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Economic valuation of tree cover in Perth, Western Australia

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Outline

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- Background context
- Research questions
- Study area
- Method/model and data
- Key results
- Conclusions
- Questions

Thought to remember…

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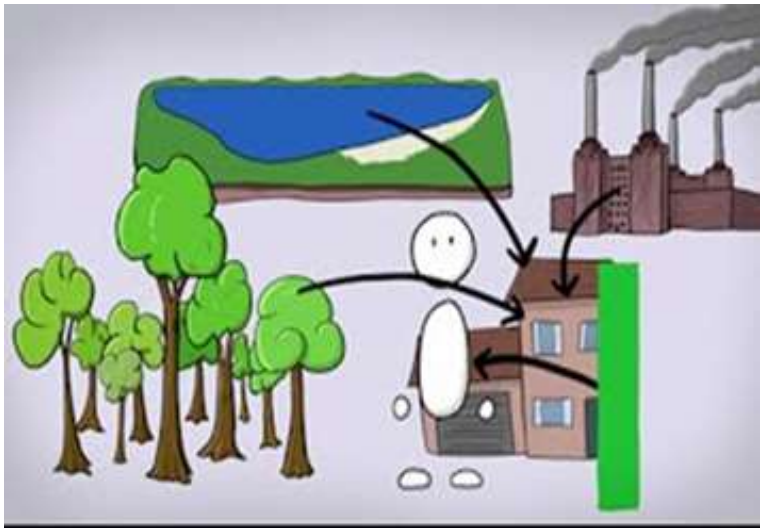

Urban trees and forests

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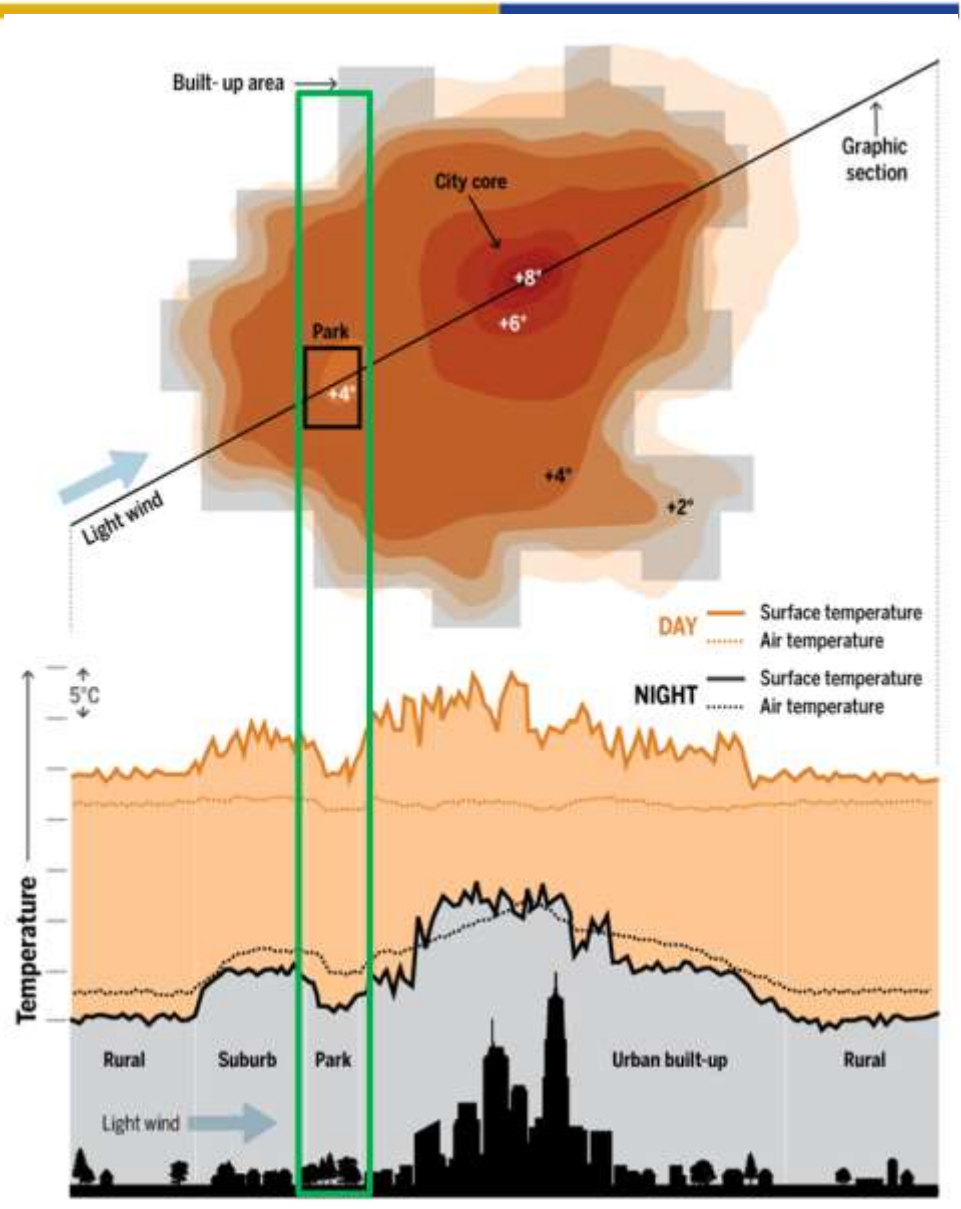
Improve air quality (Nowak, et al. 2006; Kim et al. 2003); Health benefits (Donovan et al., 2011; Dadvand et al., 2012; Mitchell & Popham, 2007; Pereira et al., 2013, 2012; Astell-Bell et al. 2013); Space for physical activity (Bedimo-Rung, et al., 2005); Reduce energy consumption (Akabari et al., 1997; Simpson, 1998; Donovan & Butry, 2009; Pandit & Laband, 2010); Increase property value (Anderson & West, 2006; Cho et al., 2008, 2010; Mansfield et al. 2005; Poudyal et al. 2009; Sander et al. 2010)

Source: Woodland trust, UK



Economic valuation of tree cover

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- The economic values of various benefits of urban trees and forests are often poorly recognised and ignored by planners and land owners (Sanders et al. 2010).
  - Many such benefits are not traded in the markets

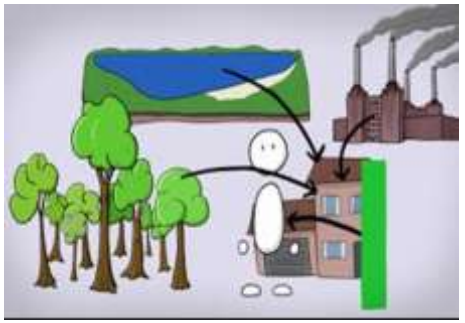

CSIRO Building in Brisbane, Australia

- Emphasis in urban greening
  - Australia-> Vision202020 = 20% more urban green space by 2020

- Individual households can also contribute if they know the economic value of these benefits
  - Such as property values

Empirical evidence on property value

- USA/Europe
  - USA – e.g. Anderson & West, 2006; Cho et al., 2008, 2010; Mansfield et al. 2005; Poudyal et al. 2009; Sander et al. 2010)
  - Europe – e.g. Tyrvainen, 1997; Tyrvainen and Miettinen, 2000;
  - China – rapidly evolving
- Australia – not much, but evolving…
  - e.g., Hatton McDonald et al. 2010 for Adelaide
  - Different housing markets
  - Differences in opportunity costs associated with private land in cities
  - What are the economic values of urban trees and forest covers in Australian cities that are capitalized in property prices?



Research questions

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1) Are tree covers in different locations (in relation to the property) equally valuable?

- Tree cover on own private space vs. on neighbouring private space vs. on neighbouring public space

2) Are all types of green covers created equal?

- Trees & shrubs vs. lawns
- What about overhead powerlines?

Where is Australia (of course Perth?)

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Study area - Perth city

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WA and Perth

Perth CBD from Kings Park

Perth from distance

A closer look of a suburb

A closer look of a street

Study area and properties

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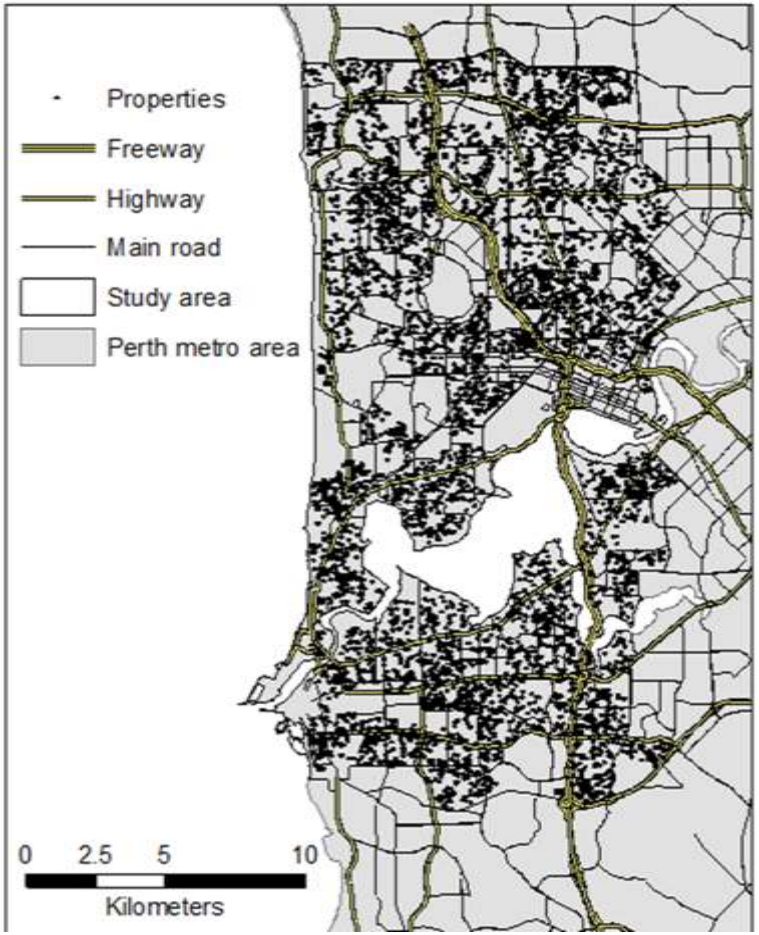

Tree cover

* % of tree cover on private space
* % of tree cover on public spaces within 20 m buffer
* % of tree cover on neighboring private space within 20 m buffer

Zoomed view of a section of study area

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Residences, parks and trees

Method

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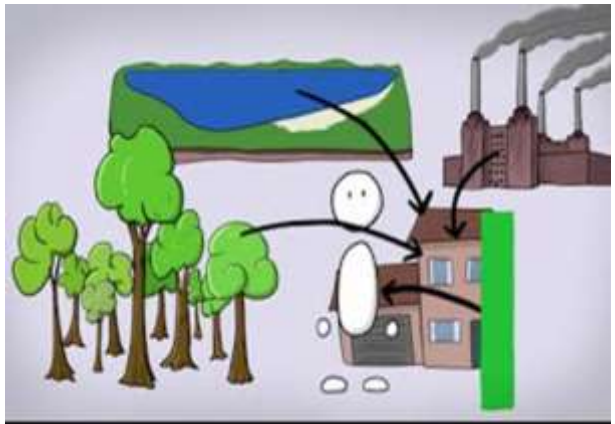
- Hedonic Pricing Method
  - A revealed preference technique
  - The amount of money an individual is willing to pay for a good depends on its individual characteristics (Rosen, 1974; Freeman, 1979)
  - The variation in house prices is explained by the differences in preferences for structural, locational and environmental characteristics of houses
- The value of a house consist of values of its attributes reflected in sales price:

P = f(**X**) = f(**S, L, E**)

S - structural variables

L - locational characteristics

E - environmental attributes



Model

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- The implicit value of each attribute can be estimated using regression model (hedonic price function):

$$P_i = \alpha + \boldsymbol{X}_i'\boldsymbol{\beta} + \varepsilon_i$$

  - Spatial econometric models (parametric - SEM, SLM or both)
  - Spatial fixed effect model (spatial delineation – zoning, suburbs, school district, zip code etc.)
  - Geographically weighted regression (GWR) – parametric
  - GAM (‘flexible fixed effect’ – non parametric, uses polynomials of latitude-longitude coordinates of the property with a number of base functions)

Model

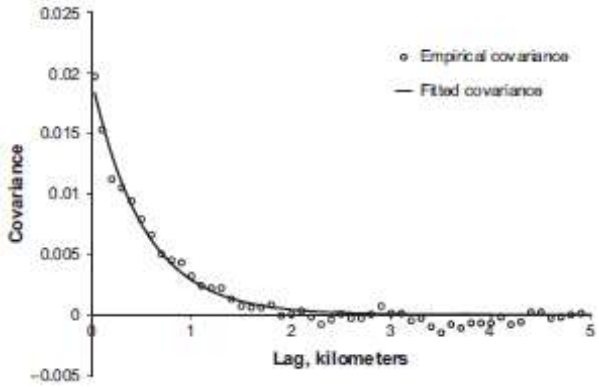
- Spatio-temporal model:

$$P_i = \alpha + \rho \boldsymbol{Z}_i' \boldsymbol{P} + \boldsymbol{X}_i' \boldsymbol{\beta} + \boldsymbol{W}' \boldsymbol{X} \boldsymbol{\theta} + \varepsilon_i,$$

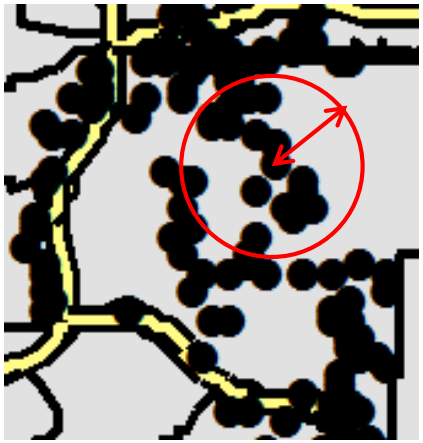
where $\varepsilon_i = \lambda \boldsymbol{W}_i' \boldsymbol{\varepsilon} + v_i$, $v_i \sim N(0, \sigma^2)$

  - **Z** = spatio-temporal weight matrix for house price [based on lag prices of previous sales (>90 days prior) within threshold distance derived from the data
  - **W** = spatial weight matrix for explanatory variables [distance-based weight matrix for independent variables, doesn't depend on time, derived from the data]

    (residual of the OLS model)



W = 1548 m



Data

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- Dependent variable: Property sales price = P
- Independent variables (**X**):
  - Structural characteristics of the property
  - Locational/neighbourhood characteristics
  - Environmental amenities/features

Age, yr
Land area, m^2
Foot-print of structure, m^2
Property shape index
# of bath/bed/study/ dining & meal room
# of garage/car port
Dummy for pool/wall/roof

Relative elevation, m
Slope (degree)
Dist. to bust stop, m
Dist. to free-&high-way, km
Driving time to city/ocean /river, min
# of burglaries/1000 houses
# of robberies/ 1000 people

- Proportion of tree cover on private space
- Proportion of tree cover on public spaces within 20 m buffer
- Proportion of tree cover on neighboring private space within 20 m buffer
- Gravity index for recreational areas (small reserves, bush land, playing field, lakes, golf courses)

Data sources

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- Property sales price and structural data -> Landgate, WA
- Tree cover was derived (using Feature Analyst in ArcGIS] from Quick Bird satellite imagery of the study area
- Property shape index, $PSI = {}^{p}/_{\sqrt{a}}$, $\mathrm{p} = \mathrm{perimeter}, \mathrm{a} = \mathrm{area}$
- Gravity index = $GI_{ri} = \sum_{1}^{k} \frac{A_{rk}}{D_{ik}^{2}}$,
  - r = type of recreational area (small reserves, bush land, playing field, lakes, golf courses)
  - i = ith house
  - k = number of 150m x 150m grid cells within 3km radius of ith house
  - A_{rk}= area of the rth type of recreational areas within kth grid cell
  - D_{ik}= distance between ith home and the center of kth grid cell

Descriptive statistics

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Home sale price 2009, AUD (n=4200)	Median=$800,000	Mean=$1,007,051

Structural var	mean
House age, yr	43
Property area, m^2	677
Footprint of built structure, m^2	294
Property shape index, p/sqrt(a)	4.41
Bathrooms	1.55
Bedrooms	3.20
Garages	0.90
Car ports	0.50
Pool	24%
Brick wall	86%
Iron roof	15%

Environmental var	Mean (median)
Tree cover-private	0.24 (0.22)
Tree cover-street verge (20m)	0.24 (0.20)
Tree cover-neighbours (20m)	0.26 (0.25)
GI - Small reserves	0.87 (0.65)
GI – Bush reserves	0.73 (0.34)
GI – Playing field	0.67 (0.45)
GI - Lakes	0.17 (0.02)

Neighbourhood var	Mean
Elevation	1.18
Slope (degree)	2.35
Dist bus stop, m	302
Dist freeway, km	3.5
Dist highway, km	0.9
Drive time–city, min	8.8
Drive time-ocean, min	6.9
Drive time-river, min	4.8
Robberies/1000 pop	0.9
Burglaries/1000 h	28.9

Results (dependent var. Ln(price))

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Key variables	OLS model	Spatio-temporal model
Age/Age-squared	-/+, S	-/+, S
Footprint/Land area, m^2	+, S	+, S
Property shape index	-, S	-, S
Bath/bed/study rooms, Carport, Garage, #	+, S	+, S
Swimming pool/ Brick wall/ Iron roof	+, S	+, S
Relative elevation (m)/ Slope ^{0} (degree)	+, S	+, S
Ln dist to bus stop, m	+, S	+, S
Ln dist to highway or freeway, km	+, S	+, S
Burglaries/1000 houses	-, S	-, S
Robberies/ 1000 people	-, S	-, NS
Prop. tree cover on own property	**0.0556***	**0.0305**
Prop. tree cover - neigbouring property	**0.0007**	**-0.0762****
Prop. tree cover on street (20 m buffer)	**0.3026*****	**0.1814*****

Key findings

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- Tree cover on **own property** (private space) has no significant effect on property price
- At a median property price of $800,000, and 20% and 25% canopy cover on street verges and adjacent properties:
  - A 10% increase in tree canopy cover on **street verges** **increases** the property price by @$14,500.
  - A 10% increase on tree canopy cover on **neighbouring properties** **reduces** the house price by @ $6100.

Pandit, R., M. Polyakov, and R. Sadler. 2014. Valuing Public and Private Urban Tree Canopy Cover, *Australian Journal of Agricultural and Resource Economics*, 58(3): 453-470.

Conclusions

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- The benefits of urban tree cover have been capitalised in property markets in Perth, depending on the location
- Trees/tree covers on public space add value to properties, but not when they are in private space.
- These results provide further rationale to Australia's urban forestry vision202020 by indicating potential space to target for urban greening program to generate both public and private benefits.

Next-step: Disamenity value of overhead powerlines

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- Study focus:
  - Street verges only
  - Valuing **disamenity** value of overhead powerlines
  - Shades of greens
    - *Ground cover (lawn) and*
    - *Above ground cover (trees/shrubs together)*

Variable	Model				
	OLS	SEM W 8nn	FEM	GAM k=1970	GAM k=243
Presence of overhead network (OHN)	-$33,569	-$21,492	-$7,077	-$8,752	-$17,174
Per 1% of grass (OHN present)	$8,936	$5,991	$5,554	$5,019	$5,368
Per 1% of grass (no OHN)	$7,525	$6,823	$6,350	$5,893	$6,106
Per 1% of trees and shrubs (OHN present)	$829	$627	$757	$603	$355
Per 1% trees and shrubs (no OHN)	$1,398	$1,117	$681	$740	$482


Overhead powerline


Underground powerline

Thank you!

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