STAGE TWO REPORT

DATA ANALYSIS

Urban Forest Strategy

Ku-ring-gai Council

FINAL – Revision 0

Acknowledgement of Country

We acknowledge Aboriginal and Torres Strait Islander peoples as the First People and traditional custodians of the land and waters of this place. We express our gratitude in the sharing of this land, our sorrow for the personal, spiritual and cultural costs of that sharing and our hope that we may walk forward together in harmony and in the spirit of healing.

We acknowledge the importance of Aboriginal custodial and cultural connection to place which is embodied in the term ‘Country’. We recognise and admire the ecological knowledge of Aboriginal people that has developed from thousands of generations of careful, sustainable land management practices.

We seek to integrate Aboriginal values around Country with scientific and mainstream land management approaches and to learn about complex indigenous knowledge systems and encourage greater understanding of Aboriginal cultural and spiritual connections to Country.

Figure 1: **Red Hands Cave walking track - Ku-ring-gai Chase National Park**

(Image credit: https://blog.nationalparks.nsw.gov.au/aboriginal-heritage-walk-ku-ring-gai-chase-national-park/)

Document Quality Assurance

Prepared by	Reviewed by
Dr Harry Eslick **Naviin Hardy** **Briony Williams**	Briony Williams

Approved & Released by	Position	Approval Signature
Dr Paul Barber	Managing Director	

Revision Schedule

Revision	Report Description	Submission Date	Author(s)
A	Urban Forest Strategy Stage 2 – Mapping Analysis	30/10/2021	Dr Harry Eslick
0	Urban Forest Strategy Stage 2 – Mapping Analysis	17/03/2022	Dr Harry Eslick

Disclaimer

ArborCarbon Pty Ltd has prepared this document using data and information supplied from Ku-ring-gai Council and other individuals and organisations, who have been referred to in this document.

This document is confidential and intended to be read in its entirety, and sections or parts of the document should therefore not be read and relied on out of context. The sole use of this document is for Ku-ring-gai Council only for which it was prepared.

While the information contained in this report has been formulated with due care, the author(s) and ArborCarbon Pty Ltd take no responsibility for any person acting or relying on the information contained in this report, and disclaim any liability for any error, omission, loss or other consequence which may arise from any person acting or relying on anything contained in this report. This report is the property of ArborCarbon Pty Ltd and should not be altered or reproduced without the written permission of ArborCarbon Pty Ltd.

Any conclusion and/or recommendation contained in this document reflect the professional opinion of ArborCarbon Pty Ltd and the author(s) using the data and information supplied. ArborCarbon Pty Ltd has used reasonable care and professional judgement in its interpretation and analysis of data in accordance with the contracted Scope of Works.

ArborCarbon

GOOD CANOPY COMPANY

CONTENTS

1 Introduction

Ku-ring-gai's urban forest is an integral part of the Local Government Area's (LGA) character and culture. The urban forest consists of scattered remnant bushland vegetation, intertwined with gardens, parks and streets of non-native and exotic planted trees. Not only is it important to the Ku-ring-gai community, but it's also essential habitat for a number of ecologically significant animal communities.

Canopy is considered one of the most important indicators of a healthy and robust urban forest. In this report, canopy refers to vegetation that is over 3m in height. This is a generally accepted definition for canopy in Australian urban forestry. Canopy cover is regularly used as an indicator to measure the success of an urban forest. In terms of urban greening, tree canopy provides the most benefits to an LGA.

Population growth, subdivision of land and increasing densities of urban areas all place pressure on Council's capacity to maintain current canopy coverage on private lands. The NSW Department of Planning, Industry and Environment projects that Ku-ring-gai's population will increase by more than 25,000 people to a population of 140,809 in 2036. The council's Housing Strategy proposes housing provision of 3,000-3,600 new dwellings over the 15-year period 2021-2036 (Ku-ring-gai Council 2020). The majority of these new dwellings will be accommodated within the existing mixed use, medium and high-density zoned sites which are concentrated along the Pacific Highway corridor and around the local centres of Turramurra, Gordon, Lindfield and St Ives. Residual capacity within current planning controls will be supplemented by the delivery of seniors housing developments and alternative dwellings such as secondary dwellings, group homes and boarding houses where permissible. Increased housing density in residential areas has the potential to negatively impact the Ku-ring-gai urban forest. This analysis will model the impact of this development of canopy cover into the future. To compensate for the loss of canopy as a result of private development, increased planting on public land is likely to be required. However, a lack of planting space on public land has been identified as a limiting factor to increasing urban canopy. Available aerial imagery, land use boundaries and planting guidelines have been used to locate available planting space on public land throughout the Local Government Area (LGA), with the purpose of identifying the most suitable opportunities for planting investment. In addition, shade cast by canopy over current and proposed active transport routes throughout the LGA has been modelled and quantified, to further focus planting efforts where shade is required.

1.1 Review of Current Canopy

Canopy area within Ku-ring-gai was measured in March 2020 (ArborCarbon 2020) using analysis of aerial multispectral imagery to classify areas of vegetation and stratify these areas into height classes.

LGA wide, canopy covered 51.4% of the total area. Ku-ring-gai is composed of a mix of land use types, including large areas of 'National Parks and Reserves' and 'Environmental Conservation' areas, such as sections of the Garigal National Park and Lane Cove National Park. These areas had high canopy coverage of 83.3% and 76.2% respectively. Canopy of the urban area (i.e. the LGA excluding C1 zoned land (National Parks and Nature Reserves) was 45%. This is well above a measured 2014 median of approximately 25% canopy cover across 39 NSW LGAs (Jacobs 2014).

Canopy cover was compared for each suburb within Ku-ring-gai. Percentage of canopy cover in each suburb is spatially presented in Figure 1 as a thematic map. Increasing green intensity in the map corresponds to increasing proportional canopy cover.

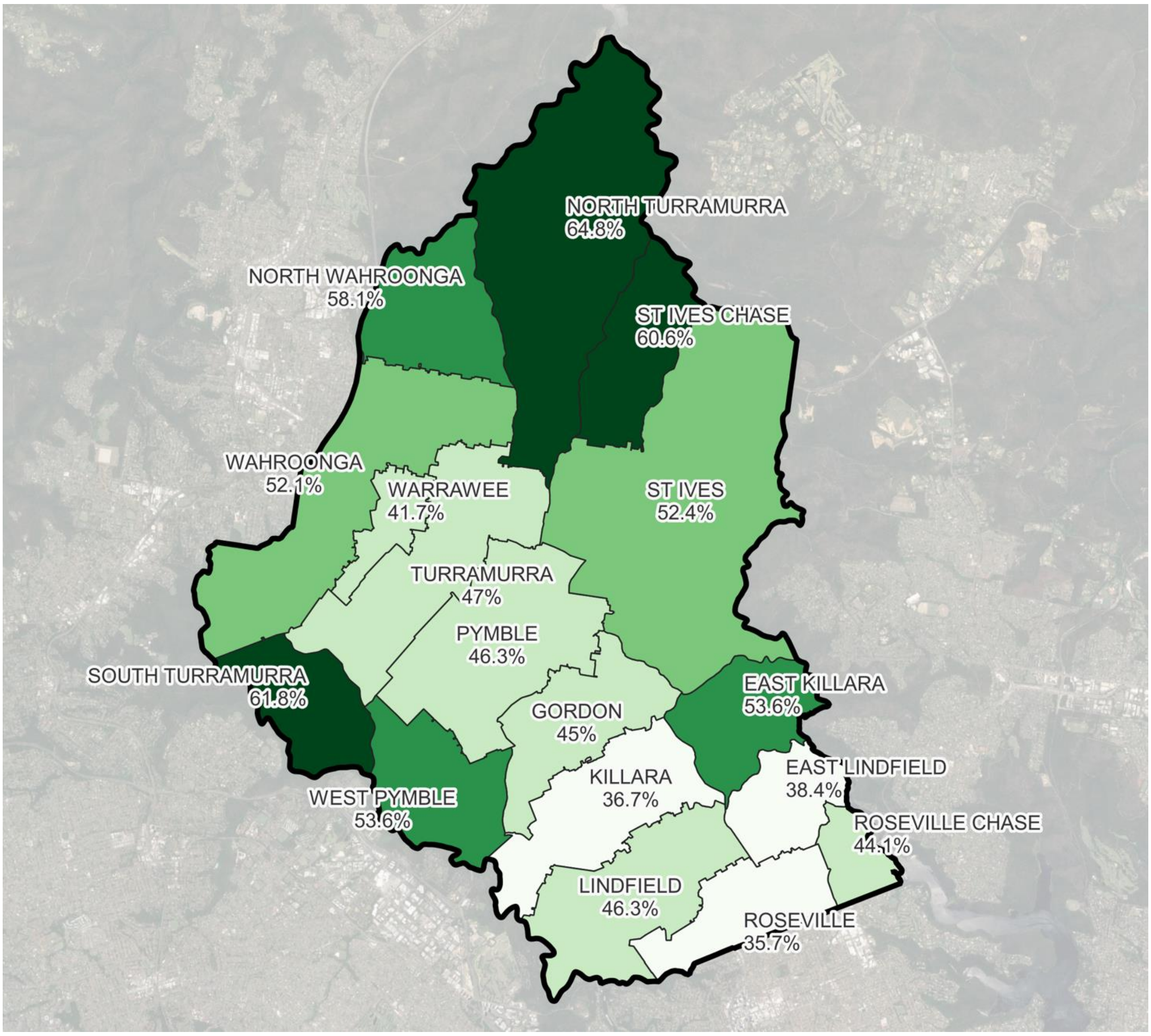


Figure 1: Thematic map showing canopy cover as a percentage of total suburb area. The darker green indicates higher relative canopy cover percentage.

The suburb with the greatest proportional canopy cover was North Turramurra (64.8%), closely followed by South Turramurra (61.8%), and St Ives Chase (60.6%) (Figure 2). North Turramurra and St Ives Chase are northern suburbs, and South Turramurra is in the south-east of Ku-ring-gai; large portions of these suburbs are National Parks and Reserves or Environmental Conservation areas. These areas, such as the Ku-ring-gai Chase National Park, are almost exclusively forest, therefore contributing significantly to canopy cover in these suburbs.

Meanwhile, Roseville had the lowest canopy cover at 35.7%, followed by Killara (36.7%) and East Lindfield (38.4%). The majority of the area in these suburbs is made up of Low Density Residential areas, with less area covered by National Parks and Reserves, Environmental Conservation and Environmental Living than other suburbs in Ku-ring-gai; they therefore have comparatively less canopy.

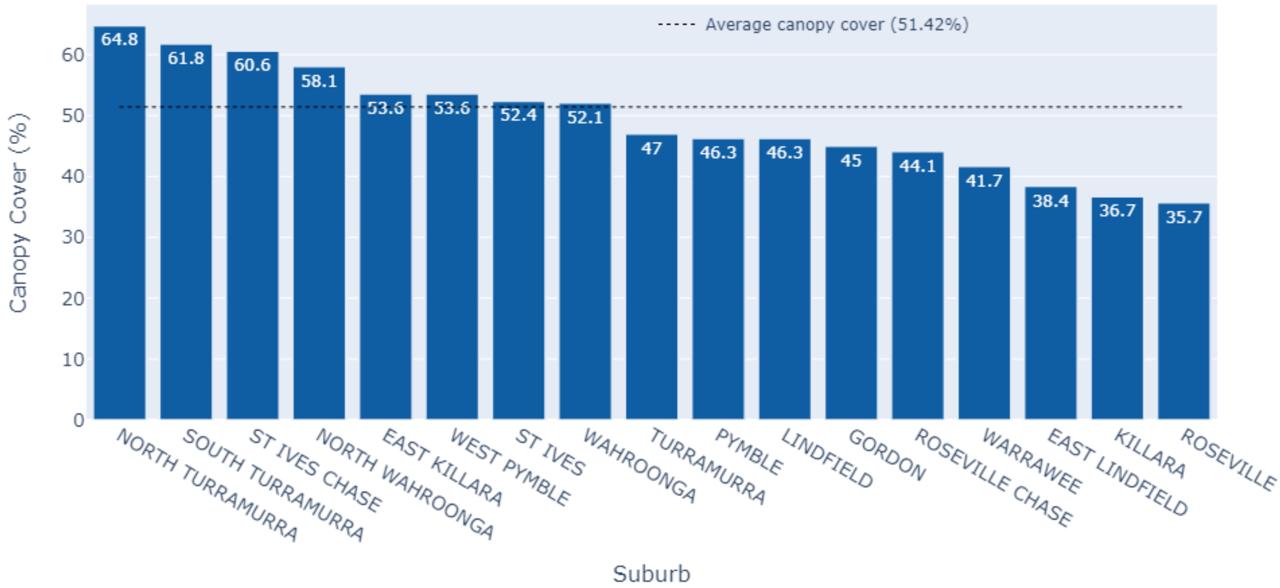


Figure 2: Canopy cover of each suburb in Ku-ring-gai Council by percentage of total suburb area.

Of the 3986.6 ha of canopy within the entire LGA boundary, just under half falls within the state and federally managed lands, such as Garigal National Park and Lane Cove National Park. Of the remaining canopy area, 33.8% lies within private land, and just 23.4% falls within land directly managed by the Ku-ring-gai Council, which includes local parks, road reserves and municipal buildings (Figure 3).

Ku-ring-gai's urban forest is in a good position relative to many other LGAs. However, the threats of climate change, pests and diseases, bushfire threat management, an aging tree population, and urban sprawl are all concerning. To maintain and improve on current levels, the Ku-ring-gai Council will still need to be active and targeted in management of the urban forest.

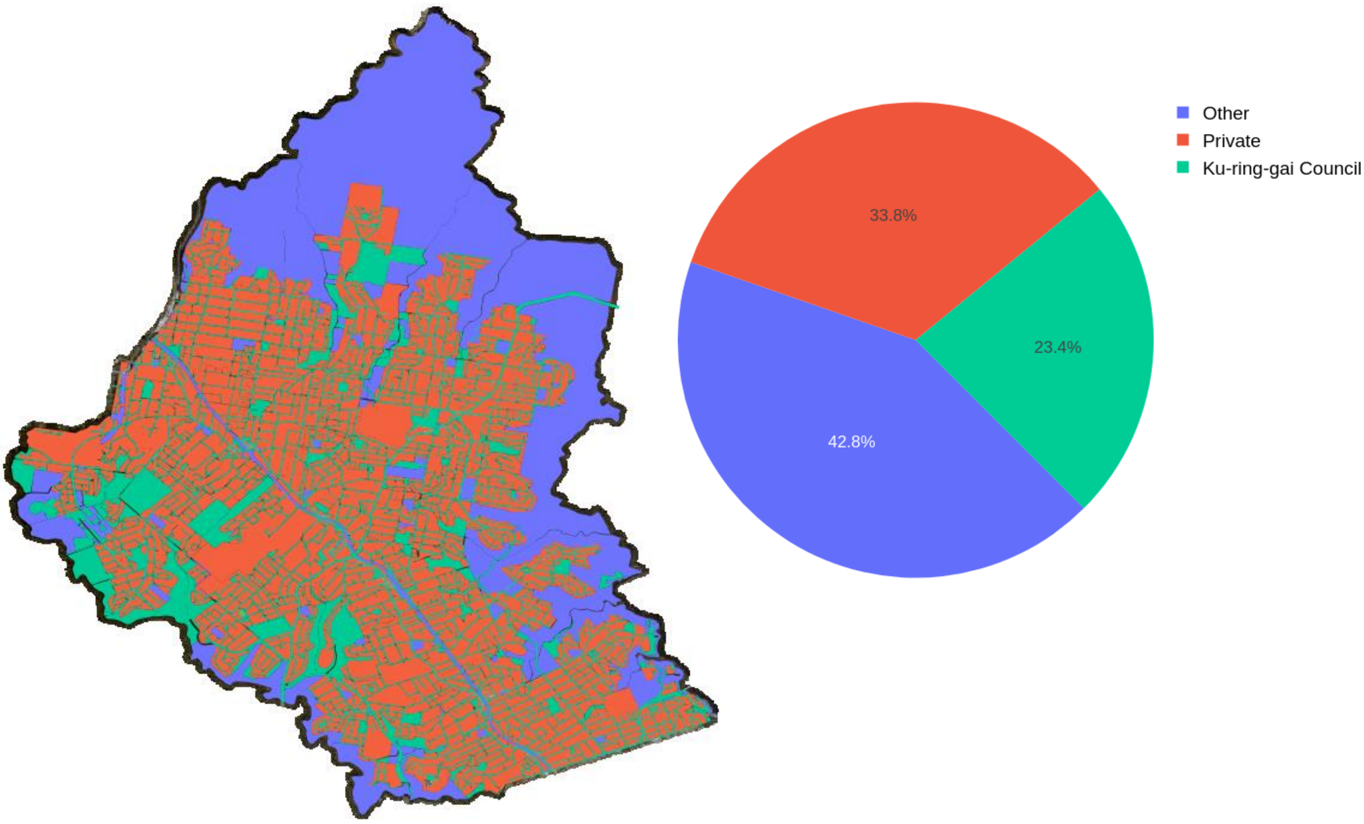


Figure 3: The Distribution of land tenure classes (left) and the proportion of Tree Canopy within Ku-ring-gai. Ku-ring-gai Council land includes council managed land including roads and road reserves. Other includes national Park, state managed lands, and all other land tenure classes.

2 Methods

2.1 Canopy Projection in Local Centres

A key objective of the Ku-ring-gai Housing Strategy is to promote liveability and mobility by providing new housing within and around the local centres, within a 10-minute walk to frequent train and bus services and cycle routes. The majority of new dwellings will be accommodated within the existing mixed use, medium density (townhouse) and high density (apartment) zoned sites which are concentrated along the Pacific Highway corridor and around the local centres of Turramurra, Gordon, Lindfield and St Ives.

Council's Housing Strategy proposes housing provision of 3,000-3,600 new dwellings over the 15-year period 2021-2036. Residual capacity within current planning controls will be supplemented by the delivery of seniors housing developments and alternative dwellings such as secondary dwellings, group homes and boarding houses where permissible.

This analysis models the effects of increasing housing density of the local centres by comparing the land parcels identified as having development potential to those which are already fully developed. The information has been sourced from the Ku-ring-gai Housing Strategy Appendix 3 - Residual Capacity Maps.

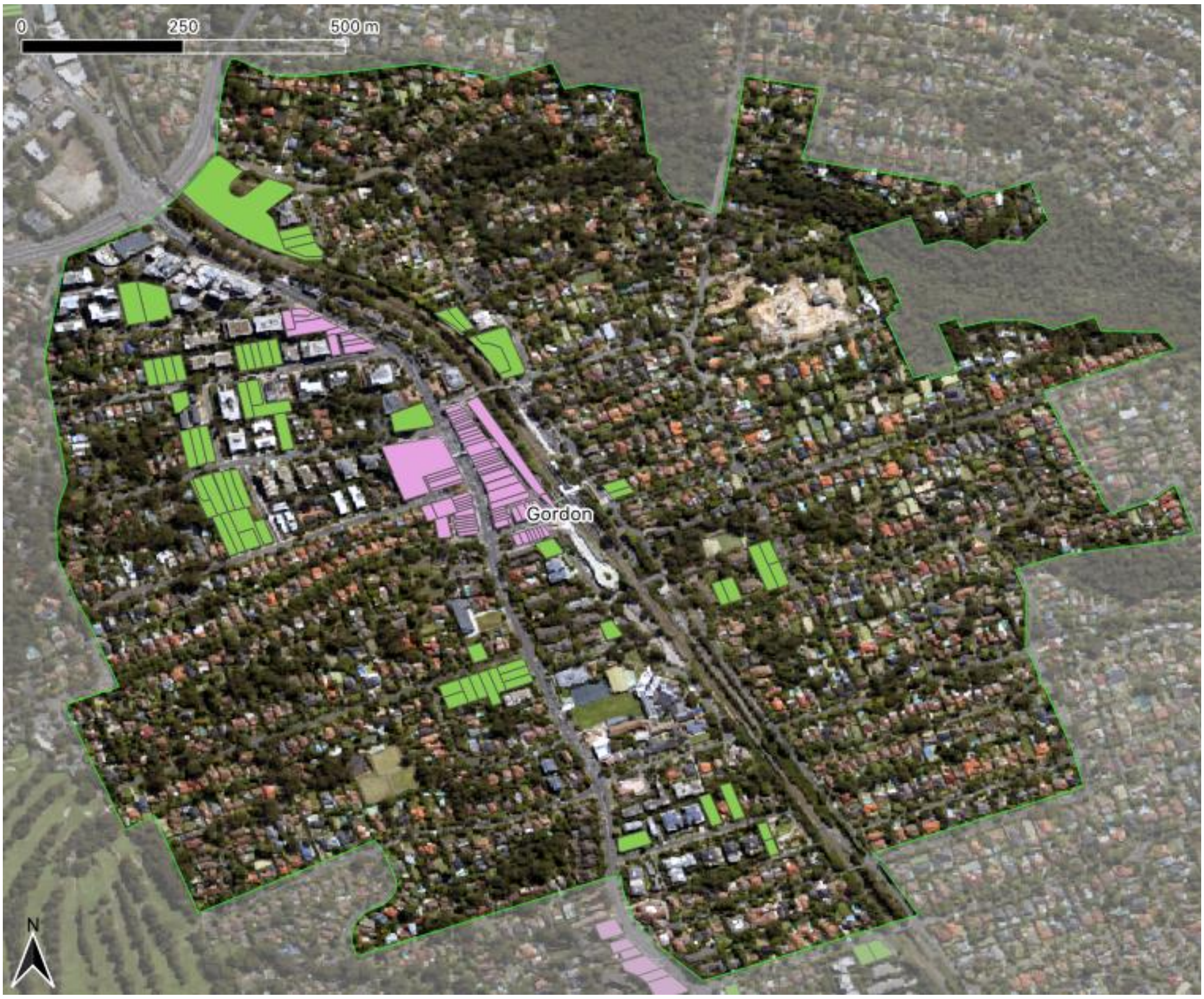


Figure 4: Gordon Local Centre. Green parcels indicate the location of undeveloped R3 and R4 zoned lots with development potential under the Ku-ring-gai LEP, the Pink areas show areas of mixed use zoned land (B2 and B4) which generally have little or no development potential (Ku-ring-gai Council 2020).

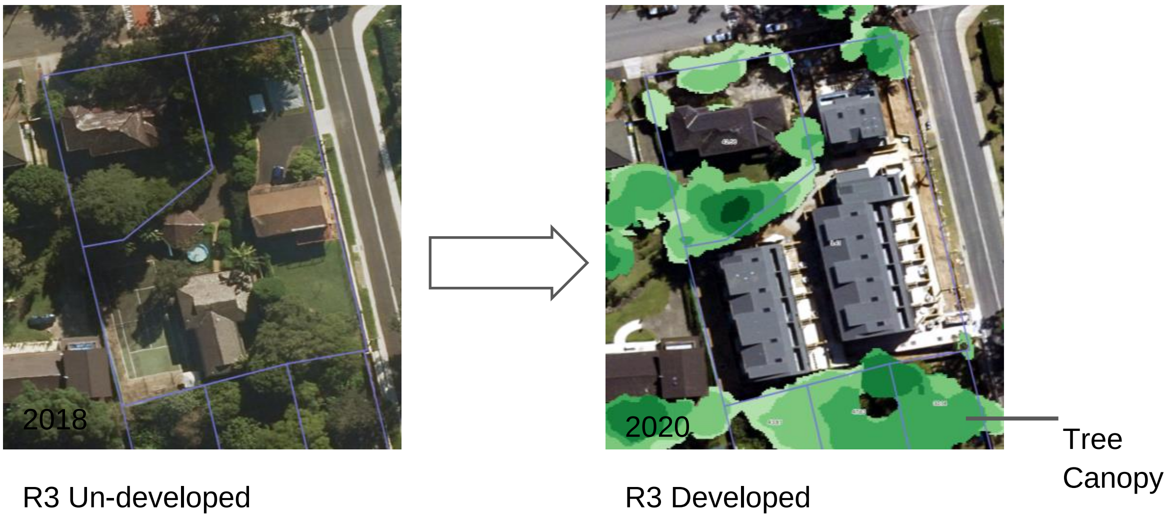


Figure 5: Aerial imagery from 2018 and 2020 of a R3 zoned lot (blue) in the Gordon Local Centre. The green shaded area in 2020 shows the extent of tree canopy >3m in height. The developed lot has a 9.4% canopy measured soon after completion of the development.

Land parcels were categorised as either fully developed or undeveloped (therefore having development potential). Developed parcels include recently developed where newly planted trees are yet to fully establish. However, in the R4 zoned parcels, the canopy cover of older developments was not substantially different from the average of all developed land. It was not always possible to establish the date of development, therefore the average canopy cover of all developed land was used. Only R3 and R4 zoned areas are considered as these areas are where the largest impacts will occur. Re-development within the B2, B4 and B5 areas have not been considered as part of this study as these areas typically have a low existing tree canopy coverage (<18% on average).

Table 1: Number of land parcels in the R3 and R4 residential zones identified as having potential for further development in the housing capacity study (Ku-ring-gai Housing Strategy: Appendix 3 - Residual Capacity Maps).

Local Centre	Number of lots			Area (ha)		
	R3	R4	Total	R3	R4	Total
Gordon	18	37	**55**	1.58	4.72	**6.30**
Killara	8	24	**32**	0.78	2.48	**3.27**
Lindfield	16	40	**56**	1.72	3.78	**5.50**
Pymble	3	28	**31**	0.50	2.76	**3.26**
Roseville	0	36	**36**	0	2.86	**2.86**
St Ives	31	36	**67**	4.31	3.80	**8.11**
Turramurra	21	24	**45**	2.46	2.46	**4.92**
Wahroonga	2	16	**18**	1.58	4.72	**2.16**

2.2 Identification of Additional Planting Spaces

An analysis of Available Planting Space (APS) was conducted across the LGA using a range of geospatial datasets produced during ArborCarbon's airborne imagery acquisition of Ku-ring-gai in 2020 and vector datasets provided by the Ku-ring-gai Council.

All possible planting spaces across the extent of Ku-ring-gai were initially calculated by spectrally classifying pixels in ArborCam imagery from 2020. Pixels with a spectral signature of vegetation (including low vigour vegetation corresponding to mostly bare patches of soil) were classified as possible APSs after excluding existing canopy (vegetation >3m). The full list of APSs across Ku-ring-gai was then filtered according to the following criteria:

- Excluded land zoned as "C1/C2" according to the "LABEL" attribute in the Council supplied zoning vector dataset.
- Excluded roads not management by "Council" according to the "Management" attribute in the Council supplied road vector dataset.
- Excluded "Private" land according to the "Owner" attribute in the Council supplied public/private land vector dataset.

- Excluded sport fields delineated in the Council supplied sport field vector dataset.
- Excluded golf courses and other sport fields absent from the Council supplied sport field vector dataset by manually delineating such areas based on their appearance in the high resolution RGB ArborCam imagery from 2020.
    - In cases when it was unclear whether a particular open grassy area was a sport field or available for planting, it was not removed from the APSs layer.
- Excluded a 3m buffer around streetlights based on the Council supplied streetlighting vector dataset:
    - The 3m buffer distance was derived from a specification in the Marrickville Street Tree Masterplan for street lighting poles. “Street lighting pole - minimum distance from pole to centre of tree trunk (unless there are other light sources to consider): 3m.”
- Excluded a 10m buffer from the intersection point between two roads, based on analysis of the Council supplied road vector datasets (Figure 6).
    - The 10m buffer distance was taken from a specification in the Marrickville Street Tree Masterplan (2014) for street intersections. “Street intersection – distance from projected line of the intersecting kerb line on approach side: 10m”. The Marrickville Plan uses a smaller spacing of 7m for the non-approach side of the street intersection. However, approach direction could not be calculated based on the data available in the roads vector, so the larger distance of 10m was used for all approach directions.
    - The accuracy of this calculation was impacted by the representation of roads in the supplied road dataset. Each road included the adjacent verge, ranging in width from a few metres up to more than 7 metres, rather than delineating the road surface alone. As such, the calculated road intersection lines did not correspond to actual intersection lines between road surfaces. To compensate for this a fixed offset of 5m was factored into the exclusion zone calculation, based on the approximate average verge width in the road layer. After taking the 5m offset into consideration, the road intersection lines in the vector dataset were buffered by 5m, corresponding on average to the full 10m exclusion zone required around intersections. This approach resolved the problems with the road dataset in most cases.
    - Adjacent road features with the same road name were merged prior to analysis, to prevent ‘artificial’ intersections being introduced along a road due to it being segmented in the dataset.
- Excluded APSs with a total area of less than $30m^2$. These were considered too small for planting, so as to keep the focus of the analysis on larger APSs with the capacity to support more planted trees.
- Excluded narrow slivers of land (less than approximately 1.5m wide) that would otherwise be suitable for planting, such as small areas of grass on the edge of a verge with an existing tree (Figure 7).

The APSs that remained after this process formed the final planting spaces vector dataset supplied to the Council.

The number of mature trees that could potentially fit in each APS was calculated for each site by determining the average crown size of trees within 100 metres of the APS. Taking into consideration the size of existing trees in the surrounding area enabled a more accurate planting count to be calculated, given the assumption that similar trees will likely be planted in the APS, assumed to grow to a similar size. To determine the average crown area of surrounding trees, a remotely sensed tree inventory survey was conducted across Ku-ring-gai (Figure 8) based on the high-resolution imagery acquired by ArborCarbon in 2020. The height stratified vegetation cover dataset, DSM and hires imagery were utilized in an artificial intelligence (AI) approach for identifying location, approximate crown width (in both north-south and east-west directions), and canopy height for every tree in Ku-ring-gai, excluding C1/C2 zoned land. This inventory was then used for the calculation of average crown area surrounding each APS, which was further used to calculate the number of trees that could potentially fit each APS. Both planting count (APC_#) and available planting area (APA_m2) are attached as attributes for each APS in the vector dataset.

While the APSs in this analysis provide useful information on planting availability across Ku-ring-gai, it is unlikely that all APSs can support as many trees as indicated, due to several other constraints on planting that were not factored. Many of these are detailed in the Marrickville Street Tree Masterplan (2014); for example, minimum planting distances are required from driveway edges, stormwater inlets, traffic lights, and cycle ways. These factors required additional data inputs that were not available at the time of analysis and thus were excluded. Overhead powerlines were also not considered and may result in the planting of a greater number of smaller trees than indicated in the APS dataset, in order to maintain vertical separation between the top of the crown and the asset. If future refinements to the APS dataset is required, the Ku-ring-gai Council may wish to develop its own unique specifications for minimum planting distance between new trees and other assets that reflects the context of Ku-ring-gai.

A limitation of the current analysis is the inability to differentiate between shrubs/other vegetation <3m tall and grass within the APSs. While some of this non-grass vegetation could possibly be replaced with canopy, some also corresponds to juvenile trees that will later grow into canopy. Without planting data, such as species and planting date, differentiation between these categories remains a challenging task. One approach for overcoming this limitation is the development of an additional height stratum for grass only, then excluding all other existing vegetation (including shrubs and low vegetation <3m tall) from APSs.

Figure 6: Exclusion zones (black hatched) around road boundary (blue) intersections used to exclude available planting spaces (APS; red) from within 10m of projected line of the intersecting kerb line. Note the offset between road intersection line in exclusion zone and the actual road surface intersection.

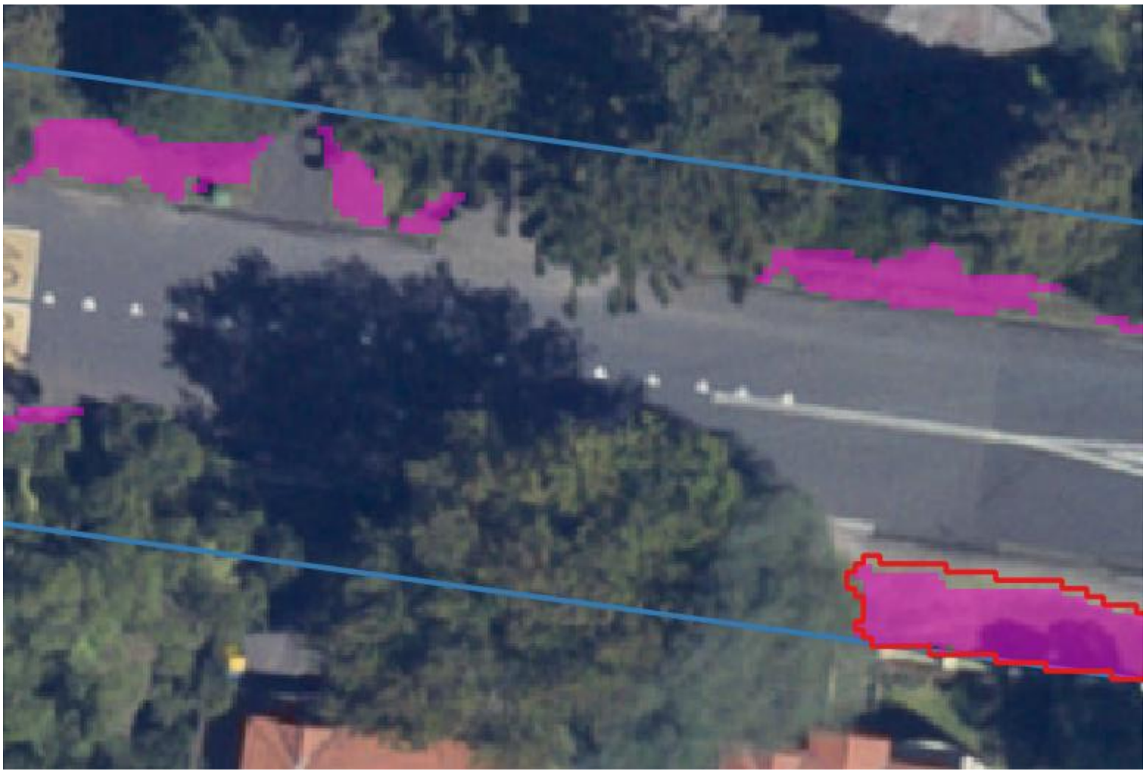


Figure 7: Narrow slivers of potential planting space (purple) excluded from final available planting space (APS) dataset (red) due to being too narrow to support additional trees, with road boundaries (blue) as an overlay.

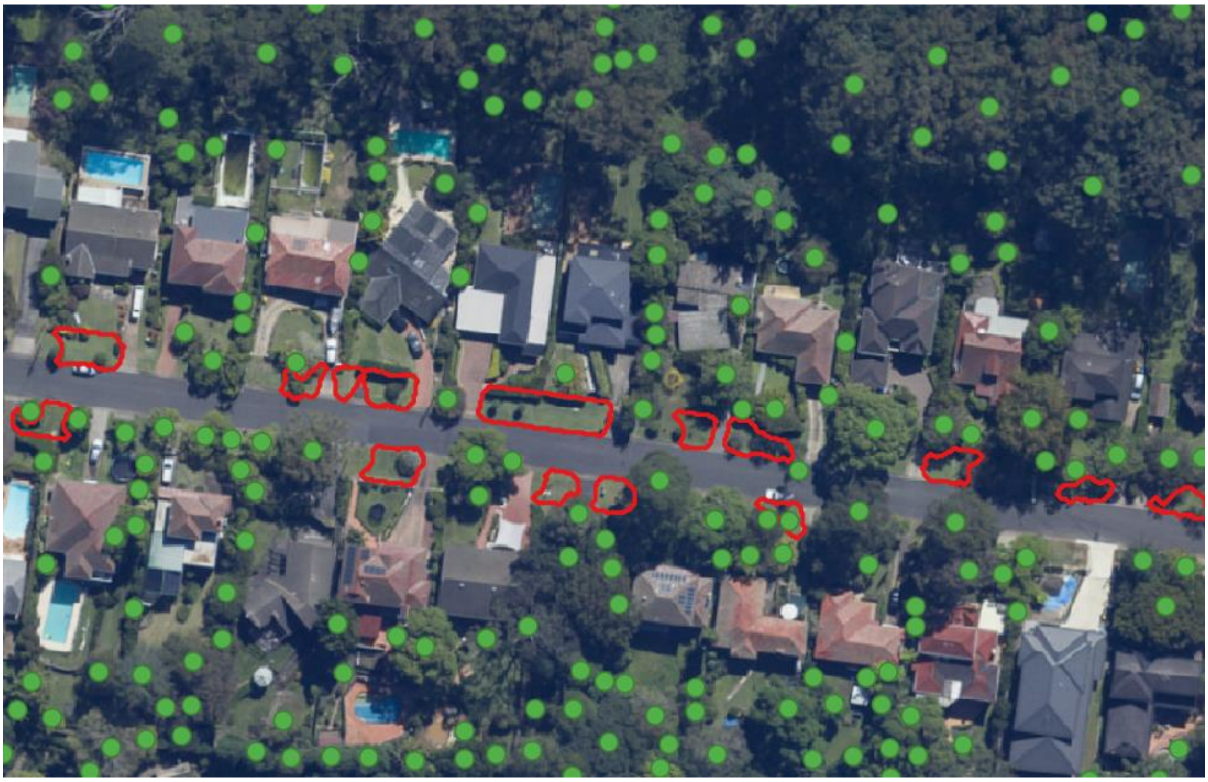


Figure 8: Remotely sensed tree inventory points (green) surrounding available planting spaces (APSs; red). Each inventory point has an associated crown area, with the mean crown area of inventory points within 100m of each APS used to calculate the number of trees that can be planted in the APS.

2.3 Shade Modelling of Existing and Proposed Cycle Routes

Shade modelling over cycle routes was conducted across the Ku-ring-gai using a Digital Surface Model (DSM; 70cm GSD) produced from high-resolution airborne imagery acquired by ArborCarbon for the Ku-ring-gai Council in 2020 for the purposes of canopy mapping (ArborCarbon 2020).

Consolidation of the proposed and existing cycle route vector datasets supplied by the Ku-ring-gai Council was undertaken prior to shade modelling (Figure 9). Where the proposed and existing cycle routes were within 20 metres of each other, the proposed cycle route was discarded and the existing route kept, to reduce redundant data outputs.

Cycle routes were split at suburb and Local Centre boundaries to increase granularity and assist with management (**Error! Reference source not found.**). The remainder of the LGA area outside Local Centre boundaries was called the "Suburban Area" for the purpose of this analysis. Long cycle routes within the same suburb and Local Centre were also split into segments at vertices with a target maximum length of approximately 500 metres, also to assist with management. The length of each segment was stored as an attribute in the vector dataset, along with the suburb and Local Centre the segment was part of, the status of the cycle way (proposed or existing, according to the Council-supplied vector file the segment belonged to), and the type of cycleway (for example, on road, shared footway, etc.). Prior to shade modelling, each cycleway line was buffered by 10 metres in each direction to produce a polygon corresponding approximately to the road area of the cycleway. This ensured the actual cycleway was included in the analysis in the case of misaligned geometries in the cycleway datasets.

The quantity of shade cast on the prepared cycle routes was modelled for between 3:00pm and 6:00pm AEDT on 21st December (the longest day of the year). This time was selected as it corresponds to both the hottest part of the day and the peak of afternoon commuter activity. The shade modelling methodology utilised the theoretical position of the sun and calculated a percentage shade value for each pixel in the cycle route by intersecting solar rays with features (man-made and natural) in the DSM (Figure 10). Pixels corresponding to canopy in the DSM (according to the height-stratified vegetation layer delivered to the Ku-ring-gai Council by ArborCarbon in 2020) were considered to be completely in shadow for the duration of the time window. Mean percentage shade values were calculated for each feature in the cycle route and appended as an attribute in the vector dataset.

While the high resolution of the DSM resulted in an accurate shade model, the relationship between the modelled shade percentage and the amount of shade physically present along the cycle route was limited by the accuracy of the vector dataset representing the cycle routes. The key limitation was the representation of cycle routes by line-string geometries, rather than polygon geometries delineating the full width of the cycleway. Furthermore, the position of the line-string in relation to adjacent roads varied, with some cycle routes crossing roads (particularly at road bends) rather than running parallel to the road as expected (Figure 11). While the 10m buffer applied to either side of the route ensured the actual cycleway was contained in the analysis, adjacent features – such as verges, private property, and buildings – were also included in the final percentage for many segments.

Figure 9: Duplicate cycle route appearing in both the existing (green) and proposed (blue) cycle route vector datasets supplied by the Council prior to consolidation to a single cycle route to simplify analysis and management.

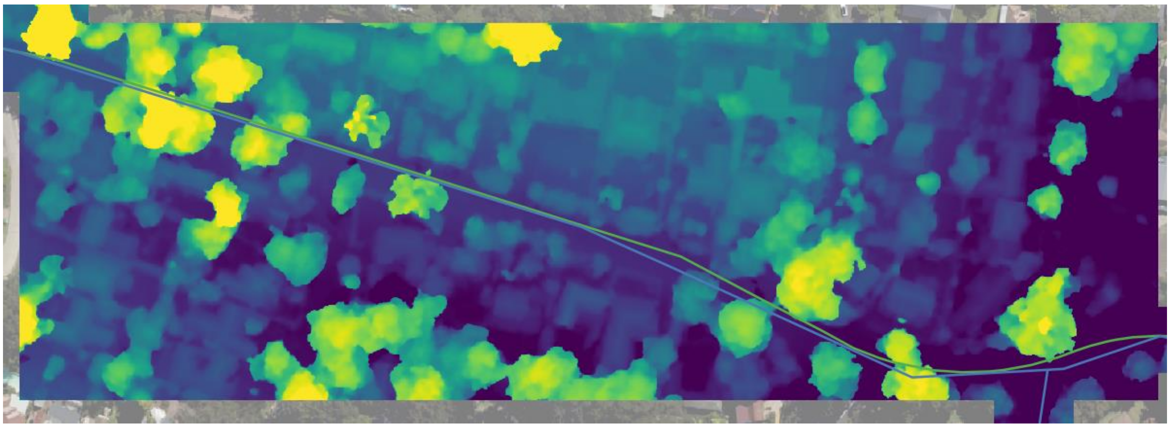


Figure 10: Section of Digital Surface Model (DSM) used for shade modelling along cycle routes showing the height of surface features from low (dark purple) to high (yellow) with proposed (blue) and existing (green) cycle routes prior to consolidation as an overlay.

Figure 11: Inaccuracies in cycle route vector dataset (orange line), with route on the far eastern side of the road in the north of the scene and along the centre of the road toward the south of the scene. The buffered 10m boundary used for shade modelling analysis is shown in a black hatched pattern.

3 Results and Discussion

3.1 Canopy Projection in Local Centres

Comparison of current canopy cover on developed and undeveloped parcels revealed that undeveloped R3 and R4 parcels have similar canopy cover as the fully developed R2 parcels, ranging from 36.5 to 39.3% canopy cover (Figure 12). Developed parcels in R4 have 35% canopy cover, a similar proportion to R2 parcels. In contrast, proportional canopy cover considerably decreases on R3 zoned land following development (26%).

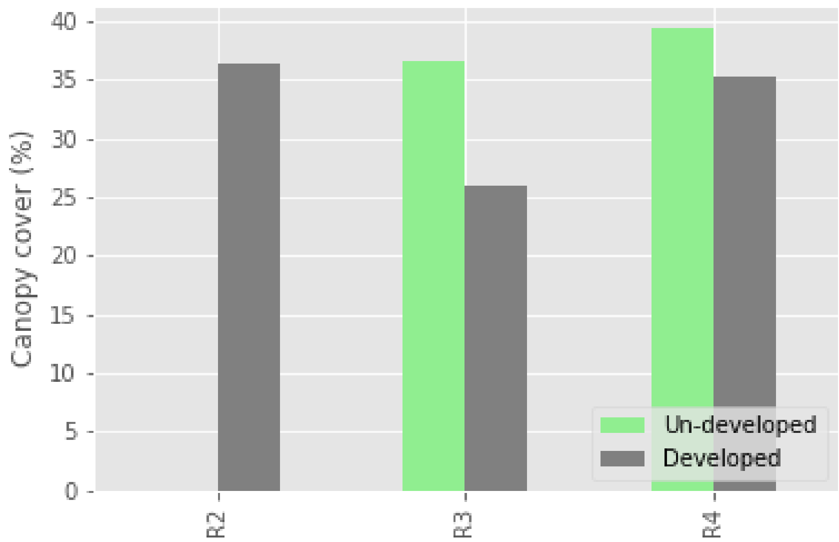


Figure 12: Comparison of canopy cover on developed and undeveloped residential areas within Ku-ring-gai Local Centres.

This suggests that future development uptake within R3 zoning is likely to result in a net reduction in canopy cover within the LGA, particularly within the local centres. The reason for this is possibly an effect of the reduced deep soil requirements within and greater maximum building footprint permitted within R3 areas compared with R4. However, many of the R3 developments within the LGA have only been developed within the last 10 years, therefore the median age of R3 developments is less than that of R4 developments which may also contribute to the observed reduction in tree canopy cover in the R3 zones.

Projecting these canopy cover reductions across all un-developed lots within the LGA is expected to have only a minimal impact on total canopy cover (Figure 13A). This is not unexpected, given the short timeframe considered (5 years). In terms of change in canopy area (Figure 13 B), Turramurra Local Centre is projected to lose the most canopy area (approximately 7000m^2), while Roseville Local Centre is projected to lose the least (less than 1000m^2). Gordon Local Centre is projected to gain approximately 1150m^2 of canopy. The predicted canopy change appears more closely related to the current canopy cover than the number of undeveloped lots within each Local Centre. The most significant losses are expected in Pymble and Turramurra. These Local Centres have the greatest current canopy cover (both over 40% canopy; Figure 14). Conversely, Gordon Local Centre is predicted to increase in overall canopy cover, because the current canopy cover in the undeveloped lots is below the LGA average for these lots post-developed.

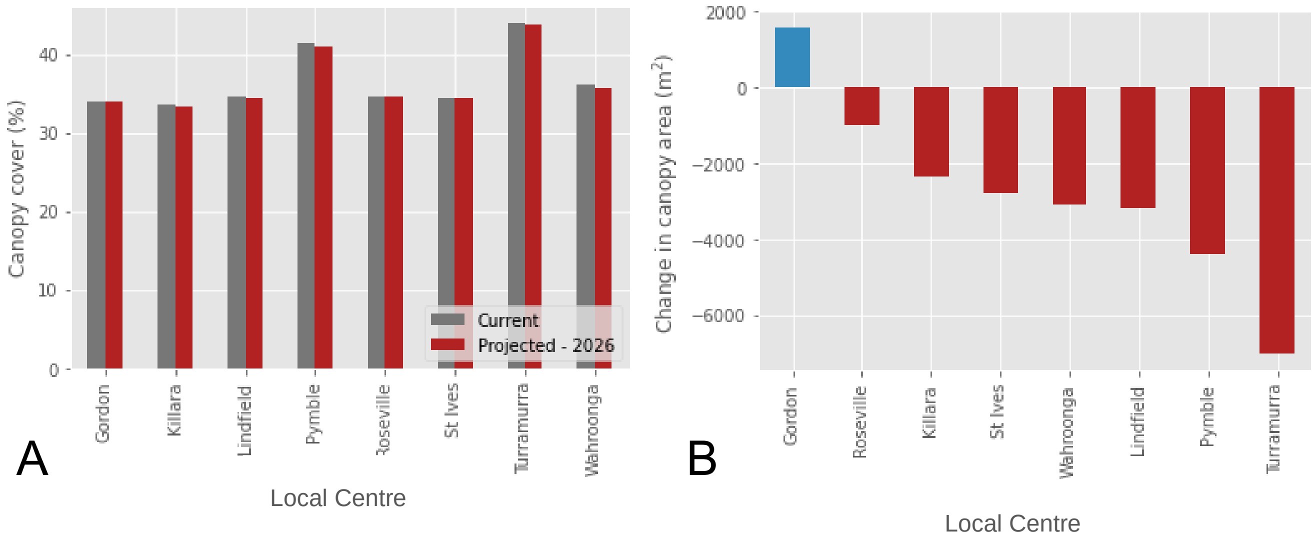


Figure 13: A) Current and projected canopy cover (%) in each Local Centre, and B) Projected loss of Canopy area (m2) in order of increasing canopy loss.

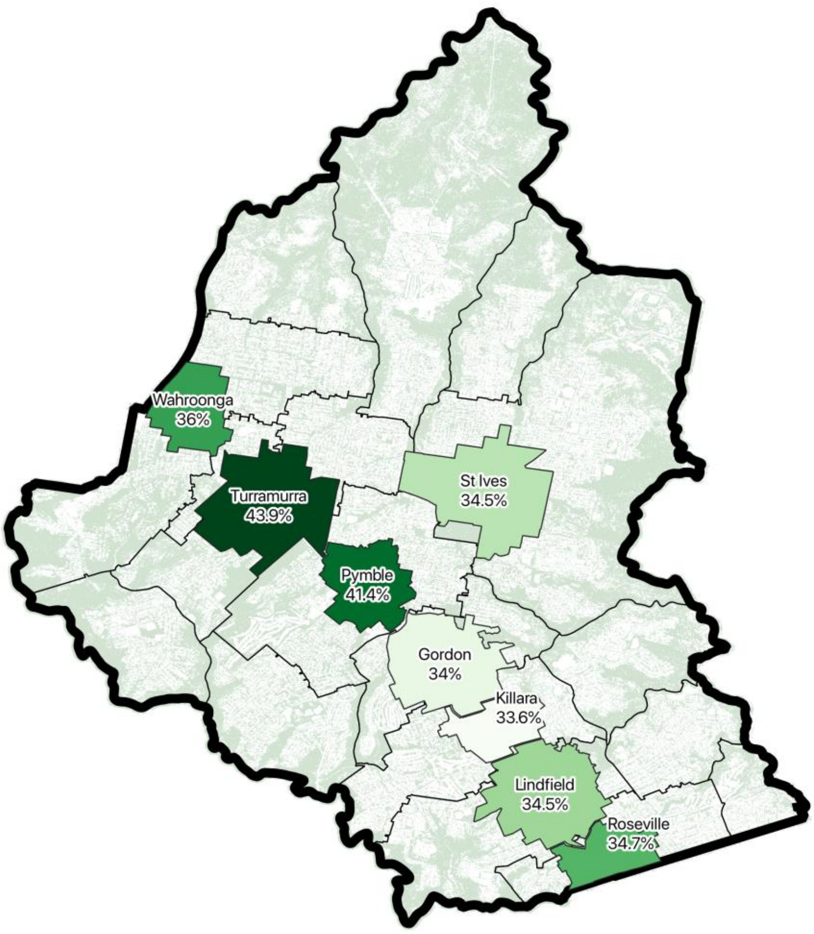


Figure 14: Ku-ring-gai Council area showing the canopy cover proportion within each of the Local Centres

Case Study

154 Mona Vale Rd, St Ives

Seniors Living

Development date:	2005 - 2007
Lot size:	3753 m^2
Dwelling number:	12
Building footprint:	37 %
Canopy cover (2020):	22.4 %

Development controls for Seniors Living developments are defined by the State Environmental Planning Policy (Seniors Living) 2004.

Seniors Living: Self-contained dwellings, are permitted a maximum building footprint of 50% and a minimum landscaped area of 30%, at least 15% must be reserved as a deep-soil zone.

154 Mona Vale Rd was developed between 2005 and 2007. Examination of the historical imagery below shows that a number of mature trees were retained during development, although not all persist to the present day. subsequent landscaping has favored smaller trees and shrubs. Front and rear setbacks of 10m have not been landscaped with tall trees, with the rear garden area prioritising turf to capitalise on views over the adjacent golf course. Buffers of 3.5m between adjacent building have been planted with large hedging plants to provide privacy between building, which contribute to the canopy cover figure, but the space does not permit tall trees.
The main building footprint covers 37% of the lot, well under the maximum allowed within the SEPP.

2005

2007

2020

Case Study

2-8 Burleigh St, Lindfield

R4 – High Density Residential

2008

2021

Development date:	2005 - 2007
Lot size:	2790 m^2
Dwelling number:	31
Building footprint:	30 %
Canopy cover (2020):	40.3 %

Development controls within the R4 – High density residential zones are outlined within Ku-Ring-Gai DCP Section A Part 7: Residential Flat Buildings.

The plans have multiple objectives to regulate the impacts of development on the natural landscape character of the LGA, including building setbacks, the provision of deep soil zones, and requirements for the landscaped areas.

Residential flat building can have a maximum site coverage of 30%, with a further 40-50% (depending on lot size) of the remaining area dedicated as a Deep Soil zone to support tall trees and vegetation.

2-8 Burleigh Street was developed between 2005 and 2007. Examination of the historical imagery from 2007 shows that few trees were retained during development. Street front setback of 10-15m and 5m between adjacent properties result in large open areas of landscaping which accommodate large trees and shrubs. The main building footprint covers 30% of the lot, in line with the DCP requirements. Larger trees have been planed along the Pacific Hwy side which effectively screen the building from the main road.

2005

2007

2020

Case Study

6 Shinfield Avenue, St Ives

R3 – Medium Density Residential

2009

2020

Development date: 2012
Lot size: 1943 m^2
Dwelling number: 11
Building footprint: 39 %
Canopy cover (2020): 24.6 %

Development controls within the R3 – Medium density residential zones are outlined within Ku-Ring-Gai DCP Section A Part 6: Multi-Dwelling-Housing

Multi dwelling housing can have a maximum site coverage of 40%, with another 40% dedicated as a Deep Soil zone to support tall trees and vegetation.

Townhouse Development at 6 Shinfield Avenue was completed during 2012. Eight years after development canopy cover has reached 24.6% of the lot, although a significant portion of this appears to originate from the overhanging crowns from adjacent properties. Street front setback of 12m has been planted mainly with low shrubs and hedging. A setback of 3m between adjacent properties provides a strip of landscaping area to support trees and shrubs, which are yet to reach maturity. A further 3 to 4 meters of outdoor living area is provided, but this is largely unplanted and sits above basement-level parking. The main building footprint covers 39% of the lot, in line with the DCP requirements. A 6m rear setback, when combined with that of the adjacent property, provides a space to support larger tree growth.

2005

2020

2020

3.2 Identification of Additional Planting Spaces

Figure 15 shows an example of the Additional Planting Spaces (APS) dataset. The majority of APS identified in the analysis is verges and parks. The example shows a number of APS identified on verges on Montah Avenue and Rosebery Road in Killara. Many verges have space available for planting, as indicated by the red outline. Several verges do not have a tree planted and have space available to accommodate one or two trees (indicated by the number). The dotted blue line represents overhead distribution power lines, as observed in the aerial imagery. Powerlines were not accounted for in this analysis due to a lack of available data, and this is a limitation of the dataset, as they will affect the size of tree that could be established. In addition to verges, available planting space was identified in Quarry Masons Reserve. The Reserve consists of mature trees and a small section of open turf, which could accommodate eight trees. However, the analysis does not consider other competing land uses, such as recreation. As such, APS will require on-ground evaluation to determine their suitability prior to planting.

Figure 15: Example of APS dataset, showing identified APS in red, and the number of trees that could fit in the available space (label). Overhead power distribution lines observed in the aerial imagery is illustrated as a dotted blue line.

1.1.1 Tree Planting Capacity

The total number of trees able to be planted was also calculated for each Local Centre (Figure 16) and suburb (Figure 17) by aggregating the number of trees for every APS within the suburb or Local Centre boundary. Lindfield and Gordon had the capacity for the greatest number of tree plantings (941 and 865, respectively). Roseville had the fewest planting opportunities (233). Assuming an average tree area, calculated to be 69.5m^2, the potential canopy increase from planting these spaces is 6.54 ha in Lindfield and 1.62ha in Roseville

At the suburb level, St Ives had by far the most capacity for new tree plantings (5552) translating to 38.6 ha of additional canopy, compared to 390 in North Wahroonga (2.7 ha of canopy).

These additional planting spaces are likely to be sufficient to offset the expected losses due to residential development presented above. For example, the greatest loss is expected in Turramurra, of 7000m^2 (0.7ha) of canopy. The potential for canopy increase in Turramurra by planting APS is 5.68 ha.

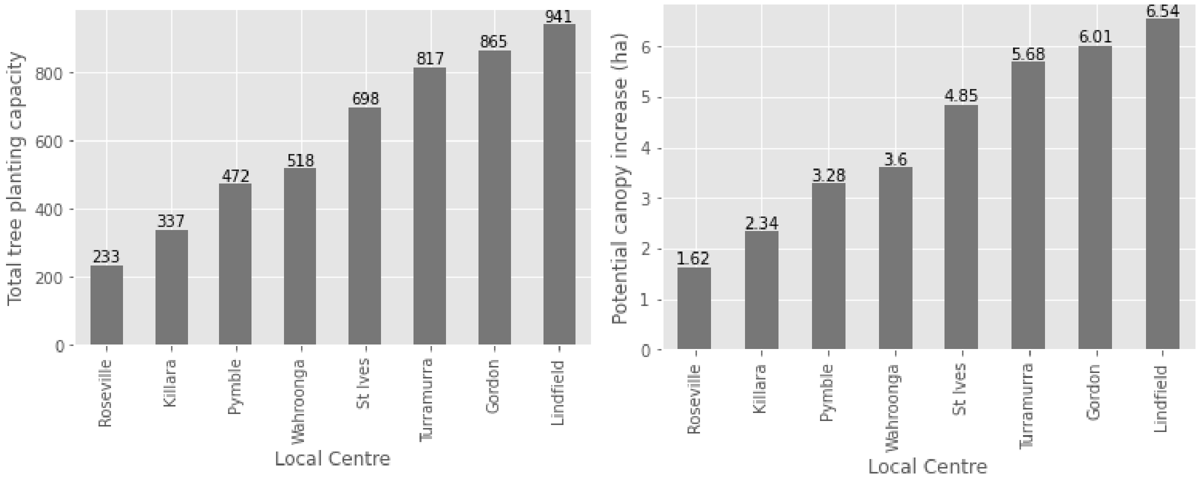


Figure 16: Total tree planting capacity across all available planting spaces in each Local Centre (left). The potential canopy increase from planting each APS with a tree with mean diameter of 69.5m^2 (right).

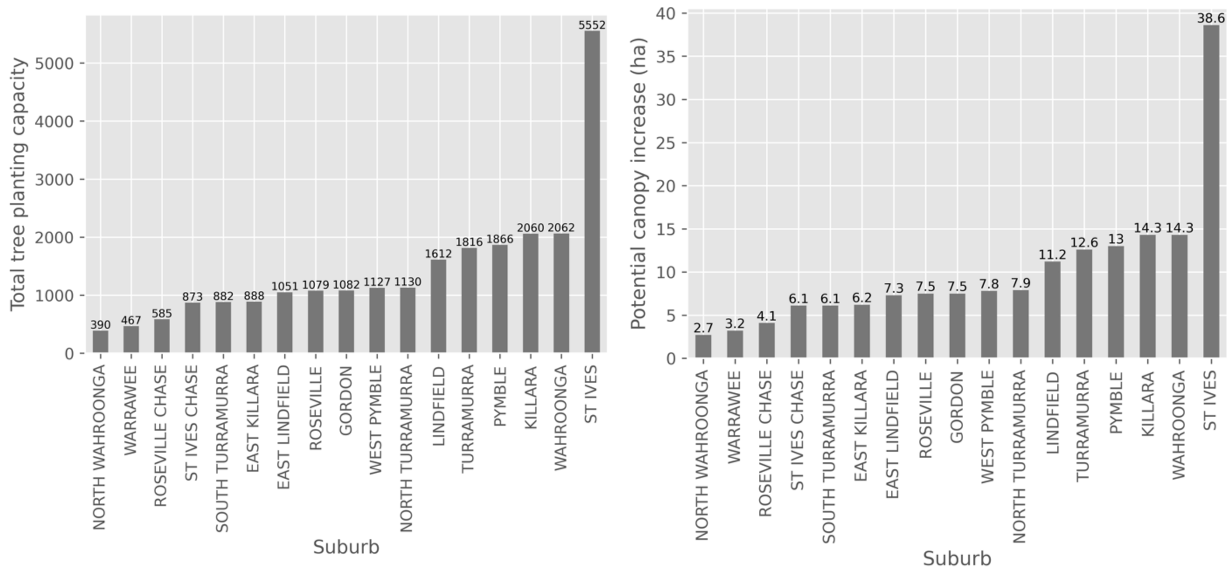


Figure 17: Total tree planting capacity across all available planting spaces in each suburb. (left). The potential canopy increase from planting each APS with a tree with mean diameter of 69.5m^2 (right).

1.1.2 Available Planting Area and Existing Canopy

A more detailed analysis comparing existing canopy (as a percentage of boundary area) and available planting area (APA; as a percentage of boundary area) was conducted for suburbs.

In general, suburbs with the highest current canopy cover, are also those with the lowest area available for additional tree planting (Figure 18). For example, North Turramurra had the highest existing canopy cover percentage and the second lowest APA percentage. Roseville had the lowest existing canopy cover percentage and one of the higher APA percentages.

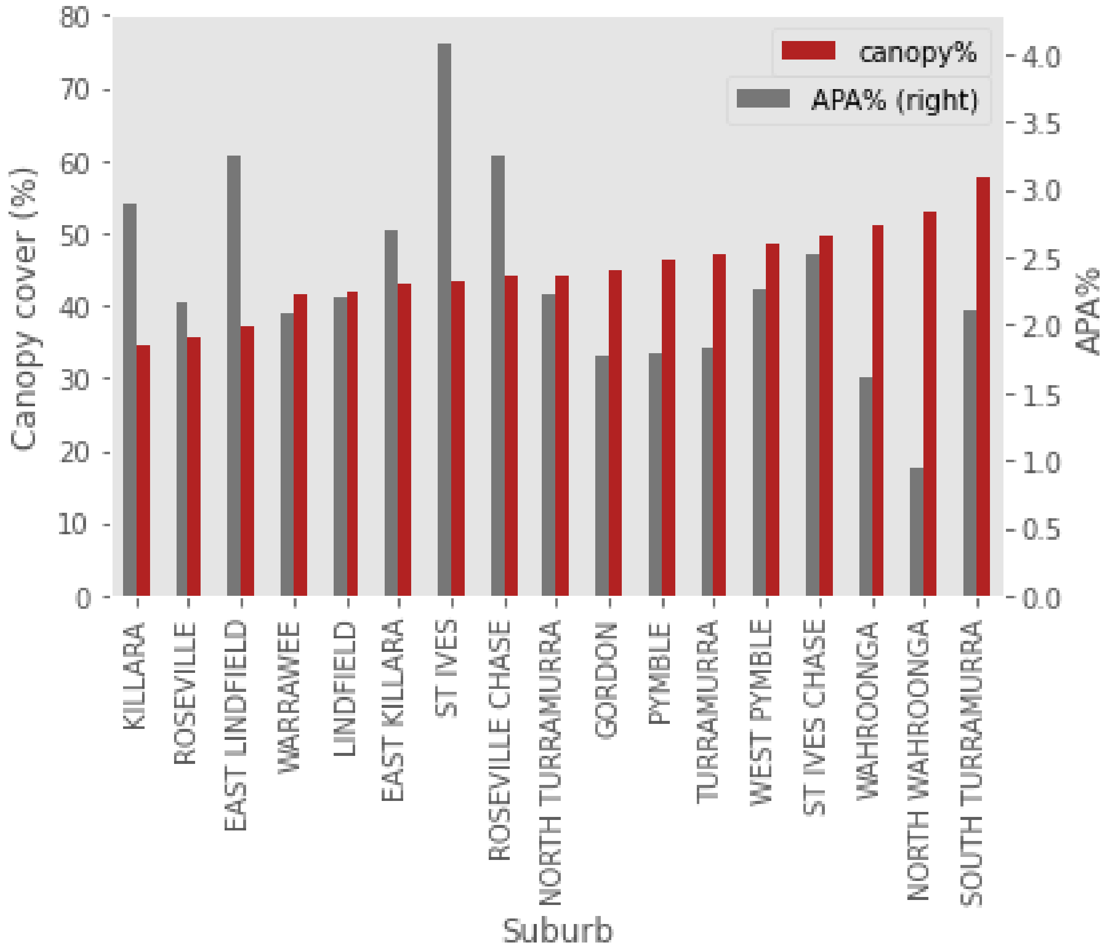


Figure 18: Existing canopy cover as a percentage of total suburb area (red) and available planting area (APA) as a percentage of suburb area (grey) for each suburb in the urban area Ku-Ring-Gai LGA.

This correlation between canopy cover and APA quantifies the decreasing opportunity to increase canopy cover in areas that already have high canopy cover. This data can be used to target suburbs with the greatest planting opportunity, helping the Ku-ring-gai Council achieve its overall objective of increasing LGA-wide canopy.

3.3 Shade Modelling of Existing and Proposed Cycle Routes

The results of the shade modelling demonstrate that shade cover over current and proposed cycle routes varies from 0% (full sun) on some sections to 100% (full shade) on others (Figure 19). In general, sections of cycle routes that pass through environmental conservation areas tend to have a high proportion of shade cover, while cycle routes that are part of major highways and main roads tend to have lower shade cover.

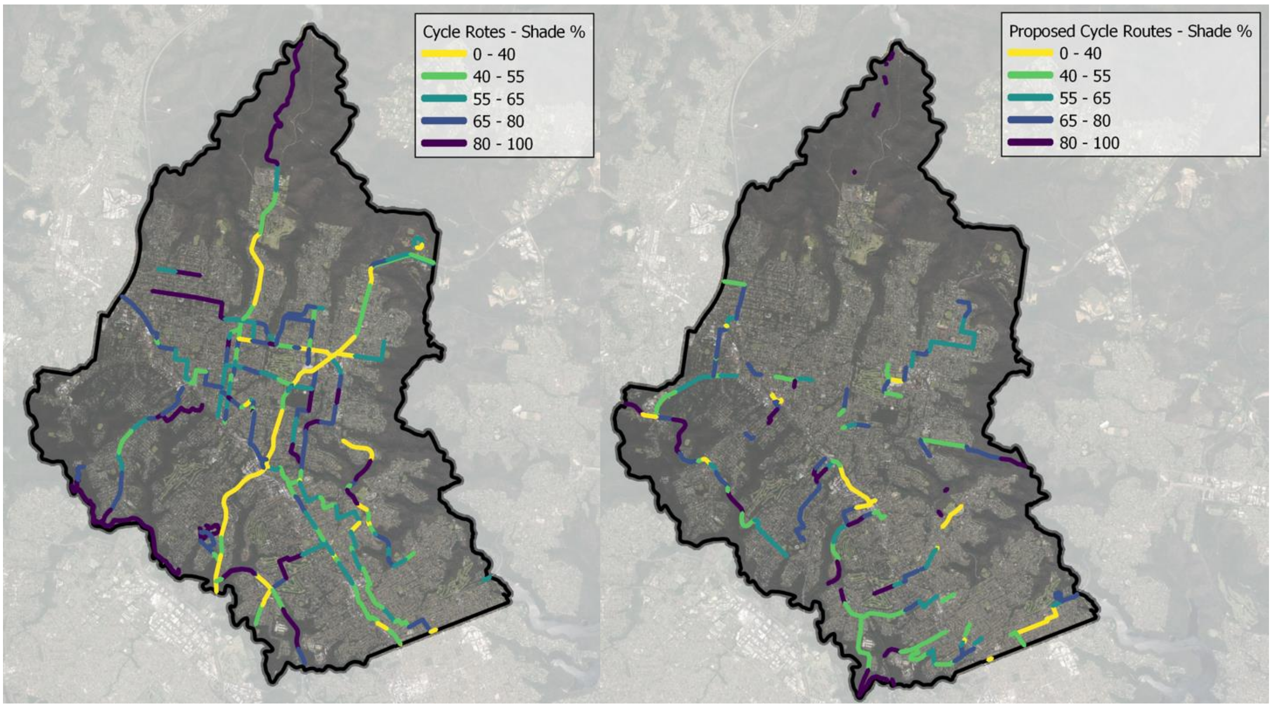


Figure 19: Cycle routes (left) and proposed cycle routes (right) divided into approximately 500m segments and coloured according to average proportional shade cover between 3 and 6pm on the 21st December.

There is 138km of proposed and existing cycle routes throughout the Ku-ring-gai LGA. In general, they are well shaded – approximately 120km of these routes have 40% or more shade cover during the time period analysed. Routes with less than 40% shade cover were generally sections of main roads, such as parts of Ryde Road, Pacific Highway and Mona Vale Road in Pymble, Gordon and West Pymble. These are state owned arterial roads, with high traffic and multiple lanes. Planting large trees along these roads to create additional shade is restricted due to land ownership and lack of suitable space. A number of sections of regional roads, such as Bobbin Head Road in North Turramurra and Eastern Arterial Road in St Ives, have less than 40% shade cover. Increasing shade on these routes will be challenging due to competition with infrastructure. Both roads have overhead distribution power lines, restricting the location and height of trees that can be planted underneath. This is a particular issue on Bobbin Head Road, where the distribution lines on are on the western side of the road, therefore limiting the number and position of tall trees that provide the most shade from afternoon sun. However, verge side parking is permitted along sections of Bobbin Head Road. Establishing tall trees in a number of the available parking spaces along the length of the road presents an opportunity to increase shade on this cycle route. Existing and proposed cycle routes that are positioned along local roads tend to have more than 40% shade cover. However, there are a number of sections that have less. For example, sections of the proposed on-road cycle route through Roseville Chase long Addison Avenue, Allan Street and Warrane Avenue have less than 25% shade cover. These streets are further examples of cycle routes with low potential for increased tree cover, due to low overhead distribution power lines and narrow verge space available for additional planting.

Case Study

Ryde Road

Proposed Cycle Route

Suburb:	Pymble, West Pymble and Gordon
Status:	Proposed
Road Ownership:	State
Average shade cover:	19%

Ryde Road is a six-lane arterial road that forms part of Sydney's A3. It begins where it intersects with Pacific Highway, between Pymble and Gordon Town Centres. It extends south to the border of Ku-ring-gai Council, where it becomes Lane Cove Road. Across the Pacific Highway Intersection, it becomes Mona Vale Road.

The beginning of the proposed Ryde Road cycle route will be situated in between Pymble and Gordon Town Centres, the land on either side classified as mixed business and residential use, or solely for business. On the northern side, in Pymble, recent multiple story business development has resulted in the loss of shade providing mature trees near to the road edge. The majority of the remainder of the route is through Low Density Residential areas on either side, as well as some National Park and Environmental Conservation land.

Increasing shade cover for the proposed cycle route on this road will be difficult. There appears to be limited sections of verge that could be planted with a practical and suitable variety of tree, as well as a reasonable sized median strip in sections of the road. However, planting in such locations presents a variety of safety concerns. It's important to consider potential planting locations like this on a site-by-site basis.

Shade cast by trees adjacent to Ryde Road, from high (purple) to low (yellow).

Case Study

Killeaton Street

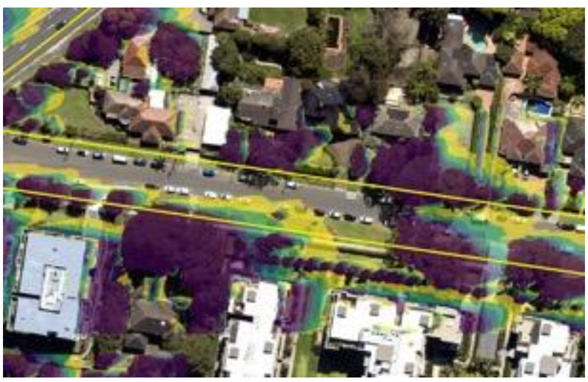
Existing and Proposed Cycle Route

Suburb:	St Ives
Status:	Existing and Proposed
Road Ownership:	Local
Average shade cover:	37%

Killeaton Street is a local street in the suburb of St Ives. A large portion of the street is within the St Ives Town Centre. The proposed cycle route along Killeaton Street (eastern portion) will intersect with Mona Vale Road, before joining an existing shared footpath cycle route on Link Road and the western portion of Killeaton Street.

The existing and proposed cycle route along Killeaton Street begins in the east, on the edge of the Garigal National Park and near Acron Oval. It extends along Killeaton Street, through the intersection with Mona Vale Road, until the street becomes Sandford Road, finally intersecting with a cycle route on Bannockburn Road.

Most of the land on either side of this street is classed as low density residential, as well as some high and medium density residential around the intersection with Mona Vale Road. Most of the road is single lane, with wide verges between property and road edge. There is a significant proportion of verge area along Killeaton Street currently without trees, that would accommodate a large shade providing tree. Whether the proposed cycle way will be on the footpath or on the road, increased verge planting will increase shade for both.



Shade cast by trees adjacent to Ryde Road, from high (purple) to low (yellow).

3.4 Storm Damage Mapping

In November 2019, a severe storm swept through parts of greater Sydney, including Ku-ring-gai. The storm caused damage to trees and property throughout the LGA, but particularly around Pymble and Gordon, where the majority of NSW State Emergency Services calls were received. The storm caused loss of tree limbs and collapse of entire trees in parts of the LGA, as well as significant defoliation. Several months after this extreme weather event, in March 2020, aerial imagery was captured as part of the *Ku-ring-gai Urban Forest Monitoring – an Aerial Measurement of Vegetation Cover* report. The report quantified vegetation cover, and these measurements are being used to inform the strategy of baseline vegetation and canopy cover. In addition, the data is being used to develop future canopy projections and targets.

There is concern that the baseline vegetation and canopy values may be underestimated, as trees may not have regained their entire canopy of foliage back by the time of the data acquisition. Ku-ring-gai Council requested that the effects of the storm on canopy be considered when developing canopy targets and projections based on the baseline data acquired in March 2020. The first step of this is to estimate the amount of canopy 'missing'. Unfortunately, the data available does not permit adequate estimation, and this analysis is more likely to introduce error to the overall canopy estimates. The imagery acquired most recently prior to the storm was acquired while deciduous trees were naturally without foliage. This was going to be compared to the imagery acquired after the storm, to determine net difference. However, it would be difficult to differentiate between seasonal lack of foliage and lack of foliage due to the storm. In addition, due to differences in acquisition technology and processing method, the two sets of imagery do not align. This can be overcome but was considered likely to introduce errors larger than the effects of storm damage itself.

It was therefore agreed to not pursue this analysis.

4 Conclusion and Recommendations

In 2020, analysis of aerial imagery determined Ku-ring-gai's overall canopy cover to be 51.4%. The urban area (exclusion of C1 zoned land National Parks and Nature Reserves) average canopy cover was 45%. This is considered high relative to many other LGAs, but in order to maintain and improve Ku-ring-gai's unique urban forest in the face of threats, Ku-ring-gai Council must develop data-based targets and management policies.

Increasing urban population densities is a challenge facing Local Government areas throughout Australia. This is particularly problematic in traditionally low-density areas, where the majority of the urban forest asset exists within private land therefore is at greatest risk from urban development. The existing Ku-ring-gai development control plans prescribe a range of forward-thinking measures to minimize the impacts of urban development including large deep-soil zones, tree retention and replacement requirements. The analysis presented here attempts to quantify the actual effects of these policies using the area canopy cover (vegetation >3m in height) as the metric for urban forest extent. The analysis shows that high-density residential developments tended to retain similar levels of canopy cover after development, after the required plantings in Deep Soil Zones had fully developed. Whereas medium density developments tended to result in lower levels of canopy cover post-development. The impacts of these changes resulting from the current land zoning in the Local Environment Plan (LEP) were calculated for each Local Centre within Ku-ring-gai. The study finds that the overall change in canopy cover, as a result of increasing densities will be less than 1%, through to 2036. If at some point in the future further changes to the land zoning are required to meet the needs of future population growth it is recommended that modelling of the impact on the canopy are prepared as part of the review.

Given the risks associated with loss of urban forest area on private land, it is imperative that attempts are made to offset these potential losses with increased planting in public land. Prior to this study a lack of available planting space in public land was considered an issue to maintaining and increasing canopy cover over Ku-ring-gai. The current analysis has provided an in-depth APS dataset, indicating a significant number of potential planting places, and an estimate of number of trees that the APS could accommodate. However, the dataset is not without a number of limitations. For example, the APS dataset does not take into account certain infrastructure that could limit tree planting, such as overhead power distribution lines, or minimum planting distances from roadsides, driveway edges and other street trees or bushfire risk. Further refinement of the model is proposed, for the dataset to be as practical as possible. The suitability of each site for planting will ultimately require ground validation and approval by appropriate personnel.

The shade modelling has identified a number of existing and proposed cycle routes, which have low shade coverage at peak commuter time during summer. Increasing amenity and comfort of activate transport routes supports the cities goals of improved sustainability and liveability. These areas could be considered potential priority planting zones for the Ku-ring-gai Council. Similarly, to the APS analysis, a number of routes have limited capacity to increase their shade cover due to existing infrastructure and guidelines preventing establishment of shade-providing trees. This analysis has also highlighted the number of cycle routes with a high proportion of shade cover, emphasizing the quality and extent of Ku-ring-gai's current urban forest.

5 References

ArborCarbon. (2020). Ku-ring-gai Urban Forest Monitoring – an Aerial Measurement of Vegetation Cover (Project No. J20443). Perth, WA.

Ku-ring-gai Council. (2020). Ku-ring-gai Housing Strategy to 2036. Unpublished document of Ku-ring-gai Council, Strategy and Environment, Urban and Heritage Planning.

Marrickville Council. (2014). Marrickville Street Tree Master Plan. Unpublished document of Marrickville Council, by Arterra Design.