should be reported immediately to the relevant state or territory agriculture agency through the Exotic Plant Pest Hotline (1800 084 881). Early reporting increases the chance of effective control and eradication.

Reporting an exotic plant pest should be done only via the Exotic Plant Pest Hotline. Careless use of information, particularly if a pest has not been confirmed, can result in extreme stress for individuals and communities, and possibly damaging and unwarranted trade restrictions.

If you suspect a new pest, call the Exotic Plant Pest Hotline.

Calls to the Exotic Plant Pest Hotline will be forwarded to an experienced person in the department of agriculture from the state of origin of the call, who will ask some questions about what you have seen and may arrange to collect a sample. Every report will be taken seriously, checked out and treated confidentially.
In some states and territories, the Exotic Plant Pest Hotline only operates during business hours. Where this is the case, and calls are made out of hours, callers should leave a message and contact details and staff from the department of agriculture will return the call the following business day.

Suspect material should not generally be moved or collected without seeking advice from the relevant state/territory department, as incorrect handling of samples could spread the pest or render the samples unsuitable for diagnostic purposes. State/territory agriculture department officers will usually be responsible for sampling and identification of pests.

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BEAUTY, AESTHETICS AND CARE: A LINK TO A SUSTAINABLE FUTURE

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TREE ROOT MANAGEMENT

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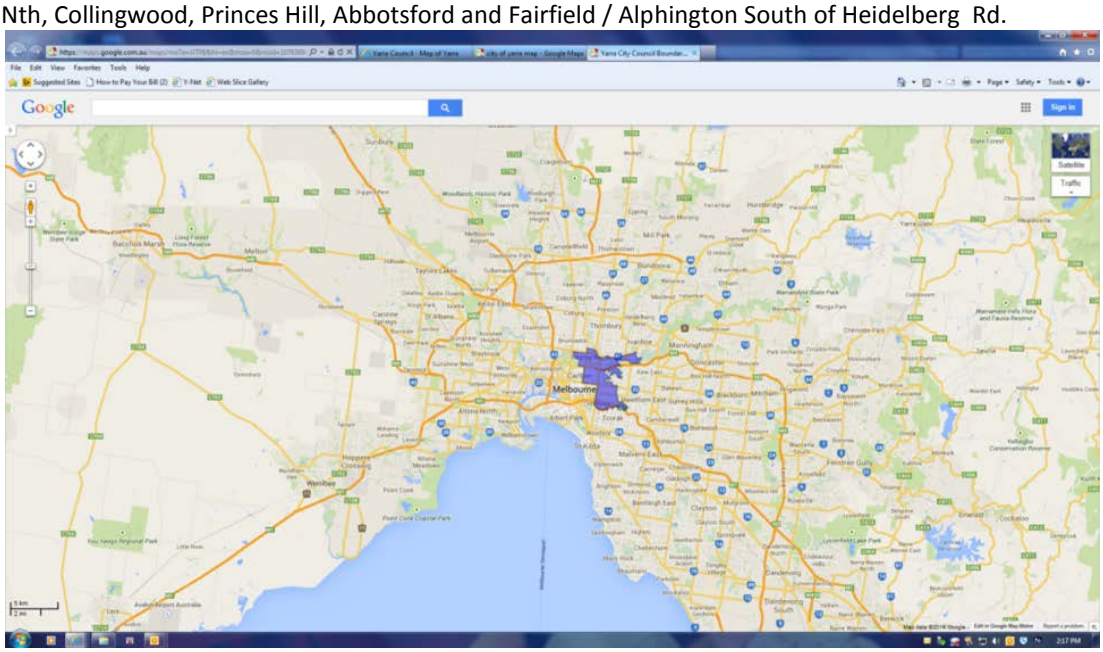
ABSTRACT

The intent of the paper is to explain and analyse tree root management practices within the City of Yarra, Melbourne. The high density of infrastructure, predominantly Victorian dwellings, reactive clay soils 'Class H' and the planting of trees often makes for conflict between infrastructure and the needs of the tree. Employed 12 years ago as the first arborist at Yarra it is my job to manage this conflict which involves the necessity of tree root management. This has resulted in practices being implemented that would normally never be recommended by an arborist with some unexpected results.

Introduction

City of Yarra is approx. 20km2 and has a population of approx. 83,000 residents and is situated in the inner north east of Melbourne and includes suburbs of Richmond, Burnley, Cremorne, Fitzroy, Fitzroy Nth, Carlton Nth, Collingwood, Princes Hill, Abbotsford and Fairfield / Alphington South of Heidelberg Rd.



Yarra consists of high density infrastructure and housing. More than half the municipality consisted of light industry in the early to mid-20th century and has given way in the last 20 years to high density housing and a café culture.

Approximately %50 of the population changes houses every 5 years. The demographic who includes 38 different spoken languages includes both extremes of the socio economic scale i.e. Government housing to multi-million dollar apartments & mansions.

Until the late 1970's the southern part of the municipality was seen as an undesirable place to live with the wealthier seeking the larger expanses of the suburbs.

Original residential dwellings are predominantly of the Victorian era, sitting on minimal footings of bluestone, brick or in many cases rubble. Very few nature-strips exist and asphalt and bluestone are prevalent.

The dominance of light industry and the influx of ethnic immigration after the 2nd world war did not see trees as a priority and minimal tree planting was undertaken. The few trees planted at this time were species proven to survive, primarily of Platanus (London Plane), Melaleuca (Paperbark) & Ulmus (English Elm). There was no thought of the consequences in relation to size or location.

The change in demographic and greater understanding of the importance and benefits of trees in the landscape has the public demanding that council provide tree planting programs and that all trees be retained where possible.

The municipality has an estimated 30,000 street trees with additional 1000 planted annually. These are planted into hard asphalt surfaces overlaying highly reactive, Class 'H' Quaternary Basalt and Silurian clays with basalt floaters and bed rock in scattered locations. The soils readily expand and contract based on the amount of moisture they hold. The northern part of the municipality has a high water table and many new plantings fail due to waterlogging even in summer months

Trees planted in the middle part of the 20th century are now fully mature and many, predominantly Plane and Melaleuca trees, are impacting detrimentally on infrastructure. The need to preserve trees has resulted in what some may see as radical solutions to resolving the conflict between infrastructure and trees.

As arborists, do we know as much about trees as we think?

As arborists most of us have spent many years studying to obtain qualifications in arboriculture where the preservation of trees is paramount and the mantra of minimal interference to trees is prevalent to their retention. This includes the necessity to minimise root disturbance and the severance of tree roots that can have a detrimental impact on tree health.

The introduction of the Australian Standard for the 'Protection of Trees on development sites' – AS4970 was a huge step forward in the preservation of trees and advantageous document in the education of the building industry.

Unfortunately, in my situation I cannot apply the formulas as recommended. This would see nearly all trees I inspect contributing to infrastructure damage being removed on the grounds that they will become unstable or die.

The decision I have to make around the preservation of trees and any damage is simple. 'Cut the roots or Remove the tree'.

This has led me to make decisions associated with tree root pruning based on my years of observed experiences and not on science or documented research. Roots are exposed using air knives and estimations are made of the extent of roots a tree may have and where these are expected to be located. Conclusions are then made of what roots can be cut that will not significantly impact on tree health or tree stability; stability being the priority due to safety reasons. I soon realised being an arborist had little to do with the decisions I was making.

Over the last 12 years I have instigated the pruning of roots on over 3000 trees. Many of these works I myself would class as barbaric and questionable. This has however, allowed me to see the consequences of my actions and the response from trees. My confidence in cutting larger and more roots has increased over the years and much to my surprise with minimal or long term impacts. Trees appear to either have no detrimental impacts or have sparse canopies for a few years and then develop full canopies. Minimal deadwood is observed. I call it sulking!

I have found trees to be significantly more resilient than we give them credit. They appear to be able to initiate feeder's roots quickly in response to root severance as long as adequate quantities of water are available.

It leads me to question the following:

- Damage or sever a portion of the roots and a corresponding portion or the entire tree may die.
- Tree roots do not search for, sense or extend towards, anything. E.g. water, nutrients, drains or dripping taps.
- Tree roots cannot extend or grow in dry soil**.**

Tree Root Distribution

Tree roots are opportunistic and will grow wherever there is sufficient water, nutrients, air and non-compacted soils that allow for root extension. Where these are abundant roots will proliferate. This can be many times the height or with of the canopy away. In general they do not have a single tap roots but may established sinker roots in sandy soils or clay fissures to access deeper water reserves.

In an open ground where trees have ample room to grow with no impediments, i.e. building foundations, underground services etc. roots would tend to spread radially from the tree to a depth of around 600mm deep, where these elements are usually in abundance, as shown above.

In highly modified urban landscapes however with substantial underground impediments, this is not the case. Roots will grow wherever they can absorb sufficient elements for growth.

This is along the bluestone kerbs where water is plentiful, in the footpaths where soils are not severely compacted and in front yards where soil is friable and often regularly irrigated.

Often several meters underground growing in disturbed soil next to underground services or many tens of metres past the canopy i.e. in stormwater drains.

In urban environments Asphalt provides an ideal environment for surface rooting. It is porous and allows water and air exchange and holds heat. The interface between the asphalt and subgrade acts like a hot house.

Roots do not grow in the roadway due to compaction. This can be within 1m of the trunk. Root plates often don't exist on the roadside of the tree.

Roots are often found where you don't expect them.






Tree Root Associated Damage

Roots can often contribute to property and infrastructure damage. They can do this in two ways:

The movement of structures physically by tree roots.
This seldom occurs on buildings or major structures that have adequate foundations but regularly occurs to masonry fences, veranda returns, pipes, gutters that are not designed to carry significant weight or have force placed upon them.

The subsidence of soils by the absorption of moisture from the soil profile by tree roots.
Predominantly in clay soils that are prone to shrinkage and expansion based on water content. Trees can absorb sufficient amounts of water to make clay shrink, undermining footings. This is the main cause of private property damage claims in Yarra.

The suction effect of roots in clay soils through diffusion can result in soils drying out many meters from tree roots, where tree roots are not observed.

Evaluating Damage Related to Tree Roots.

As arborists we should not think that we are suddenly engineers and provide advice outside our field of expertise. However, we can give opinions based on experience.

Many factors can contribute to structural damage, including the following:

- ❑ inadequate or poor quality footings & construction,
- ❑ leaking water and sewerage pipes,
- ❑ seasonal shrinkage (drought),
- ❑ poor drainage, inadequate or damaged storm water discharge,
- ❑ poor property maintenance,
- ❑ privately owned trees,
- ❑ nearby construction disturbance,
- ❑ alterations to the property,
- ❑ service pits e.g. gas, Telstra

In recent years Victorian local government insurance has under gone changes from an equal lump sum payment made by all councils to a user pays scheme. The more claims made by an individual council/shire the higher the premium. This has highlighted tree root related claims as being some of the highest. In February the formation of a working group was instigated in collaboration with the Municipal Association of Victoria (MAV), Liability Mutual Insurance, Jardine Lloyd Thomson (Risk consultants) and arborists from 8 Victorian metro councils.

The intent to develop a consistent risk based approach to investigating possible tree related damage/claims. A draft template has now been developed that will be soon available to Victorian municipalities to trial and evaluate. It is hoped this will reduce claims and lead to the retention of more trees.

Minimising Infrastructure Damage.

Species selection - Based on soil and climatic conditions, and adequate space for its mature size, above and below ground.

Construction design - Ensure footings accommodate trees and their potential size and possible impacts. Modified footings that minimise soil disturbance and subsequently root damage i.e. screw piles, pier and beam, waffle slab, individual stumps. In urban environments there is always going to be a tree in the vicinity.

Root Grinding - The grinding of roots to allow for the reinstatement of kerbing, footpath etc. This leaves a substantial part of the root intact for stability and absorption. This is usually instigated by council civil contractors to undertake repairs to infrastructure



Selective Root Pruning - The severing and removal of sections of visible root/s that maybe causing physical damage e.g. a root lifting footpath, kerbing or masonry fence. Root pruning

Root Barriers – Designed to sever roots and to install a physical membrane to prevent roots growing towards infrastructure/property. These are often moisture membranes to prevent drying of soils around footings.

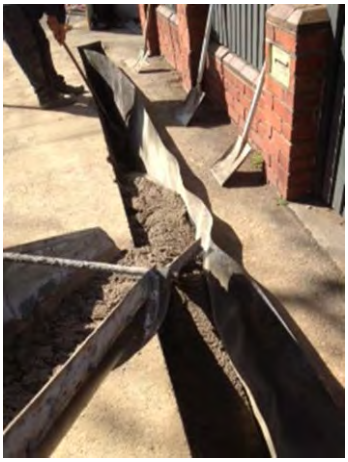
Often not seen as a long term solution they can prevent litigation for damages and preserve the life of the tree. Their success is based on location, size and quality of installation.

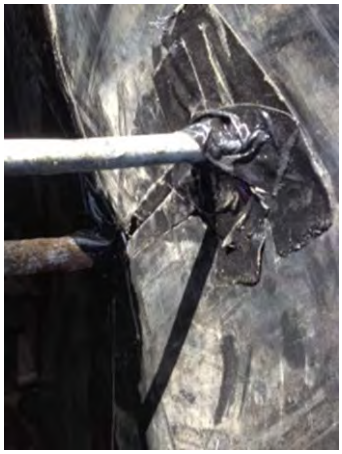
Barriers consist of high density polyethylene barrier to 1.5m deep (2m if roots discovered at this depth) backfilled with flowable stabilised sand, 3% cement. Roots are carefully exposed using a mini excavator and spotter and severed cleanly with cutting equipment, not ripped out. The 300mm bucket and subsequent trench allows access to seal around service and joins with butyl tape. Roots act similarly to human wounds in the sense that a clean cut will callus (heal) quickly. Ripped jagged surface are prone to disease and decay that can spread throughout the root system causing failure to callus and possible destabilisation in the future as the root plate decays.

The membrane is placed on the furthest side of the trench from the tree and backfilled with flowable sand on the tree side. This viscosity of the sand, which sets hard, allows it to creep into cracks, joins, around services etc. and provide an additional barrier. Initial inspections of barriers exposed after a few years shows flowable sand appears to stunt and restrict root development upon contact. Roots act like hyphae at the root sand interface.

They are instigated on property damage claims where it has been proven that the tree is having significant impact on the building. Proof is either by physically viewing roots causing the damage or with supporting evidence from the property owner i.e. soil engineers (GEO Tech) report that provides, soil moisture testing etc. This is beneficial as they identify all possible causes of any damage and footing types, depths.

Structural engineer reports are not excepted as they do not provide evidence and make assumptions that are not validated.





All significant root pruning is undertaken when tree are in advanced stages of autumn leaf drop or dormancy, usually in the months of May to October. This is climate and species dependant during autumn. *Platanusinsularis* – Cyprian Plane, did not lose its leaves till late July.

Service provider practices in response to tree involvement, previous and present.

Prior to Yarra employing an arborist trees were seen as a liability that caused damage and complicated repair works. The Arboricultural & Streetscape unit Council has slowly been able to educate the providers and council engineers and make them realise the importance of trees and how they are a valued essential council asset. Removing trees indiscriminately, ripping roots out with excavators and jack hammers was a common practice.



Thankfully it has now changed and service providers are very committed and understanding in minimising damage to trees. Aqua vacs that dislodge soil with high pressure and suck it out are always used when in the vicinity of a tree in Yarra unless council's arborist approves excavation by machine under their supervision. The aqua vac provides the necessary water to minimise tree stress and assists in accurately locating roots and services that would otherwise be difficult and result in unnecessary damage to roots.

While this does cause some damage to tree roots by partially removing bark and sections of cambium from the roots it leaves much of the root intact. This ensures stability is maintained and also provides the necessary water to retained roots for quick recovery and minimise stress.

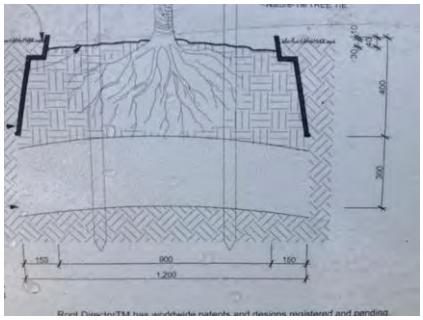



New innovations to protecting trees and minimising root damage.

To try and retain trees where root pruning is likely to significant impact on tree health and or stability, Yarra council is trialling a number of different strategies that minimise root severance or may prevent root damage to infrastructure.

Indenting kerbs to allow larger majority of roots to remain

Installing root deflectors at the time of planting to try and minimise future damage



Installing rubber footpaths to prolong footpath life and minimise trip hazards

Installation of sump holes to encourage draining and to prevent significant root pruning in gutters

Conclusion

Trees in an urban environment are an essential asset in its liveability; environmentally, aesthetically, socially and economically. The demand to plant more trees and retain the ones we have is becoming more and more difficult as the demand on opens space increases and the space available to trees diminishes.

It is essential that we retain as many larger trees as possible as these are the specimens that provide the greatest benefits and increase the likely hood of space being set aside for trees in the future. Past species and location selection practices make this task difficult and resourceful thinking is required. Innovation and sometimes debatable practices need to be implemented.

Tree managers need to keep educating engineers and civil contractors that trees are as important council asset as roads and signs and highly revered by the public.

We need to keep trialing and assessing new techniques in tree management to obtain a better understanding of trees and their responsiveness to enable larger mature trees to be retained longer in the environment for future generations to enjoy.

COMPARING APPLES WITH ANDROIDS – THE NATIONAL TRUSTS OF AUSTRALIA REGISTER OF SIGNIFICANT TREES

Anna Foley
National Trust of Australia (Victoria)

Introduction

Building on the success of the Trust Trees app launched in Victoria in 2011, the new National Trusts of Australia Register of Significant Trees website will be completed in August 2014. This brings the Trusts' state-based significant tree data together as one national dataset for the first time. Over 2,000 significant tree records have been compiled over 30 years by the National Trusts across Australia. These records represent over 25,000 trees around the country. From the Broome to Ballarat, Perth to the Parliamentary Triangle, Ingham to Innamincka… the new Register includes trees from all over Australia. They grow between skyscrapers, in suburban backyards and parks, in the main streets of regional centres, around rural towns and hamlets, and in the bush and outback. Once confined to paper files and clunky databases, these records have now been updated by volunteers and loaded into the slick new National Trusts of Australia Register of Significant Trees website at www.trusttrees.org.au.

About the Register

The National Trusts of Australia are community-based, non-government organisations, committed to promoting and conserving Australia's indigenous, natural and historic heritage through its advocacy work and its custodianship of heritage places and objects. The National Trusts of Australia have collaborated to create a national register of significant trees, which is consistent with our mission to protect and celebrate Australia's heritage.

Trees can be significant for a number of reasons, including scientific, social, historic or aesthetic significance; however the tree only needs to meet the benchmark for one of the following criteria to be included.

Horticultural

- Horticultural or genetic value
- Important source of seed or propagating stock
- Particularly resistant to disease or exposure
- Species or variety that is rare or of a very localised distribution
- Particularly old or venerable
- Remnant native vegetation
- Outstanding for its height, trunk circumference or canopy spread
- An outstanding example of the species

Social

- Unique location or context
- Contribution to landscape
- Associated with Aboriginal activities
- Important landmark
- Spiritual and religious associations
- Contemporary association with the community

Historic

- Forms part of an historic park, garden or town
- Commemorates an occasion e.g. memorial or ceremonial plantings such as Avenue of Honour
- Associated with an important event
- Associated with an important person, group or institution

Aesthetic

- A really great looking tree
- Exhibits curious growth form or unusual physical features whether naturally occurring, resulting from natural events or human intervention
- Is a better than an average example of its species, or in its particular location

In practice, many significant trees will qualify as significant under several of the above criteria. The Register includes a hierarchy of significance, so registered trees are listed as being of International, National, State, Regional or Local significance.

The role of the Significant Tree Committees is to seek and assess nominations for significant trees against the nationally-agreed criteria. Significant Tree Committees in each state and territory comprise experts in a range of relevant fields including arboriculture, botany, heritage conservation, environmental management. The Committees meet at least three times per year to discuss issues regarding significant trees and assess nominations to the Register.

To assess the nominated trees, the Significant Tree Committee will compare them to other registered trees of the same species on the Register. The Significant Tree Committees will resolve the tree's level of significance, or may reject the nomination if the tree is considered of local or no significance. The Significant Tree Committees also promote awareness of the cultural value of significant trees, and advocate for statutory protection for registered trees under the relevant local planning controls.

From Apples to Androids

Back in 2011, the National Trust in Victoria published an iPhone app, *Trust Trees*, making the Victorian Register of Significant Trees digitally available for the first time. It was funded by Victoria's Heritage Grants Program 2010-2011 (Moore and Hughes 2014). In its first month of operation, more than 1000 users downloaded the app; by comparison, only 21 copies of the hardcopy version had been sold in the nine months preceding the availability of the app (Moore and Hughes 2014). Over 5000 users have downloaded the *Trust Trees* app to date (Figure 1).

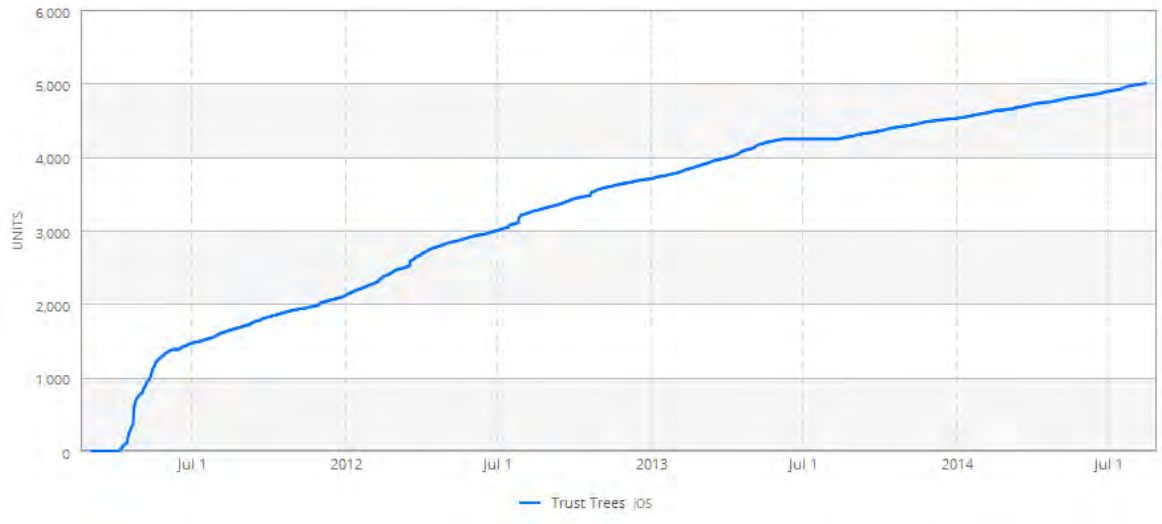


Figure 1. Downloads of the National Trust of Australia (Victoria)'s Trust Trees app since its launch on 31 March 2011, through to August 2014.

The *Trust Trees* app was revolutionary in turning the Victorian Register of Significant Trees into a geo-referenced database. The introduction of map functionality allowed users with mobile technology to use the in-built GPS in their smartphone to view nearby records using the 'Around Me' feature, which has proven popular with users frequently on the move, including arboriculture industry professionals and tree enthusiasts travelling around the state.

The data is cached on the phone, meaning the app works in areas without mobile service, as all the data (approximately 270MB) is stored on the phone hard drive itself. The *Trust Trees* app has a built-in feedback feature to e-mail the National Trust project officer. Members of the public frequently report on the tree's condition, threats to the tree, photos, suggestions of better examples in the region, and other comments about the tree. The main limitation of the iPhone apphas been that since it was launched, the market share for Android phones has steadily grown from 35% to 80% and the number of tablets sold has quadrupled (Edwards 2014, Business Insider 2014).The increasing demand from Android and tablet users brought about the need for rethinking the platform through which the public could access the data.

At the same time, a meeting of National Trust Executive Officers met to discuss national initiatives which would be supported by state-based National Trust organisations around the country. A national working group of Significant Tree Committee members from around Australia was formed, to collaborate on bringing together the state-based datasets into one national register.

App technology continued to rapidly evolve, and it became obvious that there would be ongoing redesign work to maintain an app, such as minor tweaks every time Apple or Samsung changed the size of their phone screen. It was decided to shift to a dedicated website with a responsive design that adapts for optimal viewing on any screen, regardless of whether it is a desktop, laptop, tablet or mobile device. The website cannot be cached, so although users must have an internet connection (either using WiFi or 3G mobile reception) to view the data, it means the amount of data and quality of images is now much higher. Underpinned by a custom-made database, the National Trust in each state and territory around Australia are able to upload and maintain their records in one place, and the information can be updated instantly by volunteers.

Volunteers around the country have contributed over 2500 person hours to preparing the data for the new National Trusts of Australia Register of Significant Trees website. The National Register includes over 2000 records, which represents over 25,000 trees around Australia. All eight states and territories have been involved in the development and testing of the site. Some states have been recording significant trees for over 30 years, and some states are just now beginning to identify their significant trees.

The new website allows for nominations to be made using an online form, which is a more environmentally friendly way of processing the paperwork. Nominators can save their nominations and return to them while they collate the required information. Photos, measurements of the tree, a map of its location, and any information about the tree's history are required to submit a nomination. This data is closely reviewed by the Significant Tree Committee in the relevant state or territory, and the online nomination record is edited to reflect the Committee's assessment. Once the record is classified, it is simply a matter of 'flipping the switch' to publish the live record onto the map.

The new website at www.trusttrees.org.au builds on the geo-referenced functionality of the Victorian *Trust Trees* app; retaining the "Around Me" feature for ease of use, and also allowing users to tailor map-based advanced searches.

This is the first time Australia's significant tree records have been collated nationally, and the National Trust believes making over 2,000 national records available to the public via cross-platform technology is a world-first.

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MANAGEMENT OF WILDLIFE ENCOUNTERED WHILE REMOVING AN AVENUE OF ENGLISH ELMS (*ULMUSPROCERA*): CASE STUDY

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Abstract

A Street Tree Renewal Program required the removal of 27 English Elms, which provided habitat for various wildlife species. Looking to minimise the impact to these fauna, the Council responsible (City of Unley) had a pre-removal assessment undertaken and management plans developed to deal with the resident wildlife. Thirteen Common Brushtail and Common Ringtail Possums were trapped, assessed and dealt with during tree removal. Planning investigations for the project revealed that habitat structures such as hollow bearing trees used by arboreal fauna are not adequately protected under South Australian legislation. Additionally, the Australian arboricultural industry would benefit from developing guidelines on the management and handling of native fauna encountered during tree pruning or removal activities, as no formalised approach exists.

Introduction

Pruning and removal are essential elements of tree management across the urban landscape. Arboreal wildlife species are likely to be impacted by such tree management practices. Over 300 wildlife species utilise tree cavities or hollows across Australia (Gibbons &Lindenmayer, 2002), with potentially dozens of vertebrates encountered at any given locality. The range of species utilising tree hollows may also change depending on the time of year tree management is undertaken. There are currently no industry guidelines in Australia which detail inspection measures or handling practices for wildlife, during pruning and tree felling operations.

In the United Kingdom (UK) legislation covers the protection of native wildlife species, as well as the structures or places that the wild animals occupy (Wildlife and Countryside Act 1981). The interpretation of this legislation and how it translates into practice is illustrated across the industry. A typical example from an arborist's website states "it is illegal to remove or destroy a nest while it is being built or used..." (Norfolk Trees, 2014). The legislation places the responsibility for wildlife, whether killed, injured or interfered with (intentionally or recklessly) on the individual who caused the offence.

In South Australia legal protection for native fauna is mostly dealt with through two Acts:

1. National Parks and Wildlife Act 1972
2. Animal Welfare Act 1985.

Relevant objectives of the National Parks and Wildlife Act (NPW Act) set out protections for individual native species and some rules around how humans interact with native wildlife. An omission of the NPW Act, as it was drawn up 40 years ago, was to not protect the *habitat* of wildlife specifically (e.g. hollow bearing trees), but rather to focus on the animals (and plants) themselves. Protection of individual animals is extended further when considering the Animal Welfare Act (AW Act), which guides the humane treatment of allanimals in the state; whether wild, domestic, feral, native or introduced. Under the AW Act it is an offence to knowingly or recklessly harm, injure, kill or cause suffering to an animal. If a person could have reasonably expected to find an animal when felling a tree they must take steps to mitigate the harm. Where an animal is present and likely to be harmed by the proposed activity

1. The animal can be moved if it is in immediate danger and such actions are in the animal's best interest,
2. A permit is required to trap and release or kill the animal.

Two other Acts potentially affect tree removal activities, the Native Vegetation Act 1981 (NV Act) and the Development Act 1983 (DVP Act). The NV Act protects native vegetation but is rarely used in urban situations and does not apply in the case of non-native trees. The DVP Act covers "damaging activities" to significant and regulated trees. This Act also recognises significant trees as important for their habitat value, however it does not explicitly safeguard wildlife dwelling in a tree or indicate the methods by which animals are to be extracted or removed. Hence the current legislation in South Australia is open to interpretation and wildlife may be accidentally injured or killed as a consequence.

This paper outlines a case study of the procedures used by The City of Unley, Adelaide (South Australia), to manage resident wildlife affected during the removal of a stand of mature English Elms (*Ulmus procera*) growing along a suburban street in Unley.

Native wildlife was reported to use the Elms. The trees were in poor health, despite management over a number of years, and presented a risk to life and property. A Street Tree Renewal Project incorporating water sensitive urban design had been scoped and the project planning was advanced when concerns arose for the resident wildlife. These concerns were driven by council arboricultural staff dealing with the project and the public's perception about the removal of the trees and the potential effect on the trees' resident wildlife. Wildlife habitation had not previously been considered, however The City of Unley was looking to manage the animals likely to be affected, in a responsible manner and suggested the UK model could positively influence their own approach.

Methods

The survey/tree management location was situated approximately 5km south of the Adelaide business district. The 33 elms were reasonably evenly spaced along a 350m north-south oriented street; electricity infrastructure ran along the northern side of the street, and the trees grew within the southern nature strip.

Various methods for assessing use of hollows by native fauna have been established, including techniques such as "stag watching" (Smith *et al*., 1989) and physical inspection. An arboreal inspection was likely to be most accurate, particularly given that Common Ringtail Possums (RTP; *Pseudocheirusperegrinus*) are typically missed using the Stag Watching technique, as this species tend to emerge after dark (Lindenmayer 1991b).

Wildlife Survey

The City of Unley provided an arboricultural report on the state of the elms (Thornton, C. S, 2012), as background. An aerial analysis of the surrounding streetscape was also undertaken (Google Maps) before visiting the site. The last phase of the pre-arboreal inspection involved an on ground evaluation, which enabled distances, infrastructure, connectivity and non-target vegetation to be assessed and recorded.

An elevated work platform (EWP) was employed to provide access to the tree hollows. The equipment used for inspecting the hollows included a tape measure, camera and torch. The author identified wildlife; confirmation was provided by the South Australian Museum (P. Horton *pers. comm*.) for eggs recorded in two of the nests.

The EWP operator was briefed and each tree was first reviewed from the ground to identify hollows and then aerial investigations were undertaken. The route taken to each hollow was left to the EWP operator's discretion. The information recorded included the tree number and for each hollow: entrance size, hollow depth (where possible), signs of usage, resident wildlife and associated photographs. Following completion of the first tree, each tree moving up the street was assessed in a similar manner as time and access allowed.

Tree Removal and wildlife management

In moving onto the second phase of the project, a practical guide was developed to manage any wildlife encountered during the felling process.

Two Department for Environment, Water and Natural Resources (DEWNR) permits were sought for possums, the taxa considered to most likely require management during the tree removal process. One Permit to Trap and Release (Possum: D29653; Appendix A) approved the release of four Common Brushtail Possums (BPT; *Trichosurusvulpecula*) and six RTP. Approval was also received for a Trap and Destroy permit (Possum: D29654; Appendix B), for up to eight BTP and five RTP. An additional Trap and Destroy permit was approved following the commencement of the project.

In addition to the EWP there was some specific equipment of assistance in locating and securing the wildlife, which included:

- Torch
- Towel/rags (various sizes)
- Compact Camera
- Sounding Hammer
- Catching Net
- Duck/Gaffer Tape
- Welding Glover
- Holding Bags/Containers
- Tough Clear Plastic Bag

The compact camera was used to record wildlife present, including in difficult to view hollows.

The torch was useful to gauge the depth of hollows and helped determine whether any resident wildlife were present.

A council arboricultural team (AbT) undertook the tree removals. The original wildlife survey was provided and the author gave an on-site briefing. A visual inspection was initially undertaken from the ground to identify any hollows that may contain vertebrate wildlife. The approach to inspecting an individual tree was left to the arborist; generally for smaller trees all the hollows were inspected, while larger trees were divided into workable sections, before chainsawing/felling started. All hollows with entrance diameters over 15-20mm were considered as potential wildlife (e.g. microbats) refuges, although hollows with a diameter greater than 45mm were recognised as more likely. In limbs/trunks where there were no hollows or where it could be established there was no resident wildlife - pruning/felling took place in the conventional manner.

The majority of the wildlife encountered during the second phase of this project were possums, the focal species for this aspect of the paper. Most possums retreated into thedepths of their hollow, when inspection or felling operations commenced. Once a possum was identified within a hollow, the following five tasks were carried out:
The position of the possum and depth of the hollow was determined.

The possum was secured within the hollow. Initially this was achieved by blocking the hollow with a towel or rag wedged into the entrance. For shallow hollows (<500mm depth), this isolation procedure was all that was required. In deep hollows the towel/rag was progressively moved into the cavity, thereby exposing excess timber; the excess was then removed, while ensuring the safety of the animal. By progressing in this way, and cutting small sections from the end of the limb/trunk, the cavity was reduced to 400-500mm in length, complete with a possum safely retained within it.

Table 1: Number and type of hollows recorded during the initial survey (21/10/2013).

Tree No.	All Hollows	Vertebrate Hollows	Active Hollows
4	4	4	2
5	9	7	5
6	9	2	2
7	6	5	4
8	8	5	4
10	9	6	3
11	4	2	2
12	3	1	1
15	1	0	0
16	1	1	0
17	6	6	3
18	1	1	1
19	3	3	3
20	2	2	1
21	3	3	2
24	4	0	0
25	4	2	0
26	3	2	1
27	7	4	3
28	3	0	1
29	4	4	3
30	5	2	2
31	7	6	5
32	10	6	3
33	8	2	2
No. of Hollows	**124**	**76**	**53**
Average / Tree	**5.0**	**3.0**	**2.1**

With the possum confined in the cavity, a solid wooden section below the hollow was identified (using a sounding hammer). The limb was sawn through, ensuring there was at least 150-200mm of solid wood between the possum cavity and the cut.

Once the hollow section was cut, it was steadily lowered to the ground. On the ground, the wedged towel/rag was removed from the hollow, then a layer of thick cloth was laid over the entrance and duck taped into position. This was to aid air circulation, while securing the possum/animal within the cavity.

Finally the hollow was set aside in a protected, shady location for the possums' subsequent assessment.

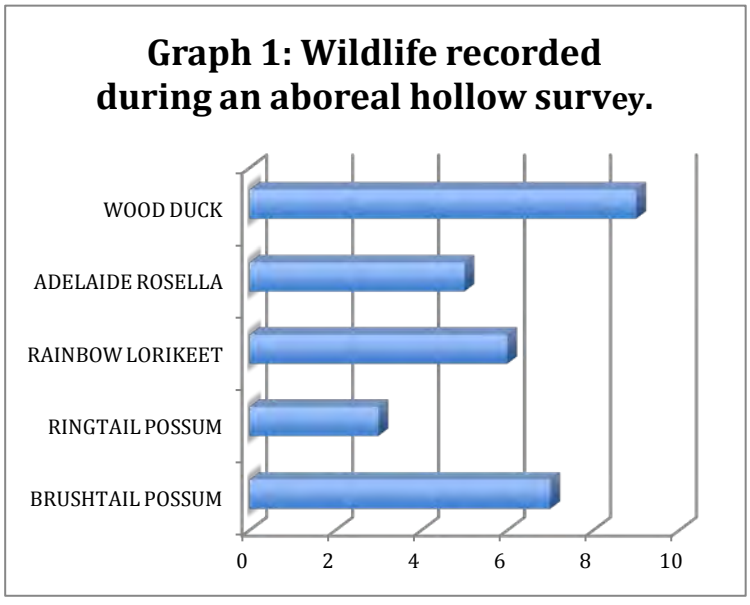
Possums that escaped ahead of felling activities were let go. Where a possum took refuge in the top of the tree that was being felled, activities ceased. If the escapee moved to the ground or a different tree, felling operations continued, however the possum's location was noted, as reference for future activities.

Prior to commencing the felling operation, contact was made with several wildlife carers and a veterinary practice recognised for dealing with native fauna. The project was explained and preparations were made to care for captured wildlife or euthanase animals, if release was not an option on welfare grounds (including under the NPW Act).

Results

Wildlife Survey

The arboriculture report stated the majority of the trees were in poor condition with a life expectancy of less than 10 years (Thornton, C. S., 2012). The aerial review and on-site ground assessment indicated that there was limited arboreal connectivity, other than that offered by the elms themselves. The only exceptions to this were provided by good shrub/tree cover at the eastern end of the street (trees 1-6) and between trees 11-15. Further west down the street there was insufficient vegetation to potentially provide for possums' habitat needs. The wildlife survey was conducted on the 21 October 2013.



Considerable variation was seen in hollow development of the elms along the residential street. Due to time, access and funding constraints, 25 of the 33 elms were surveyed (75%). The assessed trees were considered representative of the elms along the length of the street. The surveyed elms contained 124 hollows ("All Hollows" Table 1). Some cavities were likely to have been missed due to challenges with access, however it was estimated that >90% were recorded. At least one hollow was recorded in each tree; tree 32 exhibited the highest number with 10 cavities; an average of 5 hollows per tree were seen.

Seventy-six "Vertebrate Hollows" (cavities large enough to accommodate the anticipated vertebrate species e.g. possums and parrots) were recorded across the surveyed trees, at an average of 3.0 per elm. "Active Hollows" were identified as those where recent animal activity had been noted (chewing, feathers, trapped fur, etc.); these accounted for 54 of the Vertebrate Hollows (70%). Hollows occupied by bees, covered in spider webs or showing no signs of use were considered inactive.

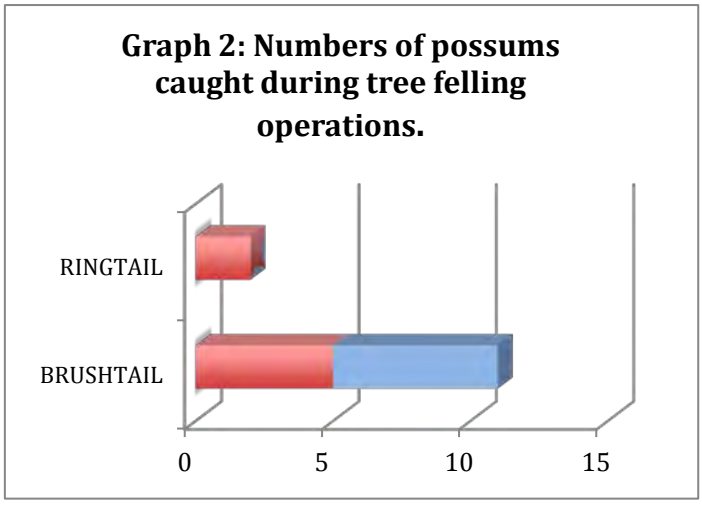
Twenty cavities (26%) of the identified Vertebrate Hollows were occupied during the survey, by five different wildlife species (Graph 1). These animals were spread across 15 (60%) of the elms surveyed. Individual BTP were recorded in seven (7) different hollows, spread the length of the avenue. RTP were observed in two trees; one included a mother and its joey, the second a single adult.

Four active Rainbow lorikeet (*Trichoglossus haematodus*) nests were observed, including two with eggs/young. Two nests containing eggs and/or chicks were also recorded for Adelaide Rosellas (*Platycercus elegans adelaidae*) and Wood Ducks (*Chenonetta jubata*). Three cavities were occupied by European honey bees (*Apis mellifera*), and a fourth was uninhabitable due to the presence of an abandoned hive.

Tree Removal and Wildlife Management

Approval of the DEWNR Trap and Release and Trap and Destroy permits enabled the felling procedure and management of associated wildlife to commence. The City of Unley had agreed to retain six elms, with the remaining 27 trees scheduled for removal. Tree removal commenced on the 11 March 2014 and was completed on the 7 April.

A total of 13 possums were removed, from 10/27 elms (37%). The captured animals were spread along the length of the street, across the available habitat. The majority of possums were caught in substantial, better quality elms with good connectivity, however some animals were recovered from poor quality, isolated trees.



The trapped possums were released or euthanased depending on their state of health and proximity to remaining habitat. Five BTP and two RTP were captured and subsequently released, based on the Permit to Trap and Release (Table 2).

The hollow sections containing the possums were secured in a shady location until nightfall. The animals were usually released within 60 minutes of sunset, at the base of a retained elm. Released possums climbed into trees and all appeared in good condition. Six BTP were euthanased by a veterinary surgeon under the Permit to Trap and Destroy (Table 2). No Ringtails required euthanasia.
During tree removal, four additional BTP possums were observed. Two retreated through the canopy ahead of the felling process and the AbT disposed of two recently deceased animals (pre-dating the tree removal process).

No nesting birds or roosting bats were observed using hollows during the felling process. The only additional wildlife specimen recovered, was one abandoned Wood Duck egg.

A report on the possums released and those destroyed under the three NPW Act permits were completed and returned to DEWNR in accordance with the permit requirements.

Discussion

The management of resident wildlife affected by pruning or felling of trees is conducted with varying degrees of rigour depending on the arborist, client, reason for removal, legislation and the public profile of the project. The described Street Tree Renewal Project was delivered under considerable public scrutiny. The AbT and The City of Unley complied with all legal requirements and extended their approach to ensure the welfare of the affected animals was addressed.

Native species had been observed using the elms, however no quantitative data were available. The arboreal survey confirmed the City of Unley's impression regarding hollow usage and identified the number and potential value of cavities found across the stand. Seventy-six of the 124 recorded tree hollows potentially provided roosting and denning sites for native vertebrate species. Of those hollows, 53 (60%) showed signs of recent activity and a total of 20 cavities were occupied by six different taxa: BTP, RTP, rainbow lorikeets, Adelaide rosellas, wood ducks and honey bees. Three feral honey bee hives were destroyed in preparation for tree removal. BTP are considered rare under the NPW Act in natural woodlands across much of South Australia, though they can be quite common in Adelaide's suburbs.

A plan was developed to minimise the impact on this animal, together with the four other protected species likely to be affected.

The broader landscape was also assessed as part of the survey. An aerial review indicated that once the elms had been removed, the suburban vegetation likely to provide suitable habitat for possums was mainly towards the eastern end of the street. On ground observations reinforced the aerial assessment and confirmed there was no appropriate habitat, nor the necessary arboreal connectivity required in which to release possums, towards the western end of this residential street.

The various findings of the survey led to three key recommendations:

- Remove the elms between March and June. This period is outside the breeding season for most bird species. By February microbats have typically completed their breeding, so maternity roosts are unlikely to be affected and all individuals are capable of flight. Minimising confrontations with wildlife has two major benefits; it reduces the impacts on wildlife and the time taken to deal with animals present, thereby reducing project costs.
- Stage the tree removal, with 6-8 elms being retained, if possible. Trees selected for retention were to be based on tree health, groupings of appropriate specimens, arboreal connectivity and the practical scope of the project.
- Produce a wildlife handling document and use this as the basis for managing any animals encountered during the felling process.

The City of Unley accepted all the recommendations and approved the retention of three elms on the central-eastern and far eastern end of the residential street.

The NPWA and the AW Act guide the manner in which wildlife is dealt with in South Australia. The NPWA was activated when the City of Unley became aware wildlife were using the elms and these animals were likely to be affected by the planned removal. The AW Act is triggered when an animal is encountered and needs to be managed. South Australian legislation states "Possums must be released within 24 hours of capture (at sunset on the day of capture) and released on the same property within 50 metres of the capture site." If release is not an option either because the animal is sick, injured or because the carrying capacity of the area cannot sustain the animal(s), it needs to be euthanased. It is illegal for a possum(s) to be released elsewhere. For the western end of the residential street, release was not possible and the two remaining elm stands were insufficient to support all the possums living along the street.

The numbers of possums likely to be trapped during the tree removal phase were estimated and application for Trap and Release (four BTP and six RTP) and Trap and Destroy (eight BTP and five RTP) permits was made. Discussion with a DEWNR senior ecologist were initiated and following a site visit the plan and associated permits were approved.

The City of Unley also undertook pre-removal tree poisoning. This was not initially recommended within the plan, but was instigated by the council arborist to prevent the elms suckering. A potential benefit of this measure was that resident RTP moved to more favourable locations once the trees had died, but before they were removed. Poisoning trees targeted for removal will be recommended as an integral part of the process in future.

The AbT were briefed within a matter of days of the permit approval. The author had personal responsibility for the NPW Act permits, so undertook an initial practical session with the AbT to ensure they understood the animal handling procedures and could fulfil the permit conditions satisfactorily.

During the initial session four possums were encountered (three live and one dead) and the recommended animal handling procedure proved effective. Having demonstrated their competence, the AbT were allowed to continue with independent removal. Daily updates were scheduled, so any issues could be addressed and trapped animals could be dealt with promptly.

The additional equipment required for handling the wildlife encountered during tree felling is modest. The storage bags were not used as the removed hollow tree section method easily accommodated each captured possum, however they provided a useful fall-back option. The camera and torch were extensively used in determining the location of animals and the extent of associated hollows. Additionally, a borescope (optical device consisting of a flexible tube with objective lens on one end, a small screen on the other linked by an optical relay) could be used - it has the benefit of longer reach and being able to see around corners; however is of limited value for large or particularly deep hollows and was not used on this project.

Wildlife carer assistance was not required during the project, however veterinary assistance was required on several occasions. On the first day three possums were taken to a local clinic to be euthanased on welfare grounds. The limb sections in which the possums were isolated and transported were between 1.2-1.7m in length. This size proved unwieldy to manage and also increased the challenge of extracting the animal. The AbT leader was briefed on this issue and the hollow log section containing the possum, were subsequently reduced to between 400-650mm total length. This simplified handling of the section, together with possum management during the remaining tree removals.

All possums caught in the central and eastern sections of the residential street were released into the retained elms. This included two RTP and five BTP; which exceeded the number of BTP approved for release under the permit, however subsequent discussions with a DEWNR representative confirmed this variance was acceptable given the scope of the project. Overall the arboreal survey provided a reasonable indication of the possums that would require management during the tree removal phase.

Nesting birds were not encountered during the tree removal phase of the project. This was considered primarily to be as a result of the season in which the tree removal took place; by March most hollow nesting birds in urban Adelaide have completed their breeding for the year. While not considered in the original management plan, killing the elms also reduced the likelihood of small passerine bird species nesting and none were encountered during the tree removal process. Microbats are an important component of the urban tree fauna, however none were recorded at any stage of the project. Handling guidelines were also developed for birds and bats as part of the recommendations, however these remain untested.

If a tree is known to contain wildlife, then provisions of the NPW Act and the AW Act are triggered. Under South Australian legislation an individual must take steps to mitigate harm if they could reasonably expect to find an animal when felling a tree. Unfortunately, the word reasonable is open to interpretation. This study highlights the importance of protecting habitat structures used by wildlife, such as hollow bearing trees. The UK Wildlife and Countryside Act 1981 could be used as a model to develop new regulations or re-interpretexisting legislation regarding habitat structures.

This project found 60% of the elms assessed in the October 2013 survey contained resident wildlife and possums (13) were removed from ten (37%) of the trees felled in March-April, 2014. Given these figures the author suggests it is reasonable to expect that for hollow bearing trees, with high connectivity, in areas known to support possums and other native fauna there is a high likelihood that wildlife could be impacted by pruning or felling activities. Under such circumstances it is incumbent upon attending arborist to obtain a DEWNR permit(s) to “trap” such an animal(s) and they are obliged by law to treat it in a humane manner. Wildlife enhance the value of a tree rather than being an inconvenience or a nuisance. Integrating wildlife management considerations into a tree felling operation will modify the approach taken. Depending on work practices, these changes may be slight or considerable. Currently, wildlife species are accidentally injured or killed if trees scheduled for removal are not adequately inspected or appropriate measures to manage the animals that dwell therein are ignored. The arboricultural industry is encouraged to develop guidelines so its members can plan for, assess and handle wildlife likely to be encountered when pruning or removing a hollow bearing tree. In doing so the industry will be brought in line with existing wildlife protection provisions and be well placed to adapt to future legislative changes.

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DEFENDING AND EXPANDING THE URBAN FOREST: OPPOSING UNNECESSARY TREE REMOVAL REQUESTS.

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Abstract
The removal of senescing trees or those which pose a genuine risk to health or property is part of professional urban tree management. However, there are many requests for tree removals that are not based on a genuine likelihood of injury or property damage, but rather on an unfounded fear of what might happen or where the tree is considered to be in the way of some other activity. Across Australia, about 97% of requests for tree removals made to local government authorities are ultimately approved. Such a high rate of approvals provides a threat to the fabric of the urban forest.

In many instances, the removal of sound and healthy mature trees has unexpected costs and consequences. The loss of shade can have an effect on the temperature experienced within a dwelling over summer and this may have health consequences in terms of heat related illnesses if the occupants are elderly. Swelling of reactive clay soils my be exacerbated by a tree removal, which can contribute to problems with footings and foundations and wind damage may also be greater after the removal of a tree than it was when the tree provided a filtering of and shelter from strong wind

Too often the consequences of removing safe and healthy trees are not fully considered when undertaking the cost benefit analysis associated with any proposed tree removal. This brief paper provides a framework for decision making that could be used in defending safe and healthy trees from removal and allows the identification of any unforeseen consequences from such removals.

Introduction
It is not surprising that after major storm events, when windthrown trees figure so graphically in media coverage or when there is a tragedy involving serious injury or death from major limb failure, people react by questioning the safety of trees and in many cases by demanding tree removals. However, understandable as knee-jerk reactions may be, professional arborists and street tree managers, have to ensure that decisions concerning removal of trees in the urban forest are logical, supported wherever possible by data and take into account the longer term consequences of such removals.

The removal of unsound and senescing trees that pose a clear and significant risk of failure with the associated likelihood of damage to property, or worse, injury is always within the ambit of the competent tree manager's decision making. There is no doubt that from time to time trees making up the urban forest have to be removed for health and safety reasons, because they are senescing or because society has made a decision concerning other land use priorities. However, there are also illogical and sometimes irrational requests for tree removals.

This brief paper is intended to provide the practicing tree manager, especially one working for local governments, with some arguments and tactics for dealing with those people demanding the removal of safe and healthy trees at a time of climate change. In many ways, a knee-jerk reaction to tree related damage or injury that sees good healthy trees removed could result in increased property damage, reduced property values and an increase in heat related illness or deaths at some time in the future. Given that heat wave related deaths are a significant killer of elderly Australians over summer, tree removals as result of tree and branch failures could lead to a higher mortality than leaving the urban forest intact.
When a request for tree removal is made there are generally two possible outcomes (Figure 1) – the request is granted or denied. It is often assumed that if the request for removal is granted, apart from the costs of removal, the action of removal will remediate the problem that precipitated the request and that there will be no further costs. But this may not be the case as removal may not remediate the problem and there can be a number of unexpected or unforeseen costs. In this circumstance it is possible that things have been made worse by removal rather than better (Figure 1).

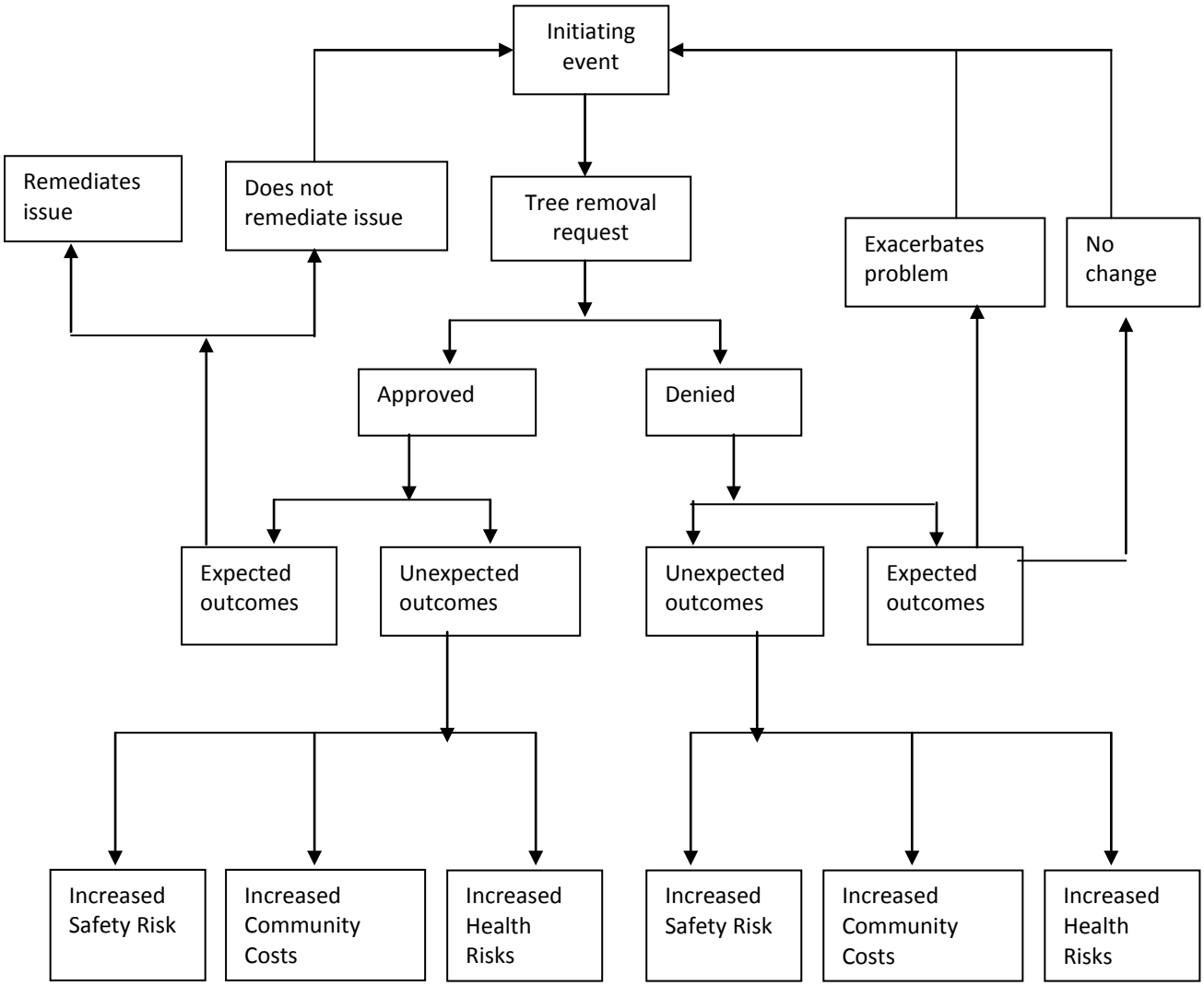

Figure 1. Decision making protocol in response to a tree removal request, showing possible expected and unexpected outcomes

In a similar way it is generally assumed that if a request for removal is denied, then the issue that precipitated the request will remain either unchanged or perhaps become worse (Figure 1). Things may remain unchanged, but there may be unexpected consequences from the denial which provide both benefits and costs. Consequently, a cost benefit analysis for any request for tree removal would seem to be worthwhile both from an economic and arboricultural perspective.

The Value of Trees in the Urban Forest

Attempts to put a monetary value on urban forests have a history extending back over 30 year (Dwyer et al 1983; 1992; Rowntree and Nowak 1991;McPherson and Muchnick 2005; McPherson 2007). In several earlier papers (Moore 2007, 2009, 2012), attempts were made to place an economic value on at least some of the services provided by urban trees (Table 1). These values have been recently reviewed and updated (Moore 2014). An expanded list of some of these services is provided in Table 1 and could be used as a template by those managing street trees on public land for dealing with unreasonable demands for the removal of safe and healthy trees.

Table 1. Some of the many benefits that tree provide in your garden (expanded from Moore 2012)

Shade can reduce roof temperatures by up to 8° C. This cools the house in summer and reduces air conditioner use and electricity consumption	Vegetation cools the area around houses. This reduces the urban heat island effect (UHI), cools cities and saves on water and electricity consumption
Trees can reduce storm wind speeds reducing the damage to roofs and other structures during storms	Absorption of water can reduce the risks of local flooding and removes the need for larger storm water gutters and pipes
Trees stabilize soil on steeply sloped blocks of land reducing building cost by thousands of dollars	Vegetation increases urban biodiversity so that there is more urban wildlife
Trees humidify air, which can help reduce the effects of hayfever and asthma and other respiratory ailments	Plants help off-set your carbon emissions and so reduce your contribution to the greenhouse effect and global warming
Trees remove airborne pollutants especially in cities and along major roadways, which helps keep levels lower and reduces health risks	Noise abatement is not easily achieved by trees alone, but a mixed planting of trees and evergreen shrubs with a high leaf area index (LAI) can reduce noise levels
Vegetation provides many human health benefits, such as reducing blood pressure and improving the quality and longevity of life	Vegetation provides social benefits. Green and leafy suburbs tend to have lower rates of vandalism, violence and graffiti
Vegetation, especially trees, encourages both active and passive recreation by people, thereby improving their health and lowering health costs	The shade provided by trees lowers water evaporation from the soil saving water and helping to reduce the UHI effect
Vegetation, particularly trees slow the front of flood waters and can be used as part of flood mitigation	Reduced water speed in floods also minimizes the erosion of river banks and the down stream silting of waterways and estuaries
Green and leafy suburbs, especially those with tree-lined streets, have a higher property values and so add to a property owners capital value	Reduced stream flow rates during storm events can be used in litter management, by allowing litter collection on land after the flood waters retreat. It is cheaper than trying to collect litter in waterways
The shade from trees protects children and adults from harmful radiation, reducing the risks of sunburn, skin cancer and melanoma	Trees contribute to the aesthetics of the landscape giving a sense of scale, providing screens for unsightly aspects of the urban landscape and acting as focal points. All adding to real estate value

The original estimate of $179 per annum for the value of an Adelaide Street tree inspired by and reported to the TREENET symposium in 2002 (Killicoat, Puzio and Stringer 2002) has also been reviewed and now stands at $424 per annum (Brindal and Stringer 2009; Planet Ark 2014). There would seem to be an ever increasing number of scientific papers on the value of trees in the urban forest, which provide a wide range of excellent data that should enable an urban tree manager to defend the current extent of the urban forest and defend safe and healthy individual specimens from ill-founded removal requests. The same data in most cities provide an excellent basis for arguing for more trees and an increase in canopy cover.

Given that requests for tree removals tend to spike following windthrow of trees and major branch failures that result in property damage or injury, it might be wise to advise people that unnecessary removals of safe and healthy trees do not come without the likelihood of increased cost, and possible increased risk to life and health in the future (Table 2). Similarly, the removal of trees to provide access to light for solar panels is usually based on a simple assumption that there is a cost to the owner if solar cells are shaded, but even at an individual level, this may not be the case when shading in summer is considered and it makes little economic sense from a community perspective.

Table 2. Some of the triggers for tree removals with expected and some unexpected outcomes.

Reason for Tree Removal Request	Expected Outcome	Unexpected Outcome(s)
Falling branches from council street tree	Avoid damage from falling debris	Lifting of tiles in storm
		Major limb shed from specimen tree on property now exposed to wind
		Loss of real estate value
Root damage from nature strip tree	Minimize damage	Multiple suckers from root system
		Loss of real estate value
		Swelling of clay soil after tree removal, causing cracking of fence and footpath
		Localized flooding
Shedding leaves into swimming pool	Abatement of leaf litter nuisance	Loss of summer shade
		Swelling of clay and damage to pool
		Lifting of tiles from exposed roof
		Loss of real estate value
		Localized flooding
Access to solar panels	More electricity generation	Higher electricity charges
		More electricity use in summer
		Loss of real estate value
		Net financial loss

Similarly tree removals for site development works or even utility service access can be countered by considering the beneficial impact that trees have on property values and peoples' perceptions of the neighbourhoods within which they live. In short, tree managers have many defensive strategies for defending sound and health trees, preserving the cover and density of the urban forest and advocating its expansion. Some of these are now considered in greater detail below.

Major Storm Events

With more frequent major storm and strong wind events predicted as a consequence of climate change, there are going to be more media images of whole trees and large limbs falling and doing significant damage to property and occasionally causing serious injury. After such events, there is usually a significant spike in requests to councils for tree removals. However, are such requests reasonable and if trees are removed do they achieve the aim of reducing risk and hazard?

Many other and often larger trees withstand the force of the storm. In a typical storm event usually somewhere between 3 and 10 trees out of a population of around 100,000 trees are windthrown. The numbers are very small, but the images of fallen trees are graphic and memorable. So what are the dangers if we accede to the spike in tree removal requests, remembering that Australia-wide 97% of tree removal requests are ultimately approved?

Trees in windbreaks can reduce wind speeds by up to 90%. If individual trees are planted in the right place around a house, they filter and slow the speed of the wind which reduces the uplift forces on house roofs and so can reduce the risks of having tiles and sheeting lift from the roof. Thus unnecessary removal of safe and healthy trees could lead to more rather than less storm damage (Table 1). Wholesale tree removal from a suburb could lead to widespread damage of a district from strong winds.

Furthermore, the reduction of shade with tree removals could result in a rise in the urban heat island (UHI) effect. Any increase in the UHI would have the usual economic consequences of the removal of services provided by trees such as an increased air conditioner and electricity use and higher evaporation rates due to the warmer temperatures. There would also be an increase in heat related ambulance call outs, hospitalizations and deaths as the climate warms and the Australian population ages (Table 1). It is possible to envisage a scenario where a local government removes trees in response to citizen requests and then is held accountable for a heat related illness or even death when the loss of shade is deemed by a court to be excessive.

Access to sunlight

People have a right of access to sunlight and it was one of the earliest elements of modern building codes over a century ago with the aim of preventing the diseases, such as "rickets", which is now known to be associated with vitamin D deficiency. Today with the current increased interest in the role of vitamin D in many aspects of human health, people are only too aware of the importance of exposure to proper levels of sunlight.

However, in summer people should also have the right to suitable levels of shade and the protection that it provides from sunburn, skin cancer and melanoma. Such protection is particularly important for young children with more sun-sensitive skin as they play in streets, school grounds and public playgrounds, as well as in the surrounds of their homes. It is amazing how often people successfully argue for the removal of a tree in the depths of winter only to regret the loss of the shade it provided a few months later when the first sunny days of late spring and early summer arrive – a classic case of act in haste and regret at leisure.

There are also a growing number of demands for tree removal based upon solar access for solar panels and the assumption that any shade from trees reduces generation capacity and so costs the owner of the solar panels (Table 1). The Office of the Commissioner for Sustainability and the Environment, Canberra (2011) report on the Canberra urban forest found that there could be some loss of solar efficiency when panels were shaded by trees. However, the situation proved to be somewhat more complex than the simple assumption that shade costs might imply.

Modern solar panels are much more efficient than early generation models and so are more efficient with some level of shade. Furthermore, while there may be some loss of electricity generation capacity, this has to be considered in light of the cooling effect of the shade provided by trees in summer with the likelihood of lower electricity use for cooling. In short the loss of generation capacity due to shade may be offset by the cooling effect of shade in summer. The removal of a tree, or trees, to provide solar access for panels could be to the economic detriment of the home owner if they have air conditioning and use it over summer.

Property Value

It has been estimated that a good tree in a good front garden can add some $5,000 to domestic property values, and others put the value as high as $50,000 or 5% of the property value (Boyd 2010). Turf Australia after surveying 114 estate agents across the nation, estimated that people were prepared to pay an additional $75000 for a house with a green lawn (Williams 2014). There is also a strong likelihood of having a positive return if you spend wisely on landscaping (Anderson 2012). It is clear that the real estate industry does recognize the value that trees, both specifically and generally, add to properties.

The Planet Ark (2014) survey, Valuing Trees: What is Nature Worth, reported that for a house valued at $500,000 Australians would be prepared to pay an extra $35,000 for a house in a green and leafy area and 34% would be prepared to pay an extra $100,000. Other survey results were that 73% of Australians want a backyard and that for 57% of respondents, having a park within a 5-10 minute walk of their home is important to them. Earlier work had estimated that a tree-lined nature strip added 30% to properties in streets that had trees compared to similar houses on treeless streets just two streets away (Gonzalez 2007).

In Melbourne, in many of the green and leafy suburbs, there have been many permit applications for townhouses and multi-unit developments on large blocks full of mature trees, in which some developers are driven to maximize their yield on a particular site, and ignore the community's valued, local characteristics. Property prices have been affected by these tree removals and tree felling definitely has an effect on the value of properties (Table 1), particularly in areas known for their leafy character (Gonzalez 2007).Given that these are significant financial considerations, the unnecessary removal of a safe and healthy tree from a streetscape could precipitate legal action by a resident for the loss of property value.

There is also an indirect but significant financial benefit for a local council in increased house prices. Residents prefer leafy tree-lined streets with large specimens and the higher prices for these properties are reflected in the council property rates that are linked to the value of the property. A conservative estimate of 5% increase in property values can translate to millions of dollars for councils (Dwyer et al. 1992). So excessive tree removals in a particular council area or in part of a council's area of control could impact on its income when properties are next valued for rating purposes

Once again care must be taken that in a short term reaction to a particular tree related incident, trees are not unnecessarily removed which could leave local authorities exposed to legal action. It would seem prudent then, for such authorities to have sound decision making processes and criteria for one off tree removals that ensure that only trees that pose a risk to human health, are in poor condition or pose a significant risk to property are removed. Similarly, it would seem sensible to have street tree replacement strategies in place so that purchasers are aware of any short term tree replacement programs when they purchase a house.

Damage from tree roots

It is not uncommon for a tree removal request to be made because of alleged tree root damage to pipes, footings and foundations, pathways or utility services. More often than not, the tree targeted for removal is selected by virtue of its close proximity to the damage and often there is little, if any, direct evidence that it is the roots of that particular tree that are causing the damage – it is more guilt by association. Sometimes, however, the association of tree roots and damage is both clear and demonstrable.

Tree removals for alleged root damage are common, however, there can be unexpected consequences. One of the more common outcomes is wholesale suckering from the roots of the removed tree (Table 1). Such a response is species-dependent and in some instances many hundreds of suckers may result that can be a far greater nuisance than the tree that was removed ever was. Suckers may even develop under the floor of a house where they can be seen emerging between the floor and skirting boards. The many rapidly growing suckers can also reduce soil moisture levels in reactive clay which can worsen shrinkage and exacerbate damage to footings and foundations.

Even without sucker growth the removal of a large old tree from a reactive soil may result in greater swelling of the soil and a greater extent of swelling and shrinkage which may make a pre-existing problem of cracking worse. A similar situation may arise with the removal of a tree resulting in very wet soils due to poor drainage at the site once the moisture uptake by the tree has ceased. In both cases, the removal of a tree can have an effect virtually opposite to that intended by its removal. If a number of trees are removed from a lowland area of a council district, one of the consequences could be an increased risk of local flooding.

Conclusion:

Climate change presents the prospect of more frequent storms with higher wind gusts for many Australian cities and regional towns, and despite lower overall annual rainfall these storm events will often be accompanied by heavy localized rainfall. There will also be warmer summers with a significant increase in days above the thresholds for heat related illness. The urban forest has much to offer in providing environmental services that have the capacity to ameliorate some, if not all, of these occurrences.

While many of the services provided by trees in the urban forest are substantially undervalued, if valued at all, at present, this will change as the impact of climate change becomes clearer. Similarly, the contributions of individual trees to the cover of the urban forest are also often undervalued. Consequently, the request of the removal of any safe and healthy trees must be subjected to a proper cost benefit analysis, especially of any unexpected consequences of the removal. There is a real risk to the urban forest and the cover it provides through attrition by the unnecessary removal of trees, one specimen at a time.

Consequently, it would seem prudent that each time a request for a tree removal is received, a proper cost benefit analysis for the removal should be undertaken. An analysis that considers both the expected and unexpected outcomes of the removal would go some way to ensuring that the integrity of the urban forest is maintained in the face of unnecessary tree removals.

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