Green Infrastructure for Cities

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An Australian Government Initiative

CRC AUSTRALIA

Presentation outline

- Introduction
- Quantifying the benefits of green infrastructure
- Green infrastructure policy
- Scale
- Trees in the urban environment
- Water and trees
- Green infrastructure implementation
- Conclusions

What is green infrastructure?

- *"Urban green infrastructure (UGI) can be defined as the network of planned and unplanned green spaces, spanning both the public and private realms, and managed as an integrated system to provide a range of benefits" (Norton et al. 2014)*

- Includes:
  - Green open space (GOS) (parks, etc)
  - Street trees
  - Green roofs
  - Green walls
  - Vegetated water sensitive design
  - Urban agriculture
- Does not include:
  - Energy efficient 'green' buildings
  - Solar panels and wind power
  - Bicycles!
  - Etc…

Interviews with policy makers found (Bosomworth and McEvoy, 2011)

- different interpretations
- may generate some miscommunication
- may not be a particularly useful term for dialogue with communities.

Green infrastructure benefits

Urban heat related:

- Bowler et al 2010. **Urban greening** to cool towns and cities: A systematic review of the empirical evidence.
- Chen & Wong 2009. Thermal Impact of **Strategic Landscaping** in Cities: A Review
- Santamouris 2014. Cooling the cities – A review of reflective and **green roof** mitigation technologies to fight heat island and improve comfort in urban environments.
- Coutts et al 2013. Watering our Cities: The capacity for **Water Sensitive Urban Design** to support urban cooling and improve human thermal comfort in the Australian context
- Hunter et al 2014. Quantifying the thermal performance of **green façades**: A critical review
- Norton et al 2015. Planning for cooler cities: A framework to **prioritise green infrastructure** to mitigate high temperatures in urban landscapes..

Multiple benefits:

- CO_2 reduction
- Reduced runoff
- Air quality
- Amenity
- Physical health
- Mental wellbeing
- + MORE!!!

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Green Cities and Microclimate:

- Investigate the benefits of water sensitive urban design and urban greening on the urban climate and urban heat mitigation, at a range of scales
- Evaluate the benefits of improved urban climates on heat-health outcomes and Human Thermal Comfort

Evidence → Guidance → Tools

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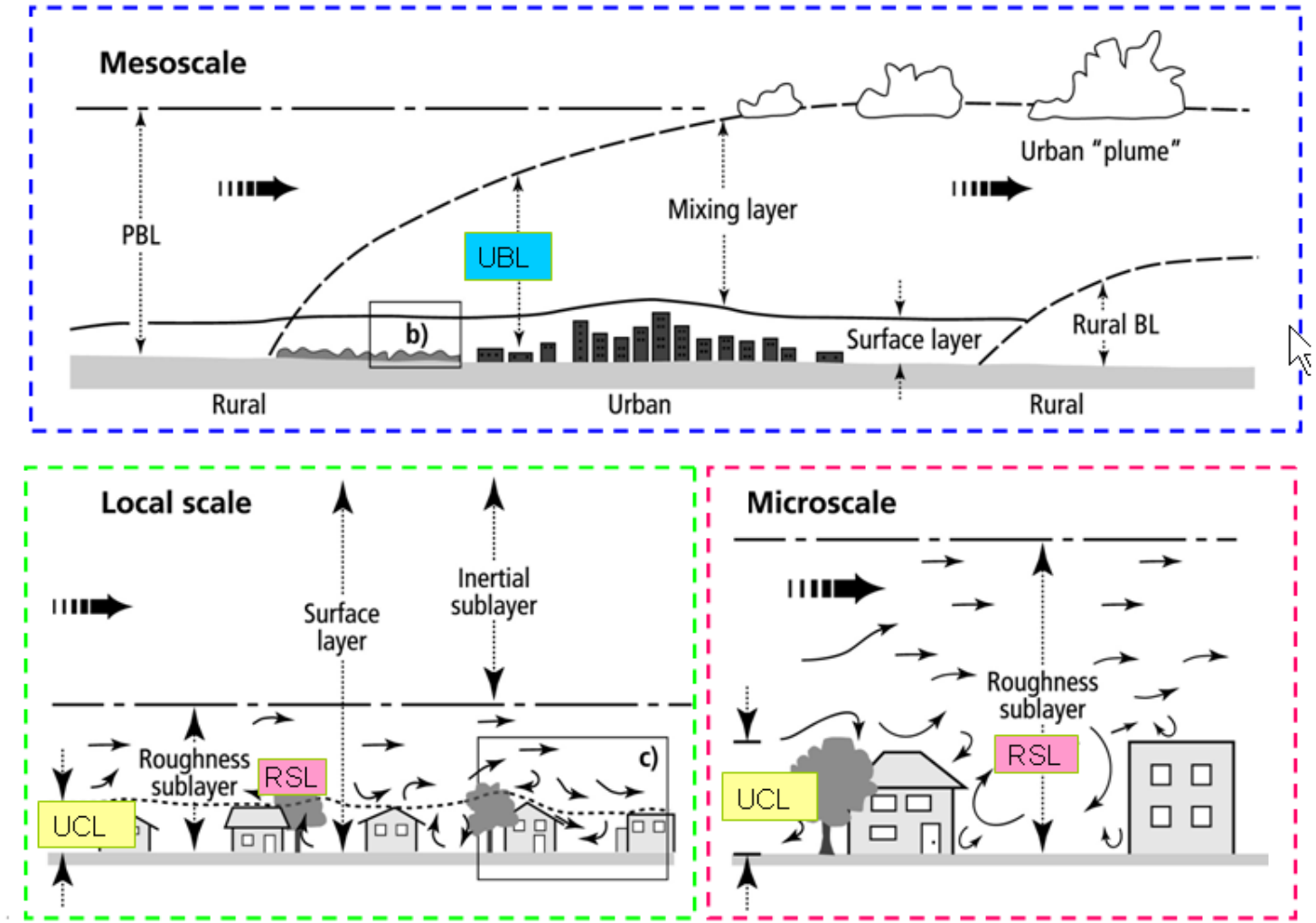
Quantifying the benefits of GI - Scale



Oke, 2009

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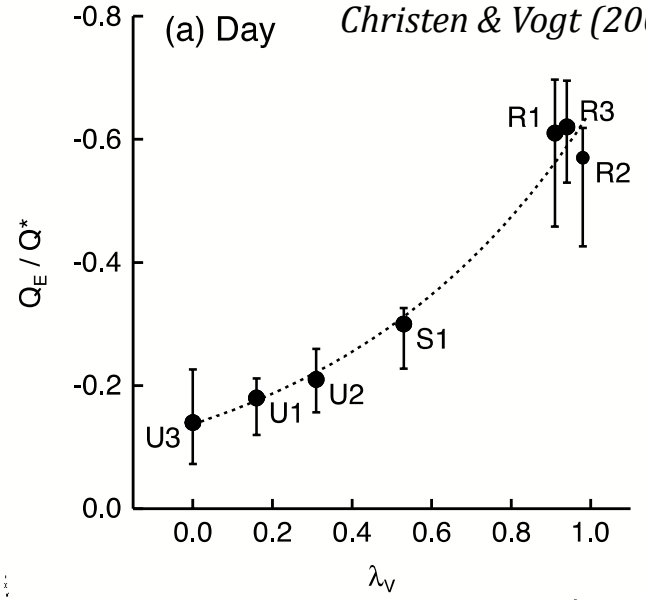
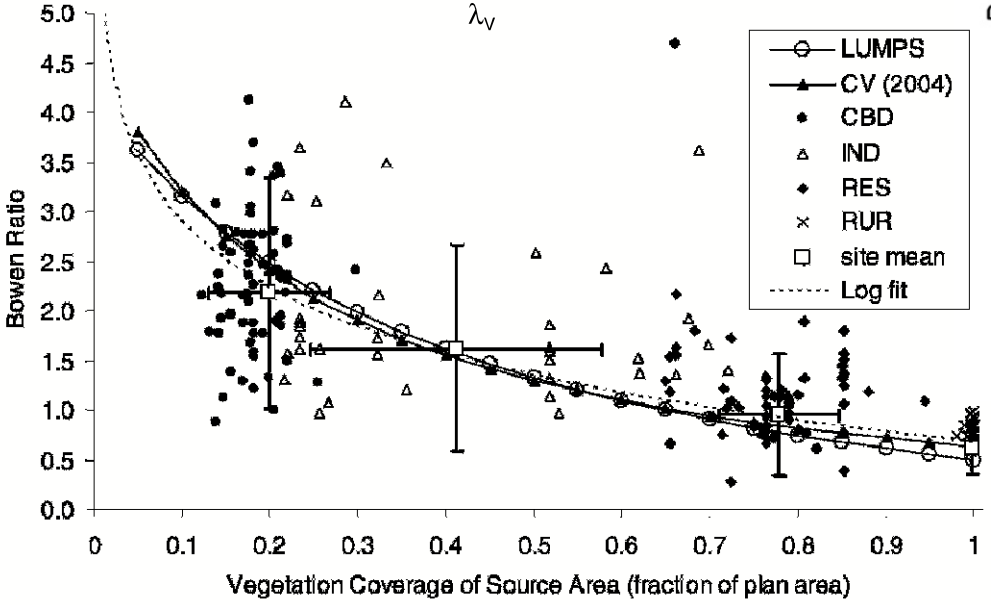
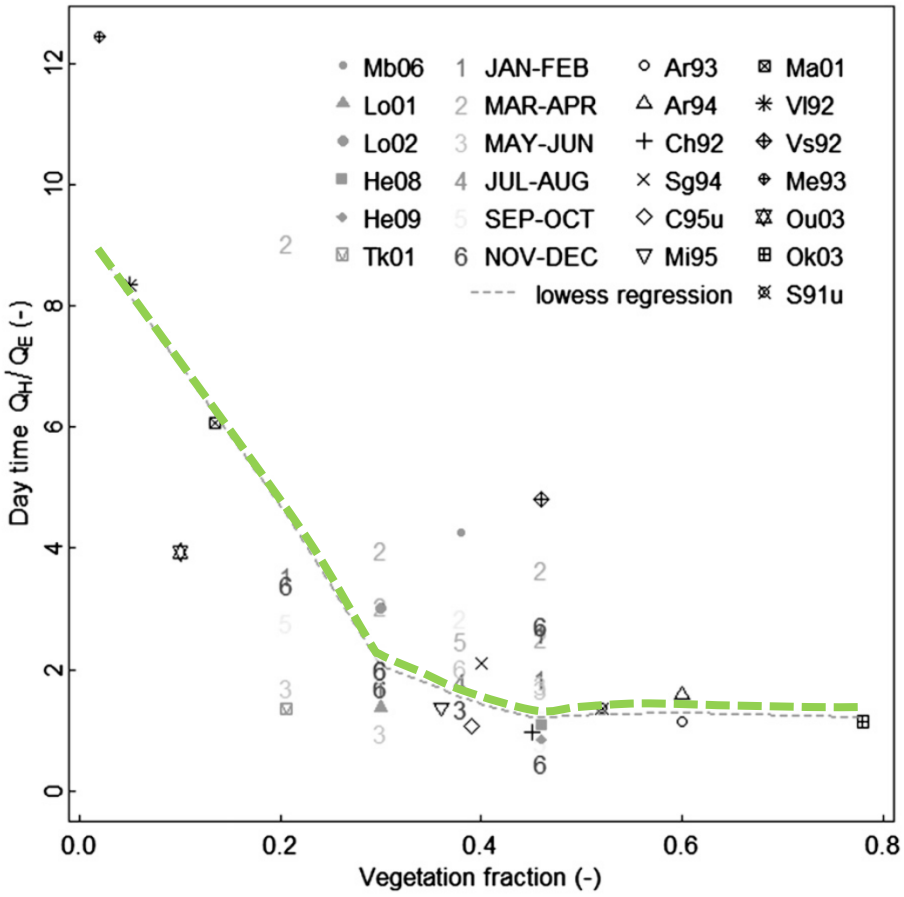
Benefits of Green Infrastructure



Christen & Vogt (2004)



Offerle, Grimmond, Fortuniak & Pawlak (2006))



Loridan & Grimmond (2012)

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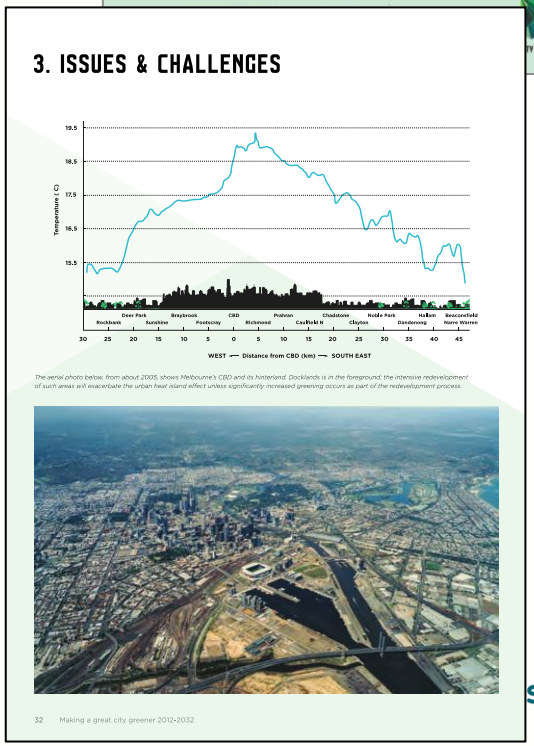
Policy

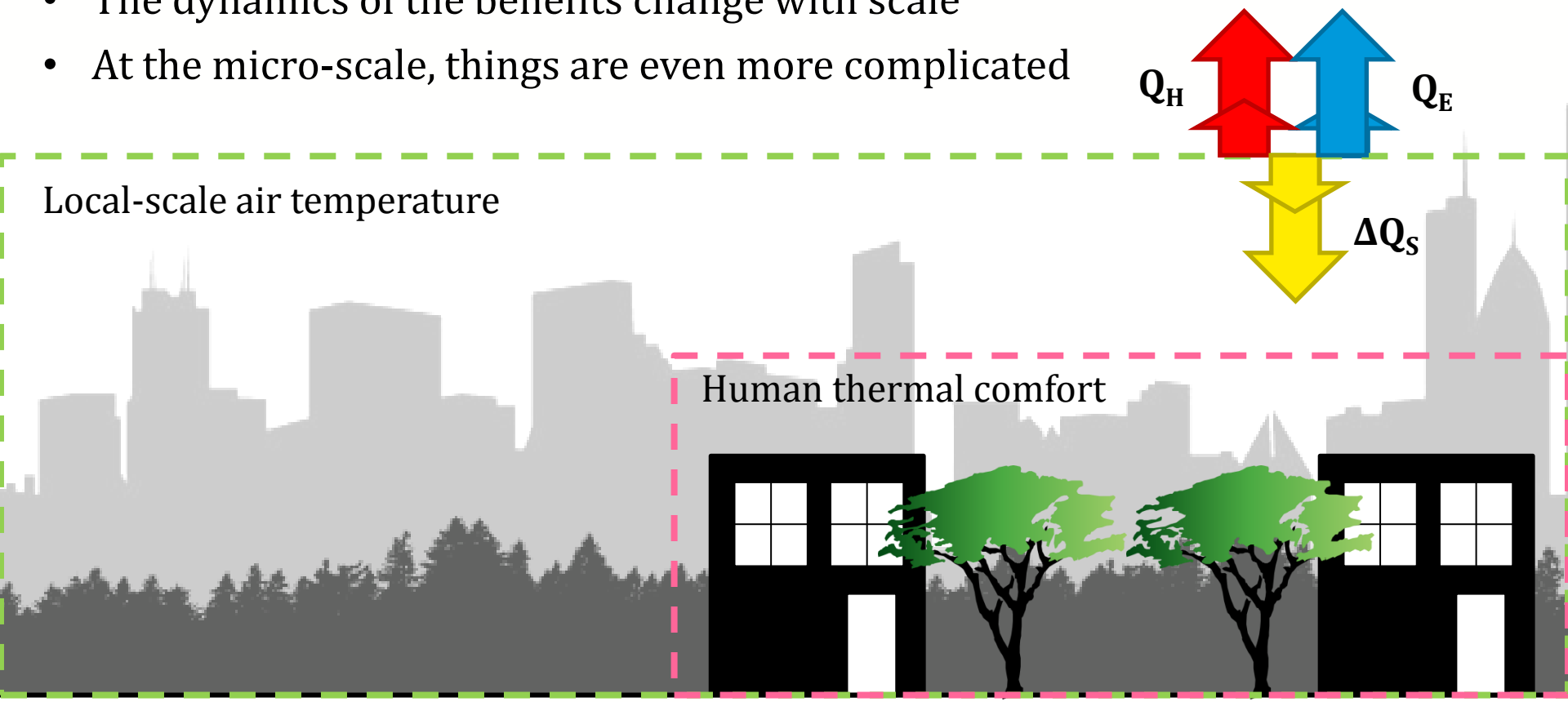
- The evidence that green infrastructure can improve urban climates is 'growing' & beginning to translate into policy (e.g. Urban Forest Strategies)
- Canopy Cover targets:
  - **City of Melbourne, AU** – 40% by 2040
  - **City of Sydney, AU** – 27.13% by 2050
  - **City of London, CA –** 25% by 2035, 32% by 2065
  - **City of Vancouver, CA -** plant 150,000 trees by 2020
- Does it matter **WHERE** this green infrastructure goes?
- Does it matter **WHAT** green infrastructure is used?
- What does this mean for urban climate?



The scale of implementation…

- At the local scale, yes, vegetation reduces local-scale T_a
- More vegetation generally increases Q_E and decreases Q_H and ΔQ_S
- This has implications for heat-health relationships at the local- & meso-scale

- The dynamics of the benefits change with scale
- At the micro-scale, things are even more complicated



Green infrastructure cooling depends on…

Green open space

- Park design
- Tree coverage
- Planting density
- Species
- Irrigation regime
- Water bodies
- Surrounding urban density
- Surrounding urban geometry
- Met. Conditions
- Time of day

Street trees

- Tree size
- Canopy coverage
- Planting density
- Species
- LAI
- Root water avail.
- Tree health
- Location
- Urban geometry
- Met. Conditions
- Time of day

Green roofs

- Substrate depth
- Substrate type
- Vegetation species
- LAI
- Water retention
- Vegetation health
- Roof slope
- Height of building
- Building insulation
- Urban geometry
- Met. Conditions
- Time of day

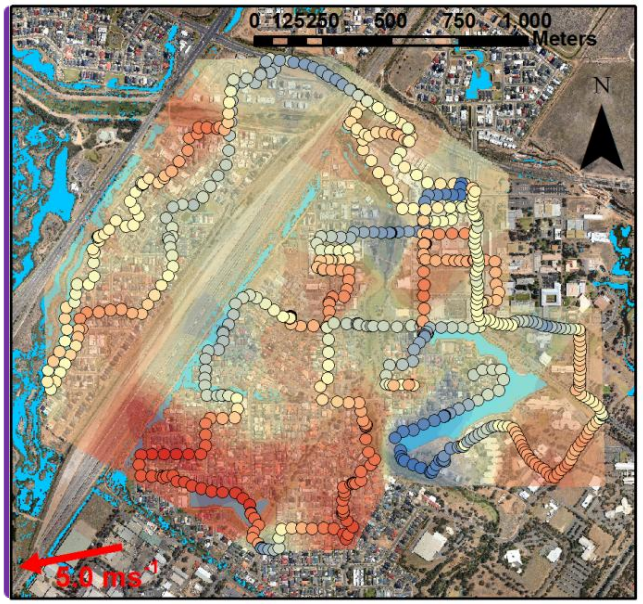
Vertical greening

- Façade or wall
- Direct or support
- Species
- LAI
- Wall coverage
- Water availability
- Vegetation health
- Wall aspect
- Wall material
- Urban geometry
- Met. Conditions
- Time of day

Some broad points

- Cooling effects are highly localised
- Cooling effects will vary with type of green infrastructure and abundance
- Cooling depends as much on the urban environment as it does on the green infrastructure

- How do we marry the micro- and local-scales?



Broadbent, Coutts, Demuzere, Tapper, Beringer (2015)

UGI	Green open spaces	Trees	Green roofs	Vertical greening
Shades canyon surfaces?	Yes, if grass rather than concrete	Yes	Shades roof, not internal canyon surfaces	Yes
Shades people?	Yes, if treed	Yes	No, only very intensive green roofs	No
Increases solar reflectivity?	Yes, when grassed	Yes	Yes, if plants healthy	Yes
Evapo-transpirative cooling?	Yes, with water	Yes (unless severe drought)	Yes, with water when hot	Yes, with water when hot
	No, without water		No, without water	No, without water
Priority locations *Norton et al (2015)*	• Wide streets with low buildings – both sides • Wide streets with tall buildings – sunny side	• Wide streets, low buildings – both sides • Wide streets, tall buildings – sunny side • In green open spaces	• Sun exposed roofs • Poor insulated buildings • Low, large buildings • Dense areas with little available ground space	• Canyon walls with direct sunlight • Narrow or wide canyons where trees are unviable

It's all about trees!!!

Trees are especially beneficial because:

- They provide shade, reducing mean radiant temperature
  - Mean radiant temperature is the dominant driver of human thermal comfort during the day
- They access water from deep layers of the soil
  - Trees "*...act as conduits for water loss to the air*" Oke et al 1989
- Diversity of species allowing more tailored greening options
  - Selection based on environmental conditions
  - Selection based on objectives
- They deliver multiple benefits
- People just 'get' trees

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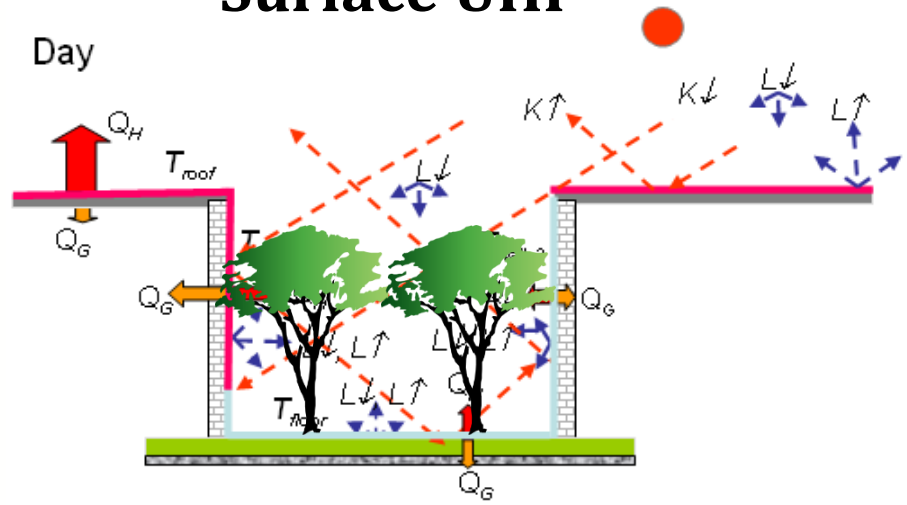
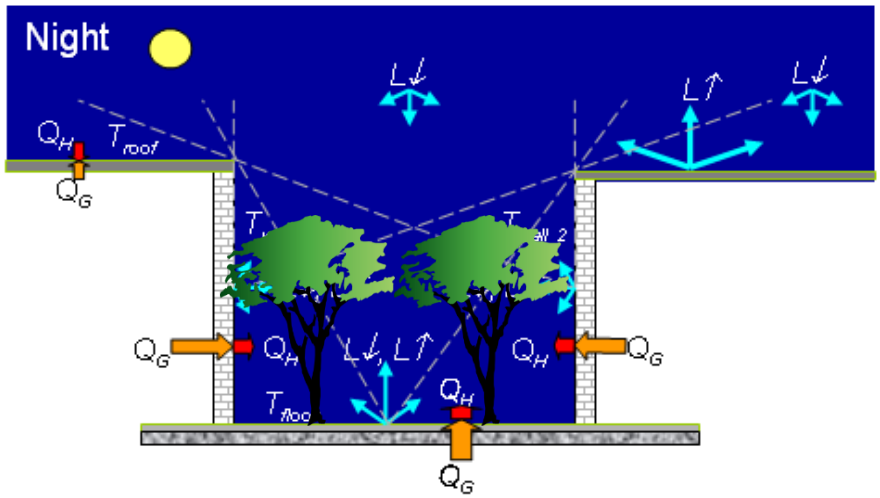
Urban canopy energetics

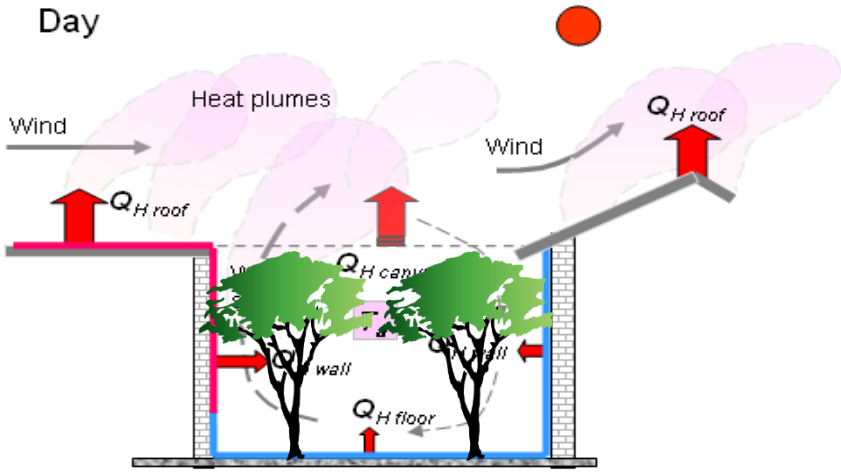
Oke, T (2009) The Need to Establish Protocols in Urban Heat Island Work. 8th Symposium on Urban Environments. Phoenix, Arizona. 11-15 January 2009

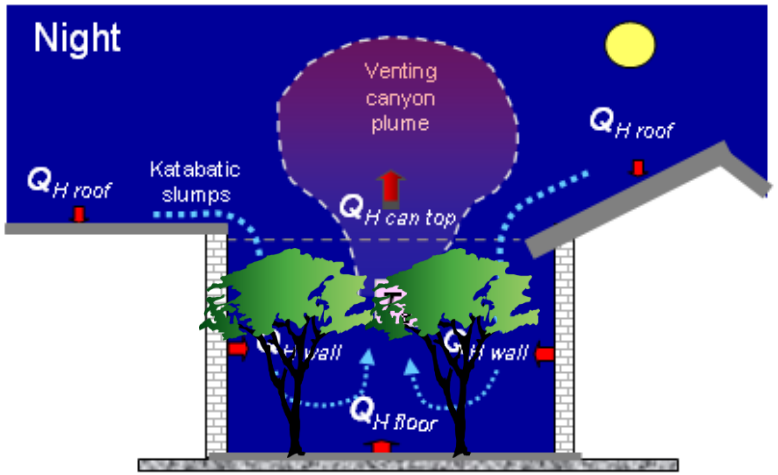
Surface UHI





Canopy layer UHI

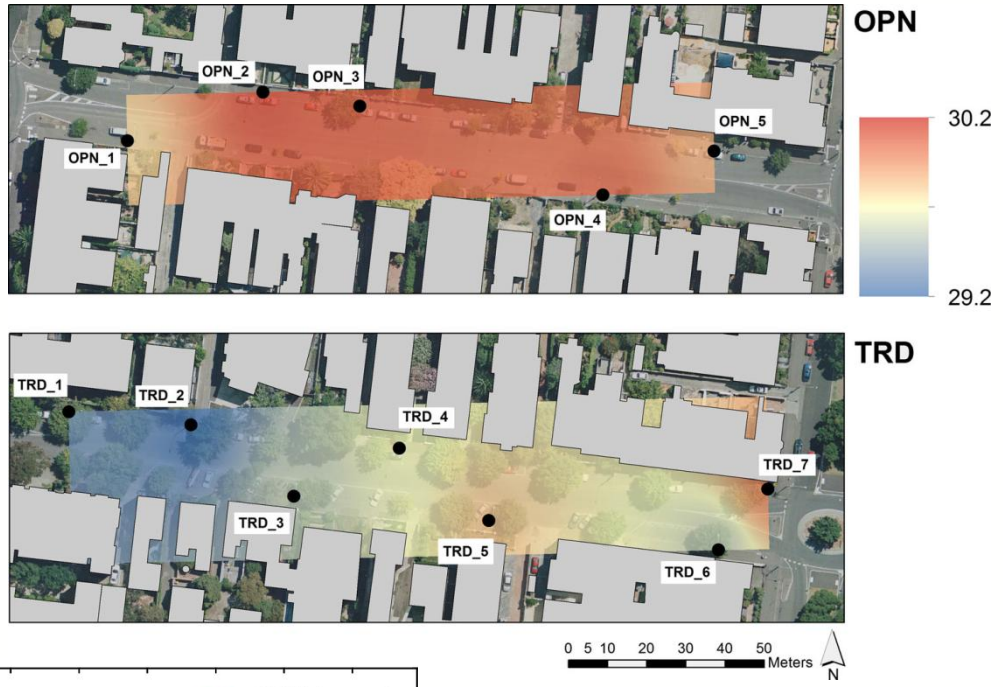


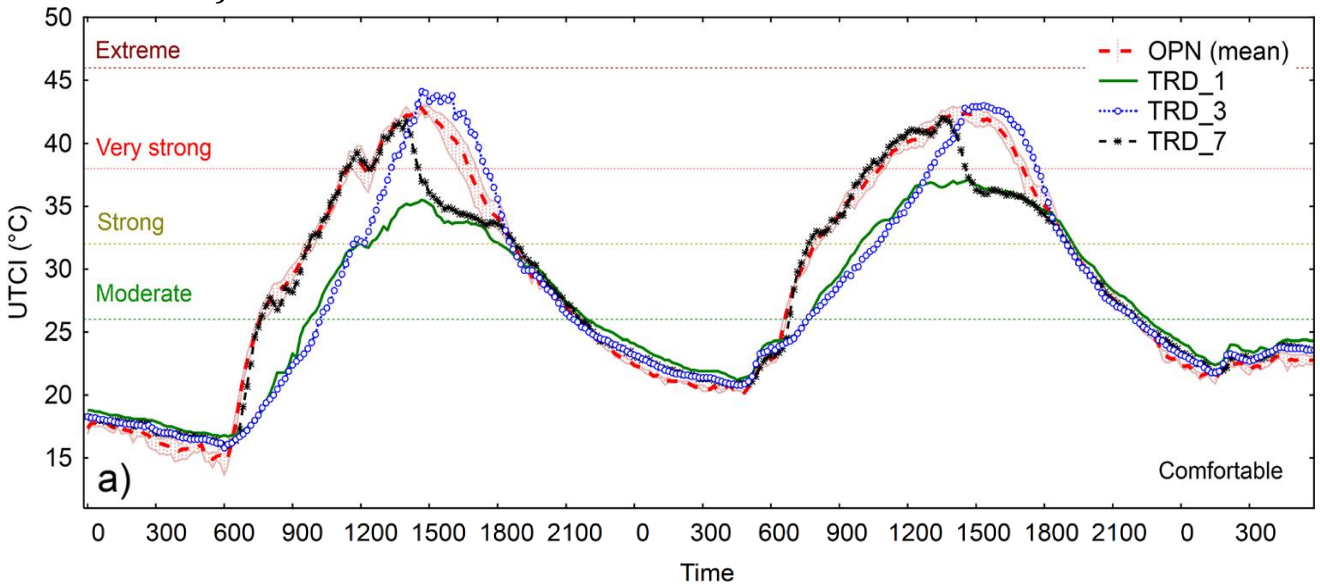


Trees in the urban canyon

Daytime

- Daytime reduction in T_a in the urban canopy
- Large reductions in mean radiant temperature from shading
- *"In the studied sites, shading in summer is provided by the trees: on the average, about 80% of the cooling effect was contributed by tree shading."*(Shashua-bar and Hoffman 2000)
- *"... probability that much of the transpiration occurs from the top of the trees"* (Oke et al., 1989)





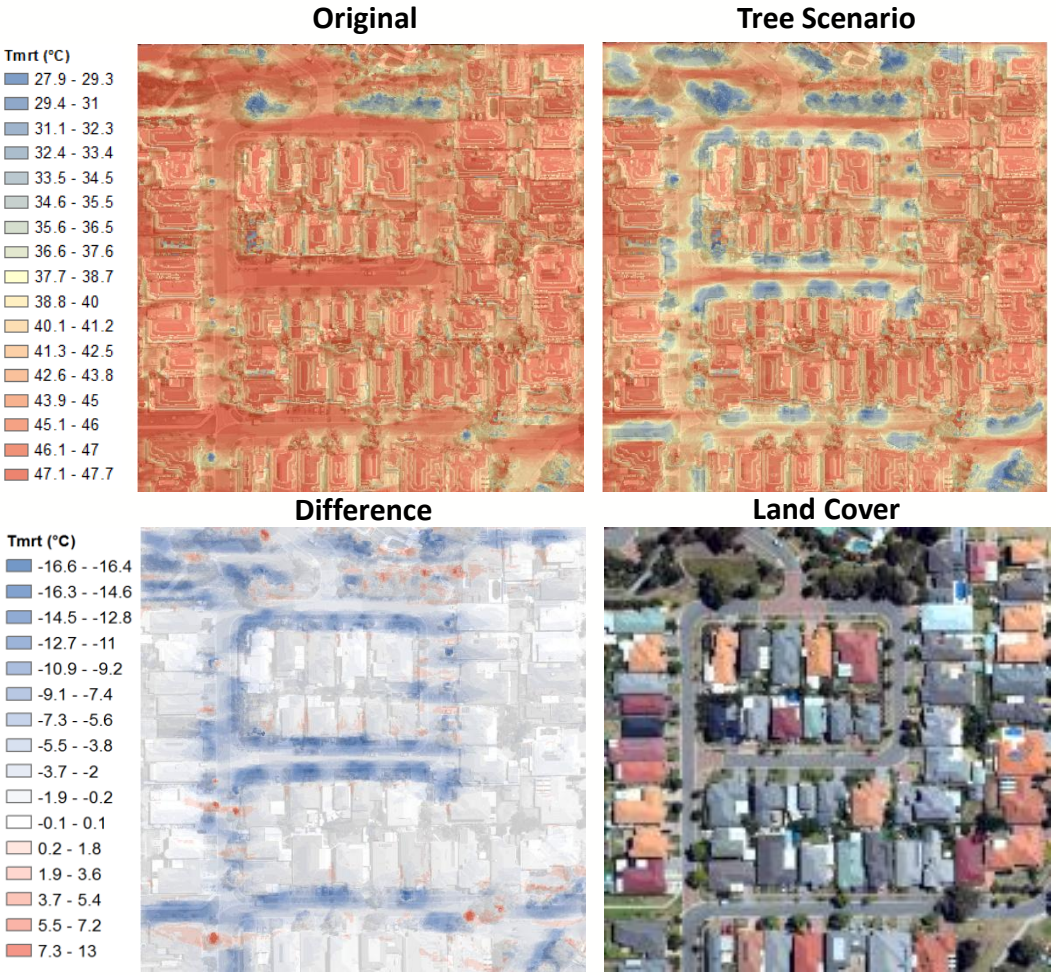
Coutts, White, Tapper, Beringer & Livesley (2015)

Trees in the urban canyon

Daytime

- SOLWEIG model (Lindberg and Grimmond, 2011)
- Explore the potential for street trees to reduce T_{mrt}
- Potentially large reductions in mean radiant temperature (T_{mrt})
- Tree scenario reduces average T_{mrt} by 1.7°C
- Maximum T_{mrt} beneath trees of 17.2°C

- T_{mrt} benefits are highly localised.



Thom, Coutts & Tapper (2015)

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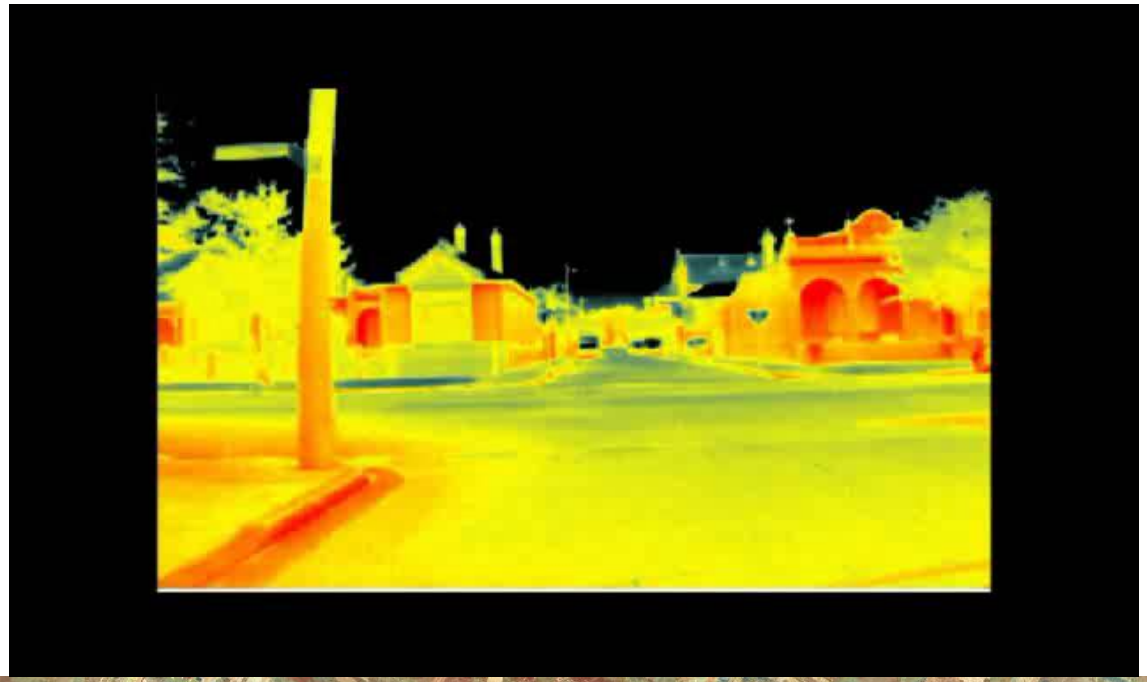
Trees in the urban canyon



Night time

- Long wave cooling restricted by trees
- Elevated mean radiant temperature below tree canopies
- Reduced wind speed
- Daytime benefits outweigh negative effects at night

Video:

- Radiation trapping under trees, cars etc.
- Warm walls, vertical surfaces
- Difference to airborne observations

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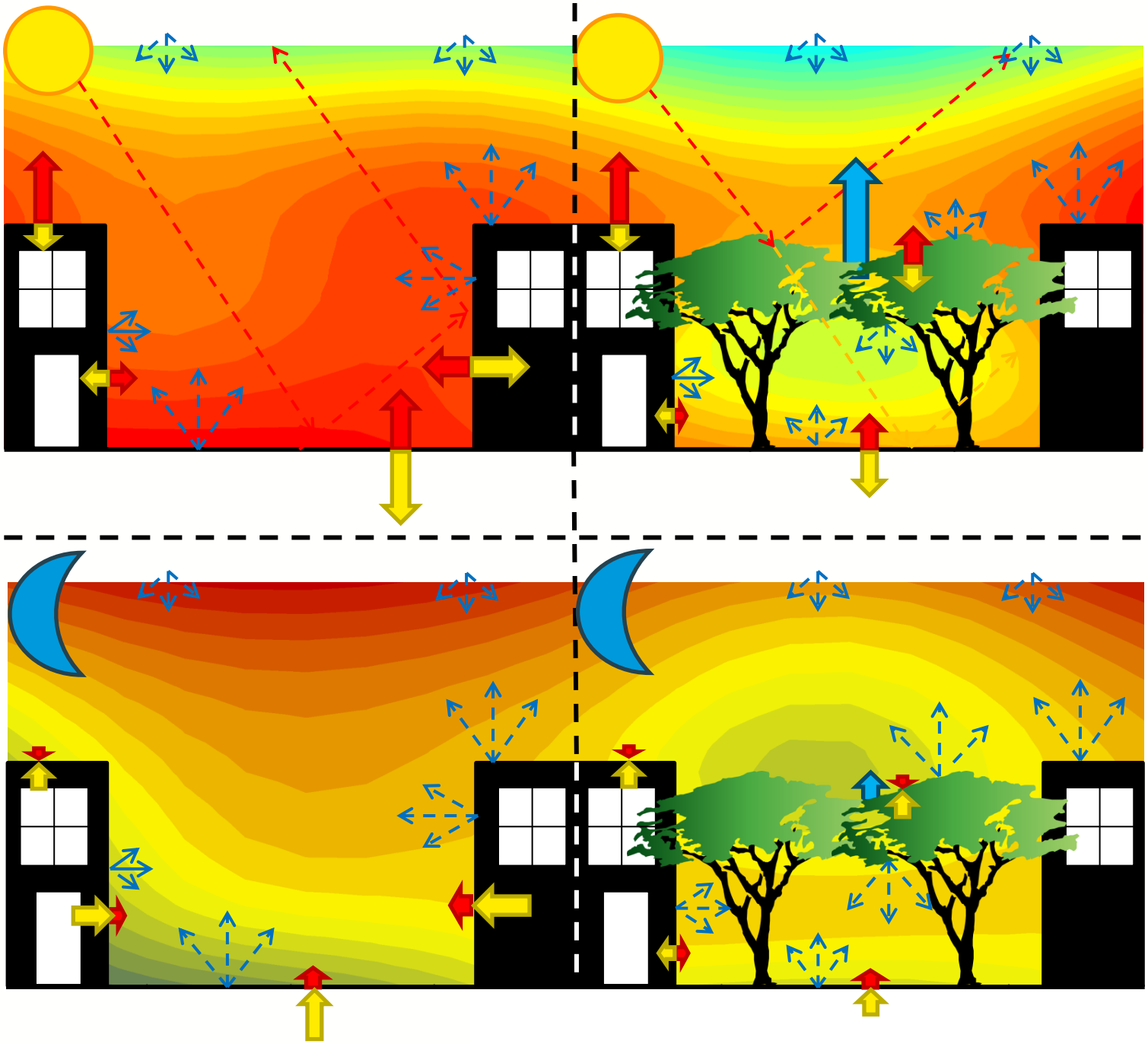

Not all green infrastructure is equal…

This is a tree…

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Not all green infrastructure is equal…

Tree in poor condition

Tree in good condition

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Water and trees

City of Melbourne, 2012

Trees can be extremely beneficial for urban climate BUT:

- They must have full canopies to provide shade
- Be actively transpiring to provide evaporative cooling

A lack of water compromises this (Whitlow and Bassuk, 1988):

- Low soil water availability:
  - High stormwater runoff
  - Drought
  - Water restrictions
  - Reduced infiltration:
    - Hydrophobic soils
    - Compacted soils

City branches out to replace drought-hit trees

Dewi Cooke
May 11, 2010

Comments 17

Extreme weather and the ravages of time have left many of Melbourne's trees in need of replacement. *Photo: Justin McManus*

MELBOURNE will look to such countries as Spain, Chile and the US for replacements of thousands of drought-ravaged trees

The re

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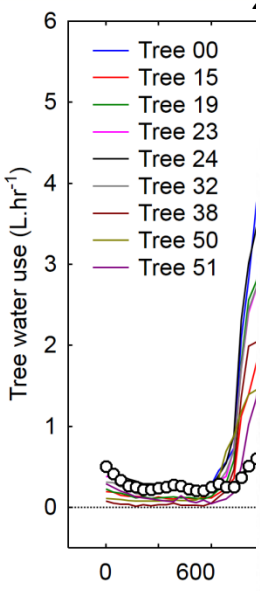
- Trees li
  needed
- 2014 S
  Lophos
- Other s
  Plantar



EXTREME WEATHER

City heatwave sends seasons into a spin

By GEOFF STRONG

THE leaves may be turning brown and falling, but it's not an early autumn.

Melbourne's trees — along with leafy vegetables such as lettuces, beetroots and even potatoes — have fallen victim to last week's extreme heat.

Also falling are some of the creatures that live in trees, including possums and fruit bats. Animals at the Melbourne Zoo have needed special attention such as sprinklers, and our wine industry, already hit by stalling exports, has had about 20 per cent of its grapes scorched.

Even the sacred Aussie passion for sport is not immune, with Nillumbik Council in Melbourne's north-east shutting down 14 cricket pitches, causing the local cricket association to admit in an emergency meeting last night there would be fewer games this year.

With more extreme heat predicted this weekend, the game that originated on the village greens of England is struggling on the suburban browns of Melbourne.

Even though other councils have not closed grounds, Bruce Dowland from the Southern District and Churches Cricket Association said that on some grounds that had not received a water ration, the game was beginning to resemble beach cricket.

Melbourne's Botanic Gardens have been undertaking a program to save plants and director Richard Barley said they were in reasonable condition, but he is concerned about the long-term prospects for Melbourne's established street trees such as planes and elms. "Dropping their leaves is a normal reaction for trees in these circumstances. They have been hit by the two factors of the extended dry and the extraordinary hot air temperatures of last week.

"If we had cooler, wetter conditions to the end of April it is possible they could grow back some of their foliage, but if these conditions continue over the next two or three years, it will put them under enormous stress and it is likely a lot of them will die."

The City of Port Phillip, where plane trees in some streets have dumped large numbers of leaves, has introduced novel approaches to keeping itself green, including filling wheelie bins with recycled water to drip-irrigate those trees considered most vulnerable. It also has a recycling scheme with a company that pumps waste water from utility pits around Melbourne that is now treated and used to irrigate parkland.

At the City of Melbourne, which prided itself on recycled water irrigation, Lord Mayor Robert Doyle has declared precious parkland must be saved and has ordered an increase in both potable and recycled water use to do this.

While horticulturists are concerned that their wilted vegetables will be spurned by supermarkets and consumers, they say they are still nutritious.

■ The Adelaide morgue is almost full after a spike in deaths, some linked to the heatwave. The morgue can store 72 bodies but usually holds only about 25. On Tuesday, it had 71. With AAP

Drought's cause found

THE cause of the record-breaking drought in south-eastern Australia has been discovered far off in the Indian Ocean, according to the surprise findings of a study that overturns decades of weather research.

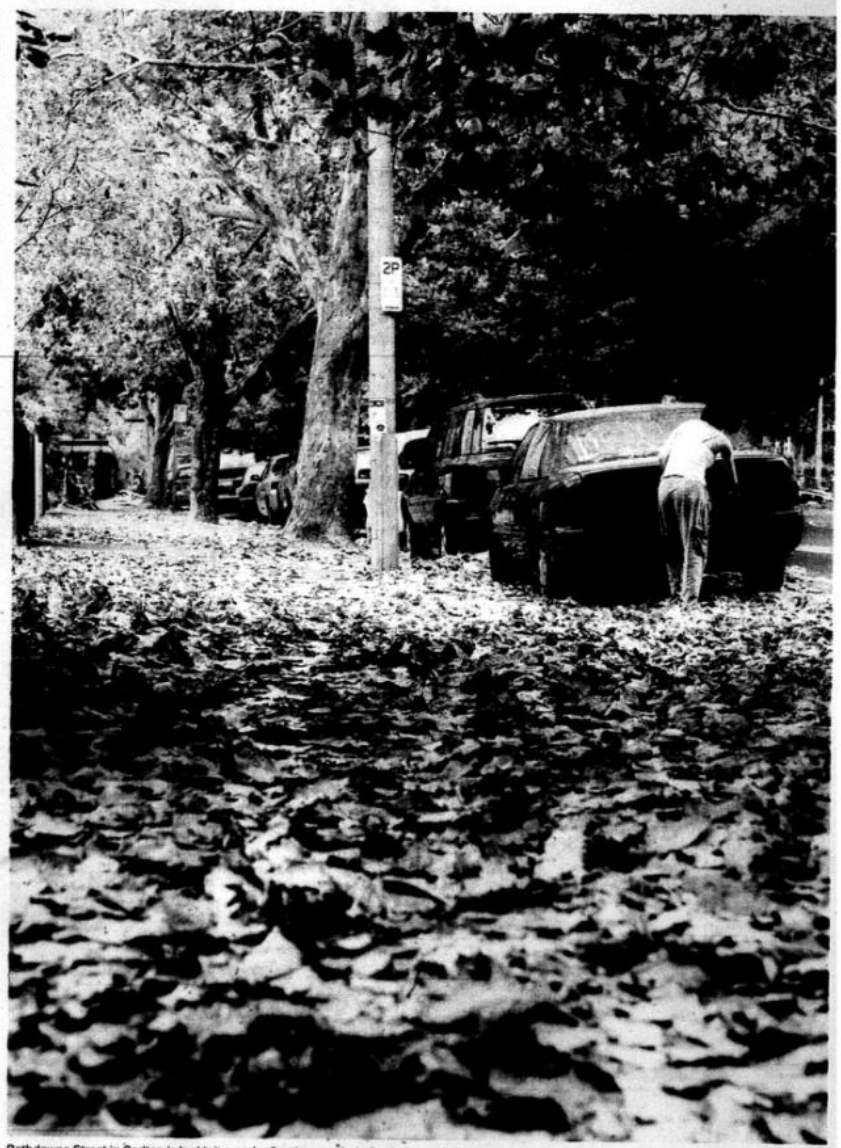
While drought in Australia has traditionally been linked to El Nino events in the Pacific Ocean, researchers from the universities of NSW and Tasmania and the CSIRO have found that it is the Indian Ocean's cycle of warming and cooling that is to blame.

The water cycles of the Indian Ocean, which is experiencing unprecedented warming 2000 kilometres away, dictates the strength of the moisture-bearing winds that travel to Australia.

Caroline Ummenhofer from the University of NSW's Climate Change Research Centre said the winds from the Indian Ocean had been weak since 2006, which had reduced the volume of water they picked up and transported to Australia.

The research explains why a string of La Nina events in the Pacific Ocean, which usually bring rain, have failed to break the drought.

The findings are presented in a paper to be published in the US journal *Geophysical Review Letters*. BRIDIE SMITH



Rathdowne Street in Carlton is looking even leafier than normal after last week's heatwave. PICTURE: CRAIG ABRAHAM

31 January 2014 1 February 2014 2 February 2014

Trees and GI in the urban environment

- High temperatures due to the UHI
- Drier urban atmosphere increases the vapour pressure deficit (VPD)
- High radiation loads:
  - Isolated trees exposed to high solar radiation
  - Additional radiation from urban surfaces
- Extreme heat events

http://www.theage.com.au/photogallery/national/cartoons-for-sunday-13-january-20130112-2cn0t.html?selectedImage=5

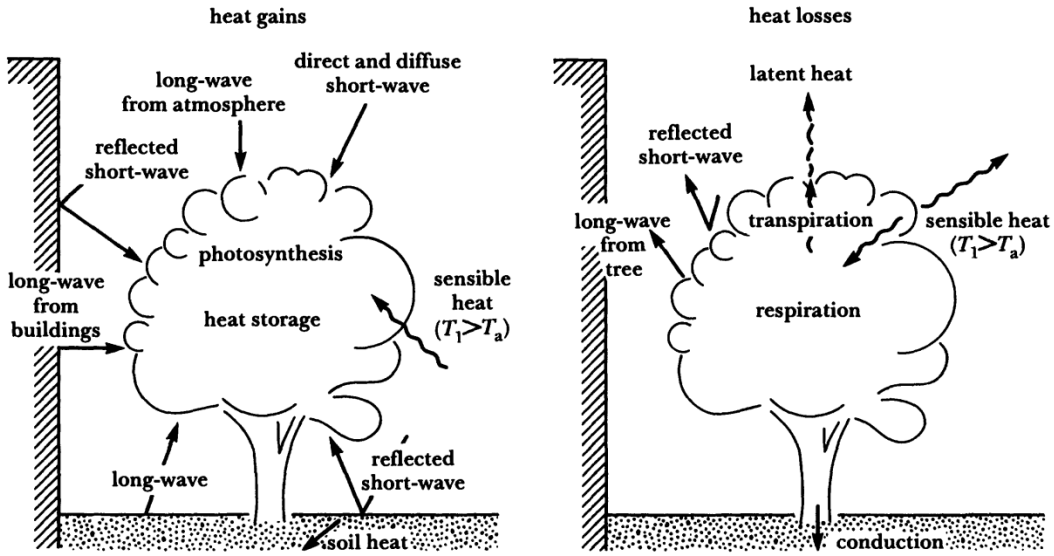


FIGURE 1. Scheme of the daytime energy exchanges between an isolated tree and its street canyon environment. (T_l, T_a, temperatures of leaf and air.)

Oke, T. R., Crowther, J. M., Mcnaughton, K. G., Monteith, J. L. & Gardiner, B. 1989. The Micrometeorology of the Urban Forest [and Discussion]. Philosophical Transactions of the Royal Society of London. Series B, Biological Sciences, 324, 335-349.

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Tree response to urban conditions

- Kjelgren, R. & Clark, J. R. 1992. **Microclimates and tree growth in three urban spaces**. *Journal of Environmental Horticulture*, 10, 139.
- Compared trees in a park, canyon and plaza in Seattle in 1986-86
- Plaza was warmer & drier than the park

- Greater evaporative demand at the plaza
- Limited water availability at the plaza
- Reduced stomatal conductance and greater water stress

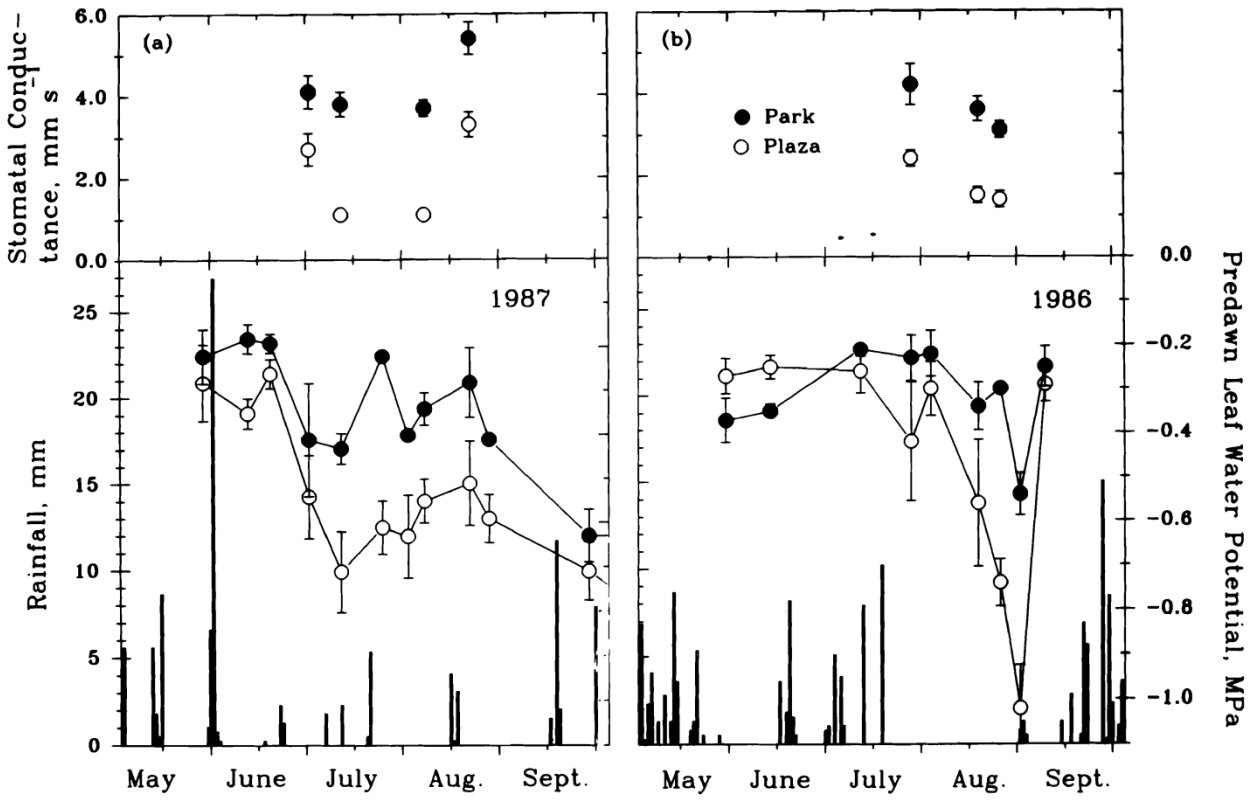
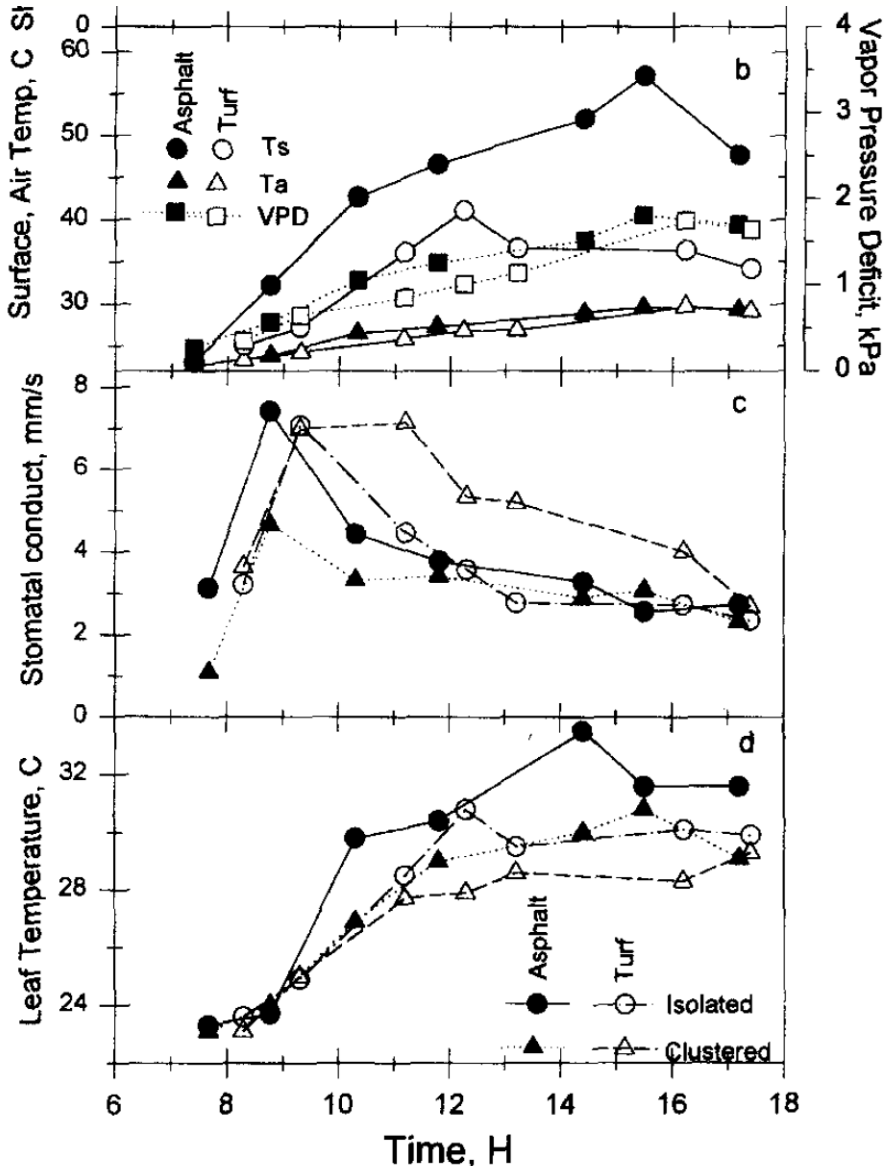


Fig. 3. Seasonal water relations at park and plaza sites for 1987 (a) and 1986 (b). Predawn leaf water potential (MPa) and rainfall (mm) in bottom graphs, and stomatal conductance (mm s^{-1}) in top graphs. Each value represents the average of three trees per site plus standard error; for some days error bars are not shown because size of drawn data points exceeded range of standard error.

Tree response to urban conditions

- Kjelgren, R. & Montague, T. 1998. **Urban tree transpiration over turf and asphalt surfaces**. *Atmospheric Environment,* 32**,** 35-41.
  - Compared isolated and clustered trees over irrigated turf and asphalt
  - Compared Flowering pear, Green Ash, and Norway Maple
  - Warmer and drier over asphalt
  - Greater radiation interception by isolated trees
  - Greater radiation interception by tree over asphalt due to high T_{surf}

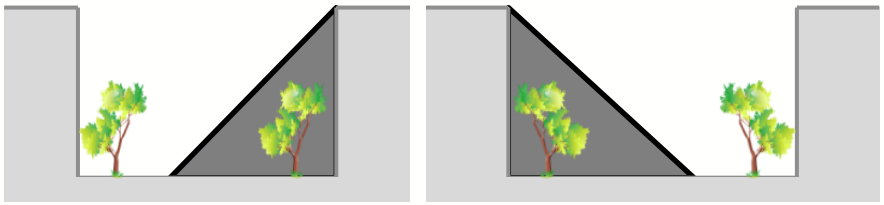
- Stomatal conductance varied between species:
  - Either met higher evaporative demand; or
  - Employed stomatal regulation to limit water loss.

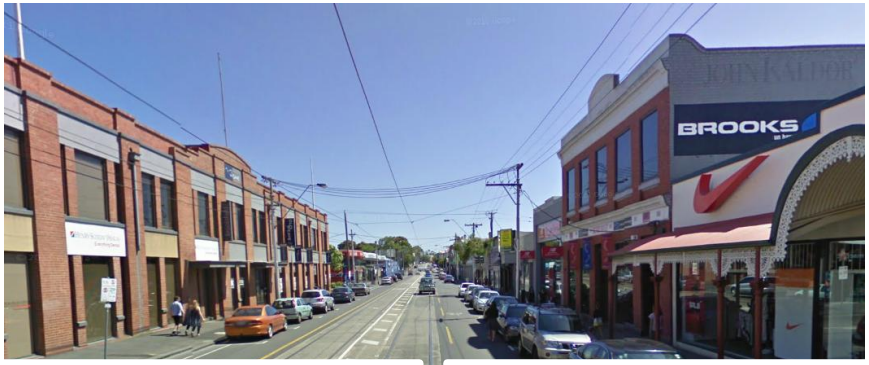


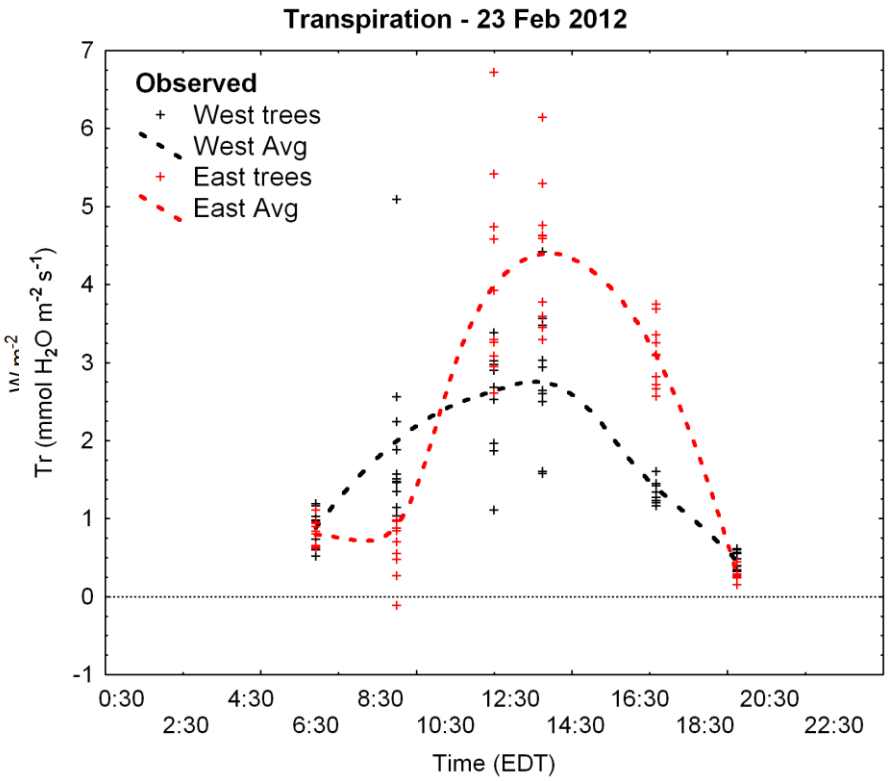
Pear trees clustered and non-clustered over paved asphalt and turf surfaces on 26 July, 1991.

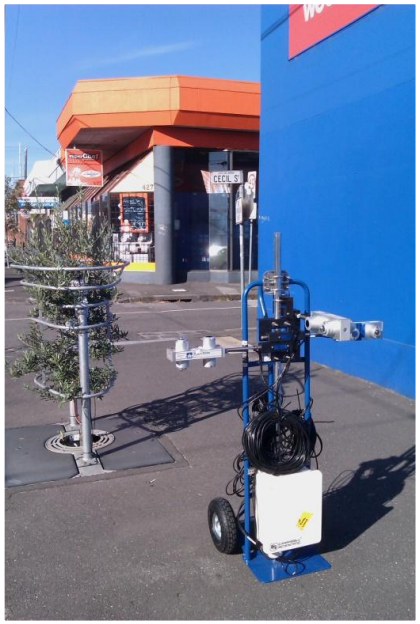
Urban landscape & tree interactions

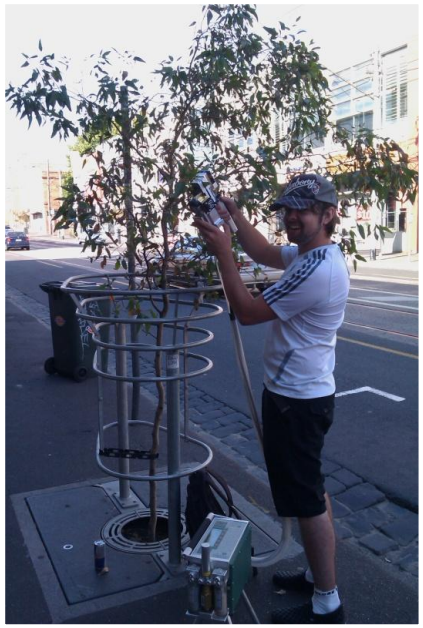
- Urban environment itself impacts on the performance of green infrastructure











Coutts, Gebert, Tapper, (2014)

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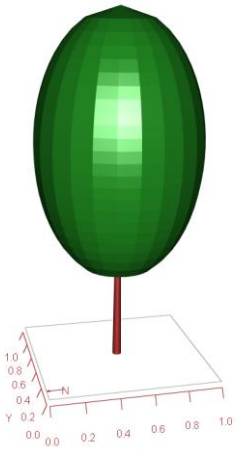
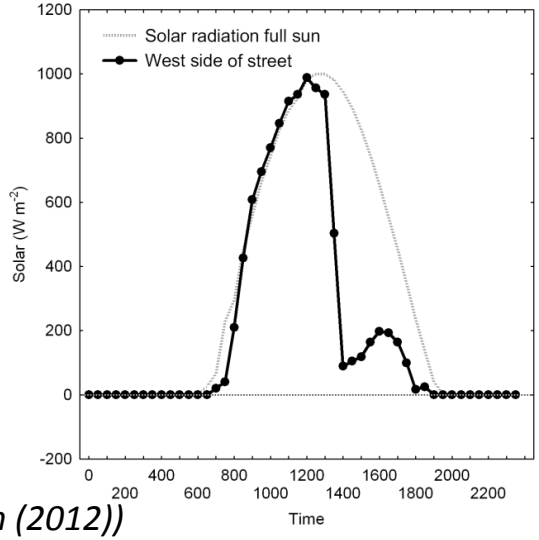
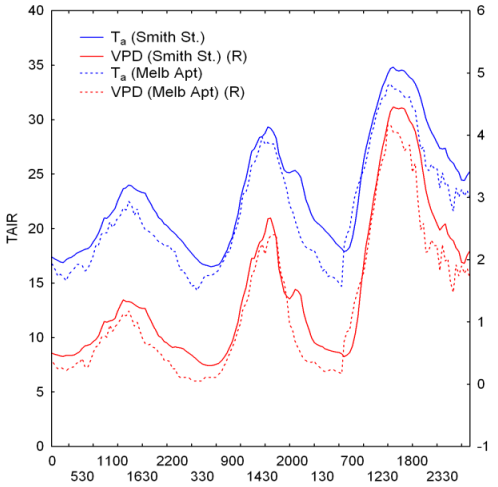
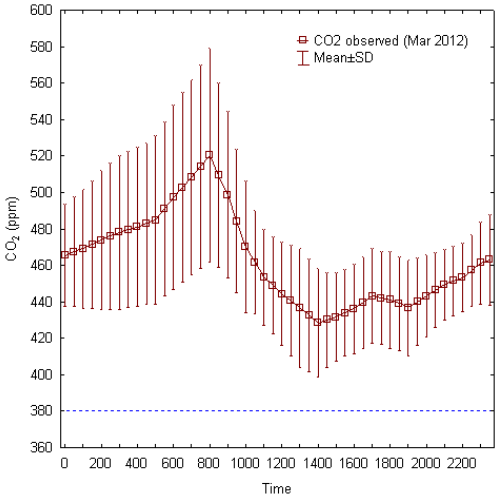
Urban landscape & tree interactions

MAESPA

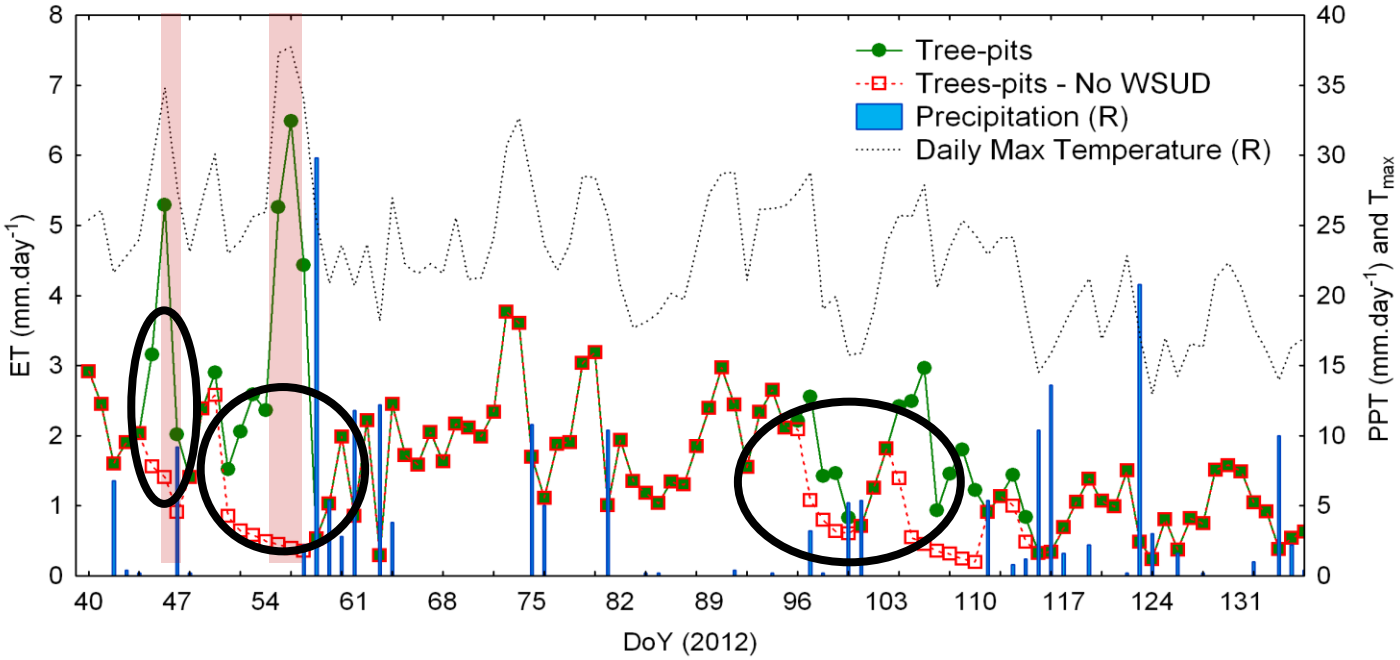






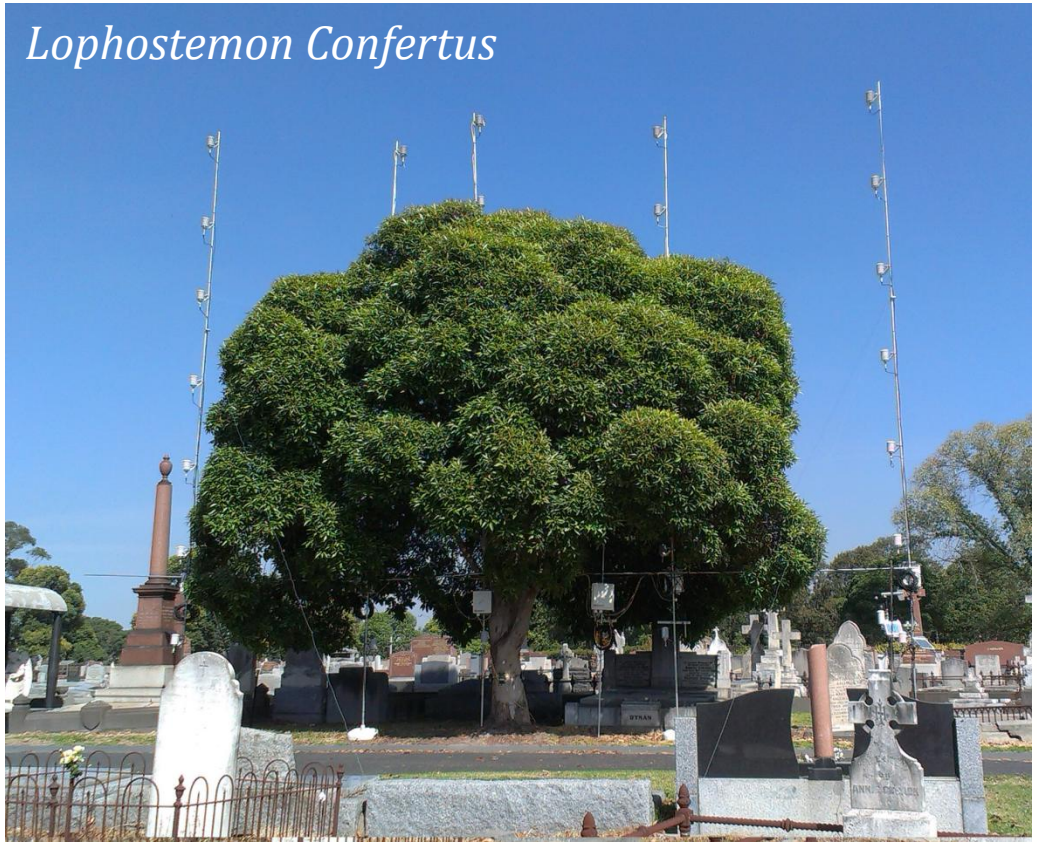


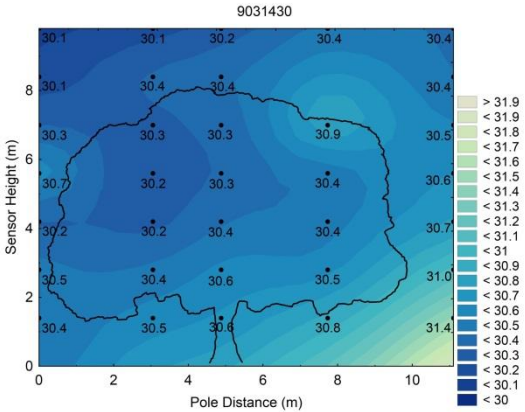
Duursma and Medlyn (2012))



Coutts, Gebert, Tapper, (2014)

Water use by urban trees





Isolated tree in a 'paved' urban area:

- Cooling effect of an isolated tree
- Water use of an isolated tree
- Feb/March in 2013-14 Australian Summer

- Array of 35 temperature sensors
  - 5 poles; 7 sensors per pole
- 4 x Sap flow sensors to measure tree water use

"The climate of the isolated urban tree is deserving of study."

(Oke et al. 1989: Pg 164)

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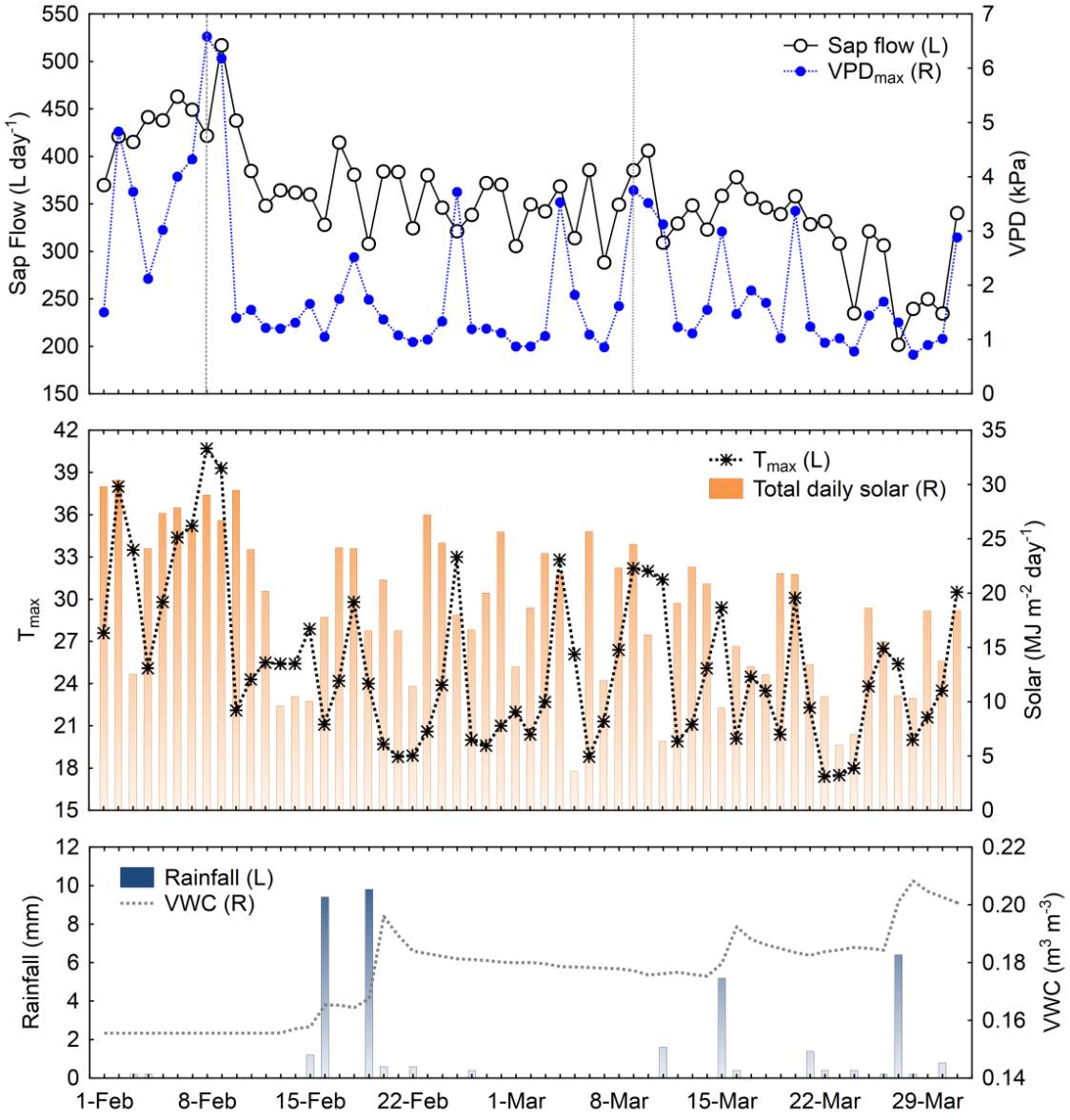
Extraordinary water use



- Consistently using around 300 – 350 L per day
- During an extreme heat event, tree used up to 450 – 500 L
- No sign of afternoon decline in water use due to high VPD
- Similar amounts of water use in 2015 Summer!

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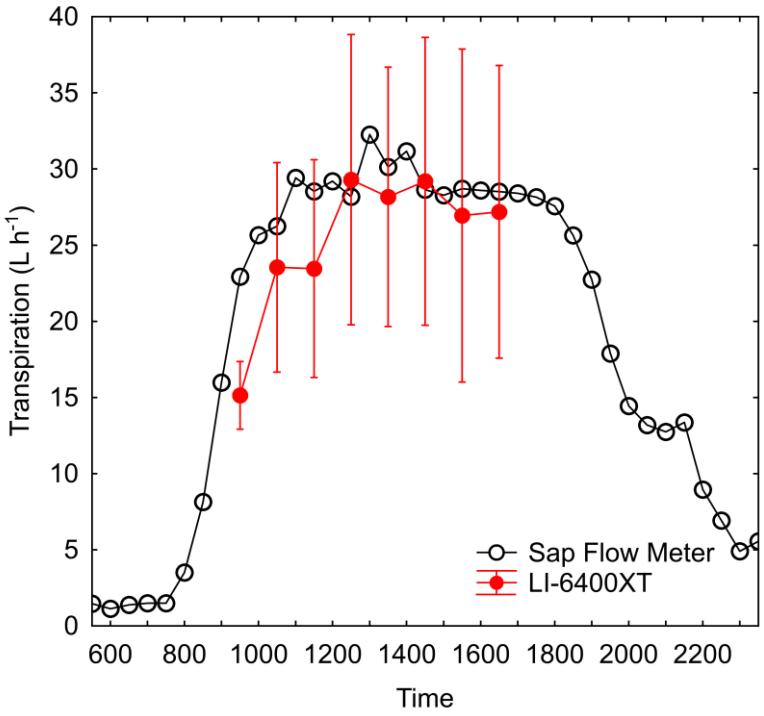
Extraordinary water use



- Consistently using around 300 – 350 L per day
- During an extreme heat event, tree used up to 450 – 500 L
- No sign of afternoon decline in water use due to high VPD

- Similar amounts of water use in 2015 Summer!
- Leaf scale observations (Li-6400XT) scaled up to tree: 20 March 2014

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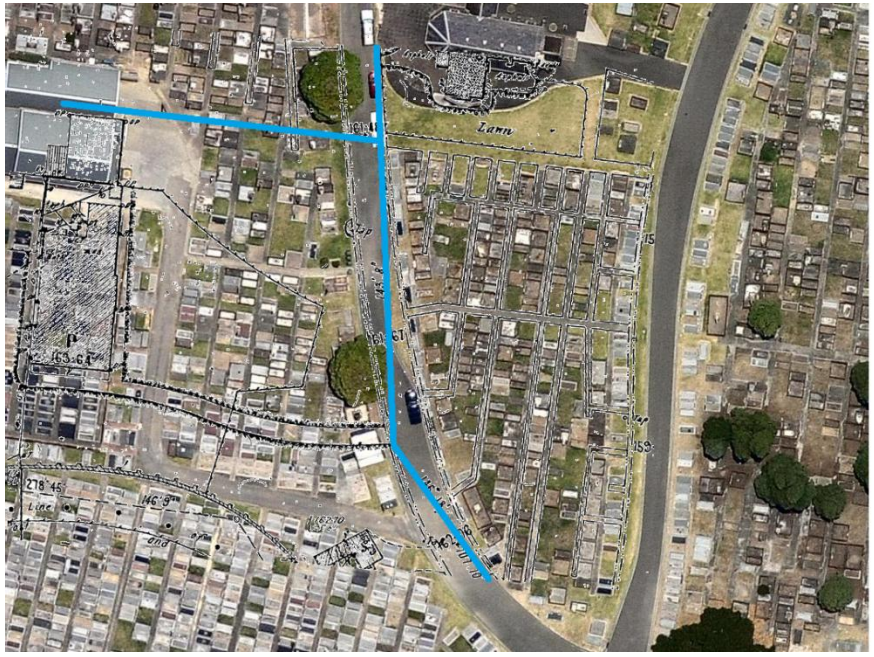
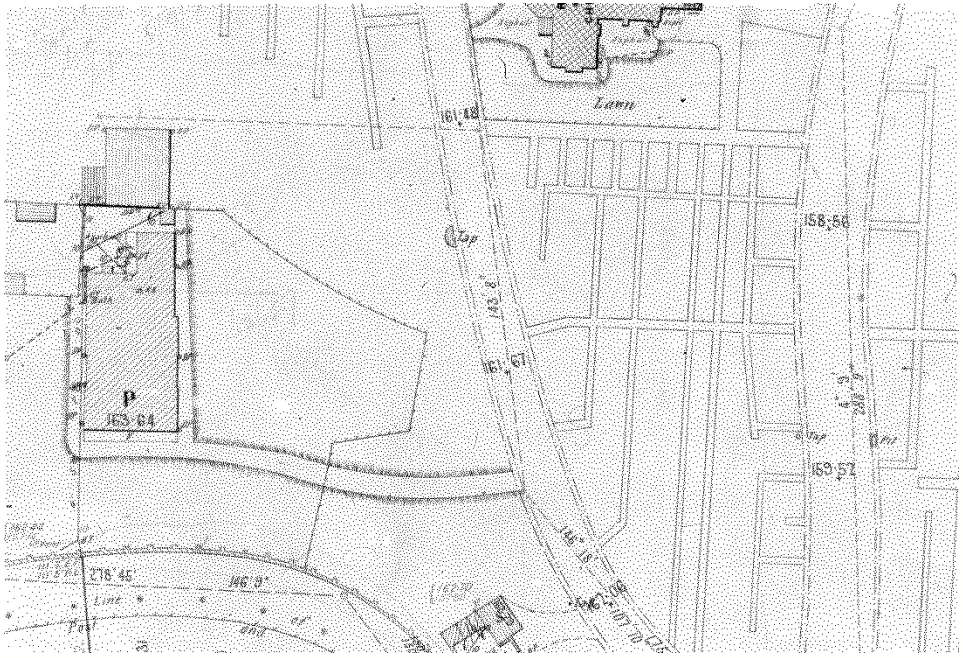
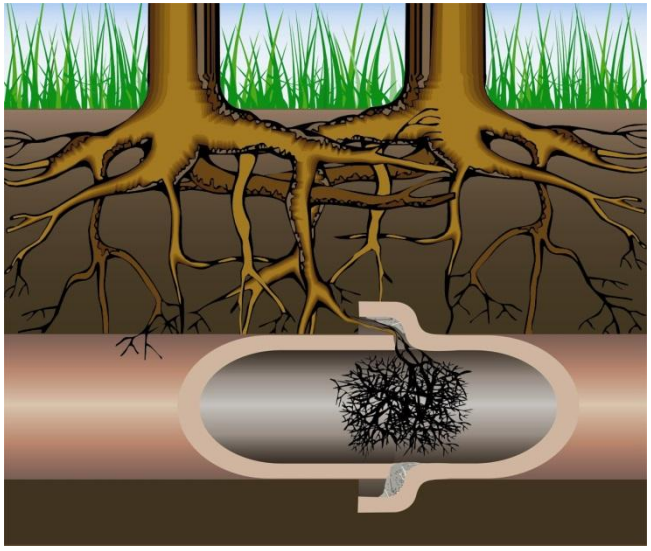
Hidden sources of water...







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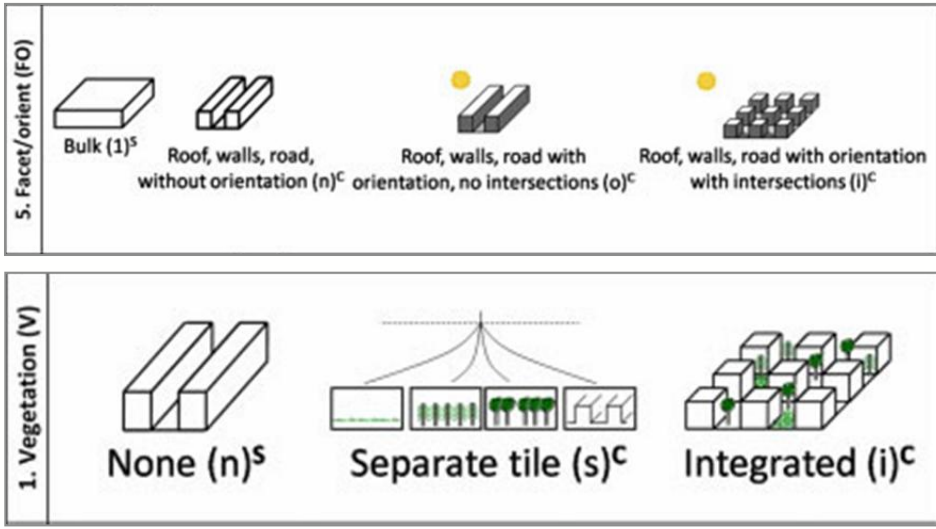
Modelling vegetation

From phase 2 of the International Urban Energy Balance Inter-comparison (Grimmond et al. 2010)

- The inclusion of vegetation improves model performance
- *"... the fact that the RMSE for the latent heat flux is of the same order as the latent heat flux itself, indicates that work needs to be done to improve simulations of this flux."*

- Are these microscale considerations appropriately captured in the urban land surface schemes?
  - Canyon T_a or Top of Canopy T_a?
- Are the urban and vegetated surfaces interacting?
  - 8 none
  - 19 separate
  - 5 integrated
- Are we accounting for characteristics of tree physiology and its heterogeneity?



(Grimmond et al. 2010)

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Modelling vegetation

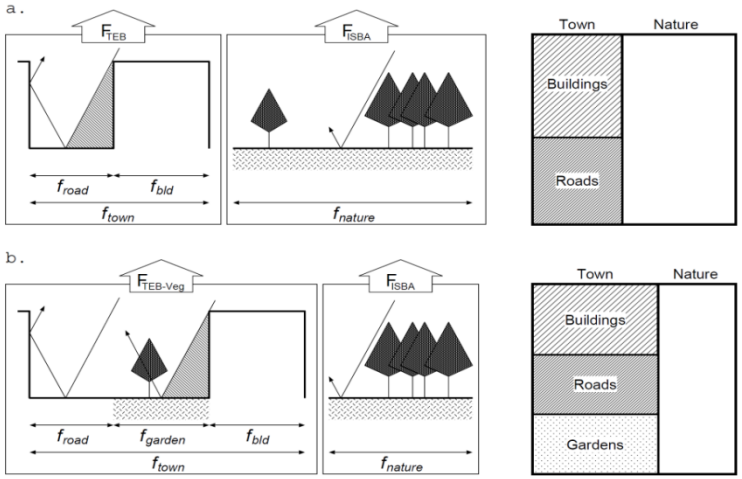
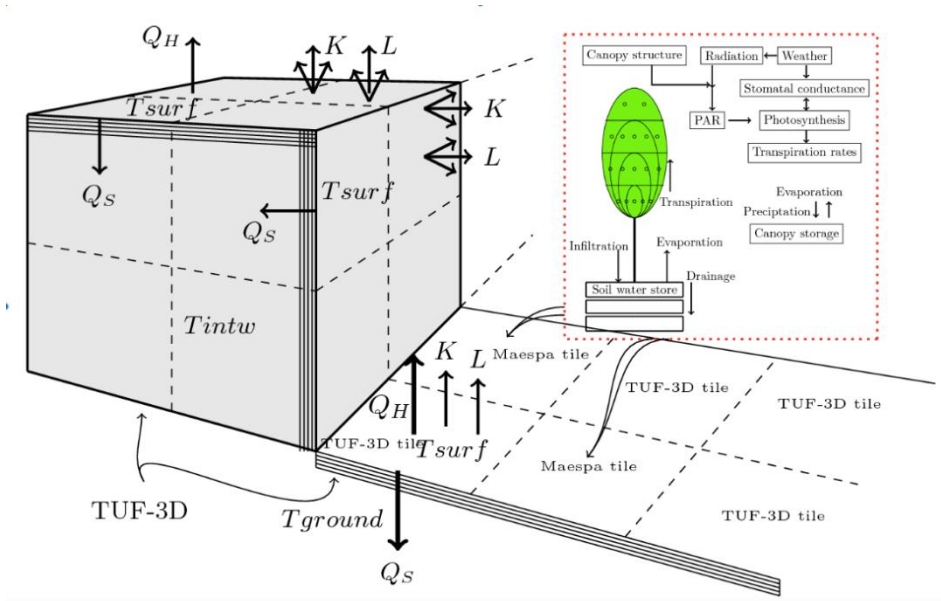


Fig. 1. Comparison of tiling approaches applied in TEB-ISBA (top) and TEB-Veg (bottom) to compute surface fluxes for a SURFEX's grid point containing pervious and impervious covers.

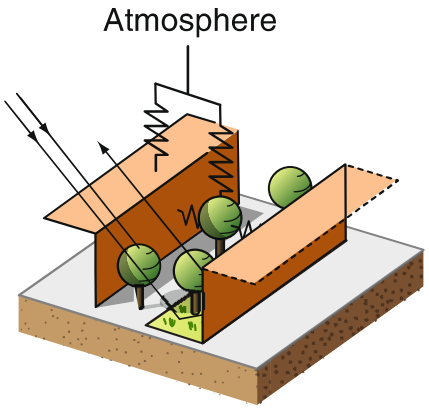
Lemonsu, Masson, Shashua-Bar, Erell & Pearlmutter (2012)

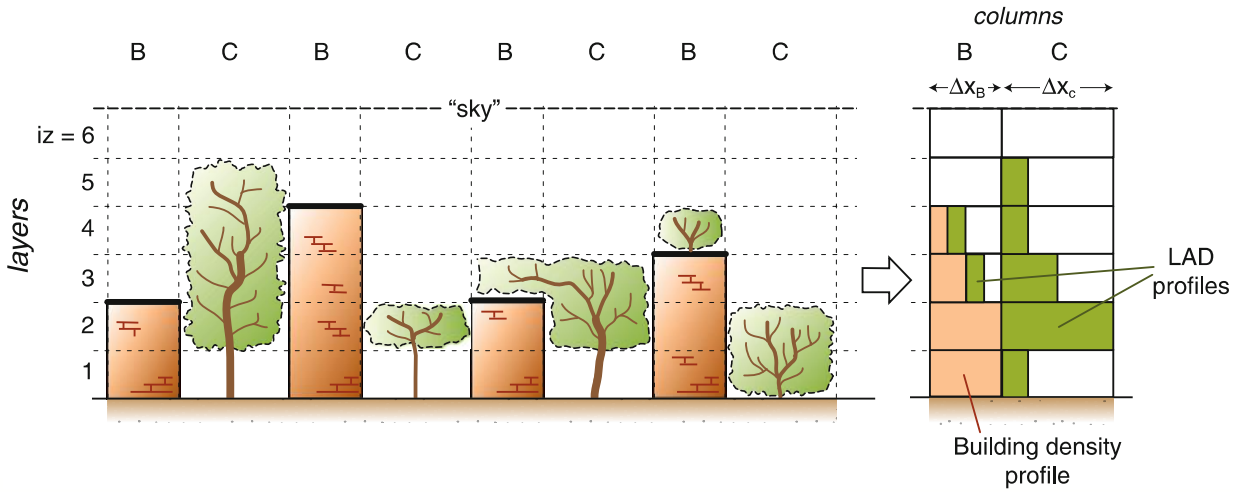


Nice, Coutts, Tapper, Beringer, Krayenhoff and Duursma(2015)

Krayenhoff, Christen, Martilli & Oke (2015)

(b) UCM with integrated vegetation



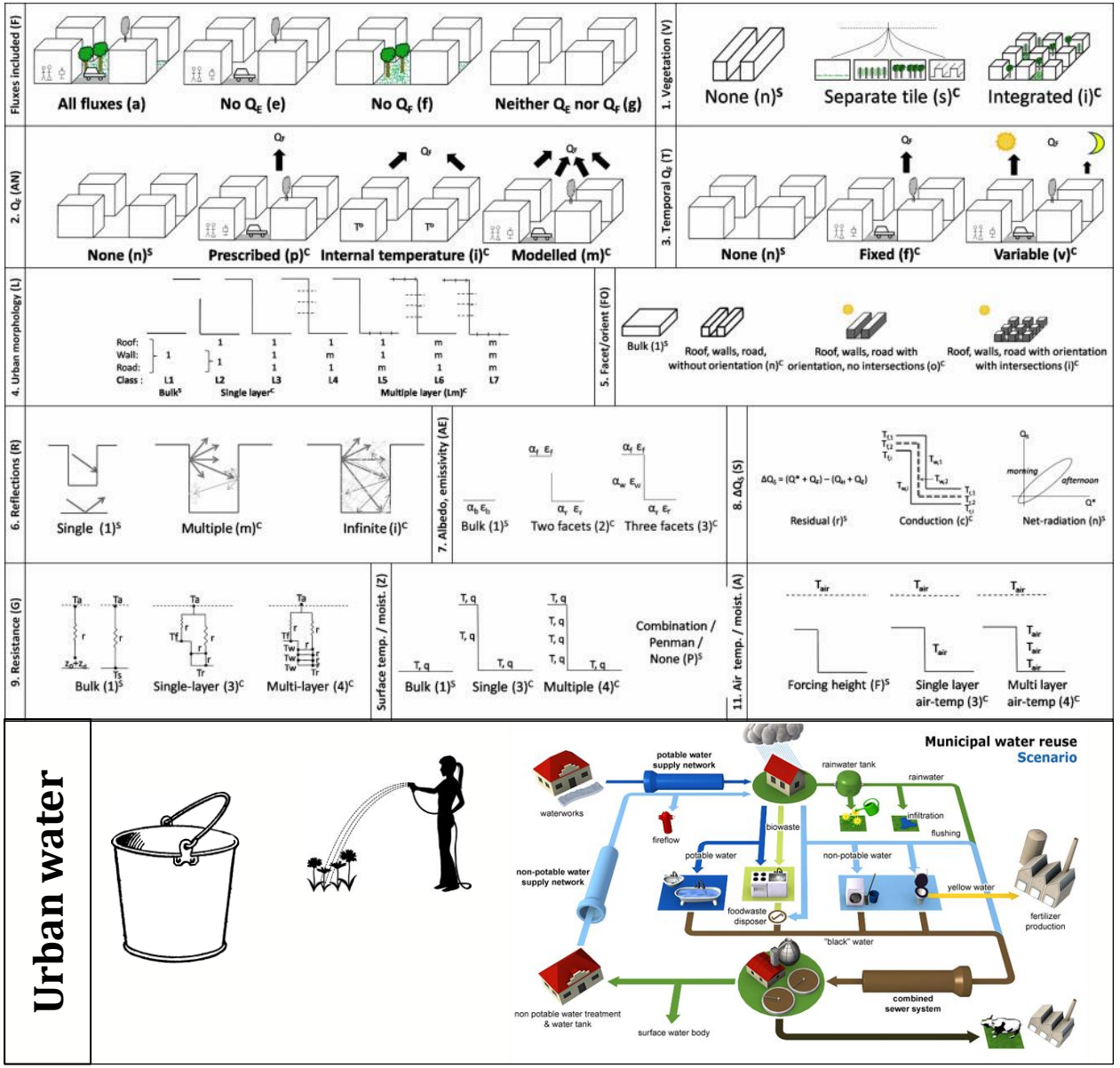


Water in urban land surface schemes

"Irrigation is a critical process that needs to be included in urban models"

(Best & Grimmond, AMS Conference, 2014)

- Urban water cycle
  - Stormwater
  - Water sensitive urban design
  - Alternative water sources (recycled)
  - Leaks?
- Vegetation physiology
  - Tree water use → soil moisture



SUMMARY

- Trees are particularly beneficial for improving urban micro-climate
- Very little research on interactions between the urban environment and vegetation and tree physiological responses
- How trees respond to the surrounding environment influences the mechanisms that provide cooling
- Green infrastructure cannot be implemented successfully without consideration of supporting water sources

On urban canopy model development:

- *"Other issues that need to be addressed include the difference between urban and rural **vegetation** due to additional stresses (e.g., pollution and heat) and how to account for **irrigation** in the estimate of soil moisture."* Chen et al (2012)

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Implementation of Green Infrastructure

Who is this? Is it…

A. Politician?
B. Policy maker?
C. Urban developer?
D. Tom Cruise?

- Governments and local municipalities have limited budgets
- Policy makers etc. need evidence and numbers
- Must justify the costs:
  - Cost/Benefits analysis
  - How much is a tree worth?

(Silva et al 2009)

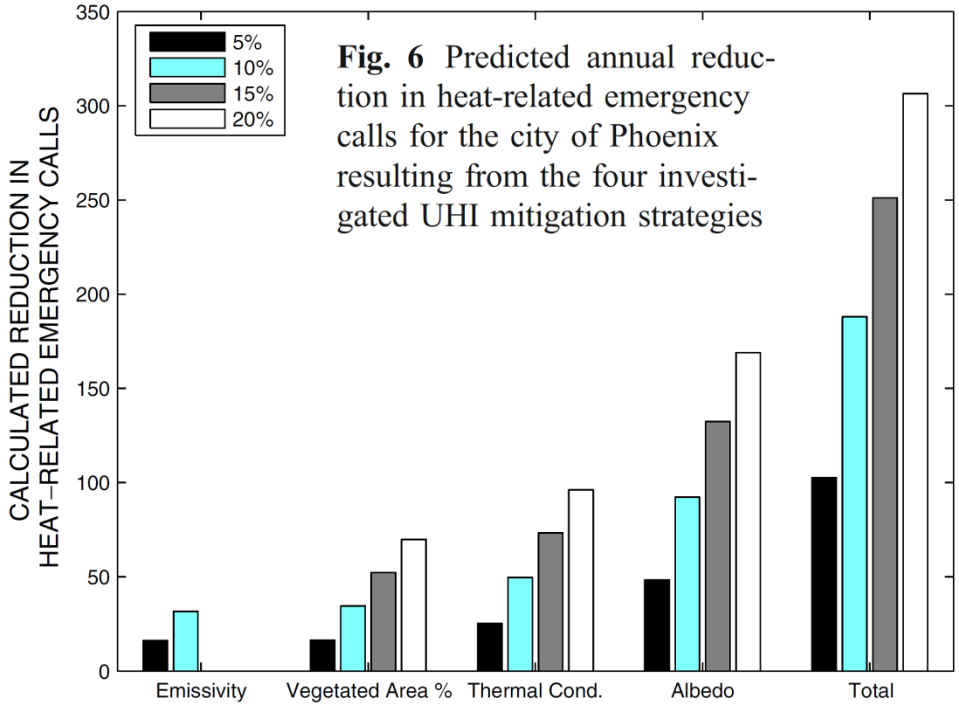


Fig. 6 Predicted annual reduction in heat-related emergency calls for the city of Phoenix resulting from the four investigated UHI mitigation strategies

$$$ - Benefits of the urban forest

Benefits 'routinely' costed

(e.g. McPherson et al 2005, 2011):

- Air quality
  - Willingness to pay for clean air
  - Pollution credits
- Stormwater runoff
  - Benefits to downstream waterways
  - Savings to stormwater infrastructure
- Energy consumption
  - Temperature and demand curves
  - Building energy models
- Carbon sequestration
  - Carbon price
- Amenity
  - House prices

Tools are available:

- **i-Tree / STRATUM**

$$$ Benefit of temperature reductions improved human thermal comfort?

Costs of premature mortality:

- **Zaragoza, Spain** – *"A total of 107 … heat-attributable deaths were estimated for the period 2002–2006, and the in-hospital estimated cost of these deaths reach* ***€426,087*** *…"* (Roldána, Gómeza, Pinoa & Díaz, 2014)

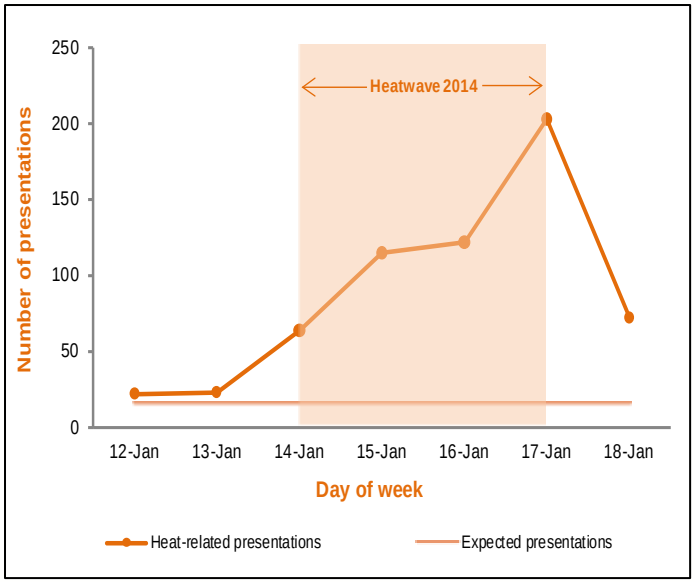
- **Rome, Italy** – "*…the monetized mortality damages in the absence of adaptation programs are thus* ***€193 million*** *for the year 2020 (2004 euro) for the city of Rome alone*" (Alberini & Chiabai, 2007)

What do your modelled temperature reductions mean for these costs???

$$$ - Benefits of the urban forest – heat mitigation

City of Melbourne commissioned report on impact of 2014 heatwave on businesses:

- An average **decline in profitability** of 10.3% across businesses during the January heatwave
- An estimated **loss in revenue of $37M** across the businesses in the Melbourne municipality

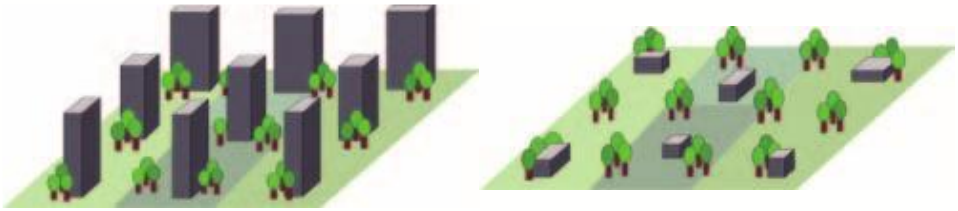


Majority of businesses report **perceived negative impacts** of the **four day heatwave** in terms of…

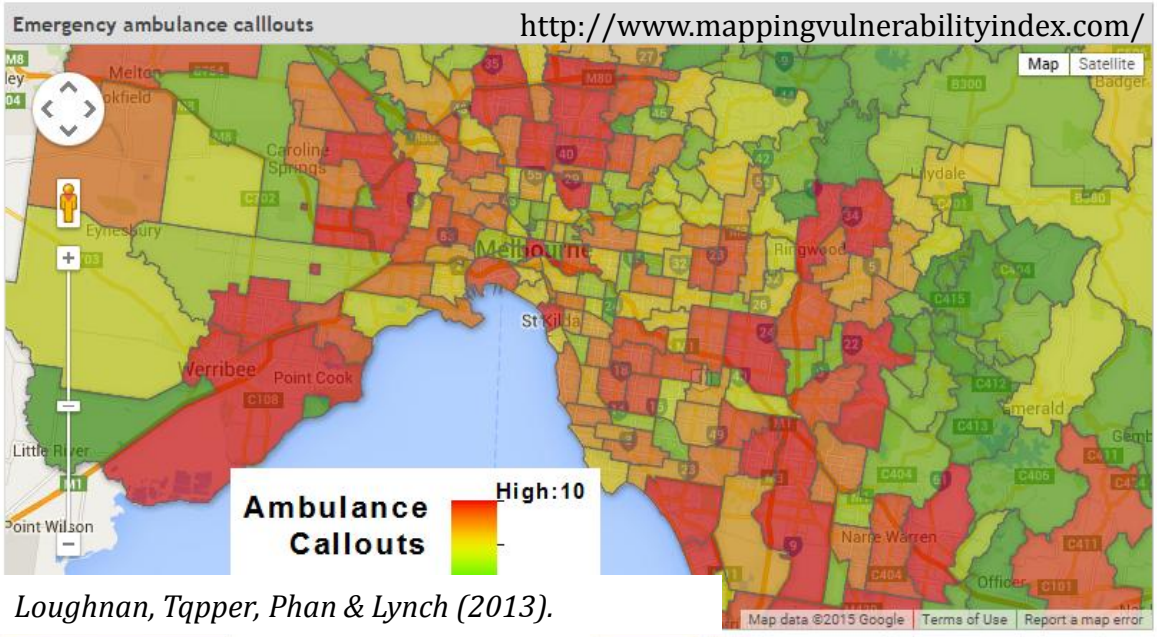
- The operational costs of air-conditioning and other cooling equipment (62%);
- The level of comfort for their workforce (59%); and
- The motivation and morale of their workforce (59%).

Tools

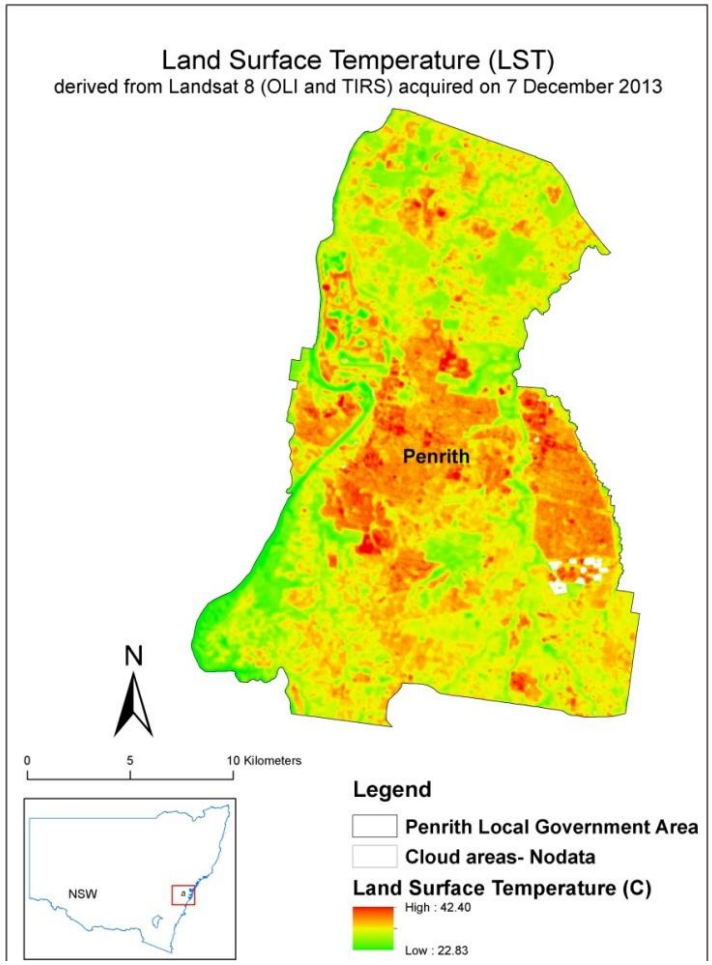
- We need to make tools available to practitioners to assist
  - Quantifying benefits
  - Cost/benefit analysis
  - Communicating benefits
- They need to be simple and user friendly
- They need to match the **scale** of the 'target' application (Oke, 2009)



Stewart and Oke (2012)



Loughnan, Tqpper, Phan & Lynch (2013).

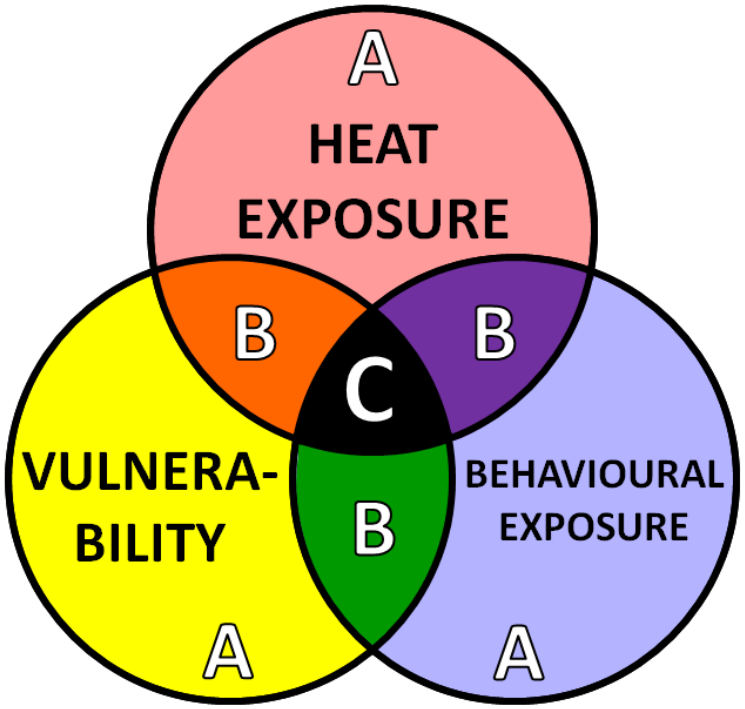


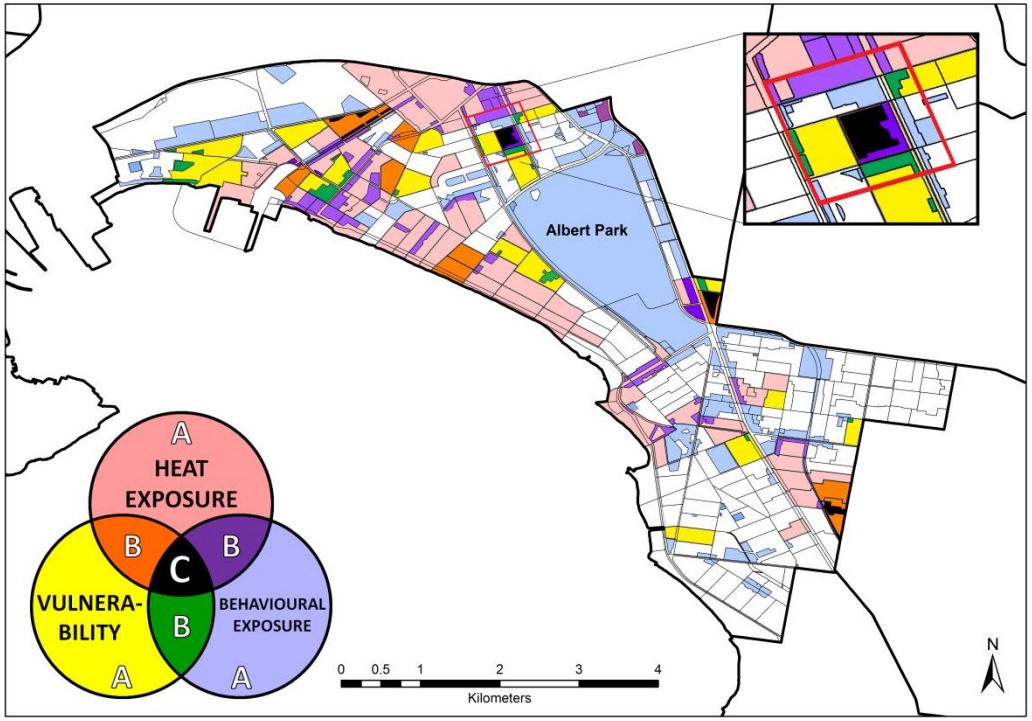
Phan and Coutts (2014)

Prioritising the implementation of GI

- Limited funds for implementation
- Where to target increases in canopy cover?
- How do we deliver the biggest 'bang for buck'?
- We need to prioritise!

"The current evidence base does not allow specific recommendations to be made on how best to incorporate greening into an urban area" (Bowler et al 2010)

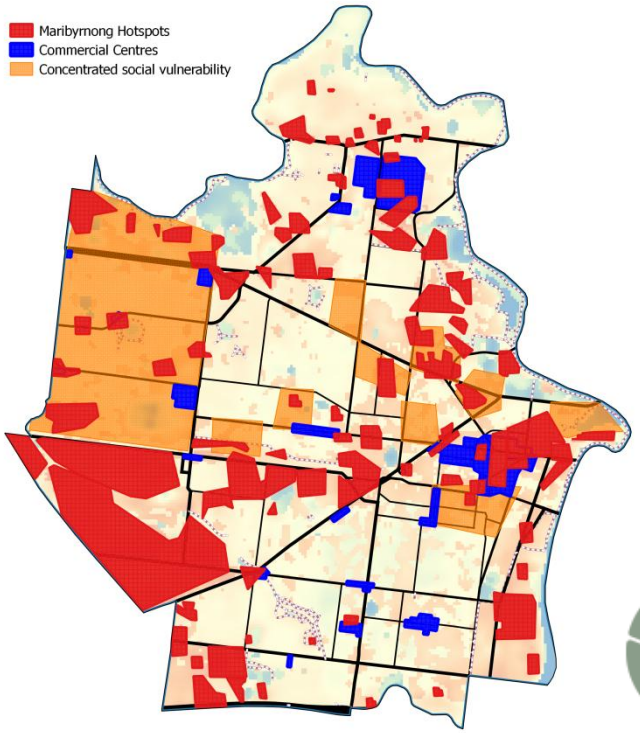


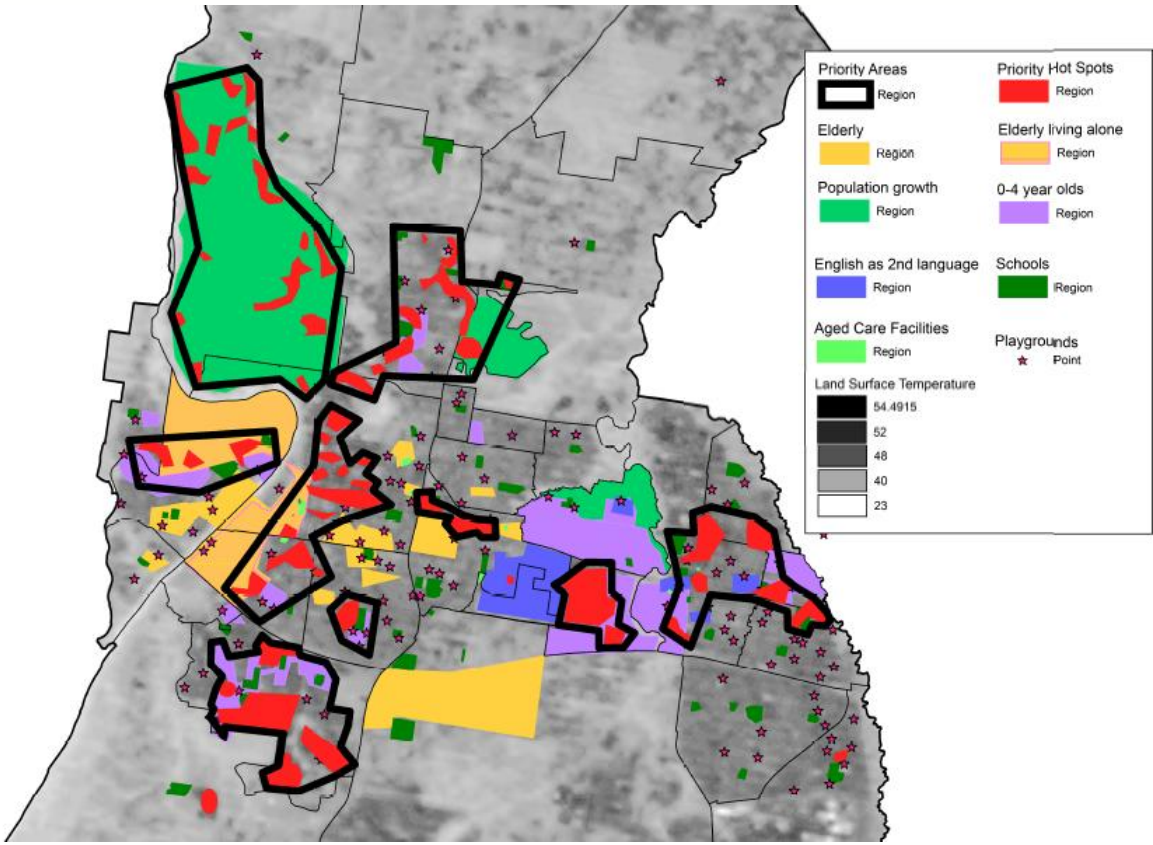


Norton, B. A., Coutts, A. M., Livesley, S. J., Harris, R. J., Hunter, A. M. & Williams, N. S. G. 2015. Planning for cooler cities: A framework to prioritise green infrastructure to mitigate high temperatures in urban landscapes. Landscape and Urban Planning, 134, 127-138.

Prioritising the implementation of GI

- This prioritisation framework is being used by councils in Australia:
  - City of Geelong, VIC
  - Marrickville Council, NSW
  - **City of Maribyrnong, VIC**
  - **Penrith Council, NSW**
  - Wyndham City, VIC
  - Moreland City Council, VIC





URBAN FOREST CONSULTING

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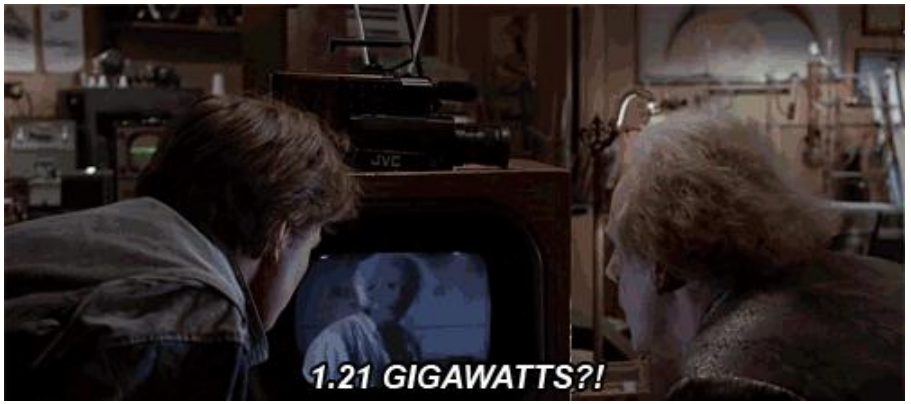
Information and advice on implementation…

- Who is going to be the one to provide advice to council? For example:

How much cooling will I get from a 20% increase in tree canopy cover?

I need an answer within 2 months

The Scientist:



- Well… it depends on
  1. the trees (size, species, location)
  2. water availability
  3. regional climate
  4. the surrounding built environment
  5. meteorological conditions
- It's difficult to put a number on it. I'll need 6 months to run the simulations…

The Consultant:

- 2 °C [1,2,3,4,5]

Challenges for models:

- Improve urban/vegetation interactions **AND**
- Provide quick, simple, user-friendly tools

Strategic placement and investment

- Prioritise green infrastructure where it is most needed
- Distributed green infrastructure at regular intervals
  - More beneficial for multiple benefits too…
- Protect and support existing green infrastructure
  - Invest in protecting established trees

Cairo

Moscow

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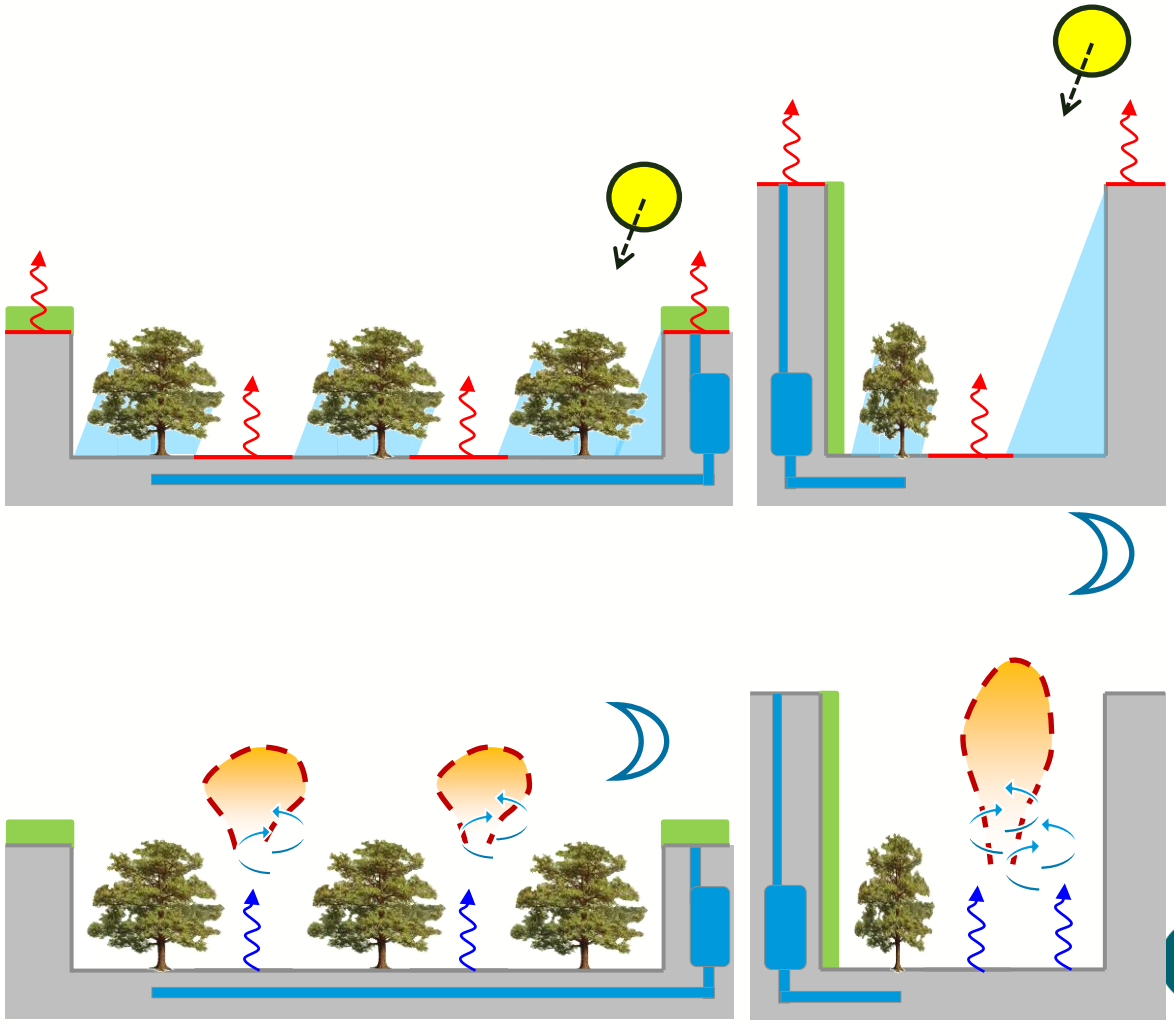
Strategic placement

Strategically placed trees with WSUD/Irrigation



- Reduce surface heating during the day
- Greatest benefit of green walls for walls receiving direct heat from the sun (Kontoleon & Eumorfopoulou, 2010).
- Provide for longwave cooling at night
- Allow for ventilation
  - Challenge for space (e.g. Road base condition; Below/Above ground services)
- Deep streets can overwhelm influence of trees

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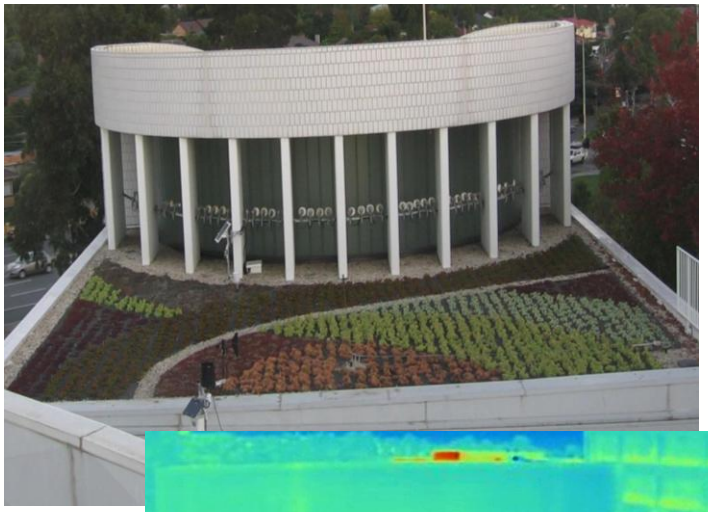
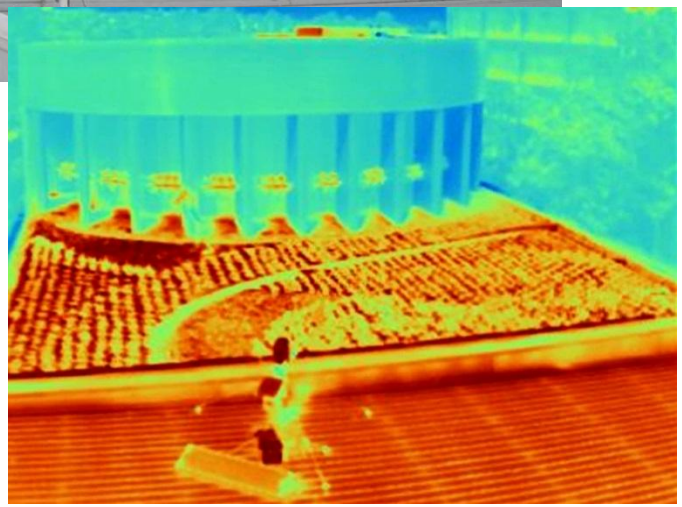
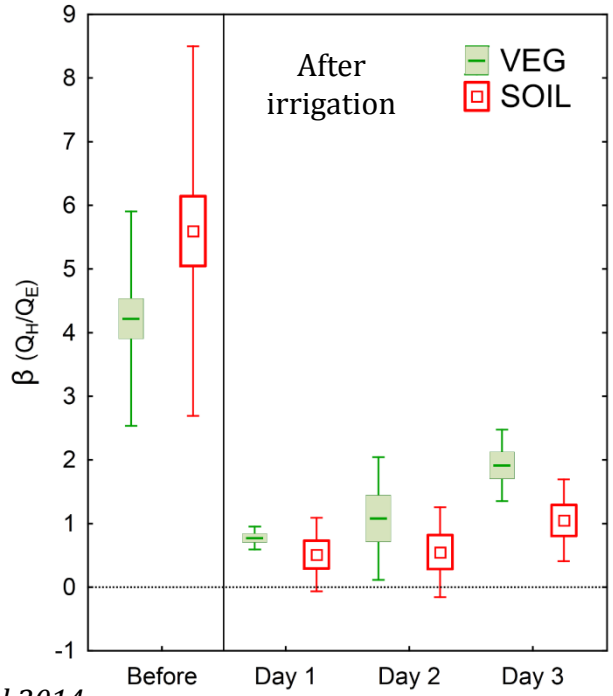
Designing green infrastructure for cooling

Monash City Council 'living roof' trial

- No maintenance provided (access issues)
- No irrigation (stormwater managment)
- Dark grey gravel roof base (intense daytime surface heating)
- Succulent vegetation (to survive the 'harsh' rooftop environment)
- Vegetation died







Coutts et al 2014

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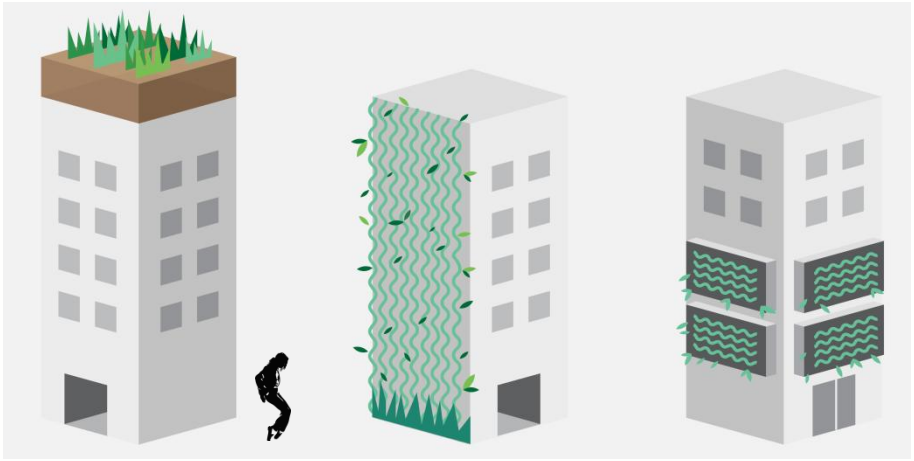
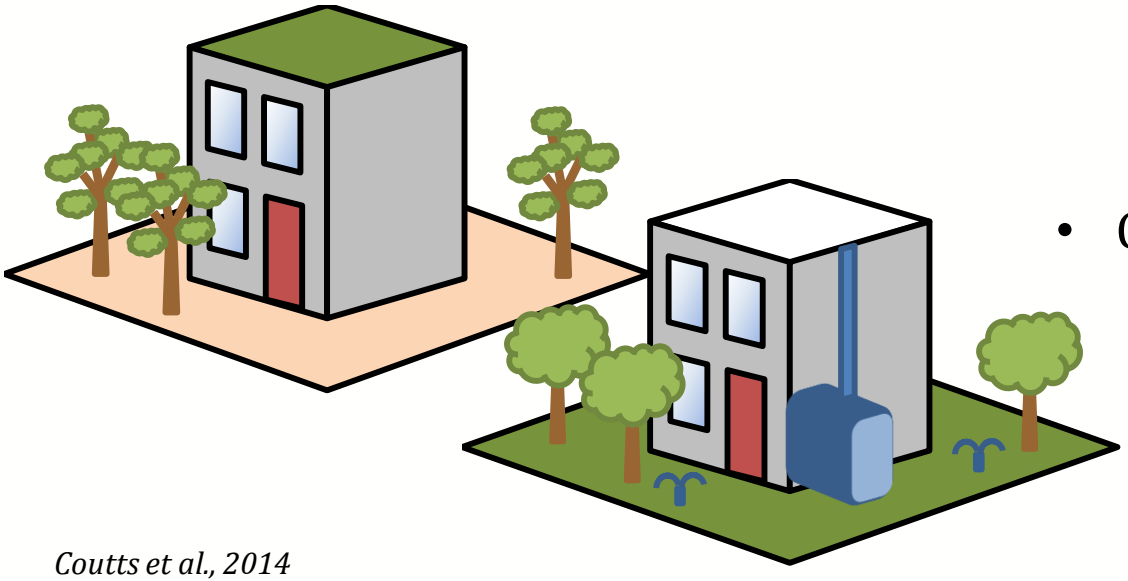
Designing green infrastructure for cooling



DEPI, 2014 Growing Green Guide



Coutts et al., 2014

- To maximise cooling benefits, design should consider:
  - Building height
    - Pedestrians at street level
    - Higher roof area to building volume ratio
  - Deep, light coloured substrate
  - Plants with high LAI
  - Avoid succulents
  - Irrigate
  - Maintain
- Consider the broader picture…
  - Remember largest benefit per $

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Designing urban landscapes for trees

Tree thermal comfort (TTC)

Support trees by:

- Water Sensitive Urban Design
- Irrigation (recycled water, potable)
- Clumping trees together – not isolated
- Match trees to location
  - Shade/light tolerant
  - Drought tolerant (**IF** necessary)
- Minimise pruning
- A mix of species
  - Builds resilience
  - Avoid monocultures
- Mesic rather than Xeric landscapes
- Benefit of increasing humidity on VPD

"It's been so hot that all the trees on my street have dropped their leaves. I thought it was an early Autumn effect, but apparently a lot of trees are dying. Hopefully these ones will survive, it's my favourite street in Melbourne because of them." A Melbourne blogger, 6 Feb 2009

http://notetoselfmax.blogspot.com/2009/02/meet-me-in-middle-of-air.html

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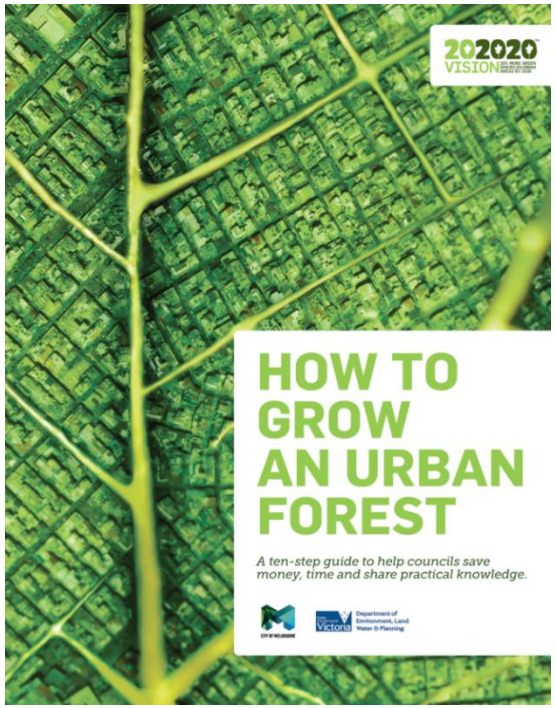
Research Policy

- Advice, best practice guidelines, and tools for green infrastructure implementation TARGETED at urban cooling are trailing/lacking
- We need to get this information and research into green infrastructure implementation so heat mitigation is actually achieved
- Some cities, towns and municipalities are already greening – others are not. Both support and advocacy are needed.



- Interdisciplinary work is needed
- Prepare for and act on 'windows of opportunity'
  - Observe the political & economic climate, not just the urban climate…
  - Have press releases ready for the next 'crisis' (heatwave)
- Act now!!! Takes years for trees to grow!!!

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An Australian Government Initiative

CRC AUSTRALIA