04 URBAN TREES IN THE ACT — NATURE IN THE CITY

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RECOMMENDATIONS

Recommendation 10: advance Action 1 of the *Canberra's Living Infrastructure Plan: Cooling the City* (2019) by convening an environmental-economic accounts steering committee with representatives from government, academics and the community.

Recommendation 11: continue to collaborate with other jurisdictions and research institutes to generate the evidence base for appropriate urban forest understorey and other plantings, having specific regard to climate change implications.

URBAN TREES IN CANBERRA

'There is a magic machine that sucks carbon out of the air, costs very little, and builds itself. It's called a tree.'[1]

Canberrans have enthusiastically embraced a commitment to urban trees for aesthetic and other reasons. Tree canopy, the associated ecosystem services, and biodiversity values are critical features of the Bush Capital's urban forest. Remedying the 'largely treeless site', wind exposure, and 'degraded shallow soils',[2] was a focus of the early work of Charles Weston[3] and Lindsay Pryor.

Wanniassa scar trees. Source: OCSE.

1 Found at https://www.conservation.org/blog/nature-now'-in-new-film-climate-heavyweights-make-plea-for-the-planet accessed 20 October 2019.
2 National Capital Authority (NCA), 2019, Our Trees website, found at https://stage.ourtrees.com.au/ accessed 20 October 2019.
3 1911 plantings of 2 million trees at the direction of George Weston was the beginning of the urban forest in Canberra.

The ACT Government has committed to increasing both tree canopy cover (equivalent) and permeable surfaces to 30% across the city by 2045,[4] but this target needs to be seen in the light of a 10% reduction in urban canopy between 2009 and 2016.[5] This loss of canopy cover was mainly due to dieback and senescence – both significant issues that require immediate intervention and ongoing research.

In 2015, Canberra's urban open space and road reserves had a canopy cover of 22%; canopy cover on residential land was 18%. The average tree canopy cover across urban areas in Canberra was measured at 19%, with established suburbs having more canopy cover compared to newer developments.[6]

Responsibility for the urban forest and canopy cover is onerous and shared across government:

- Transport Canberra and City Services (TCCS) currently has obligations for an estimated 767,000 trees which are governed by a regulatory framework.
- TCCS receives, on average, between 8,000 and 10,000 tree-related public enquiries each year about how the urban forest is being maintained.[7]
- The National Capital Authority (NCA) manages 18,000 trees and reports a canopy cover on its (Commonwealth) land of 33%,[8] and
- Protection of significant groups of trees and of individual trees on Commonwealth land is provided by the *Environment Protection and Biodiversity Conservation Act 1999*.

BENEFITS OF URBAN TREES

Urban trees provide many services including:

- spiritual and cultural wellbeing through links to the city's cultural history – both Indigenous and non-Indigenous
- recreational opportunities
- land health
- carbon abatement
- climate regulation through shading and cooling reducing heat impacts and energy consumption
- support for biodiversity by providing habitat and pollination
- reduction of dust, pollution, wind[9] and UV radiation
- management of storm water run-off
- tourism, property value and business centre benefits.[10]

Urban forests also provide significant human health benefits with exposure to green space reducing the risk of type 2 diabetes, cardiovascular disease, premature death, preterm birth, stress, and high blood pressure.[11] They also have a range of benefits for children with more outdoor time improving health and learning.[12]

4 EPSDD, 2019, *Living Infrastructure Plan: Cooling the City*, ACT Government, Canberra. https://www.environment.act.gov.au/__data/assets/pdf_file/0005/1413770/Canberras-Living-Infrastructure-Plan.pdf

5 202020 ACT Vision 2017 report, found at https://202020vision.com.au/media/72931/wsattg_act_fa3_lr.pdf accessed 20 October 2019.

6 Jacobs, B., N. Mikhailovich, and C. Delaney, 2014, *Benchmarking Australia's Urban Tree Canopy: An i-Tree Assessment*, Institute for Sustainable Futures, University of Technology Sydney.

7 OCSE has a statutory function to investigate complaints from the community. Recently the Office has received several complaints about tree management practices:

- A London Plane Tree in Manuka, about which the Conservator of Flora and Fauna, the National Capital Design Review Panel (Interim) and the ACT Administrative Appeals Tribunal have now made determinations; and
- The need to replace trees lost or damaged during development.

Complaint management follows a formal process, complainants receive responses to all interim inquiries, and these matters are reported in annual reports. Legislation which works to protect the Territory's tree cover includes the *Tree Protection Act 2005* and the *Heritage Act 2004*. A provisional tree register and a tree register are used to track the protection of heritage trees and tree scapes, including tree-lined streets. For details of complaints see OCSE Annual Reports. The Tree Register can be found at https://www.tccs.act.gov.au/city-living/trees/act_tree_register accessed 29 October 2019.

8 The most recent NCA tree initiatives are on the Our Trees website, found at https://ourtrees.com.au/ accessed 29 October 2019.

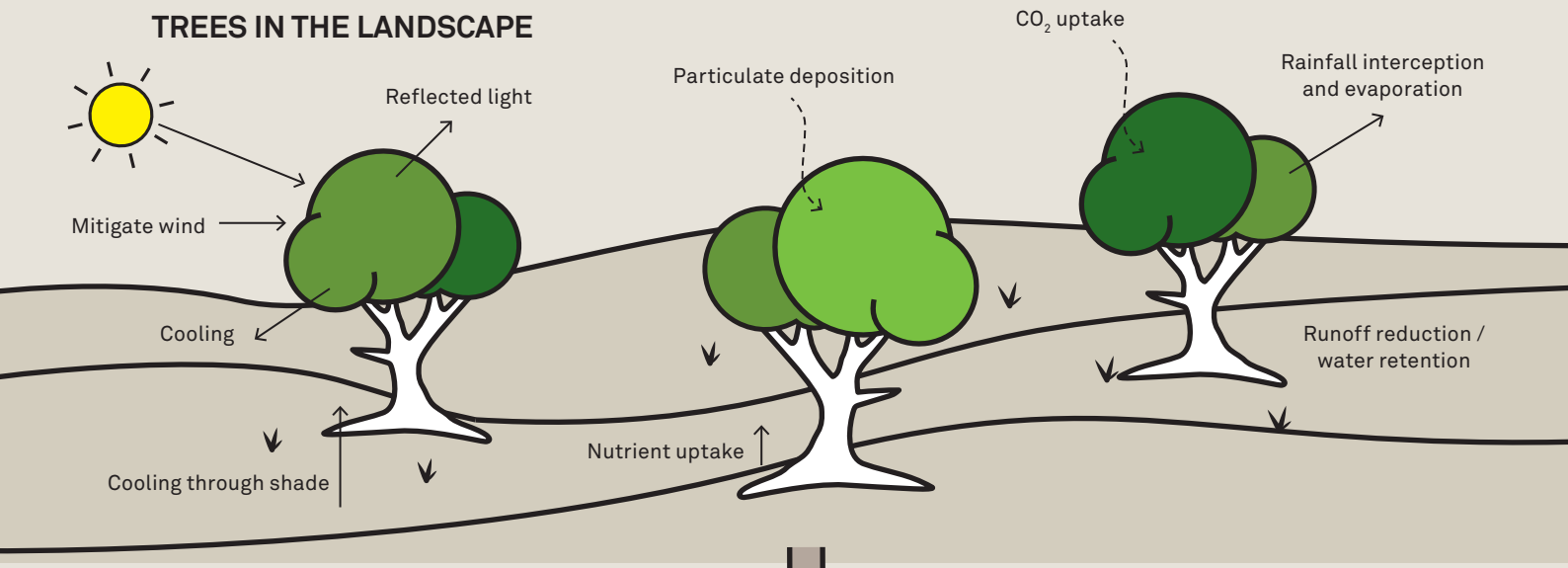
9 Haig Park was in fact established to reduce the impacts of wind. See the report on its revitalisation, found at https://www.act.gov.au/__data/assets/pdf_file/0003/1222806/16_36_Haig_Park_Place_Plan_July_17_1.pdf accessed 29 October 2019.

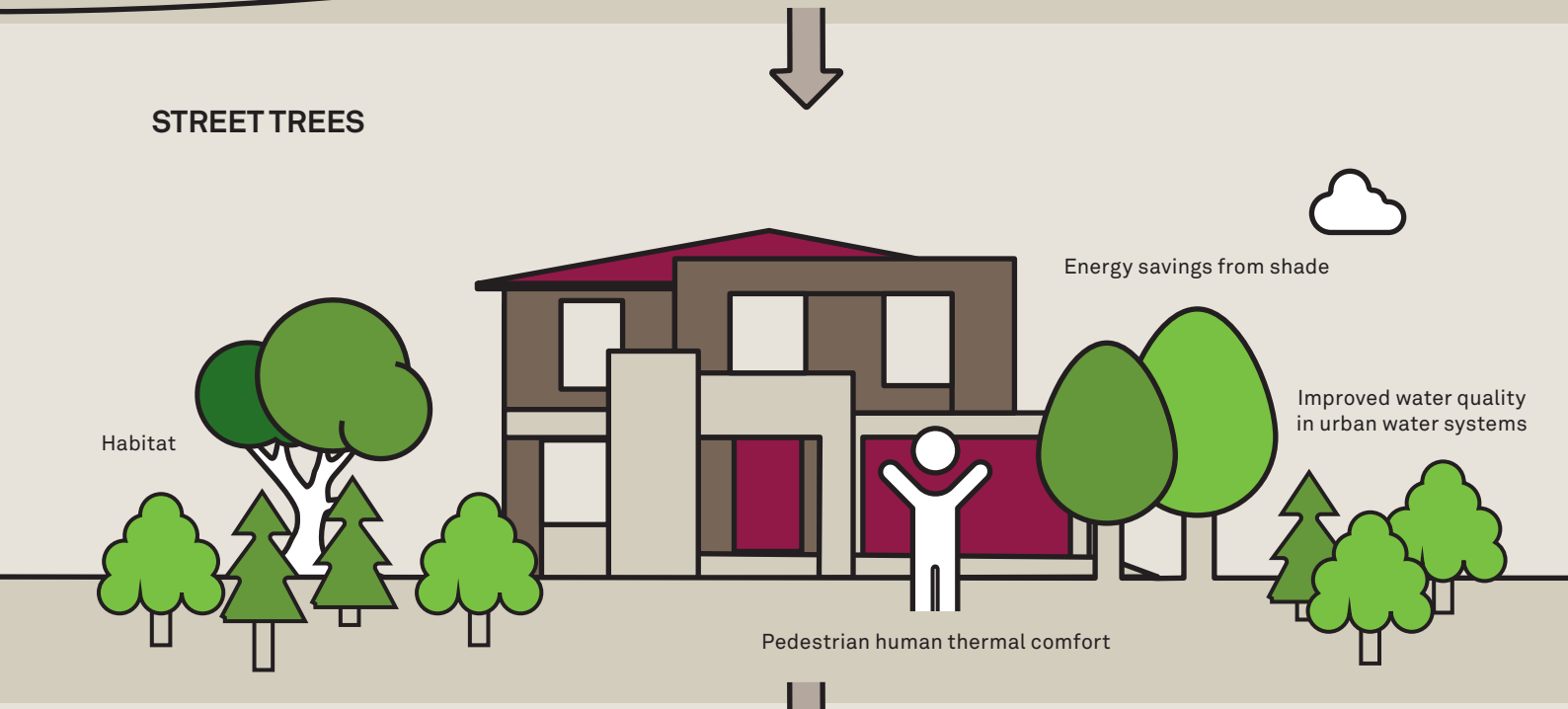
10 S. J. Livesley, E. G. McPherson, and C. Calfapietra, 2016, 'The Urban Forest and Ecosystem Services: Impacts on Urban Water, Heat, and Pollution Cycles at the Tree, Street, and City Scale' in *Journal of Environmental Quality*, 45: 119–24

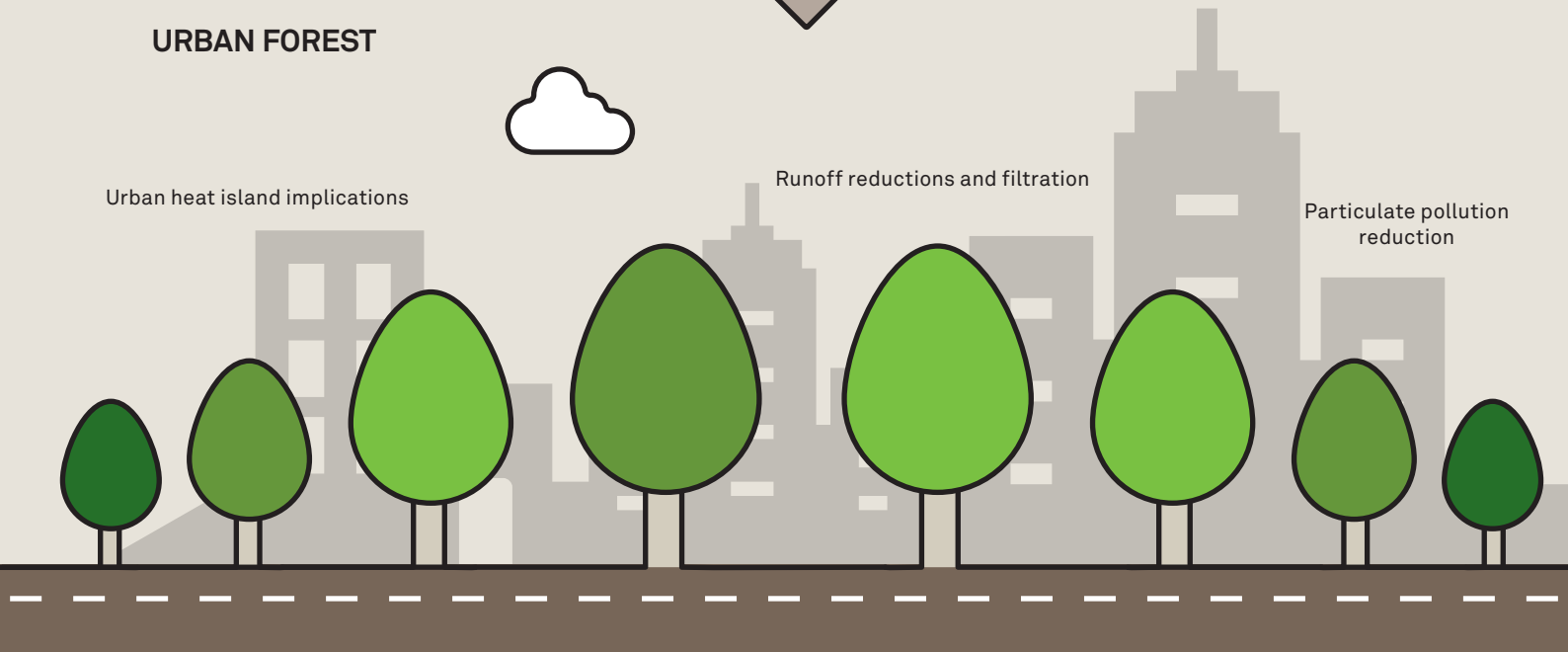
11 Science Daily 6/7/2018, 'It's Official: Spending Time Outside is Good for You', found at https://www.sciencedaily.com/releases/2018/07/180706102842.htm; White, M.P. et al., 2019, 'Spending at Least 120 Minutes a Week in Nature is Associated with Good Health and Wellbeing', *Scientific Reports*, 9(7730), found at https://www.nature.com/articles/s41598-019-44097-3 accessed 30 October 2019.

12 NaturePlay Qld, found at https://www.natureplayqld.org.au/ accessed 30 October 2019.

The benefit of trees







CASE STUDY:
ARANDA PRIMARY SCHOOL – A WATER-HARVESTED NATURESCAPE

Aranda Primary School at completion of the naturescape construction work. Source: Paul Barnett, Paul Barnett Design Group.

Aranda Primary School 3 years after completion.
Source: Paul Barnett, Paul Barnett Design Group.

'We have observed the children's play gradually evolve into a more imaginative social experience [in this naturescape]. We are excited by the way children have developed and display a more creative and diverse range of activities in a natural environment that does not predict and determine how a child's activity may be experienced, as with swings and slippery dips and climbing frames.'
(Phil Gray, Principal at Aranda Primary School)

At Aranda Primary School a dry creek bed and a micro forest now provide a natural water-harvesting system and environment for child's play. This natural water-harvesting system was first developed by Paul Totterdell and has been utilised in many educational, residential and urban settings over several decades.

The Aranda Primary naturescape masterplan identified several areas that could be converted to a naturescape system including the central courtyard, upper terrace, sloped field and oval sport area.

The sub-surface was trenched to capture water from rain, runoff, and water redirected from the natural catchment area and nearby roofs. The surface landscape was integrated, mimicking nature. This landscape includes rocks, tree logs, plants, trees and earth contouring, which works to move, hold and direct the water, and to increase biodiversity.

Aranda's central naturescape has two parallel trenches sitting on two terraces with sandpits, rock tables and pathways zigzagging through the naturescape. A hundred tonnes of rock, 120 lineal metres of water-harvesting trenching, and 32 trees have been installed. The wetlands and frog bog were a more simple design aimed at catching overland flow past classrooms, holding water at the edge of gently sloped play spaces, and creating a tree lined pathway and wetland space beside the path.

The playing field space is supported by a criss-cross of water-harvest trenches which enable the grass to be kept alive for longer periods over the summer months, minimising irrigation during hot and dry periods. Water can be fed directly into the trenches rather than air sprayed, thereby minimising evaporation and reducing the need for irrigation.

CASE STUDY: BIRDSCAPING

An ANU birdscaping volunteer. Source: Edwina Robinson.

SEE-Change's Birdscaping #CBR[13] project was inspired by ACT Scientific Committee research.[14] In 2015 the Committee concluded that Canberra's small woodland bird, the Scarlet Robin (*Petroica multicolour*), classified as 'vulnerable', was at risk of premature extinction in the next 20–25 years principally due to ongoing habitat loss.

Canberra's relatively simple layout of mature trees and mown grass lacks the dense understorey that many of these woodland birds need to nest, forage, shelter, and hide from larger birds and other predators.[15] The concept SEE-Change came up with, in consultation with the community, was to plant native grasses, climbers, shrubs and forbs beneath existing mature trees in O'Connor. The project was funded by a $43,000 environment grant from the ACT Government in 2017.

SEE-Change factored in the cost of watering (a Greening Australia employee with a water cart) and the heavy work of spreading mulch and removing weeds into the grant application, while the Molonglo Conservation Group did the hard work.

Canberra Ornithologists Group recorded the number of birds on the site prior to planting and will follow up with regular bird surveys. With the help of Greening Australia ACT and ACTforBees, SEE-Change developed a list of local native plants that would provide habitat for small woodland birds and pollinators. A total of 2000 grasses, forbs, groundcovers, climbers, trees and shrubs were grown from locally sourced seed, provided by Greening Australia. To protect them from wood ducks and cockatoos the plantings were surrounded by waxed cardboard guards. Logs and insect hotels were added to encourage beneficial insects into the space.

More than 100 people participated in the working bees in 2018. Turner Primary School and a local scout group worked on the project. These kinds of projects connect people and encourage the community to make a positive impact in their local area.

Despite January 2019 being the hottest Canberra summer on record with temperatures 6°C above average, most of the plants have thrived, due to good soil preparation and follow-up watering. This suburban revegetation project provides habitat and enhances landscape connectivity while cooling the suburb.

13 This case study has been provided by Edwina Robinson, the Executive Officer of SEE-change, Canberra.
14 Further information on the ACT Scientific Committee can be found at https://www.environment.act.gov.au/cpr/advisory-bodies/act-scientific-committee
15 The ACT Government also maintains unmown parks; the point made here relates to more cultivated spaces.

URBAN TREES

A 2018 CSIRO study commissioned by the ACT Government to inform *Canberra's Living Infrastructure Plan: Cooling the City* (2019) valued the public urban forest at $3.4 billion; assessed the annual benefits of the urban forest at $27 million; and attributed the recreational value of non-sports grounds as $24,000 per hectare, and $76,000 per hectare for sports grounds.

A study undertaken by AECOM in 2017 reported that a $50,000 increase in the value of real estate followed a 10% increase in tree canopy.[16] In Blacktown (in a study which should be read with some care due to a number of variables), the Cool Street Pilot Project 2015–2016 suggested energy savings of up to $800 annually from improved tree canopy.[17]

ACT INITIATIVES FROM 2015 TO 2019

The ACT's urban forest has been the subject of a number of initiatives since 2015.

The ACT Government's Actsmart Plant Selector Guide of 2017[18] helps the public to choose plants suitable for the Canberra region, which is largely descriptive. The Municipal Infrastructure Standard 25 (2019) augments this with indicators about pollination properties of trees, shrubs and other flora.[19]

A volunteer group, ACTForBees, was instrumental in driving this initiative.[20] Haig Park – unloved for many years – now has its own website, and people are encouraged to join in 'Haig Park Experiments'.[21]

The Better Suburbs consultation produced the Better Suburbs Statement 2030 which seeks community involvement in tree-planting and maintenance programs.[22] *Canberra's Living Infrastructure Plan: Cooling the City* outlines actions such as auditing, valuing, and setting targets of 30% tree canopy by 2045 and 30% permeable surfaces.[23] The ACT's tree canopy target sits in the mid-range with other Australian capital city targets – only Brisbane and Melbourne aspire to 40%.

The City Renewal Authority assists TCCS with tree-planting programs and has:

- set a target of 30% tree cover by 2025 in its Sustainability Strategy
- planted 39 advanced trees to fill gaps due to vandalism and damage across Braddon and Civic
- successfully advocated that mature deciduous trees should be retained and replanted in Dickson as a demonstration of the viability of such projects; and
- promoted planning which responds to the Urban Tree Strategy and the *Tree Protection Act 2005*.[24]

16 AECOM, 2017, *Green Infrastructure. A Vital Step to Brilliant Australian Cities*, found at http://www.aecom.com/content/wp-content/uploads/2017/04/Green-Infrastructure-vital-step-brilliant-Australian-cities.pdf accessed 20 October 2019.
17 Gallagher Studio and CRED Consulting, 2016, Blacktown: Cool Street Pilot Project, 2015–2016, found at http://www.gallagherstudio.com.au/blacktown-cool-streets-pilot-project accessed 20 October 2019.
18 Found at https://actsmart-plantselector.com.au/browse-plants/ accessed 20 October 2019.
19 Transport Canberra and City Services (TCCS) 2019, *Plant Species for Urban Landscape Projects, Municipal Infrastructure Standard 25*, ACT Government, Canberra. Found at https://www.tccs.act.gov.au/__data/assets/pdf_file/0004/1378543/MIS25-Plant-Species-for-Urban-Landscape-Projects.pdf accessed 20 October 2019.
20 For more information, go to https://actforbees.org/ accessed 20 October 2019.
21 City Renewal Authority 2018, *Haig Park Place Plan*, ACT Government, Canberra, found at https://www.act.gov.au/__data/assets/pdf_file/0017/1401407/0.-Haig-Park-Place-Plan_03-PAGES_FINAL-FORMAT-A18048685.pdf accessed 20 October 2019; Haig Park website is found at https://www.haigparkcbr.com.au/Home accessed 20 October 2019.
22 Transport Canberra and City Services (TCCS) 2018, *Have Your Say on City Services for Better Suburbs Statement 2030*, ACT Government, Canberra, found at https://s3.ap-southeast-2.amazonaws.com/hdp.au.prod.app.act-yoursay.files/4215/3722/6646/Better_Suburbs_Statement_accessible_SEPTEMBER_2018.pdf accessed 20 October 2019.
23 EPSDD 2019, *Canberra's Living Infrastructure Plan: Cooling the City*, ACT Government, Canberra, can be found at https://apo.org.au/sites/default/files/resource-files/2019/09/apo-nid259131-1386826.pdf https://www.environment.act.gov.au/__data/assets/pdf_file/0006/1413771/Canberras-Living-Infrastructure-Plan-Summary.pdf accessed 20 October 2019.
24 City Renewal Authority, 2019, *City Precinct Renewal Program*, ACT Government, Canberra. Found at https://www.act.gov.au/__data/assets/pdf_file/0011/1384679/City-Renewal-Program-semi-accesible.pdf accessed 30 October 2019.

SAFE AND USEFUL LIVES OF TREES

Any assessment of the extent, value and viability of tree cover in the ACT has to take into account the biological and 'safe' life of Canberra's tree cover, and the fact that many trees are reaching the end of their 'useful' life.[25] For example, research suggests that any tree in Belconnen that currently does not have dead branches or other problems in the canopy has a 50% probability of developing them within the next year. This indicator means that half of the currently healthy trees this year will not look healthy next year.[26] In addition, dieback is increasing in the ACT's populations of Blakely's Red Gum (see section **5.5 Biodiversity**) and Red Stringybark dieback has been identified as a problem in the Aranda Bushland.[27]

The NCA is also considering the issues associated with ageing trees, regeneration, and single species plantings. Two species, *Eucalyptus mannifera* (Brittle Gum) and *Eucalyptus bicostata* (Southern Blue Gum) comprise 12% and 11.5% of trees on NCA land respectively. This does not meet industry best practice which suggests that no single species should constitute more than 5–10% of the canopy cover. Where any individual tree species makes up a high proportion of the total tree cover there is an increased risk of significant tree loss where conditions become unsuitable for such species.

URBAN DEVELOPMENT PRESSURES

As Canberra becomes a more compact city with increasing population and moves toward greater urban infill, public space and the urban forest will come under pressure. This is particularly the case for trees and understorey on private residential blocks which are subject to redevelopment. In the Molonglo Valley, 2.4 hectares of public space is available for every 1000 people, compared with 8.6 hectares in older suburbs. House lots are also much smaller: 350 square metres in the Molonglo Valley compared to 650 square metres in older suburbs, which will mean that trees on public green space will be subject to a much greater community need. [28]

The OCSE has conducted an independent audit of the impact of development on matters of national environmental significance in both Gungahlin and the Molonglo Valley and made a number of recommendations to the ACT Government. These include the finalisation of the Kama Nature Reserve Buffer Zone, which is intended to provide protection for flora and fauna against edge effects.

Apart from the pressures associated with development generally, specific old growth and individual trees have been felled to make way for buildings and infrastructure. Their loss is keenly felt by the community, even when they are 'repurposed'.

Again, the Molonglo Valley is instructive. Large, mature native trees, often remnant trees which makes them even more valuable for biodiversity, are unique landscape features that play a critical role in the quality of the urban forest. These trees are extremely important as a habitat and food resource for wildlife and have high cultural and landscape significance. Scrutiny of repurposed trees for biodiversity value has produced some interesting results.

25 Personal communication, Associate Professor Cris Brack of the Fenner School of Environment and Society, ANU, 2019.
26 Associate Professor Cris Brack, presentation at the Life and Death in a City of Trees Synthesis Workshop at ANU, 12–13 September 2019.
27 Commissioner for Sustainability and the Environment (OCSE), 2017, *Implementation Status Report on ACT Government's climate change policy*, ACT Government, Canberra, 108. Found at https://www.envcomm.act.gov.au/__data/assets/pdf_file/0018/1116324/CSE-ISR-Report-Aug2017_FA_AccPDF_c2.pdf accessed 30 October 2019.
28 Commissioner for Sustainability and the Environment (OCSE), 2018, Independent Audit of the Molonglo Valley Strategic Assessment, ACT Government, Canberra. Found at https://www.envcomm.act.gov.au/investigations/independent-audit-of-the-molonglo-valley-strategic-assessment accessed 30 October 2019.

CASE STUDY:
MOLONGLO – REPURPOSING TREES FOR BIODIVERSITY

Barrer Hill translocated dead trees. Source: OCSE.

Associate Professor Philip Gibbons (Fenner School of Environment and Society, ANU), an expert in the edge effects of development on natural landscapes,[29] has collaborated with ACT Parks and Conservation Service and the ANU School of Art and Design, to set up monitoring sites on power poles and translocated dead trees (cut down to make way for development) to observe usage by wildlife. One of the trees translocated to the Barrer Hill site in the Molonglo Valley to make way for development was a 400 year old Yellow Box (*Eucalyptus melliodora*).[30]

Birds, bats, reptiles and insects visiting the structures have been captured on videos which are then made available to the public, who are also invited to post their photos on the website (http://molonglo.life/#!/).

Visitors have included wood spiders, ladybirds, microbats, and Crimson and Eastern Rosellas, starlings, Yellow-tailed Black Cockatoos, Galahs, Red Wattlebirds, Willie Wagtails, Red-rumped Parrots, Kookaburras, a Peregrine Falcon, Nankeen Kestrel, Tawny Frogmouth and a range of insects. During the study there was a four-fold increase in bird species at power pole structures, and a seven-fold increase in bird species at the salvaged trees.

Dr Gibbons observed that planting juvenile trees would not provide the habitat of the repurposed mature (dead) trees. However, Dr Gibbons reported that 37% of bird species that relied upon mature forests did not use the structures:

> '… we need to preserve as many mature trees as we can, [and we have to] continue to plant more new seedlings for the future … at the end of the day you can't beat real trees … but they take years to grow. So this is a great option in areas needing regeneration or while you wait for trees to mature.'[31]

29 Commissioner for Sustainability and the Environment (OCSE), 2018, Independent Audit of the Molonglo Valley Strategic Assessment, ACT Government, Canberra. Found at https://www.envcomm.act.gov.au/investigations/independent-audit-of-the-molonglo-valley-strategic-assessment accessed 30 October 2019.

30 This research report is drawn from *ANU News*, 23/8/2019, 'Artificial Trees Capture New Bird Species on Candid Camera', found at https://www.anu.edu.au/news/all-news/artificial-trees-capture-new-bird-species-on-candid-camera-1 accessed 30 October 2019.

31 Associate Professor P. Gibbons, *ANU News*, 23/8/2019, 'Artificial Trees Capture New Bird Species on Candid Camera', found at https://www.anu.edu.au/news/all-news/artificial-trees-capture-new-bird-species-on-candid-camera-1 accessed 30 October 2019.

CLIMATE CHANGE PRESSURES AND IMPLICATIONS

Climate change is increasingly recognised as one of the most pressing issues confronting cities. There is growing recognition that increasing temperatures due to urban heat and climate change are a threat to some tree species in our cities.[32]

Canberra is expected to have a climate like Dubbo by 2090. The population will continue to grow, and our urban forest will continue to mature and age. This will increase the need to:

- respond with climate change adaptation plans
- design the urban forest with a focus on resilience and flexibility
- design water-sensitive landscapes and respond to understorey needs in accordance with landscaping best practice, and
- protect, maintain, and manage for senescence and other issues, including drought and pests.

The National Environmental Science Program's Clean Air and Urban Landscape Hub (CAUL) assessed the viability of 356,547 of Canberra's trees (from a data set of 446,730 trees). In ordinary circumstances the three species at risk are the Common Oak (*Quercus robur*), the Dutch Elm (*Ulmus x hollandica*), and the Turkey Oak (*Quercus cerris*).[33]

The picture is of greater concern when considered under climate change Representative Concentration Pathways (RCP) scenarios.

Subject to RCP4.5 (GHG emissions limited, temperatures rising from 0.89°C to 2.6°C and stabilising in 2100) and RCP8.5 (GHG emissions, business as usual, temperatures rising from 1.4°C to 4.8°C),[34] CAUL has concluded many more tree species will struggle.

CAUL's complete list of species at risk across Canberra (Table 1) provides an illustration of the extent of climate change concerns for the urban tree canopy. This research has been replicated for 29 Australian cities including Perth, Melbourne, Adelaide, Sydney, Brisbane, and Darwin.

In considering the implications of climate change on tree canopy, regard should be given to the United Nations Intergovernmental Panel on Climate Change (IPCC) 2018 report *Global Warming of 1.5°C*.[35]

Canberra's Living Infrastructure Plan: Cooling the City provides a launching pad for a response, but care needs to be taken to avoid planting species which will not survive, even though they might be of local provenance.

32 Clean Air and Urban Landscapes Hub (National Environmental Sciences Programme), 2017, *Risks to Australia's Urban Forest from Climate Change and Urban Heat*, University of Melbourne, Melbourne. Found at https://apo.org.au/sites/default/files/resource-files/2017/11/apo-nid136871-1230256.pdf accessed 30 October 2019.

33 Clean Air and Urban Landscapes Hub (National Environmental Sciences Programme), 2017, *Risks to Australia's Urban Forest from Climate Change and Urban Heat*, University of Melbourne, Melbourne. Found at https://apo.org.au/sites/default/files/resource-files/2017/11/apo-nid136871-1230256.pdf accessed 30 October 2019.

34 Representative Concentration Pathways (RCP) are the GHG concentration trajectories used in the Fifth Assessment Report of the United Nations Intergovernmental Panel on Climate Change (IPCC). In summary, RCP 4.5 scenarios are predicated on modelling which suggests a temperature range increase from 0.9 to 2.6 degrees to the end of the century and RCP 8.5 scenarios suggest a future range (adopting a business as usual approach) in the range of 1.4 to 4.8 degrees.

35 United Nations Intergovernmental Panel on Climate Change (IPCC), 2018, *Special Report: Global Warming of 1.5 °C*, https://www.ipcc.ch/sr15/ accessed 30 October 2019.

Table 1:
Temperature risk to the most common tree species in Canberra.

No	Species	Abundance (%)	Number trees	Current climate	RCP4.5 future	RCP8.5 future
1	Unknown		87388			
2	Eucalyptus mannifera	16.50%	58813	green	green	orange
3	Eucalyptus spp.	9.95%	35494	green	green	yellow
4	Casuarina cunninghamiana	9.89%	35251	green	green	green
5	Eucalyptus polyanthemos	5.12%	18244	green	green	yellow
6	Eucalyptus melliodora	5.00%	17814	green	green	yellow
7	Pinus radiata	3.67%	13090	green	yellow	orange
8	Fraxinus angustifolia	3.27%	11651	green	green	orange
9	Pyrus calleryana	2.34%	8339	green	green	green
10	Quercus palustris	2.27%	8084	green	orange	orange
11	Eucalyptus blakelyi	2.15%	7656	green	green	yellow
12	Eucalyptus cinereal	2.12%	7542	green	green	yellow
13	Eucalyptus sideroxylon	2.09%	7445	green	green	green
14	Populus alba	1.84%	6549	green	yellow	orange
15	Ulmus parvifolia	1.63%	5794	green	green	green
16	Eucalyptus globulus	1.52%	5425	green	green	green
17	Prunus cerasifera	1.46%	5194	green	yellow	yellow
18	Eucalyptus nicholii	1.41%	5044	green	green	yellow
19	Quercus spp.	1.35%	4809	green	yellow	orange
20	Liquidambar styraciflua	1.17%	4176	green	green	green
21	Gleditsia triacanthos	1.17%	4166	green	green	yellow
22	Zelkova serrata	1.02%	3642	green	green	green
23	Populus spp.	0.99%	3536	green	yellow	orange
24	Platanus acerifolia	0.94%	3340	green	green	yellow
25	Ulmus minor	0.93%	3299	green	yellow	red
26	Pistacia chinensis	0.88%	3139	green	green	green
27	Quercus lusitanica	0.84%	3010	green	green	orange
28	Ulmus spp.	0.73%	2601	green	yellow	orange
29	Platanus orientalis	0.68%	2441	green	green	green
30	Eucalyptus viminalis	0.65%	2331	green	yellow	orange
31	Celtis australis	0.64%	2295	green	green	yellow
32	Eucalyptus bridgesiana	0.59%	2099	green	orange	red
33	Fraxinus spp.	0.58%	2051	green	green	orange
34	Cedrus atlantica	0.54%	1941	green	orange	orange
35	Styphnolobium japonicum	0.53%	1880	green	green	yellow
36	Pinus spp.	0.53%	1878	green	yellow	orange
37	Pyrus ussuriensis	0.51%	1836	green	green	yellow

No	Species	Abundance (%)	Number trees	Current climate	RCP4.5 future	RCP8.5 future
38	Cupressus spp.	0.46%	1632	green	green	green
39	Fraxinus velutina	0.43%	1526	green	green	green
40	Quercus robur	0.43%	1523	yellow	orange	orange
41	Eucalyptus elata	0.42%	1510	green	green	orange
42	Ulmus × hollandica	0.40%	1426	yellow	orange	red
43	Cupressus sempervirens	0.37%	1314	green	green	green
44	Quercus cerris	0.35%	1243	yellow	yellow	orange
45	Eucalyptus macrorhyncha	0.34%	1229	green	yellow	red
46	Populus nigra	0.34%	1212	green	yellow	yellow
47	Platanus spp.	0.32%	1145	green	green	yellow
48	Ulmus Americana	0.29%	1021	green	yellow	yellow
49	Fraxinus Americana	0.28%	1001	green	yellow	yellow
50	Quercus canariensis	0.28%	992	green	green	yellow

Source: Clean Air and Urban Landscapes Hub (National Environmental Sciences Programme), 2017, *Risks to Australia's Urban Forest from Climate Change and Urban Heat*, University of Melbourne.

Recent research by ANU's Fenner School of Environment and Society,[36] suggests the best trees for planting in the ACT under climate change scenarios include Kurrajong Veregreen (*Brachychiton populneus*), the River She-oak (*Casuarina cunninghamiana*) and the Arizon Cypress (*Cyress arizonica*). However, diversity is a key consideration and different species will be more appropriate for different circumstances.

36 Fenner School of Environment and Society, Australian National University (Associate Professor Cris Brack et al.) 2019, *Urban Forest Tree Species Research for the ACT,* found at https://www.environment.act.gov.au/__data/assets/pdf_file/0008/1437047/urban-forest-tree-species-research-for-the-act-consultants-report-2019.pdf, report commissioned by the ACT Government in 2019, accessed on 30 October 2019.

CASE STUDY: URBAN TREES AND HEAT[37]

Cities, urban areas and industrial developments can create urban heat islands, where temperatures in urban areas are warmer than those in rural areas. During the day buildings, roads and paved surfaces absorb solar radiation and then release the heat slowly at night, which slows the cooling process. For example, in summer the urban areas of Canberra have been found to be 8°C warmer in summer and 6°C warmer in winter than the surrounding rural area.

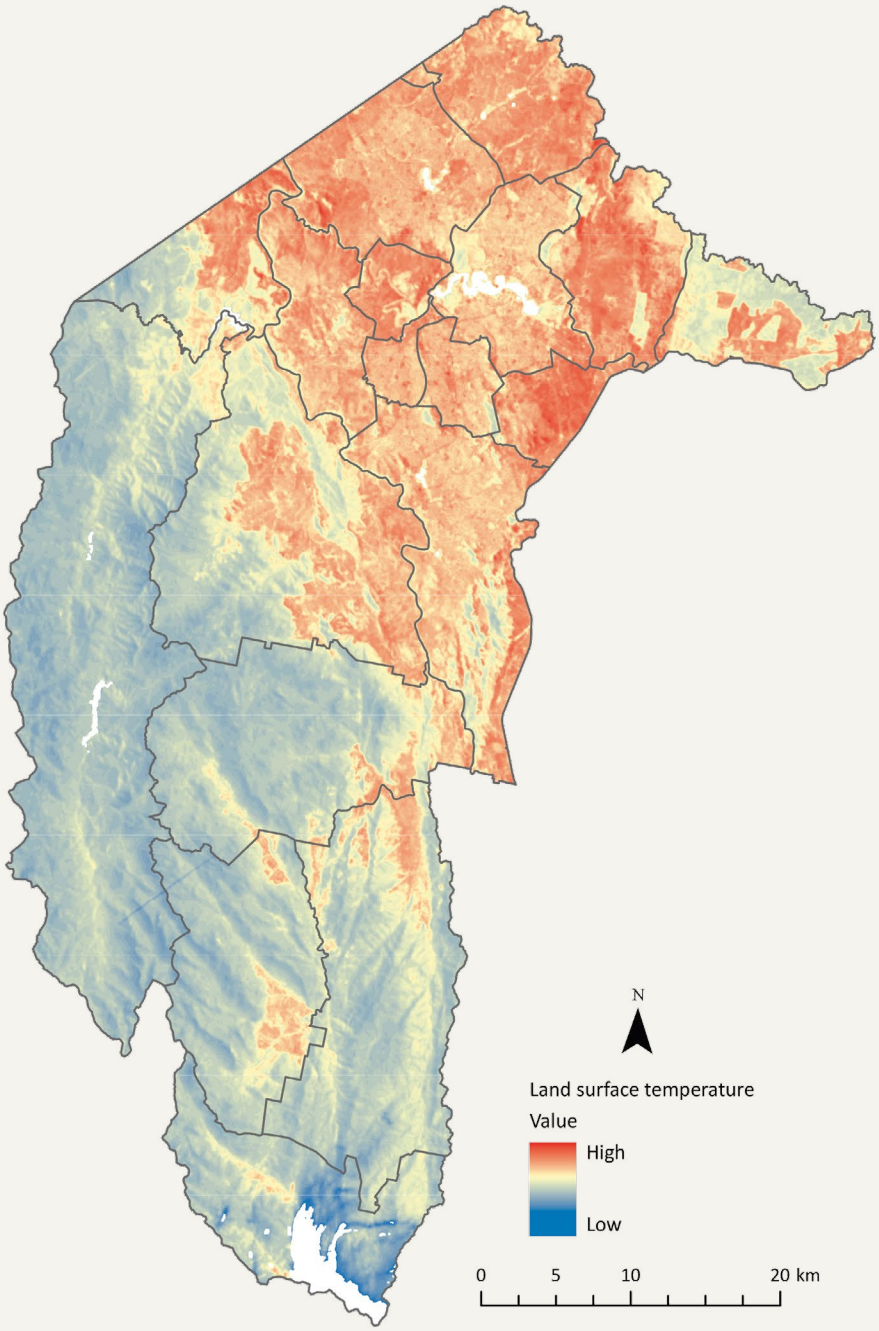


Figure 1:
Land surface temperatures for the ACT for 9 February 2017, 10.50 AM. Data for the southern-most tip of the ACT has been excluded owing to cloud cover.

37 Meyers, J. et al., 2017, *Mapping Surface Urban Heat in Canberra*, CSIRO, Canberra. Found at https://www.environment.act.gov.au/__data/assets/pdf_file/0005/1170968/CSIRO-Mapping-Surface-Urban-Heat-In-Canberra.pdf accessed September 2019.

Trees have been shown to reduce surface temperatures effectively with cooler areas recorded during summer where there is greater tree canopy cover. Land surface temperatures for the ACT on 9 February 2017 (10.50 AM) are shown in Figure 1.

When comparing the land surface temperatures with the vegetation index (Figure 2) there is a clear correlation between the high land surface temperatures and lack of vegetation, and lower land surface temperatures with greater green vegetation.

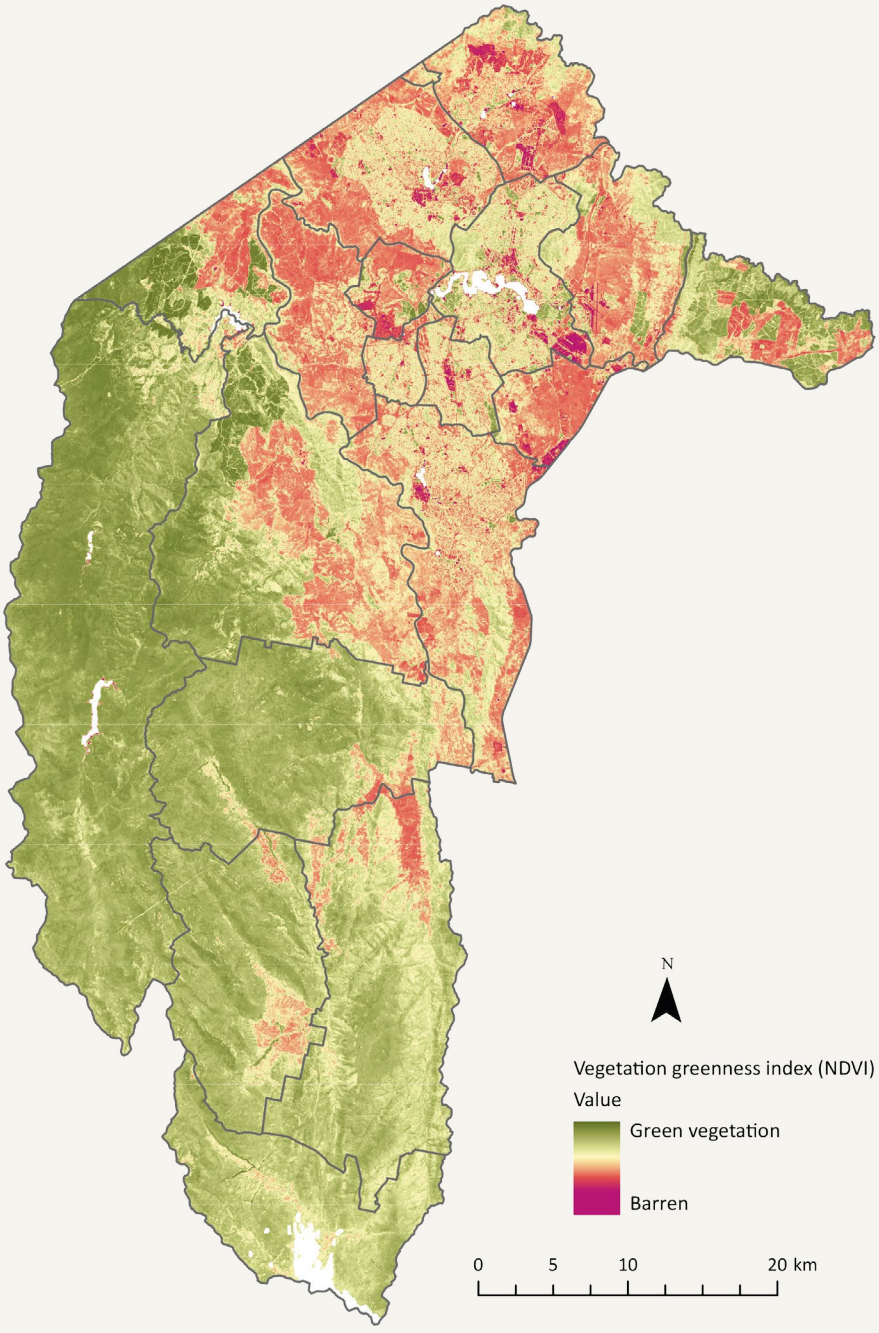


Figure 2:
Vegetation greenness index for the ACT for 9 February 2017, 10.50 AM. Data for the southern-most tip of the ACT has been excluded owing to cloud cover.

This relationship between tree cover and land surface temperature is also shown in a comparison of land use and percentage of tree cover (Figures 3 and 4, also for 9 February 2017 at 10.50 AM). Industrial was the hottest land use with 37.4°C, this is most likely due to the fact that Industrial areas in Canberra tend to have extensive impervious surfaces (rooftops and paved surfaces) and only 8.5% tree cover. In comparison parks and recreation areas had the lowest temperature (35°C) due to having the highest percentage of tree cover (28.6%).

In residential areas, high density residential land use has the highest mean land surface temperature at 37.2°C and only 9% tree cover, compared to the suburban core which was 34.7°C and had 20% tree cover.

Whilst the temperature difference appears to be small, this is because measurements were taken in the morning (due to satellite availability). It is highly likely that for afternoon temperatures, the differences between areas with low and high tree cover would be far greater. This could potentially have severe human health implications during hot periods. It is clear that improvements in tree cover are essential to Canberra's climate change adaptation.

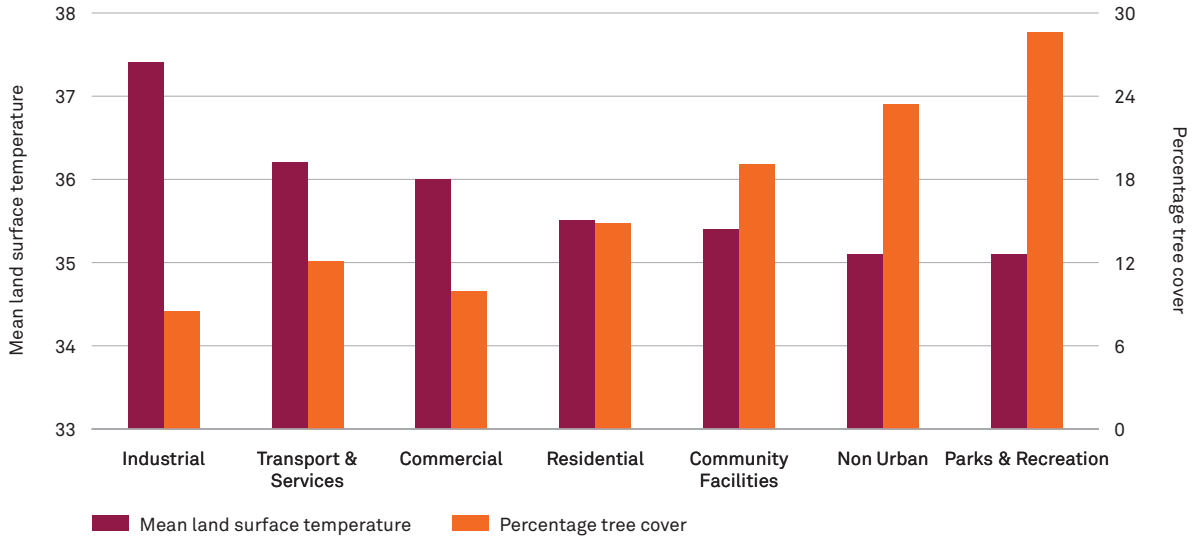


Figure 3:
A comparison of mean land surface temperature by land use type and percentage of tree cover, 9 February 2017, 10.50 AM.

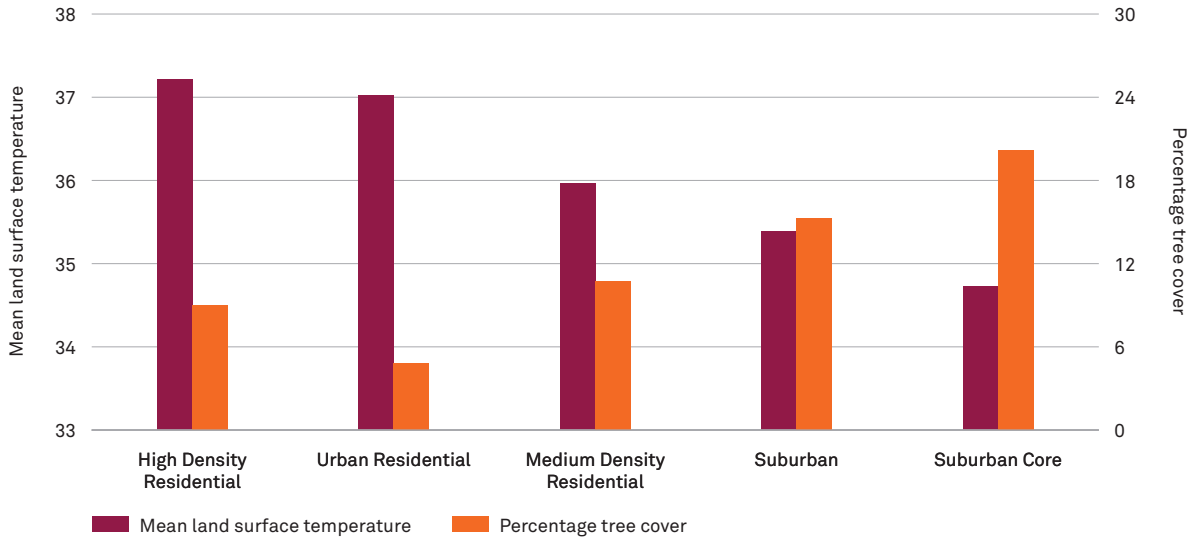


Figure 4:
A comparison of mean land surface temperature by residential land use type and percentage of tree cover, 9 February 2017, 10.50 AM.

THE LIVES OF TREES IN CANBERRA

In Canberra trees have an expected useful life of between 50 to 80 years, depending on species and conditions. Associate Professor Cris Brack concludes that the end of a tree's 'useful' or 'safe' age occurs when safety and other risks, as well as economic and other costs, start to outweigh the benefits of individual trees.

Reflecting these pressures, an average of 516 trees each year is removed under contract in Canberra and approximately 850 trees are removed by TCCS' in-house maintenance team.

Recent expert audits have shown that around 22% of trees planted in Canberra's suburbs will reach the end of their 'safe' or 'useful' life and require removal within the next twenty years. Modelling suggests a rate of 1–2% of trees per annum on average will fall into this category, although this rate might increase in drought years and show a reduction in others. This translates to potentially thousands of trees per year. The *Living Infrastructure Plan: Cooling the City* is intended to assist in establishing a response to this issue.

The UN System of Environmental Economic Accounting (SEEA)[38] is being considered as a methodology for determining the environmental and economic benefits of Canberra's tree cover to promote the sort of expenditure which will be necessary to fund this urban forest initiative. This SEEA commitment builds on the i-Tree methodology[39] which had been used previously to value an urban forest.[40] It also builds on the broader accounts that the OCSE did with the Bureau of Meteorology (BOM), the Australian Bureau of Statistics (ABS), ANU, the UN and the Office of Environmental Heritage (OEH), to examine the benefits of environmental-economic accounts in the SEEA Proof of Concept for the ACT 2017.[41]

Over the next four years (2020–2024), TCCS advises that an additional 17,330 new trees will be planted across Canberra. Planting locations will focus on areas of low urban canopy cover and areas where the canopy target is at risk of decline with the ageing of existing trees. This planting program is being used to offset anticipated tree losses that will occur between 2020 and 2035, when a significant proportion of the trees in the urban forest reach the end of their useful life.

Beyond the targeted plantings, TCCS planted an average of 937 trees annually from July 2015 to June 2019 to replace trees that had been removed or where there was space for a new tree to be planted.[42]

MAINTAINING TREES IN CANBERRA

Maintenance activities include watering, formative and ongoing pruning, removal of dead or damaged timber, and risk reduction by rectification of structural defects. Watering during the warmer months (October to April) is the primary maintenance cost for a young tree. Noting the temperature ranges anticipated under climate change scenarios and the number of trees entering the over-mature stage, this maintenance regime will require adjustment.

In the 2018–2019 financial year, TCCS watered over 25,000 young trees. Native trees are routinely watered for three years after planting. Exotics are more commonly watered for five years. The cost to maintain trees over the establishment period ranges from approximately $150 to $255 per tree, plus water costs associated with six watering events.

38 Further information can be found at https://seea.un.org/ accessed on 30 October 2019.
39 Further information about i-Tree tools are found at https://www.itreetools.org/ accessed on 30 October 2019.
40 202020 Vision references to the potential uses of i-Tree can be found at https://202020vision.com.au/ accessed on 30 October 2019.
41 OCSE, 2017, *Environmental-Economic Accounts for ACT State of Environment Reporting, Proof of Concept*, ACT Government, Canberra, found at https://www.envcomm.act.gov.au/publications/environmental-economic-accounts accessed on 30 October 2019.
42 This figure does not include tree plantings associated with estate developments, landscape renewal projects or community programs.

TREE PROTECTION AND THE TREE REGISTER

TCCS administers the *Tree Protection Act 2005* and the ACT Tree Register. Applications to remove private trees regulated under the *Tree Protection Act 2005* are managed according to the legislated process.

The Tree Protection Unit received 2,257 Tree Damaging Activity applications and Development Application submissions in the 2018–2019 financial year. A range of appeal processes are available where applications are not granted.

The ACT Tree Register protects trees in the urban area that have exceptional qualities because of their natural and cultural heritage values or their contribution to the urban landscape. The Tree Register currently includes 176 single tree registrations and 35 group registrations. Ten additional trees currently sit on the provisional tree register awaiting full registration.

CASE STUDY: REPURPOSING TREES FOR HUMAN USE

One inspired Canberra initiative, the 'Witness Tree Program', created and organised by the ANU School of Art and Design, funded by an ACT Government heritage grant and supported by the ANU Fenner School of Environment and Society, illustrates both the benefits and the complexities of repurposing unique old growth trees.

A synthesis symposium was recently conducted as part of this program – the Life and Death in a City of Trees Synthesis Workshop.[43] The forum considered the fate of trees which have reached the end of their 'useful' life, and heard from those engaged in forestry, art, crafts, various tiers of government, and the circular economy. International and local contributions reinforced the message that value-adding through repurposing is possible and responsible.

The Witness Tree project repurposed important, mature trees which had 'witnessed the unfolding of history' while noting some of the difficulties in manufacturing unique specimens.

'Witness Trees' felled and milled in 2013 by Gordon Smith (a fine furniture maker from Hall), were air dried until 2015, and then turned in to bespoke products for the ACT Heritage Festival 2016. Some of these trees were eighty years old and included

- a Silky Oak (*Grevillea robusta*) from Hargreaves Crescent, Ainslie and gazetted in 1928.
- an Elm (*Ulmus procera*) from Weston Park, Yarralumla, gazetted in 1928.
- a Pin Oak (*Que palustris*) from Torrens Street, Braddon, gazetted in 1928.
- a Himalayan Cedar (*Cedrus doedara*) from Jardine Street, Kingston, gazetted in 1928.
- a Claret Ash (*Frazinus oxycarpa*) from Hayes Crescent, Griffith, gazetted in 1928.
- a London Plane (*Plantanus x acerfolia*) from Eggleston Crescent, Chifley, gazetted in 1966.

43 This forum will be the subject of a report at a later date. This case study was provided by Ashley Eriksmoen, leader of the ANU School of Art and Design Witness Tree Project, supported by Heritage ACT.

Himalayan Cedar: Katalin Sallai

The Witness Bench of Kingston. This Witness Tree was planted as part of Weston's afforestation program in the 1920s. Himalayan Cedar is the 'timber of the gods' and native to Afghanistan, Kashmir and India. It has been used to build temples, and more prosaically, railway cars and lines. Gazetted in 1928, this tree 'survived the reign of four monarchs and witnessed the royal visit of 1954'. It also witnessed young soldiers and nurses leaving from the Kingston railway station to go to World War I. Himalayan cedars have a life expectancy in other climates of up to 600 years. The outer circle of the bench is intended to represent its potential growth and the inner circle represents its actual growth.

Grevillea Robusta **(Silky Oak),** ***Ulmus Procera*** **(Elm),** ***Fraxinas Oxycarpa*** **(Claret Ash): Myles Gostelow**

This 'barrow to push' was designed and constructed using techniques from the early 1900s. Elm was used for the tub, Ash for the spokes, the tray was made from Silky Oak. This barrow was crafted as a tribute to Charles Weston. Myles Gostelow wrote:

'There is every chance that the trees and subsequent timber used in the construction of this barrow would have been planted from stock grown in the [Weston] nursery and be aged up to 96 years old.'

THE FUTURE – CANBERRA'S LIVING INFRASTRUCTURE PLAN: COOLING THE CITY

At the time of writing this report *Canberra's Living Infrastructure Plan: Cooling the City* had only just been released (September 2019), but this plan reflects the need to respond to a number of issues which have been discussed here: climate change, development pressure, maintenance in the face of an ageing canopy, the need for understorey, water-sensitive design for best biodiversity outcomes, and the ongoing involvement of the community.

Targets and a schedule for actions have been set. Recognition of climate change implications and a commitment to water-sensitive urban design filters throughout the whole plan, which encourages an understanding of the holistic nature of urban sustainability planning, promotes adaptation to climate change, and works to build resilience.

Action 1 provides for the use of the United Nations System of Environmental Economic Accounts to measure the value of the ecosystem services provided by the urban forest. This reflects the work of OCSE in producing the SEEA Proof of Concept for the ACT.[44] There is a critical need for this analysis to assist government to understand the economic benefit of an urban forest and to promote targeted funding.

Action 2 sets targets of 30% tree canopy cover and 30% permeable surfaces by 2045; these targets are in line with the ambitions of other comparable cities.

Actions 3, 4 and 5 provide for climate-wise guides and assessments, all of which will be useful in assisting the community to understand, act upon, and adapt to the significant climate change challenges ahead.

Action 8 introduces the need for a review of the *Tree Protection Act 2005*, a timely intervention which will allow the community to have a say about the management of the urban forest. In light of the interest in tree matters in the OCSE complaints process, and noting the continuing commentary on decisions such as the mediated outcome in the Manuka Plane Tree case, review of the legislation is timely and should actively involve the public.

Action 9 directs TCCS to start the development of an Urban Forest Strategy in 2020, which should deliver biodiversity outcomes. This action item should be used to support and encourage community groups like ACTForBees, SEE-Change, the Canberra Environment Centre, the Conservation Council and Communities@Work to build their capacity to influence government about canopy, but more broadly, biodiversity, and sustainable development. The Strategy will provide an opportunity to consider biodiversity protections and enhancement across the whole urban fabric.

Action 12 provides for 'shadeways' on bicycle infrastructure. This is a matter which has been raised frequently with the OCSE and is actively supported.

Action 13 talks about promoting demonstration projects. The architecture and the arts communities should be actively encouraged to join this conversation.

Finally, it is commendable that the Living Infrastructure Plan encourages investigation of private investment opportunities. Developers and businesses have a vested interest in providing infrastructure that meets twenty-first century needs and governments have a responsibility to ensure that they do so.

44 OCSE, 2017, *Environmental-Economic Accounts for ACT State of Environment Reporting, Proof of Concept*, ACT Government, Canberra, found at https://www.envcomm.act.gov.au/publications/environmental-economic-accounts accessed on 30 October 2019.