



# Darwin Living Lab

‘Releaf’ in sight: High-resolution mapping to track, value, and restore Darwin’s urban tree cover

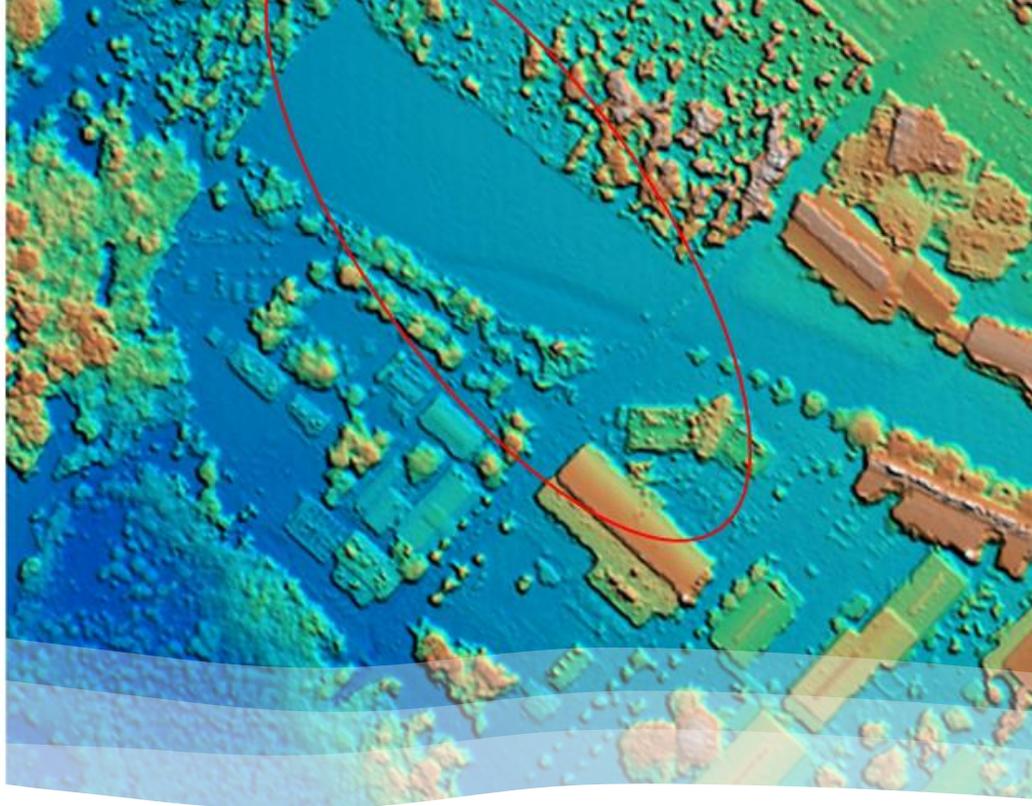
Dr Ray Marcos Martinez

27 July 2023



Monitoring changes in urban environments is critical for guiding sustainable development, livability and climate change adaptation and mitigation efforts.

How to assess and monitor urban environments in a cost-effective and timely way?



2011

2016

2021

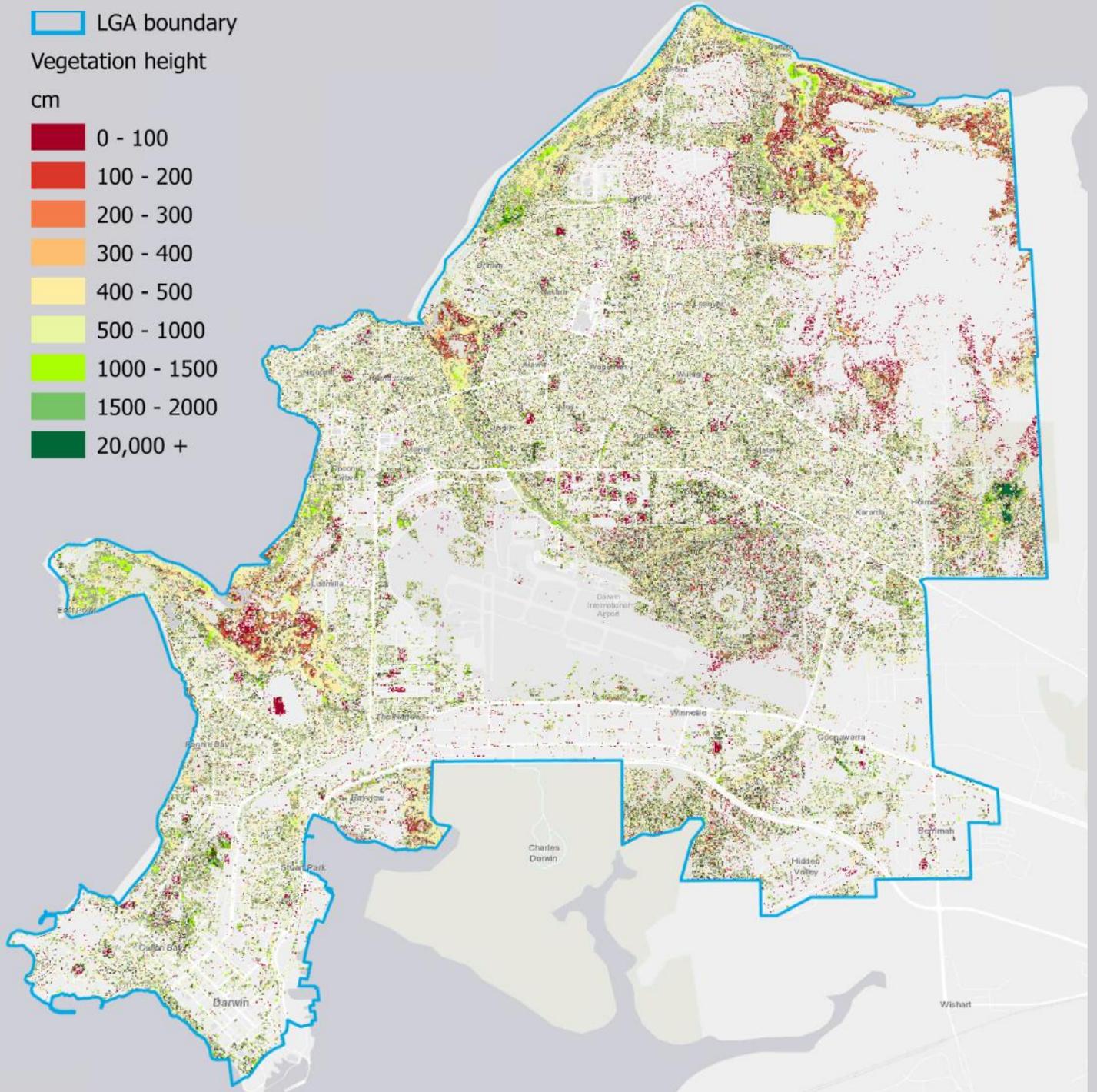
## Darwin Living Lab & Urban Monitor

Highly accurate analysis of digital aerial photography to model Darwin's environment





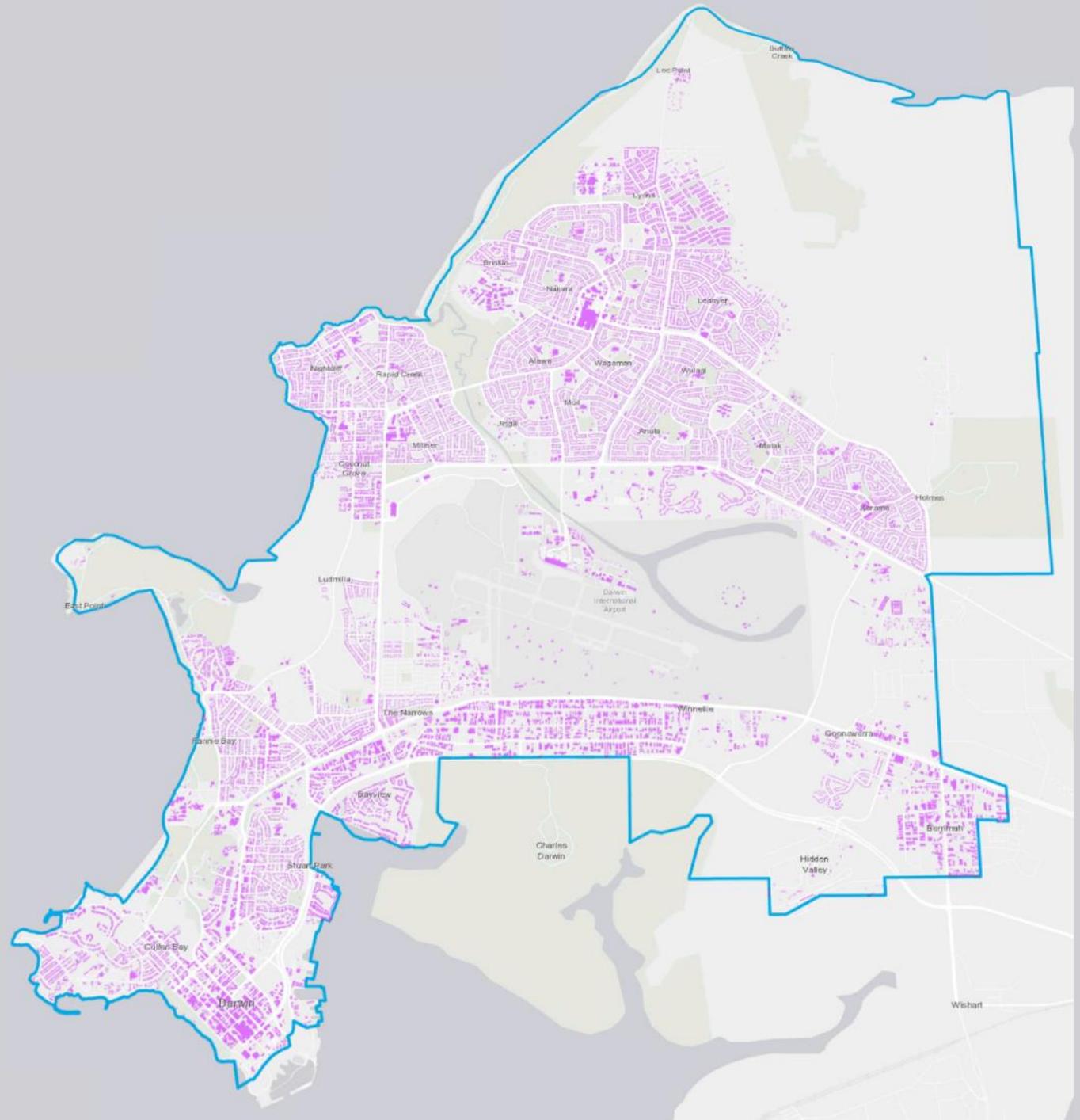
# Vegetation height





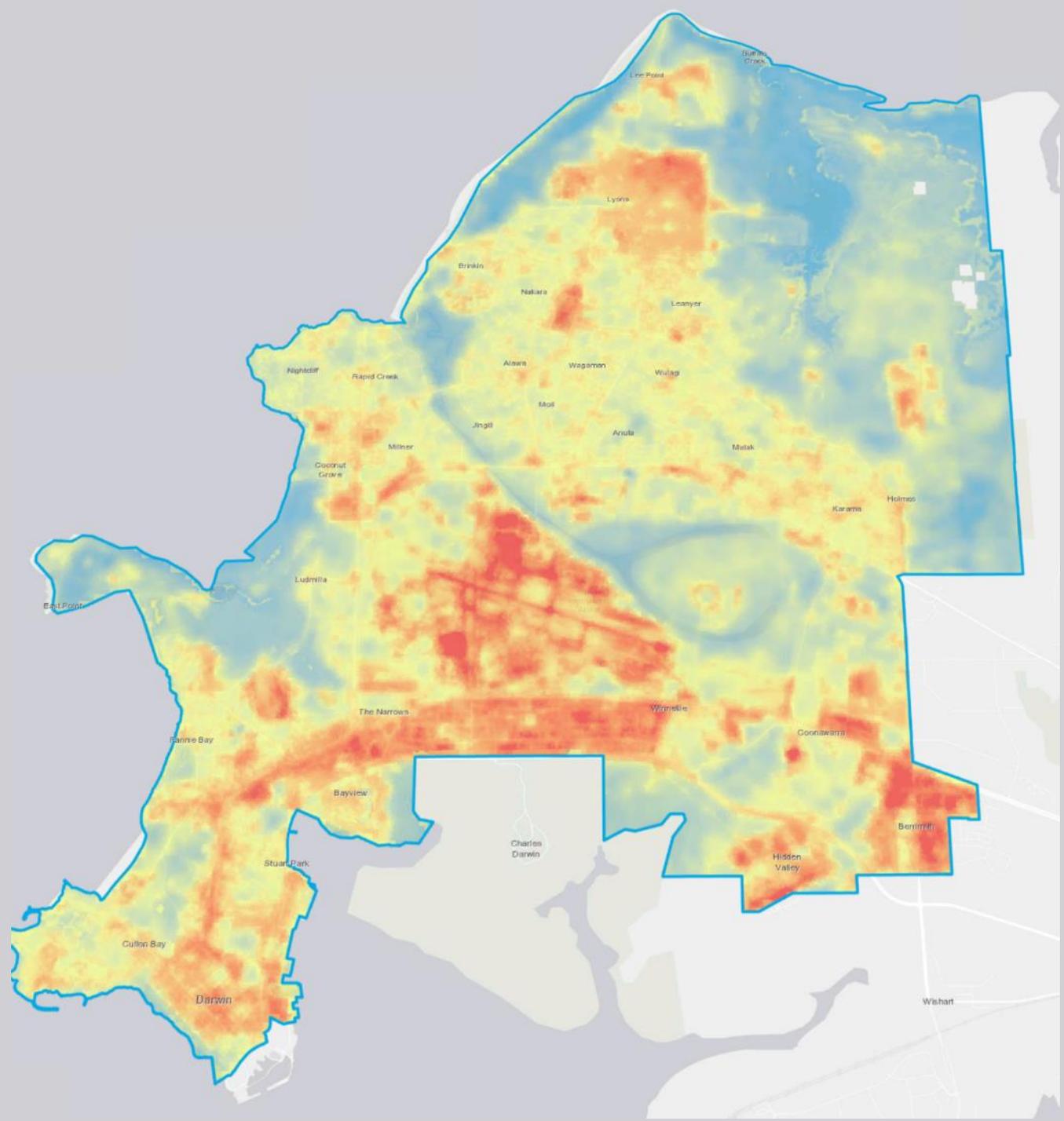


# Buildings





# Land Surface Temperature



# Tree gains (green) & losses (red) 2016-2021

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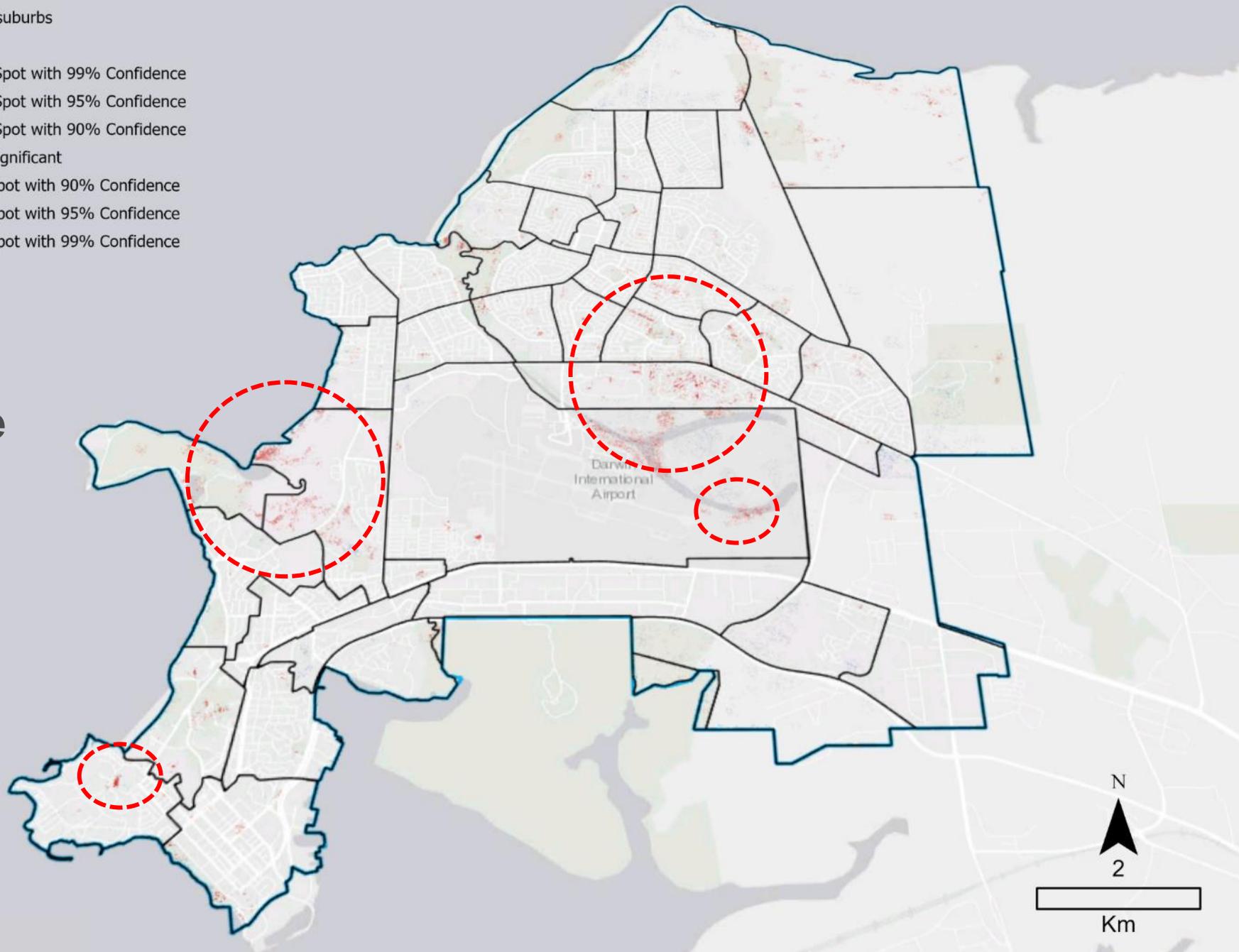




- CoD suburbs
- Gi\_Bin
  - Cold Spot with 99% Confidence
  - Cold Spot with 95% Confidence
  - Cold Spot with 90% Confidence
  - Not Significant
  - Hot Spot with 90% Confidence
  - Hot Spot with 95% Confidence
  - Hot Spot with 99% Confidence

# Spatial clustering of tree cover loss

## Hot Spot Analysis (Getis-Ord Gi\*)





- CoD\_suburbs
- Gi\_Bin
  - Cold Spot with 99% Confidence
  - Cold Spot with 95% Confidence
  - Cold Spot with 90% Confidence
  - Not Significant
  - Hot Spot with 90% Confidence
  - Hot Spot with 95% Confidence
  - Hot Spot with 99% Confidence



2022



# Darwin's LGA: Tree Cover Change

Average distribution of tree canopy cover by land tenure type  
2011 - 2021

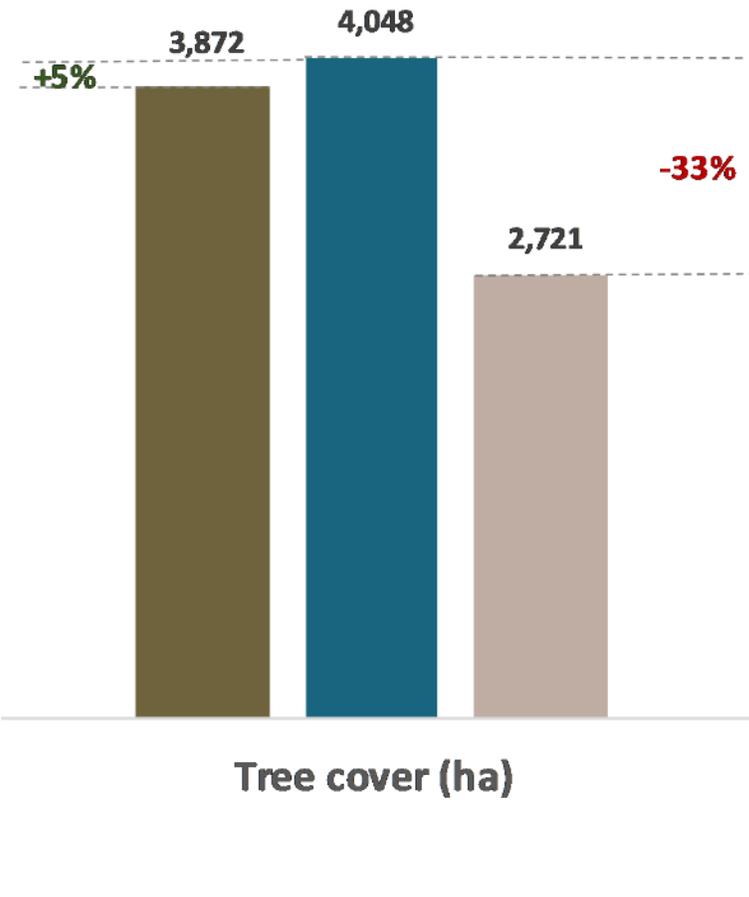




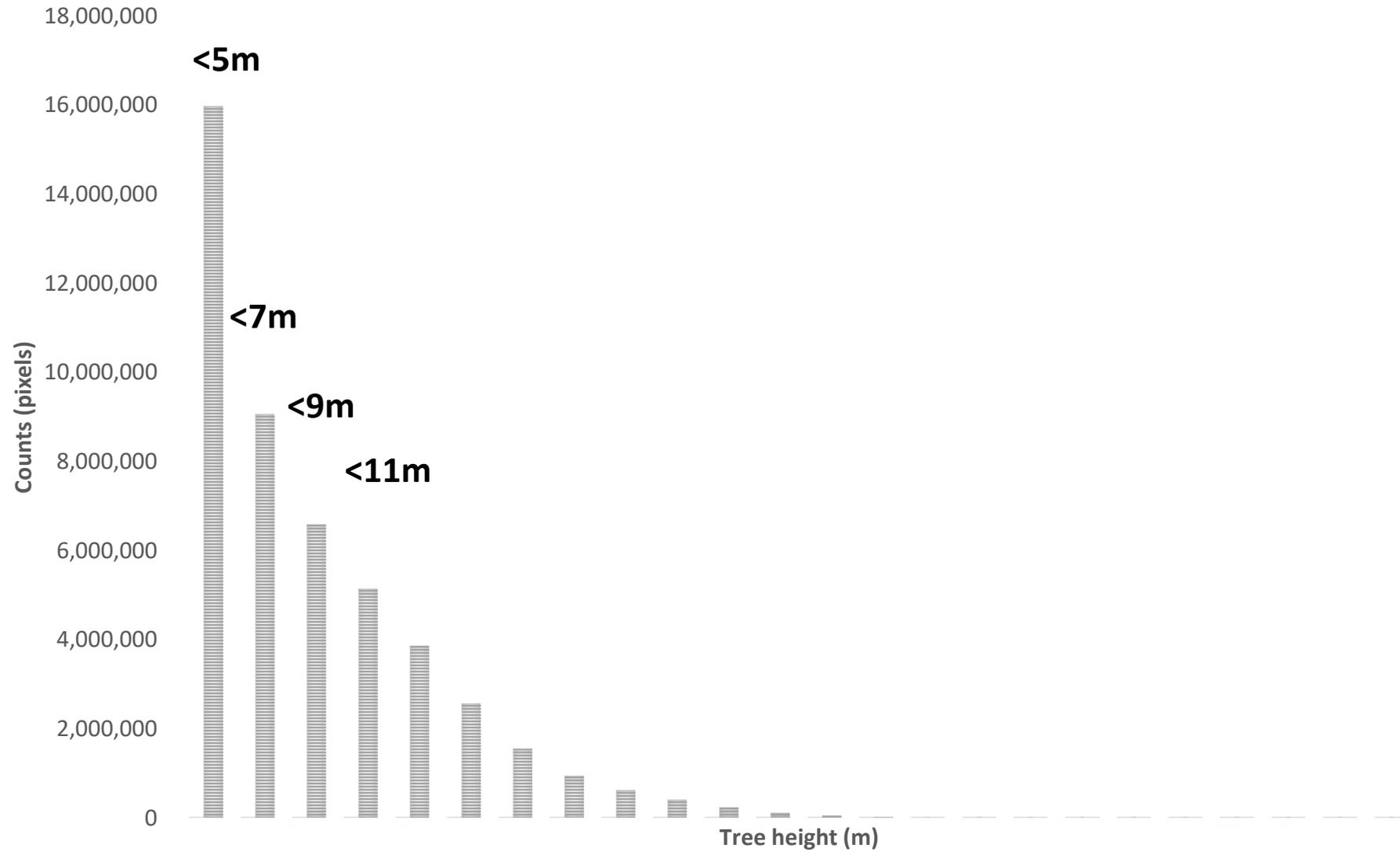
Darwin lost one third of its urban tree cover from 2016 to 2021.



# Darwin's LGA: Tree Cover Change

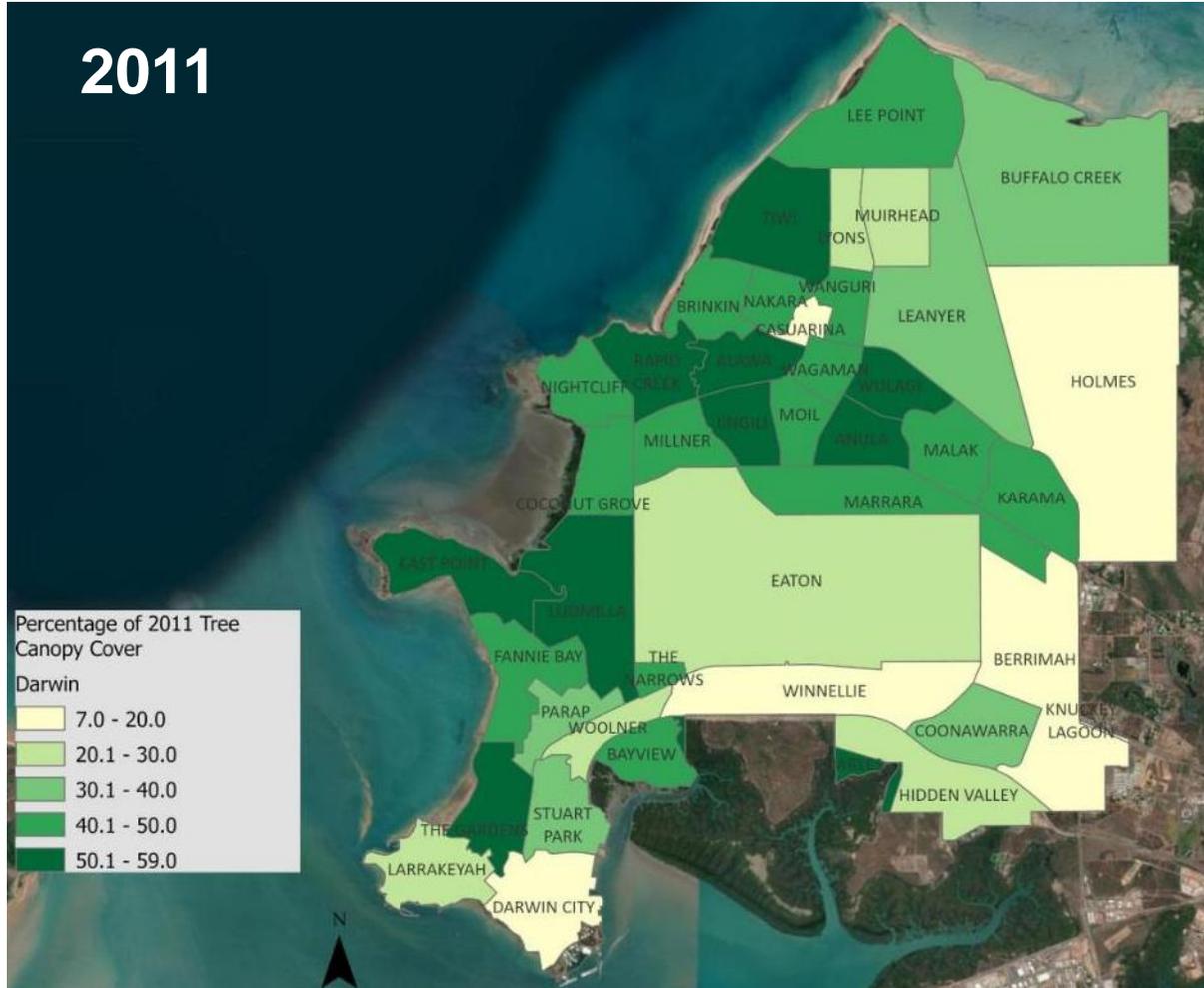


# Height distribution of tree cover loss

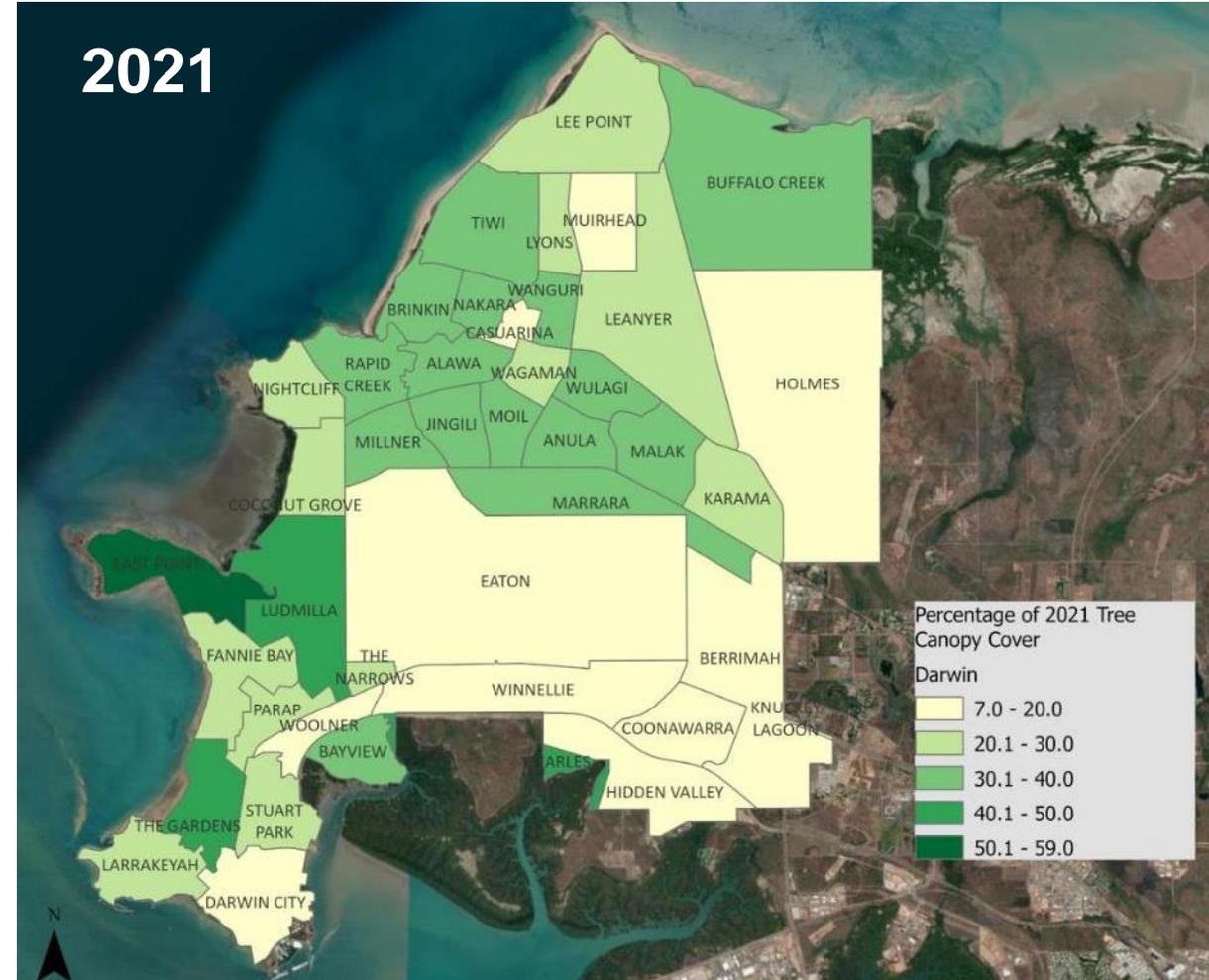


# Tree canopy cover change

2011

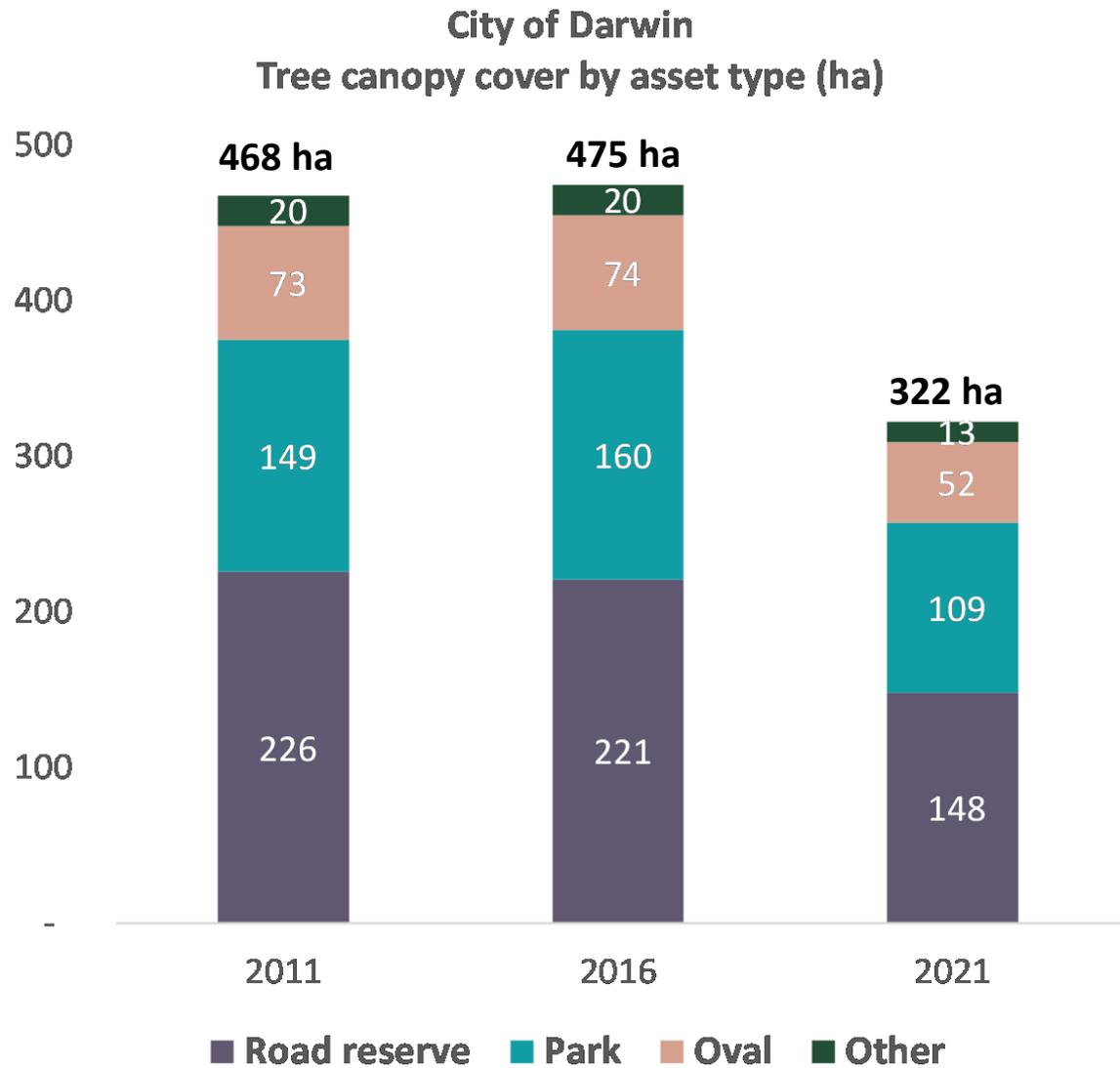


2021





# City of Darwin: Tree Cover Change





**We know the extent and change  
in tree canopy cover loss**

**Informing investments to recover  
lost canopy requires valuing the  
benefits of urban trees.**



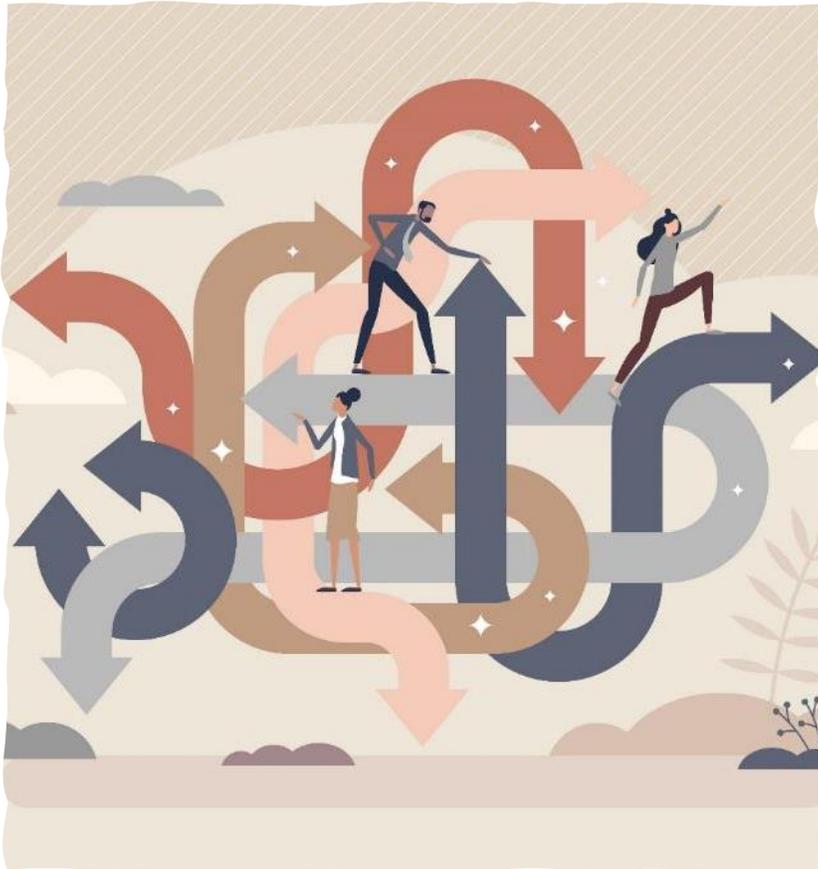
## Value of ecosystem service benefits

- Estimate the returns per dollar spent on recovering or maintaining tree cover.
- Inform city investments.

	Total	Per tree	Per hectare
Replacement value (\$)	486,875,954	4,868.76	876,282.54
Carbon storage (\$)	12,264,481	122.64	22,073.69
Gross carbon sequestration (\$/y)	73,308	0.73	131.96
Avoided runoff (\$/y)	200,403	2.00	360.69
Avoided carbon (\$/y)	117,544	1.18	211.56
Air pollution removal (\$/y)	65,454	0.65	117.79
Energy savings (\$/y)	1,966,391	19.66	3,539.12
<b>Total annual benefits (\$/y)</b>	<b>2,423,109</b>	<b>24.23</b>	<b>4,361.12</b>



The value of City of Darwin public trees reduced by around **\$134 million** from 2016 to 2021



Trees are a critical urban asset requiring long-term planning and action to ensure a sustainable provision of ecosystem services.



The Darwin Living Lab generates data to track the condition and extent of urban tree canopy cover and guide investment decisions.



The next step involves the development of a tree-planting algorithm to help identify planting locations and tree species that provide high returns to urban dwellers and are resilient to extreme weather events.



## We speak for the trees:

Tree canopy cover data from 2011, 2016, and 2021 shows Darwin lost a third of its tree cover in just a few hours due to Cyclone Marcus.

# Thank You

<https://research.csiro.au/darwinlivinglab/>

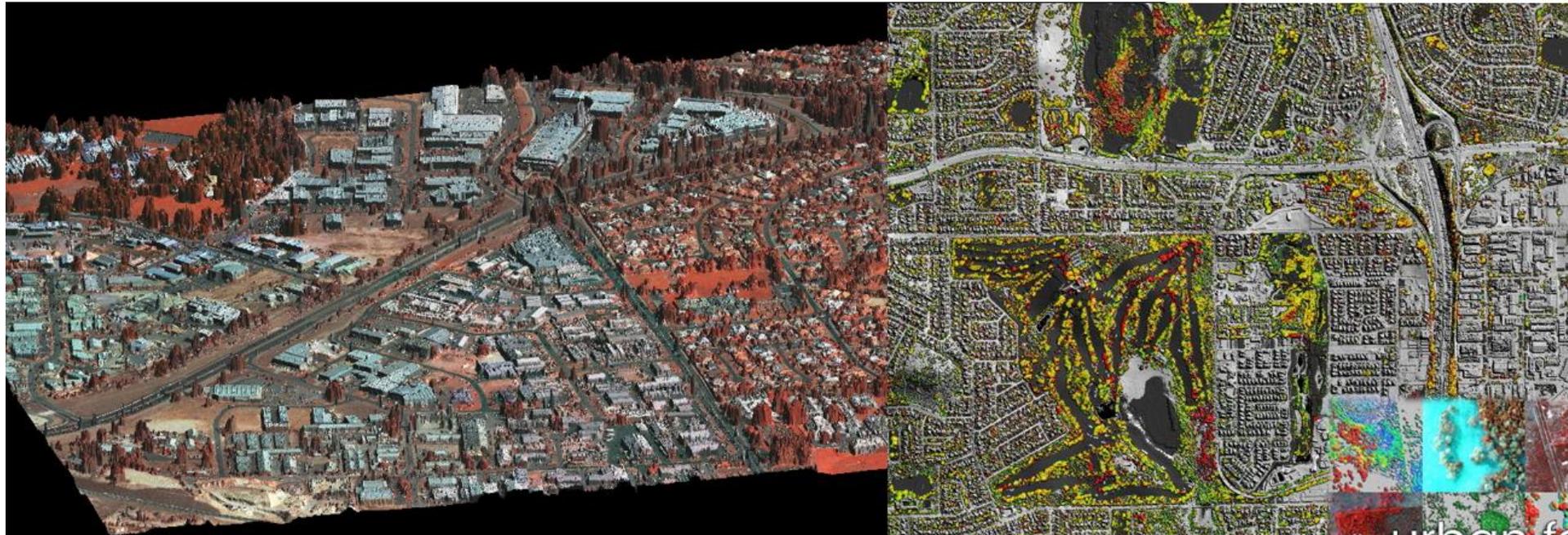
Australia's National Science Agency

The Darwin Living Lab is a joint initiative funded by the Australian Government, Northern Territory Government, City of Darwin and CSIRO as part of the Darwin City Deal.



# Urban Monitor

Quantitative monitoring in complex environments.



Aerial, satellite, underwater and ground-based monitoring of urban and coastal elements and trends

Rigorous estimates of environmental and other indicators

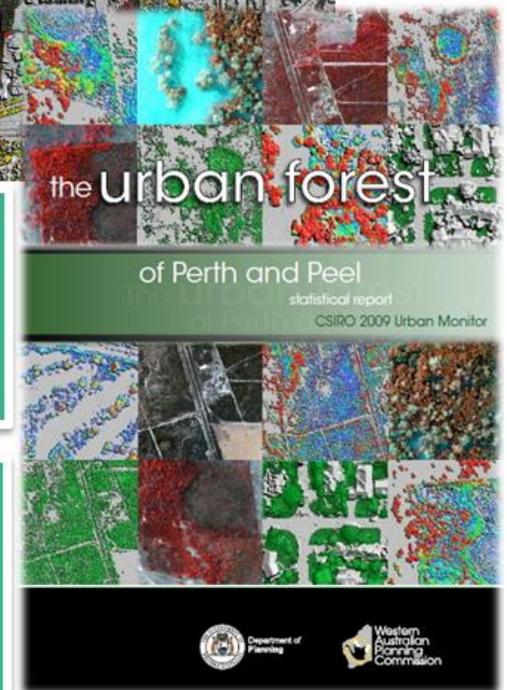
Applicable to policy relevant issues, for example within strategic assessments



Partners: Local, State and Federal Government, Utilities, Universities; HPC/iVEC

Examples : Perth and Peel Assessment; Oil and Gas environmental baselines;

Scalable technology to any region



# Urban Monitor

Quantitative monitoring in complex environments.



- [Land Monitor: Perennial Vegetation Change Images 1988 to 2015 \(South West Agricultural Region of Western Australia\)](#)
- [Australia's National Greenhouse Accounts: Land Use, Land Use Change and Forestry – CSIRO Contributions to Woody Cover Monitoring in Australia](#)
- [Implementing Indonesia's National Forest Carbon Accounting System 2009 – 2016 – CSIRO Contributions to Forest Monitoring in Indonesia](#)
- [Kenya Land Cover and Change](#)
- [Mosaicking Deepwater AUV Photography](#)
- [SAR for Land Cover Observation – Activities for Agriculture, Environmental Applications](#)



# i-Tree Eco + Sample of trees





## Ecosystem service benefits: Biophysical estimates

Ecosystem service	Total	Per tree	Per hectare
Carbon storage (kg)	159,278,963	1,592.79	286,671.32
Gross Carbon sequestration (kg/y)	952,069	9.52	1,713.54
Avoided runoff (m <sup>3</sup> /y)	99,704	1.00	179.45
Avoided carbon (kg/y)	1,526,518	15.27	2,747.44
Air pollution removal (g/y)	27,804,970	278.05	50,043.57

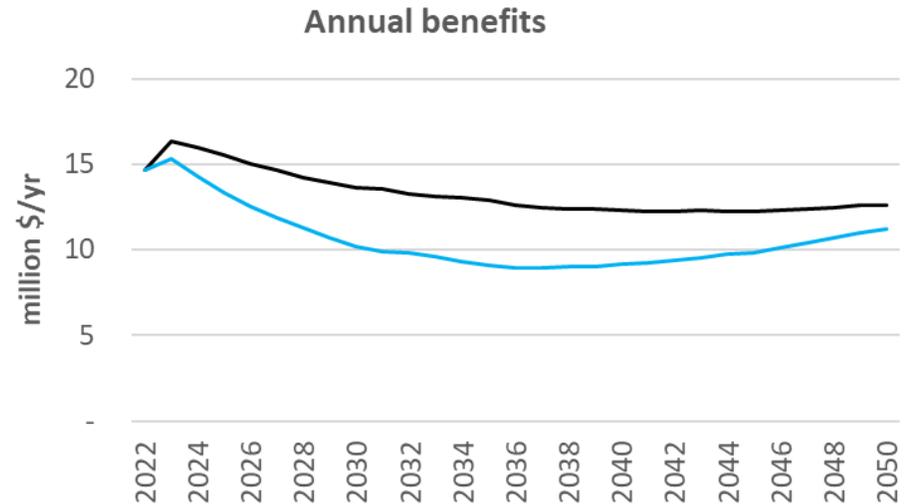
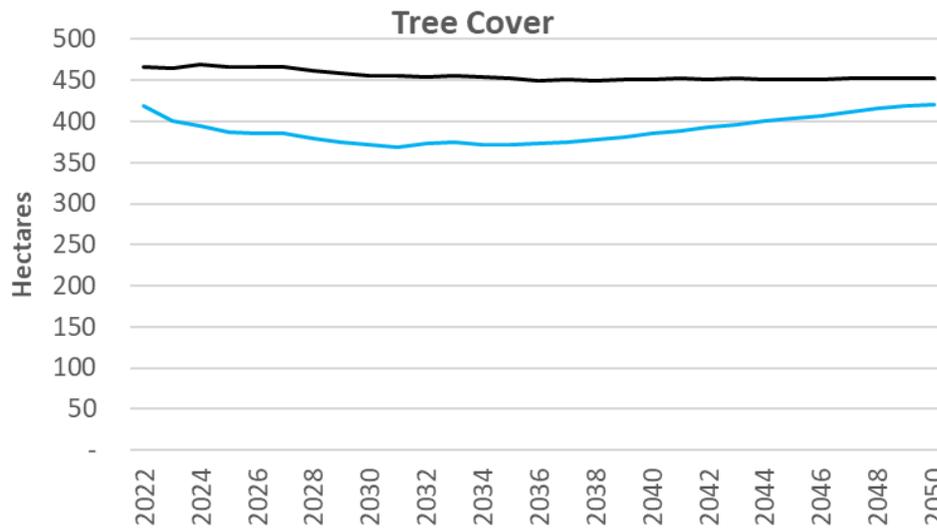
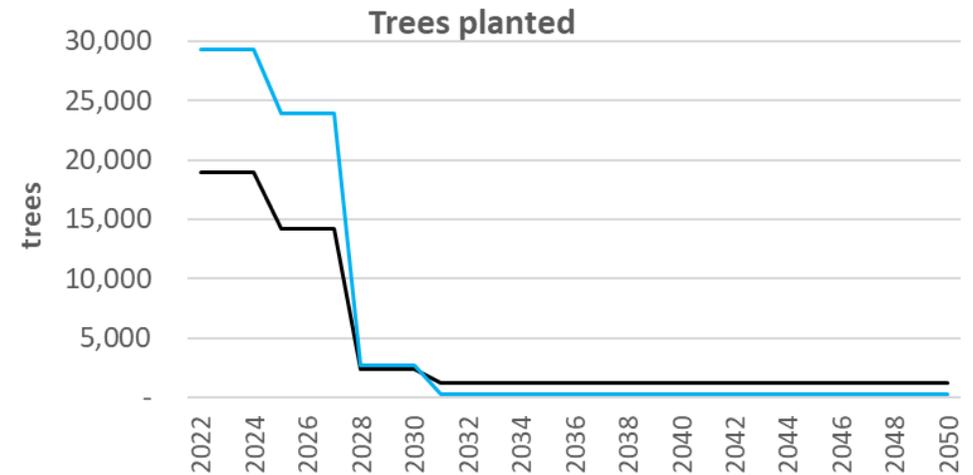
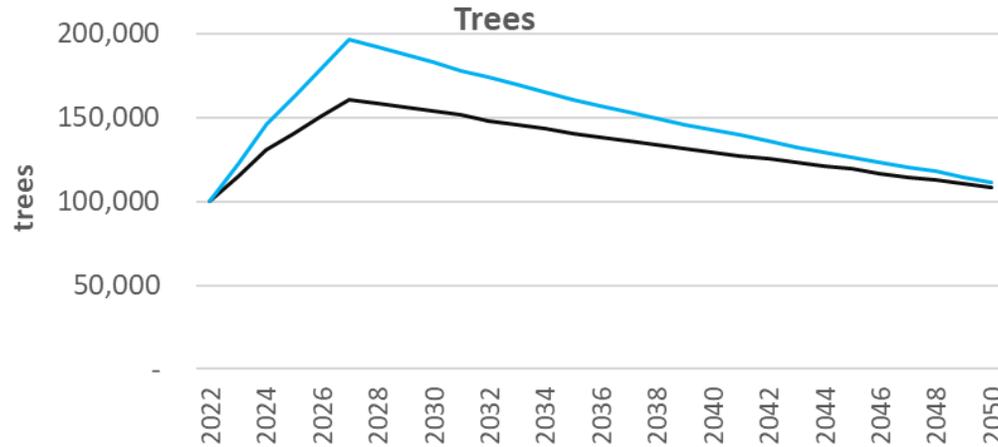


# Scenario analysis

Parameters	Maintaining tree canopy cover	Greening Darwin
Tree size	3-cm DBH	3-cm DBH
Time horizon	2022-2050	<ul style="list-style-type: none"><li>❖ Planting trees from 2022-2030<ul style="list-style-type: none"><li>· Net gain of 18,000 street and park trees over 9 years</li><li>· Net gain of 900 shading trees near key transit routes over 9 years</li><li>· Net gain of 225 city centre hardscape trees over 9 years</li></ul></li><li>❖ Keep the 2030 extent: 2031-2050</li></ul>
Base mortality rate per annum	<ul style="list-style-type: none"><li>❖ 3 % mortality rate</li><li>❖ Default mortality rate (0-49% dieback - 3%, 50-74% dieback - 13.1%, 75-99% dieback - 50%)</li></ul>	<ul style="list-style-type: none"><li>❖ 3 % mortality rate</li><li>❖ Default mortality rate (0-49% - 3%, healthy trees 50-74% - 13.1%, sick trees 75-99% - 50%, dying trees)</li></ul>



# Scenario 1: Maintaining tree canopy cover

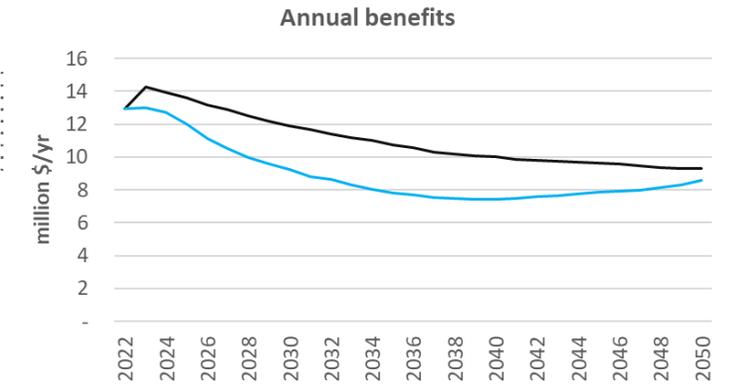
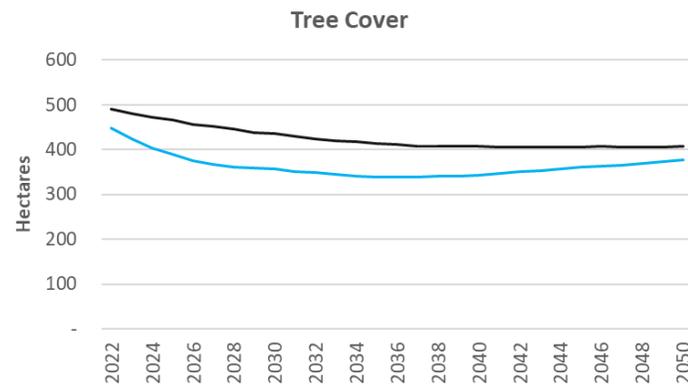
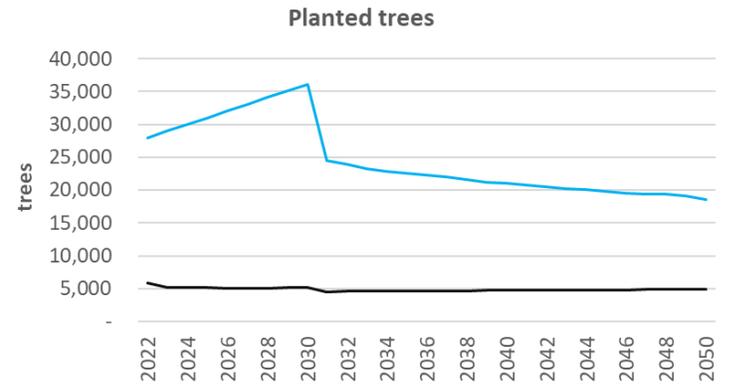
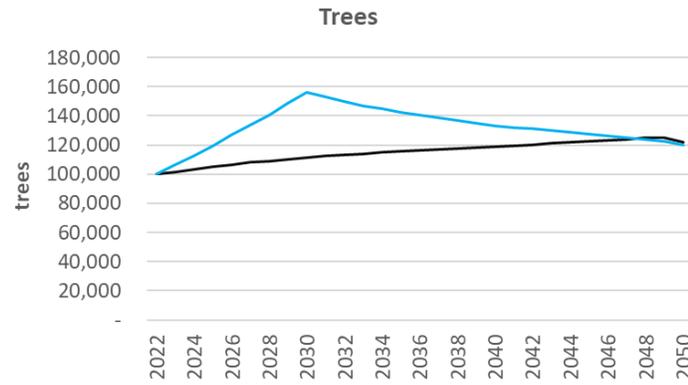


— Default mortality rate — 3% mortality



# Scenario 2: Greening Darwin

Parameters	Greening Darwin
Tree size	3-cm DBH
Time horizon	<ul style="list-style-type: none"> <li>❖ Planting targeted numbers: 2022-2030</li> <li>· Net gain of 18,000 street and park trees over 9 years</li> <li>· Net gain of 900 shading trees near key transit routes over 9 years</li> <li>· Net gain of 225 city centre hardscape trees over 9 years</li> <li>❖ Keep the 2030 extent: 2031-2050</li> </ul>
Tree planting per annum	
Base mortality rate per annum	<ul style="list-style-type: none"> <li>❖ 3 % mortality rate</li> <li>❖ Default mortality rate (0-49% - 3%, healthy trees 50-74% - 13.1%, sick trees 75-99% - 50%, dying trees)</li> </ul>



— 3% mortality    — Default mortality rate



# Darwin's LGA: Tree Cover Change

% change in tree cover by tenure type

