

STAGE ONE REPORT

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
Gwilym Griffiths, Riley Faulds, Briony Williams	Associate Prof. Paul Barber

Approved & Released by	Position	Approval Signature
Associate Prof. Paul Barber	Managing Director	

Revision Schedule

Revision	Report Description	Submission Date	Author(s)
Revision 1 v1	Draft Stage One Report for internal review (90%)	9/11/2021	Gwilym Griffiths, Riley Faulds, Briony Williams
0	Stage 1 Report – Final	17/03/2022	Gwilym Griffiths, Riley Faulds, Briony Williams

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.



CONTENTS



INTRODUCTION

- 1.1 What is an urban Forest
- 1.2 Value of an Urban Forest
- 1.3 Urban heat island effect
- 1.4 Background studies



HISTORICAL OVERVIEW

- 2.1 Indigenous history
- 2.2 Ecology in Ku-ring-gai
- 2.3 Post Colonisation
- 2.4 Changes over time



CURRENT STATE

- 3.1 Canopy cover
- 3.2 Soils Topography and Climate
- 3.3 Existing tree population
- 3.4 General observation and challenges



STRATEGIC FRAMEWORK

- 4.1 Council Policy and Strategy
- 4.3 State Planning Directions



ORGANISATIONAL CAPACITY

- 5.1 Key focus areas – Public Trees
- 5.2 Key Focus areas – Private Trees



COMMUNITY ENGAGEMENT

- 6.1 Background
- 6.2 Engagement methods
- 6.3 Engagement outcomes
- 6.4 Summary

① INTRODUCTION



1 Introduction

Trees play an important role in defining the unique character of Ku-ring-gai. The Urban Forest Strategy will aim to define how Council is currently managing its urban forest and to outline a pathway to facilitate improved urban forest outcomes so the benefits of a healthy urban forest can be maximised for current and future generations.

1.1 What is an urban forest?

Trees are essential green infrastructure assets that are critical in creating healthy, liveable cities. Ku-ring-gai Council manages both public and private trees as an 'Urban Forest'. This term refers to the concept that all trees, regardless of ownership, contribute to a broader collective 'forest' of trees in an urban or suburban setting. An urban forest is made up of the trees and vegetation that make the 'forest', including vertical gardens and rooftop vegetation. Importantly, it also includes other essential components such as the soil, water and supporting ecology which are essential to sustain the vegetation of the urban forest.

1.2 Value of the Urban Forest

Ecosystem services are the benefits that healthy ecosystems can provide to humans. It is well known that urban trees can provide a multitude of ecosystem services for our cities and their inhabitants, from temperature reduction to improved health and wellbeing. To ensure these services are maximised, cities require well managed, healthy, functioning and diverse urban forests.

Growing interest in the urban forest in recent decades has stimulated significant research, monitoring and management evaluation. These investigations have demonstrated that extensive, diverse, and healthy urban vegetation is essential for the liveability of a place. Vegetation, and trees in particular, provide important economic, social, health, environmental and aesthetic benefits for urban areas (McPherson *et al.* 1994, McPherson *et al.* 1997, Bowler *et al.* 2010a, Roy *et al.* 2012, Keniger 2013).

The contribution of trees to ecosystem services is significant. These services include air and water filtration, shade, habitat for animals, oxygen production, carbon sequestration, and nutrient cycling. Add to this the connection that the urban forest provides between nature and people, and it's clear that trees and vegetation have a crucial role as part of an urban landscape. From the native fauna species that have improved access to food and shelter, to community members who have enhanced recreational opportunities and water and air quality, to individual property owners who have a more comfortable environment and often increased property resale value – all benefit from a robust and extensive urban forest.

Health and social

Urban forests have a range of health and other social benefits for the residents of an area. These include:

- **Encouraging outdoor activity.** Urban forests encourage outdoor activity like walking in local areas and engaging in physical activities further afield like cycling and bushwalking, thus improving wellbeing and reducing healthcare costs. This is especially important as lifestyle-related illnesses like obesity increase in prevalence (Jerrett and van den Bosch 2018).
- **Sun and heat protection.** Shady canopy also reduces exposure to harmful ultraviolet rays from the sun (Heisler and Grant 2000, Grant *et al.* 2009, Bowler 2010b). Shade from urban forests and the relative coolness of vegetation compared to non-vegetated surfaces also reduce temperatures both within and outside shaded buildings,

significantly reducing the incidence of heat-related illness and mortality (Donovan *et al.* 2013).

- **Physical well-being.** Urban forests may also influence our biology in more subtle ways, acting on the autonomous nervous system and reducing chronic stress (Egorov *et al.* 2017). This can reduce ‘systemic inflammation’, a common cause of many noncommunicable diseases and related deaths (Jerrett and van den Bosch 2018).
- **Mental well-being.** Added to physical health benefits, the mental health and wellbeing of people living in cities is significantly improved by a robust and extensive urban forest. A world-first scientific study found a 63% decrease in depression and “feelings of worthlessness” in groups who had access to community gardens or green spaces (South *et al.* 2018). Urban forests may also have direct effects on brain structure and function, reducing the symptoms of depression (Bratman *et al.* 2015). Furthermore, hospital patients who have access to views of trees and green spaces recover more quickly than those without (Ulrich 1984, Brack 2002, Frumkin 2003, Verlarde *et al.* 2007). The economic implications of these improved recovery times are significant. Maintaining and extending the urban forest, especially in lower-socioeconomic areas, is an important contribution to the mental health and wellbeing of the community.
- **Traffic calming and crime reduction.** Other social benefits of greening have been found, from traffic calming and road safety effects to reduced rates of crime (Mouratidis 2019; Kondo *et al.* 2015, Kuo and Sullivan 2001). Slowing traffic and reducing the incidence of crime as effects of greening are likely to vary significantly depending on location, but the potential of these occurring adds to the positive social and health outcomes of urban vegetation.

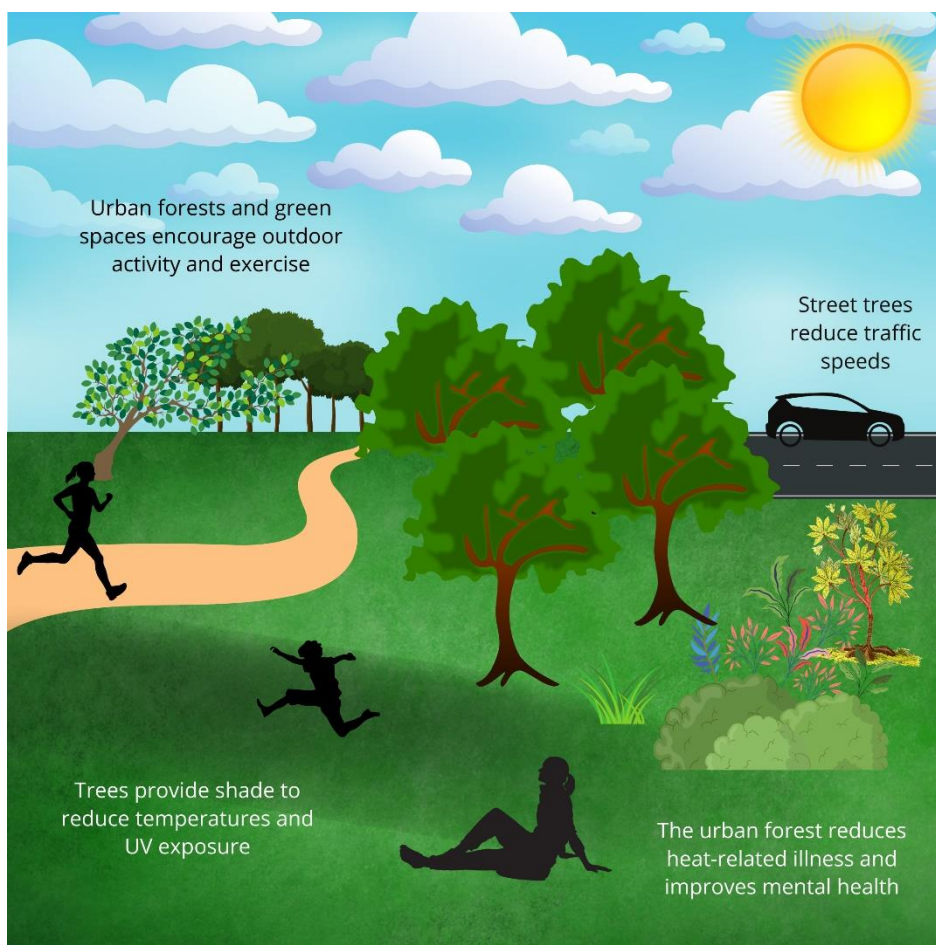


Figure 2: Social and health benefits of the urban forest.

Environmental

The environmental benefits of the urban forest include:

- **Greenhouse gas mitigation and reduction.** Through photosynthesis and transpiration, trees, shrubs and understory convert carbon dioxide to stored carbon. Urban trees thus make a significant contribution to greenhouse gas mitigation and reduction. The aquatic plants and algae in natural swamps and wetlands also store carbon (Chmura *et al.* 2003).
- **Improved air quality.** Urban forests also improve overall air quality through absorption of gaseous pollutants including nitrogen dioxides and sulphur dioxide, simultaneously producing oxygen from photosynthesis (Dwyer *et al.* 1992; Brack *et al.* 2002).
- **Water cycling and erosion mitigation.** Tree canopies, understory vegetation, gardens, and roots intercept, filter and absorb rainfall and reduce stormwater flows (Xiao *et al.* 1998, Kuehler *et al.* 2016). This reduces runoff and pollutants entering watercourses and stabilises the volume of water within the water cycle. Additionally, roots provide structure to soil, reducing erosion. Robust canopy and understory also provide a buffer from strong winds, further reducing erosion (and improving liveability).
- **Biodiversity.** Extensive urban forest canopy and total vegetated area, along with diverse vertical complexity and canopy connectivity, lead to strong biodiversity outcomes. Vertical complexity refers to the diversity of groundcover, understory, midstory and canopy vegetation. When there is good vertical complexity, habitat is diversified and the biodiversity of mammals, birds, reptiles, and insects is improved and conservation outcomes are supported (Alvey 2006; Craig, 2004; Garkaklis *et al.* 2004; Gibson *et al.* 2004; Strehlow *et al.* 2004). Connecting areas of habitat improves access to resources and allows for repopulation of areas where particular species have become uncommon. Improved urban forest design should link areas of habitat through canopy connection and wildlife corridors.

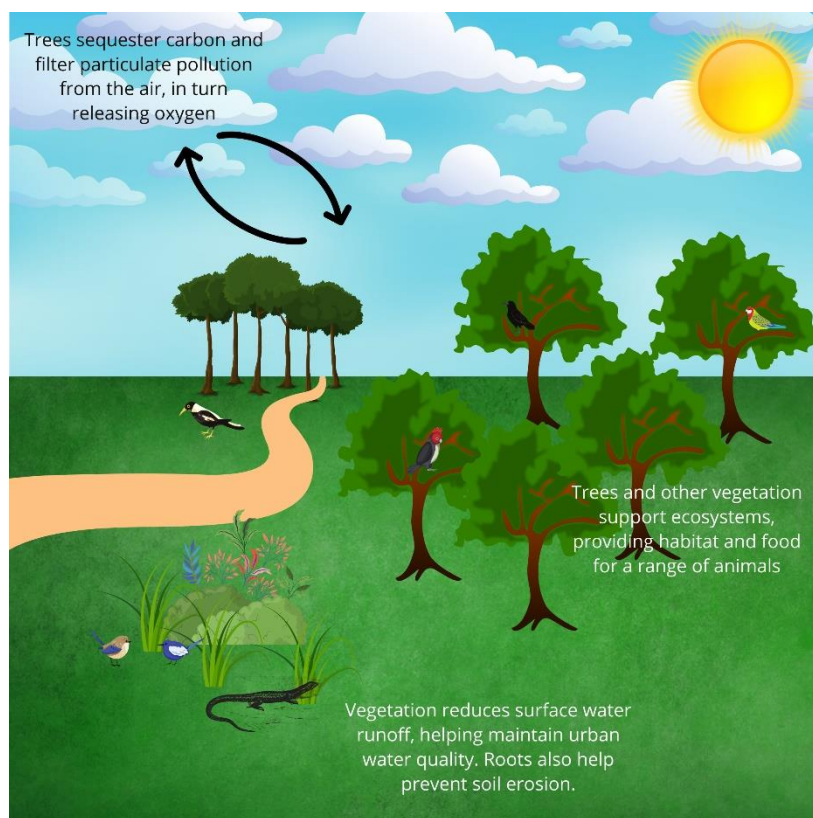


Figure 3: Environmental benefits of the urban forest.

Cultural

The urban forest forms an important part of the cultural identity of Ku-ring-gai, where residents value vegetation and the natural landscape. As Phillip Matthers wrote in *Ku-ring-gai – Living with Trees*, “More than anything else in Ku-ring-gai it is the trees...if a single bond draws Ku-ring-gai together, then surely it is the determination to protect the intrinsic value of the landscape”. Urban forests have a range of cultural benefits, including:

- **Incorporation of Aboriginal knowledge.** A review of the pre-colonisation extent of vegetation in the Ku-ring-gai area will consider the cultural benefits of vegetation that are derived for Darramuragal or Darug people with traditional custodianship and ownership of the land. Expanding and improving the urban forest provides an opportunity to strengthen these cultural connections, to include Aboriginal knowledge and cooperation in managing the urban forest, and to improve community awareness of the cultural value of the urban forest.
- **Social connection.** Urban forests improve social connection; they offer a sense of place and support community interaction through events, festivals and passive daily interaction. Parts of the urban forest can become closely linked with people’s identities and sense of place.
- **Community cohesiveness.** Studies have also shown that green space in major Australian cities is unevenly distributed, with less green space in areas with a higher proportion of low-income residents (Astell-Burt *et al.* 2014). Improving the distribution of green space and urban forests in Ku-ring-gai may foster improved community cohesiveness and a sense of shared identity across the City.
- **Aesthetic value.** Trees and naturally vegetated areas are considered beautiful by many people. The aesthetic value of trees enhances many of the other advantages discussed in this Strategy, including the mental health, economic, and other cultural values of urban forests. Furthermore, aesthetic value motivates individuals and groups to enhance the urban forest for present and future generations (Dwyer *et al.* 1991, Chapin & Knapp, 2015).

Economic

Urban forests provide a wide range of economic benefits across an urban area, for local and other layers of government, for businesses, and for residents. These include:

- **Reduced energy costs.** By shading buildings and their surrounds, canopy reduces heat effects and the need for artificial cooling. Past studies found that increasing tree cover by 10% saves annual residential cooling costs by between \$50 and \$90 per dwelling (McPherson and Rowntree 1993, City of Melbourne 2012, Ko 2018). As average temperatures rise with global warming, this effect will become increasingly valuable.
- **Increasing property values.** Areas with attractive and extensive urban forests have higher property values than similar areas with lower canopy cover. Tree-lined streets and gardens are attractive to potential buyers, with research demonstrating that street trees in Perth can increase the economic value of residential properties by around \$17,000 (Pandit *et al.* 2013).
- **Improving retail performance.** Shopping precincts with well-maintained, high-quality urban forest within the precinct and in the surrounding area, are likely to be more commercially successful. Studies have shown that people will spend more time and money, return more often, and travel further to visit retail areas featuring high-quality trees (Joye *et al.* 2003; Wolfe 2007).

- **Avoiding costs of infrastructure degradation.** The shade from tree canopy improves the useful life expectancy of municipal assets like roadways and buildings by protecting them from damaging UV rays (McPherson 2009, City of Melbourne 2012). Infrastructure maintenance costs and complexity are reduced by increased canopy.
- **Marketing the City.** Urban forests, gardens, and open spaces contribute to the culture and image of a local area or Council. An extensive and attractive urban forest communicates an attractive image for locals and visitors. Tourism in the Council and surrounding National Parks is an important industry for the region, and green spaces help to attract visitors to boost the local economy (Konijendijk 2010).
- **Health system savings.** The overall health benefits of trees lead to considerable savings for health systems. The wellness value of street trees can be greater than \$100,000 over their lifespan (Burden 2006). In Canada, the urban forests of eighty-six cities removed 16,500 tonnes of air pollution in one year, leading to human health effects valued at \$227.2 million Canadian (Nowak *et al.* 2018).

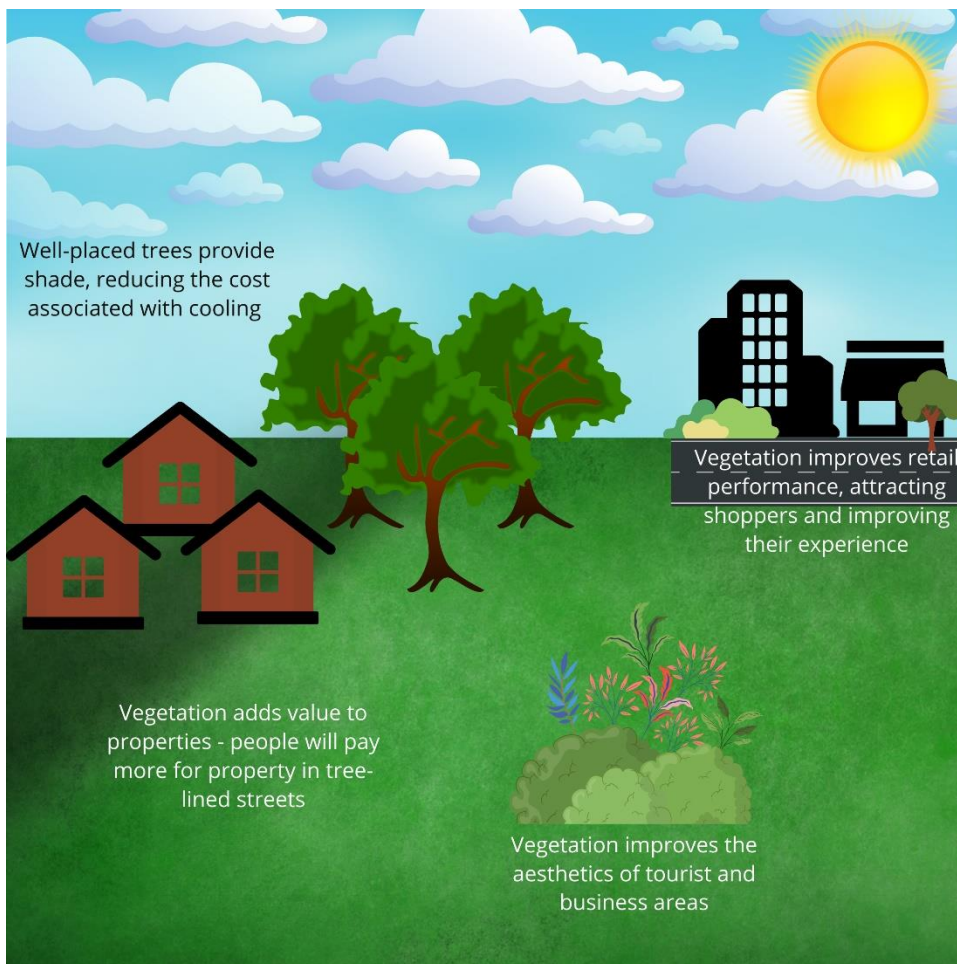


Figure 4: Economic benefits of the urban forest.

1.3 Urban Heat Island Effect

The build-up of heat in a city is referred to as the Urban Heat Island Effect (UHIE). Due to a range of drivers, especially the concentration of artificial surfaces and limited canopy cover, cities can often be significantly hotter than surrounding rural areas on hot days. The UHIE is common worldwide, as cities become warmer than the surrounding peri-urban and rural environments. The UHIE also operates at a finer ‘microclimate’ scale *within* an urban area,

with localities or even specific sites experiencing higher temperatures than others, often linked to relatively low canopy or vegetation cover.

During heatwaves, the UHIE is a critical issue for vulnerable people. Heatwaves already kill more Australians than any other natural disasters (Bi *et al.* 2010). Reducing the impacts of the UHIE through improving and extending the urban forest, particularly in areas of lower canopy cover, is crucial to limit increases in heat-stress-related deaths. The UHIE also affects the amenity and recreation opportunities for residents: increasing temperatures and urban hot spots mean people are less able to go outdoors comfortably, exacerbating health issues and the economic costs of cooling buildings.

An increasing UHIE also has significant environmental costs. Energy use will increase, water resources will become scarcer, and the remaining street trees, vegetation, and green spaces will be placed under increasing stress. Vegetation, including native vegetation, can struggle to survive and remain healthy at increasingly extreme temperatures and under water stress, both of which are exacerbated by the UHIE. The costs to maintain infrastructure will also increase because of heat-exposure degradation.

Trees, conservation areas, parks and gardens all reduce the UHIE, with trees reducing surface temperatures more effectively than turf and vegetation below canopy height (<3m). Water also has a cooling effect for locations and urban areas as a whole, both through the surface cooling effect of waterways like rivers and through efficient timing and use of water for irrigation. To address the effects of urban heat in the face of a heating climate, the Council seeks to maintain a vibrant, diverse, and well-linked urban forest, across land use types and guided by this Strategy. The activities in the Council's Water Sensitive Cities Policy further support the mitigation of urban heat through management of waterways and efficient irrigation of vegetation to aid survival.

1.4 Background and related studies

A desktop review of other national and international Urban Forest Strategies and related policies was conducted to determine what information or formatting styles could be incorporated into the Ku-ring-gai Urban Forest Strategy.

Urban Forest Strategies and related tree policies that were referenced include:

- *Greening Greater Bendigo 2020* – A clearly presented and detailed document that sets out a 50-year vision and 10-year action plan for the urban forest. The layout of this document is easy to follow, and information is presented and simple to understand. Actions are aligned to key strategic directions with a clear framework for monitoring and evaluation.
- *Auckland's Urban Ngahere (Forest) Strategy 2019* – A very robust approach, providing good use of urban forest data. Perhaps the most unique part of this document is that is presented in dual English and Maori language, which provides for what appears to be a genuine representation of their first nations people.
- *City of Canning Urban Forest Strategy 2019* – A very thorough and comprehensive document that harnesses extensive urban forest data to inform the strategic actions – including detailed heat mapping information. It is clearly laid out and graphically presented.
- *San Francisco Urban Forest Plan 2014* – Structured in three phases 1. Street Trees 2. Parks and Open Space 3. Private Property. Clear articulation of the challenges that face the SF urban forest and well-defined actions to achieve stated goals.
- *Greening Sydney Strategy 2021* – A significant far reaching document with clear connections and alignment with strategic framework and operations within Council. Bold targets and an

ambitious action plan with impact over several areas of influence i.e., incorporating greening into buildings and public domain.

- *Living Melbourne Our metropolitan urban forest 2019* – a regional approach to urban forest planning produced in collaboration by Resilient Melbourne, The Nature Conservancy and metropolitan Melbourne’s 32 local government authorities. A unique document with clearly defined goals that seeks to facilitate a collaborative approach to best practice Urban Forest management.



Figure 5: Other Urban Forest Strategies and related polices reviewed



HISTORICAL OVERVIEW



2 Historical Overview

2.1 Indigenous History

Aboriginal peoples, including the Darramuragal or Darug people, have lived in the Ku-ring-gai area for tens of thousands of years. These peoples have deep and complex ties to their Country, including rich cultural, spiritual and practical relationships with the flora, fauna, and geology of the area.

The arrival of Europeans in 1788 resulted in widespread disease and famine for Aboriginal peoples, as well as violent dispossession of land and the disruption of cultural practices. Many Aboriginal language groups and peoples in the Sydney area were displaced and scattered by colonial expansion and policies of cultural displacement, meaning some historical accounts of the Aboriginal history of the Ku-ring-gai area are unclear or based on limited information (Aboriginal Heritage Office 2015).

An example of this is illustrated in the naming of the district. The name 'Ku-ring-gai' was first coined by John Fraser in 1892 as a description for the Aboriginal people in and around the area now defined by the Council. This word potentially originated from the Gringai people of the Hunter River district, well to the north of the area now known as Ku-ring-gai. In reality, this term for the local people was likely invented based on Fraser's conjectures rather than any robust research, and applied to the district based on misguided information (Aboriginal Heritage Office 2015 & 2018). This illustrates the complexities and difficulties associated with accurately and respectfully relating the Aboriginal history of the area. Other research based on historical journals, linguistic analysis, and the knowledge of Aboriginal people, has identified Darramuragal as a more likely clan name for the Aboriginal people that lived in the Ku-ring-gai area prior to colonisation; however, this name is also not entirely authoritative, while other clans also probably lived in and around the modern-day LGA, like the Wallumedegal in the south and the Garigal in the north (Attenbrow 2010). The descendants of the Aboriginal people of the area, as well as various other Aboriginal peoples, still live in the Council area today, and may or may not identify with one of these clans (AHO 2015).

What is clear about the Aboriginal people of the area, is that they have and had a deep connection to the land that they live on and alongside. Plants, animals, seasons, waterways, and landforms all influenced the culture and spirituality of Aboriginal peoples across the Sydney area and beyond. The identity and practices of Aboriginal people are inextricably linked to Country and certainly were pre-colonisation, with the landscape actively and skillfully maintained and altered by the people who relied on it. Victor Steffensen writes in *Fire Country* that:

"All of the animals and plants are skin names, sacred, a totem to Aboriginal people today, and their ancestors. The trees play an important role for the people and have done for thousands of years. Looking after the trees and landscape meant looking after the animals and plants that were special to the people culturally."

Researchers have suggested that some cultural practices based on the natural environment were similar across different groups, while others had notable differences (Attenbrow 2010). Aboriginal people in the area continue to maintain close connections to Country and actively work to maintain and strengthen cultural traditions.

People in the area have a close relationship with plants and animals in practical ways as well as cultural and spiritual ones. Vegetation was used for food, medicine, tools, shelter, and clothing. People of the Darramuragal and other local peoples would have hunted, fished, and gathered plants in and around the area. Some Aboriginal names for plants remain in common usage, from what is referred to by many scholars as 'the Sydney language' as no name was given for this language in historical sources until the late nineteenth century (Troy 2019). This

language is often now referred to by clan names of the area, including Gadigal and Dharug, but the naming of the language, as with the naming of Ku-ring-gai, is contested.

In the following lists are a range of plants, some of which are still found in the urban forest of Ku-ring-gai, and others which are now only found nearby but were more widespread throughout the area prior to the clearing and development of the past two centuries. Plants gathered for food include cycads (*Macrozamia* species especially), known as Burrawang in the Sydney language. The seeds of these Burrawang, and the roots or tubers of sedges like *Eleocharis sphacelata* and orchids like *Calochilus paludosus*, were ground and cooked as a kind of cake or bread. Some plants, like the Burrawang, required extensive preparation in the form of soaking and cooking before they were safe and palatable for consumption. Other plants provided edible fruits, like heath species in the family Epacridaceae, as well as Geebung shrubs (*Persoonia* species, 'Geebung' also from the Sydney language), Native Cherry (*Exocarpos cupressiformis*), Kangaroo Apple (*Solanum aviculare*), and Currant Bush (*Leptomeria acida*). Some larger trees also produced fruit, including the well-known Lillypilly (*Syzygium smithii*), the Apple Berry (*Billardiera scandens*), and native figs (*Ficus*) and blackberry (*Rubus*). Nectar was also a valuable food source; the flower spikes of various *Banksia* species, as well as *Xanthorrhoea* Grass Trees (Gulgadya in the Gadigal language), were collected for their nectar (Benson and Howell 1990).



Figure 6 Gulgadya and Wiryagan are names in the Sydney language for *Xanthorrhoea* sp. and *Banksia serrata* (image credit: Royal Botanic Gardens Sydney)

Plants were also important for use as tools. Fishing was a common activity in the rivers of the area, and along the estuarine coastlines north of the modern-day LGA. Boats were made from the bark of River She oaks (*Casuarina cunninghamiana*), which was cut off when the bark was flexible and strong after heavy rains. Carrying bowls were made from hollowed-out eucalypt branches or rounded tree outgrowths. Baskets were woven from various plants including Cabbage Palms (*Livistona australis*), while axes were made from split sapling stems, with a sharpened stone head held in place by a strong twine, such as the bark of *Pimelea* species. Spears were made using *Xanthorrhoea* or Gulgadya flower spikes, with heads attached using glue-like Gulgadya resins (Benson and Howell 1990).

Cultural and religious considerations were important in food gathering and preparation for Aboriginal peoples around the Ku-ring-gai Council area, as they were and are for First Nations Australians across the continent. Obligations to ancestors and spirits guided what foods could be eaten and when. People could not eat foods that were part of their totem, as one example

of this. Fire was also used in various cultural practices, including as a tool to assist in hunting and in promoting the flowering and growth of many plants (Benson and Howell 1990).

Trees are of deep cultural importance for Aboriginal people; Steffensen writes that “the trees were managed to stay on the country, to grow old and become the Elders of the landscape, maintaining their gift of providing life and prosperity for every other living thing within their environment”. Trees are clearly deeply valued and emphasised within Aboriginal culture and land management practices.

2.2 Ecology in Ku-ring-gai

Many of the forests and woodlands that survive in parts of the Council area, as well as neighbouring National Parks, are representative of the kinds of vegetation that existed prior to colonisation; however, the vegetation prior to colonisation was more extensive and better connected. A diverse range of vegetation types existed in the wider Sydney area. In what is now the Ku-ring-gai Council area, the major vegetation types were Blue Gum High Forest (BGHF); and Sandstone Heaths, Woodlands and Forests (SHWF). There were also some scattered areas of Sydney Turpentine-Ironbark Forest (STIF) (Benson and Howell 1990).

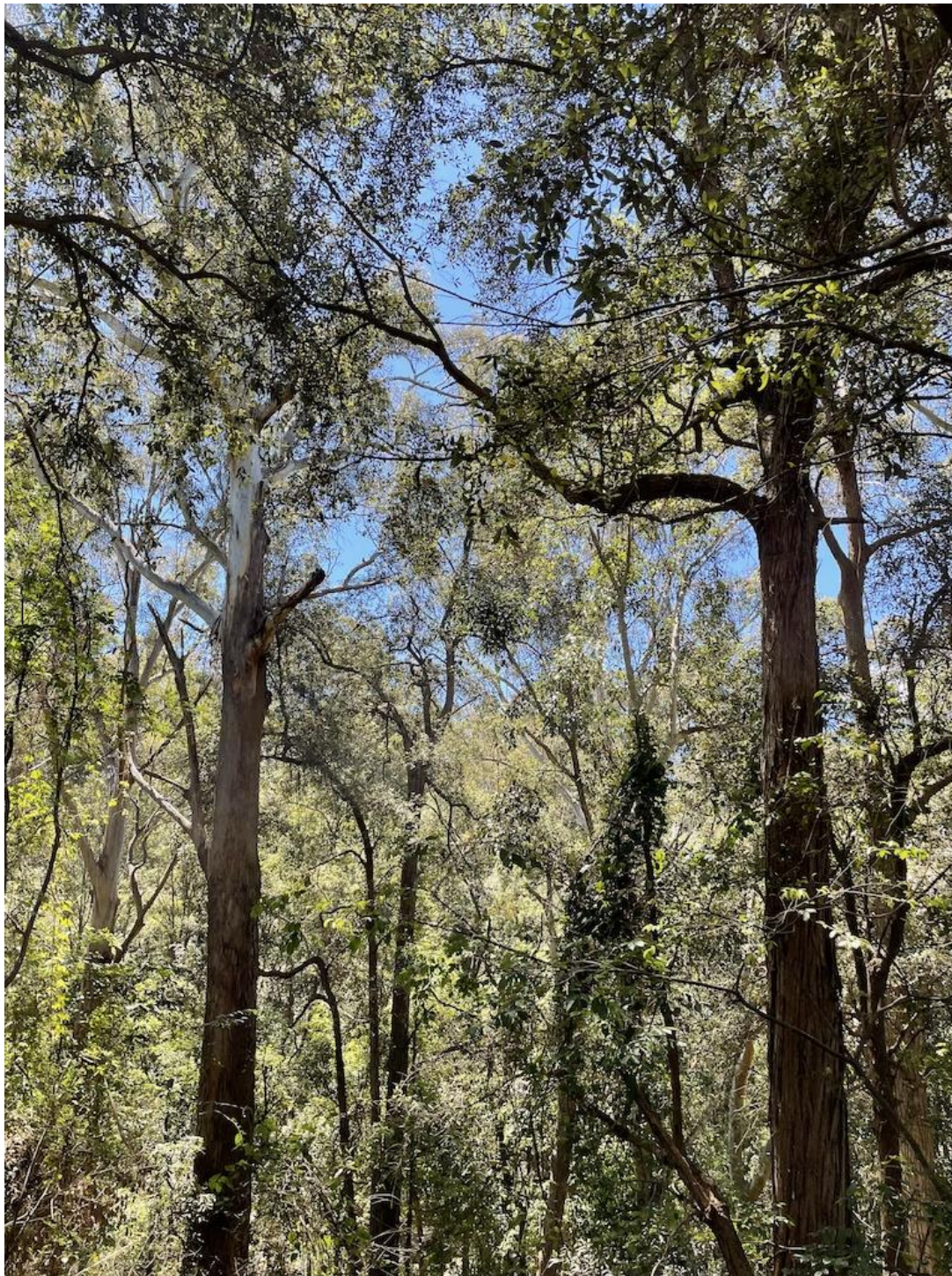


Figure 7: Example of an intact Blue Gum High Forest vegetation community in Dalrymple-Hay Nature Reserve (image credit G.Griffiths)

The Aboriginal peoples of the region were a significant influencing force in the landscape and ecologies of the area. Vegetation was actively managed and Aboriginal people had and maintain a close relationship with Country. Aboriginal identity, culture, and practices are inextricably linked with landscape and ecology; similarly, ecologies of the area were integrally defined by Aboriginal influence.

BGHF was found in the highest-rainfall areas; some of Sydney's highest-rainfall localities are found in the Ku-ring-gai LGA. The BGFH areas were dominated by an overstorey of Sydney Blue Gum (*Eucalyptus saligna*) and Blackbutt (*Eucalyptus pilularis*). Other trees included Smooth-Barked Apple (*Angophora costata*), Turpentine (*Syncarpia glomulifera*) and Forest

Oak (*Allocasuarina torulosa*). Understorey varied, with drier ridgelines home to shrubs like *Dodonaea triquetra*, *Breynia oblongifolia*, *Pittosporum revolutum*, and *Hibbertia aspera*, and moister sites supporting ferns like *Culcita dubia*, *Adiantum aethiopicum*, and *Doodia aspera* as well as small trees like *Pittosporum undulatum* and *Glochidion fernandi*. Moving from high-rainfall to lower-rainfall areas, the BGHF gradually gives way to STIF, open forest featuring Turpentine (*Syncarpia glomulifera*) and Grey Ironbark (*Eucalyptus paniculata*) along with other eucalypts as overstorey, with *Acacia* species, *Dodonaea triquetra*, *Pittosporum undulatum* and *Polyscias sambucifolia* examples of understorey in this vegetation type.

The sandstone areas of the north and east of the LGA supported a diverse range of heathland, woodlands, and forests, grouped into the SHWF vegetation complexes. Woodlands on ridge-tops and upper slopes are characterised by trees like Scribbly Gum (*Eucalyptus haemastoma*), Snappy Gum (*Eucalyptus racemose*), and Red Bloodwoods (*Eucalyptus gummifera*), and understorey trees and shrubs like *Banksia serrata*, *Leptospermum attenuatum* and *Lambertia formosa*, as well as various *Grevillea*, *Boronia*, and *Acacia* species. In areas of shallower soil, heathland became the dominant vegetation type, with *Banksia ericifolia*, *Allocasuarina distyla*, *Hakea teretifolia* and *Kunzea ambigua* shrubs examples of common species. Areas with poor drainage were home to sedgeland with various sedges and low shrubs like *Kunzea capitata*. Meanwhile, steep sandstone slopes supported open forests with *Angophora costata*, Sydney Peppermint (*Eucalyptus piperita*), and *Eucalyptus gummifera* among the common overstorey species, with small Christmas Bush (*Ceratopetalum gummiferum*) and Blueberry Ash (*Elaeocarpus reticulatus*) trees also common.

Small areas of rainforest also existed on fertile valley soils, supporting Lillypilly (*Acmena smithii*), Cabbage Palms (*Livistona australis*), Scentless Rosewoods (*Synoum glandulosum*), Sandpaper Figs (*Ficus coronate*), Native Laurel (*Cryptocarya glaucescens*) and various shrubs and vines.

The diverse and extensive vegetation of the area provided habitat for a diverse range of animals. Diverse bird species, from the common Australian Magpie and Eastern Spinebill to ground-based Brush Turkeys, populated the forests, woodlands, and heaths; so too did mammals like Grey-Headed Flying Foxes, Eastern Pygmy Possums and Swamp Wallabies. Lizards were also common, including various species of skink and goannas like the Rosenberg's Goanna. These animals still populate the LGA, and many can be found in the urban forest. These animals rely on the trees and shrubs for habitat, and eat vegetation or the insects and small animals that that vegetation supports. Some species have become uncommon or disappeared from the LGA entirely though, due to habitat loss from land clearing over the period since colonisation.

2.3 Post Colonisation

Ku-ring-gai was originally settled by timber getters, orchardists and farmers and supplied much of the timber for Sydney in the early 1800s. Native bushland was cleared and settled by farmers and their workers. One notable settler was William Henry who, from 1814, farmed next to Lane Cone River, near where Fuller's Bridge stands at the southern edge of the LGA (Ku-ring-gai Historical Society 2021). Early settlement occurred from the water, from Lane Cove River and Middle Harbour.

The vegetation of the area was important for early settlers, both as an obstacle and as a resource. To settle the region, colonists had to clear the land of vegetation to farm and build houses. Local trees, including the Sydney Blue Gum (*Eucalyptus saligna*) and the Blackbutt (*Eucalyptus pilularis*), were considered particularly useful sources of timber by colonists, especially because of their height and straight trunks. Trees were logged by hand, with the use of bullock teams for transport. Logs were hauled to the Lane Cove River and punted downstream to the growing settlement in Sydney. Blue gums were used for floorboards, beams, and ship-building, while Blackbutt was used for general construction. Other eucalypts

like Red Bloodwood (*Eucalyptus gummifera*) and Grey Ironbark (*Eucalyptus paniculata*) were cut into fence posts. Turpentine (*Syncarpia glomulifera*) was suitable for wharf-building and other situations where its preservative oils were useful, while Forest Oak (*Allocasuarina torulosa*) was used for furniture-making and as roofing shingle (Benson & Howell 1990). These and other trees and shrubs were also used for firewood.

This clearing meant the vegetation of the district was altered significantly, with the BGHF that had once traced the ridgelines of the area almost entirely cleared of trees through logging. Expansion of housing and commercial areas throughout the Twentieth and Twenty-First Centuries has further affected the vegetation on ridge-tops, including the BGHF areas. These only exist today in small pockets, notably at the Dalrymple-Hay Nature Reserve and Browns Forest in St Ives.

Timeline of preservation - St Ives blue gum high forest;

- 1788 Governor Phillip, with a small exploratory party, passed very close to, if not through, St Ives blue gum high forest. John White, a member of the exploratory party, wrote: 'The land here was better than the parts which we have already explored'. However, the forest was too immense to penetrate and they returned to camp (Benson and Howell 1995).
- 1867 Thomas Brown purchased the land now known as Browns Forest. He chose not to develop it, but willed it to his children (Blue Gum High Forest Group 2007).
- 1920 The first Commissioner of Forests, Richard Dalrymple-Hay, purchased the forest for its historic interest and environmental educational purposes (Blue Gum High Forest Group 2007).
- 1931 Ku-ring-gai Council, after a struggle with development proposals, purchased the land known as Browns Forest as a 'forest reserve for all time' (Blue Gum High Forest Group 2007).
- 1972 Dalrymple-Hay was gazetted as a nature reserve (Department of Environment and Conservation 2004a).

Source – NSW Department of Primary Industry and Environment
<https://www.environment.nsw.gov.au/resources/threatenedspecies/08185tsds/bluegum.pdf>

Slopes are more likely to have retained bushland vegetation, including examples of the SHWF vegetation complexes described above. Also, the National Parks that are included in the LGA – Ku-ring-gai Chase, Garigal, and Lane Cove – have examples of the vegetation communities that were more widespread prior to colonisation.

Alongside clearing of native vegetation came the planting of exotic species for farms, orchards, and suburban gardens and roadsides. Numerous exotic species were planted in the parks, gardens, and road reserves of the area.

Following the end of logging in the 1900's there was substantial regrowth of native forest and tree canopy. During this time Ku-ring-gai was designated for suburban residential development. This has allowed the tree stands to recover. In 1930 Ku-ring-gai Council publicised a new "commandment" – 'Thou shalt preserve those trees' referring to the 'Spires that Speak to the Soul' (<https://www.foke.org.au/natural/>). In addition to this the 'Tree Lovers' Civic League' was founded by Annie Forsyth Wyatt in around 1935, after she moved to a

bushland setting at Park Ave in Gordon. The founding of the 'League' grew out of her concern at the destruction of the natural environment in the area.

2.4 Change over time

The changes over time in vegetation across the LGA can be observed in historical imagery. Figure 8 illustrates land clearing and development over an eastern section of the LGA centered on part of St Ives. This area would have been extensively cleared post-colonisation, from what would have been entirely natural vegetation prior to 1788, to the farmland shown in the top part of the 1943 imagery, through to the suburban development in recent imagery. Note how bushland was cleared for housing on ridgelines in the bottom right of the images, while farmland was developed into housing over this period in the top part of the images.

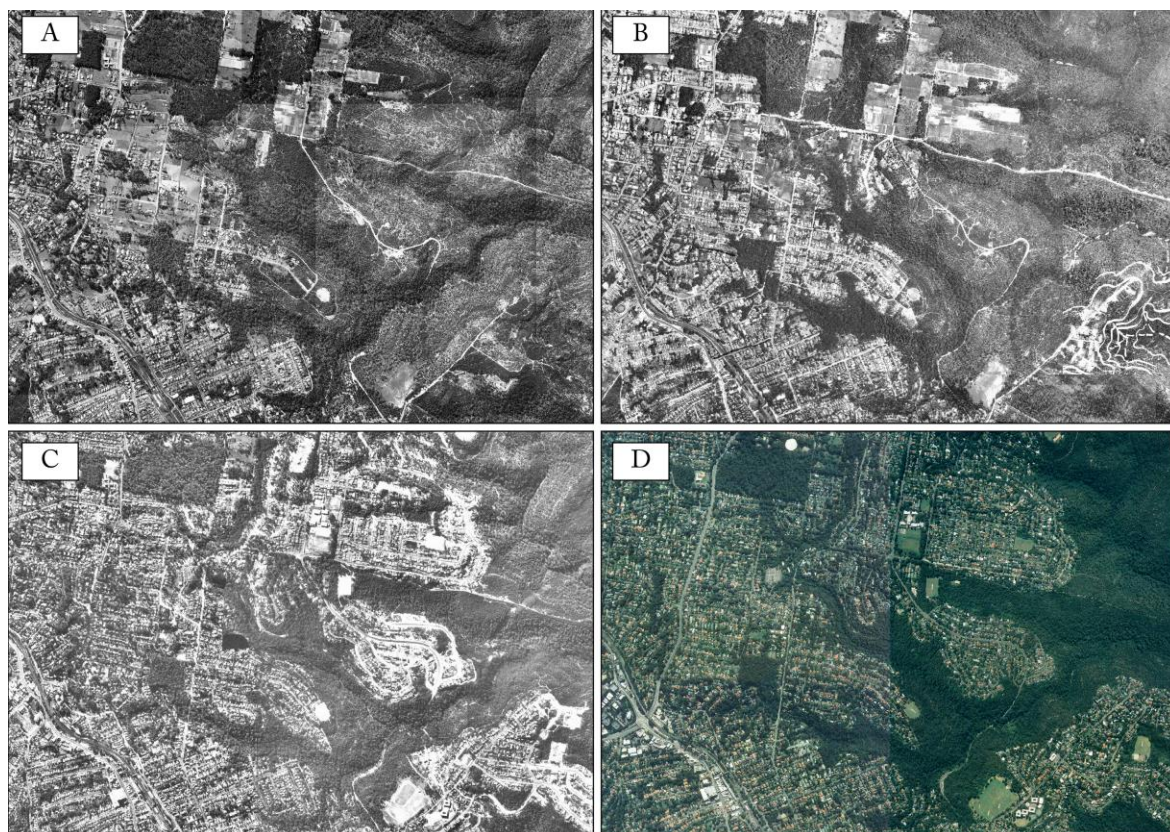


Figure 8: Development and land clearing evident in historical imagery over an area of St Ives, Gordon, and East Killara. A) 1943, B) 1956, C) 1970, D) 2001.

Unlike other more densely populated urban parts of Sydney and despite the clearing for residential housing the Ku-ring-gai area has always remained relatively well treed as shown with these 'then and now' images 9, 10 and 11 below;



Figure 9. Hill Street Roseville (image credit: Kuringai Historical Society <https://www.khs.org.au/>)



Figure 10. Coonanbarra Rd, Wahroonga (image credit: Kuringai Historical Society <https://www.khs.org.au/>)

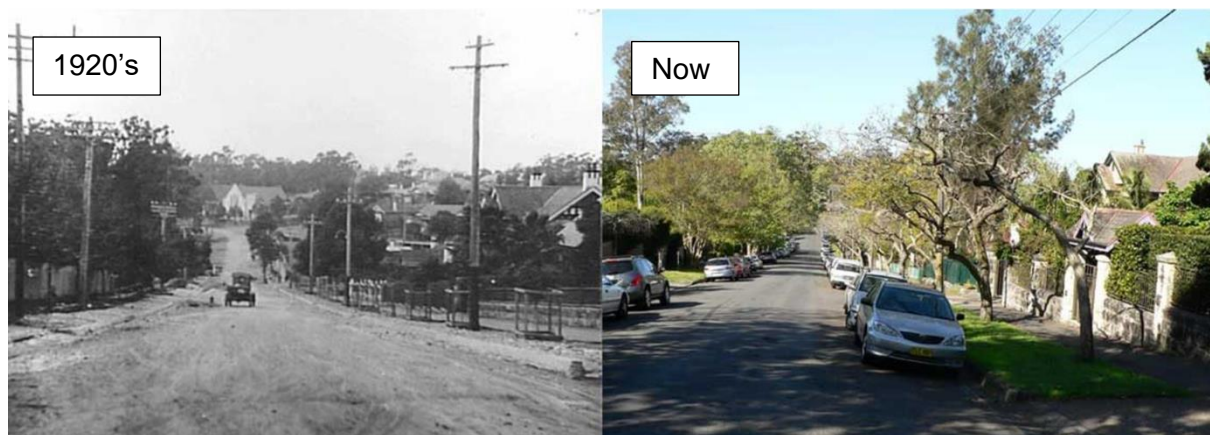


Figure 11. Locksly Street, Killara – note the early street tree planting with tree guards indicating the value placed on trees back then (image credit: Kuringai Historical Society <https://www.khs.org.au/>)

The urban forest forms an important part of the cultural identity of Ku-ring-gai, where residents value vegetation and the natural landscape. Trees have always played an important role in defining the unique physical character of Ku-ring-gai and with the help of good planning and policy will continue to do so for future generations.

③ CURRENT STATE



3 Current State

3.1 Canopy cover

Canopy mapping was undertaken over the Council area in 2020. Figure 1 shows high-resolution imagery of the Council area.

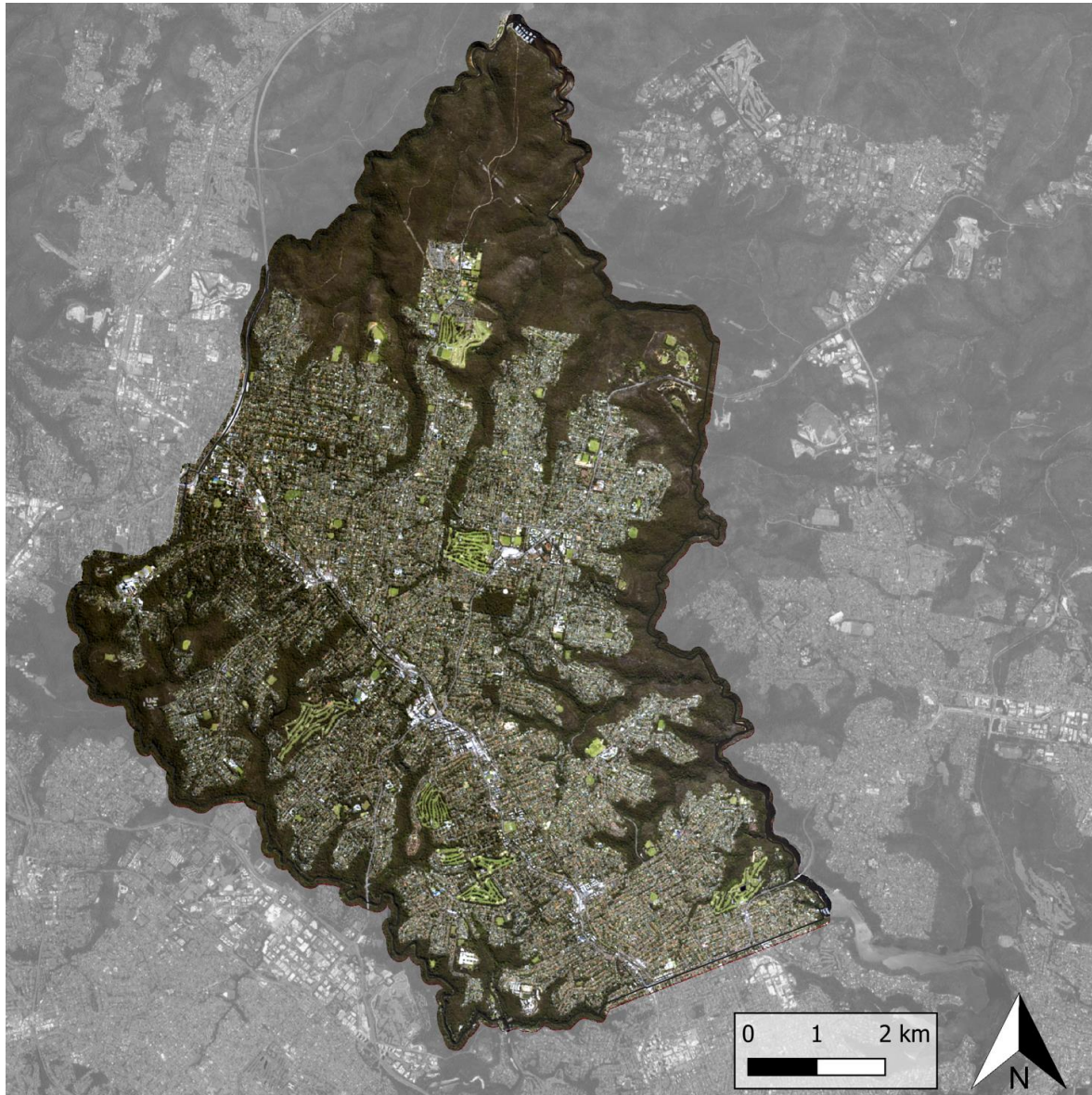


Figure 1: High-resolution RGB imagery of Ku-ring-gai Council (ArborCarbon 2020).

Analysis of average canopy cover across the Council was conducted for the Council as a whole, but also for the Council *excluding* C1 zoned land (National Parks and Nature Reserves). Excluding C1 produces results that are useful for guiding management of the non-bushland areas of the Council's area, which is especially important for an urban forest strategy.

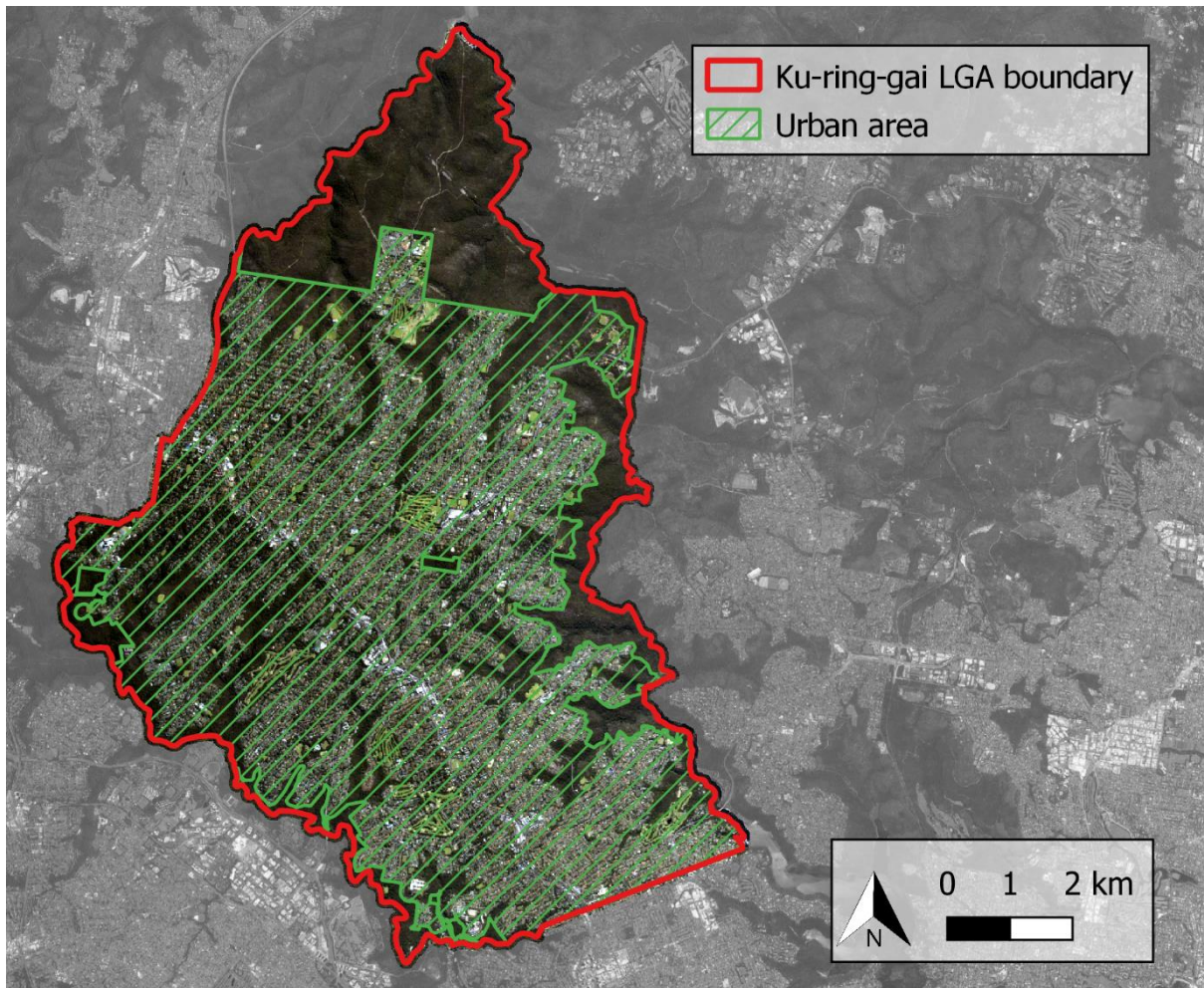


Figure 23: Ku-ring-gai Council urban area (green shaded area) within the Ku-ring-gai LGA boundary (red outline). The urban area is the LGA boundary excluding C1 zoned land (National Parks and Nature Reserves).

3.1.1 Suburbs – including National Parks and Nature Reserves (C1)

It was found that over two thirds (70.6%) of the total Council (including C1 zoned land) was covered by vegetation. 51.4% of the Council area was covered by canopy (vegetation 3m in height and above) (Figure 4).

This is above a measured 2014 median of approximately 25% canopy cover across 39 NSW LGAs (Jacobs 2014). Ku-ring-gai is in a good position relative to many other LGAs. However, many of these other LGAs don't have the benefit of National Parks to add to their overall canopy. Furthermore, the threats of climate change, pests and diseases, an aging tree population, and urban sprawl are all concerning for the resilience of Ku-ring-gai's urban forest. To maintain and improve on current levels, the Council will need to be active and targeted in management of its urban forest.

Suburbs (including C1 zoned land) varied in average canopy cover from 64.8% in North Turramurra and 61.8% in South Turramurra, to 35.7% in Roseville and 36.7% in Killara (Figure 14).

Canopy cover can be compared for each suburb within the Council. Percentage of canopy cover in each suburb is spatially presented in Figure 155 as a thematic map. Increasing green intensity in the map corresponds to increasing proportional canopy cover.

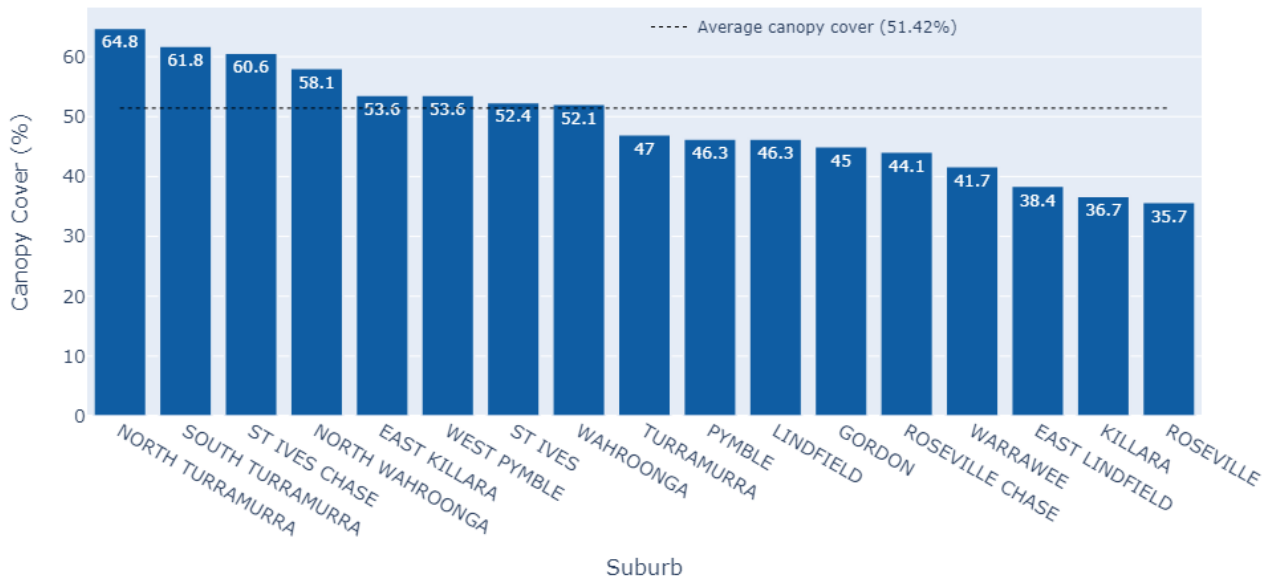


Figure 14: Canopy cover of each suburb in Ku-ring-gai Council (including C1 zoned land) by percentage of total suburb area. The average canopy cover of the LGA (including C1 zoned land) was 51.42%.

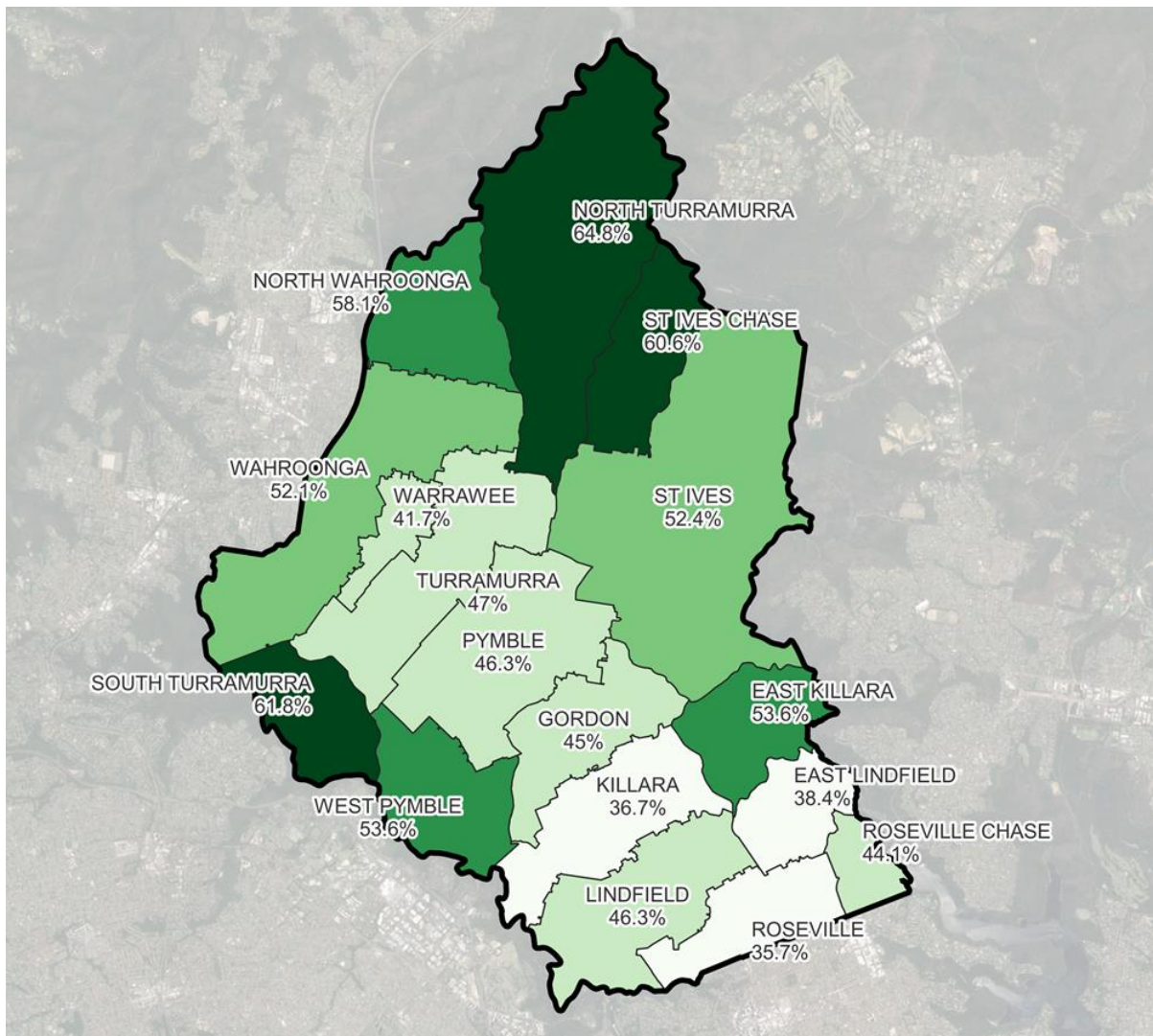


Figure 15: Thematic map showing canopy cover (vegetation >3m in height) as a percentage of total suburb area (including C1). The darker green indicates higher relative canopy cover percentage.

3.1.2 Suburbs – excluding National Parks and Nature Reserves (C1)

National Parks and Nature Reserves, classified as C1 land use zones, are managed by the State Government. While these areas are within the LGA boundary, they require different management approaches to the urban areas of vegetation. Urban areas include freehold land, and Council-managed streetscapes and public recreation reserves. For this reason, C1 land was excluded from the LGA boundary, to form a new boundary – the urban area.

Canopy (vegetation >3m in height)

Analysis of canopy cover (vegetation >3m in height) of the LGA excluding C1 zoned land was also undertaken. This demonstrated that average canopy in the areas of the LGA excluding C1 was 45% (Figure 16).

The suburb with the greatest proportional canopy cover was South Turramurra (57.9%), closely followed by North Wahroonga (53.1%) and Wahroonga (50.1%) (Figure 16). Each of these suburbs is in the western part of the Council and have a large proportion of environmentally zoned land (C2 (Environmental Conservation) and C4 (Environmental Living)), contributing greatly to canopy cover. In addition, these suburbs have a significant number of areas with particularly low-density residential housing with established, mature trees on residential blocks and along streets. Meanwhile, Killara had the lowest canopy cover at 34.7%, followed by Roseville (35.7%) and East Lindfield (37.1%).

Canopy cover can be compared for each suburb within the urban LGA area. Percentage of canopy cover in each suburb is spatially presented in Figure 17 as a thematic map. Increasing green intensity in the map corresponds to increasing proportional canopy cover.

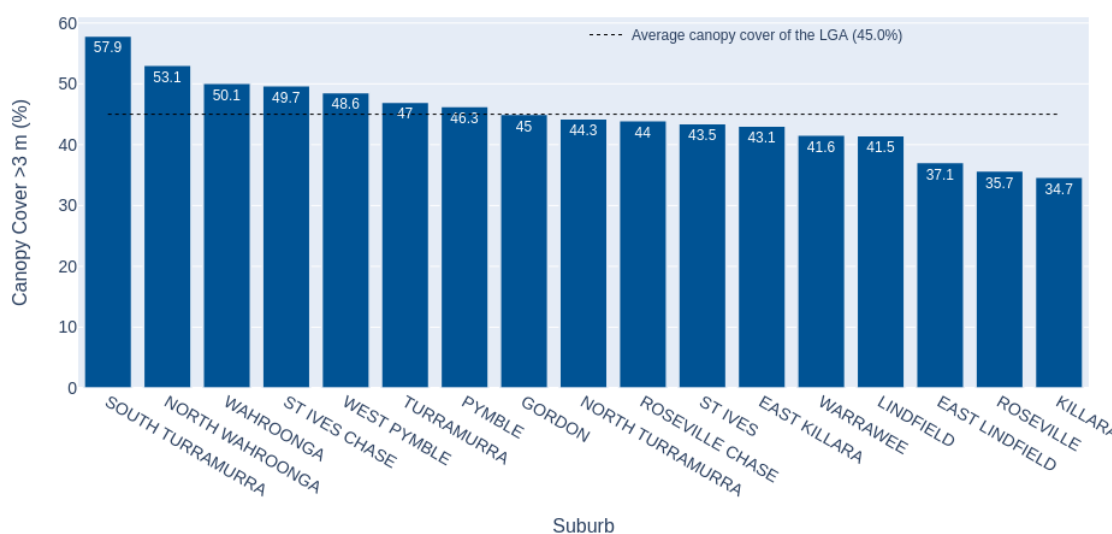


Figure 16: Canopy cover of each suburb in the Ku-ring-gai Council urban area (excluding C1) by percentage of total suburb area. The average canopy cover of the urban area was 45%.

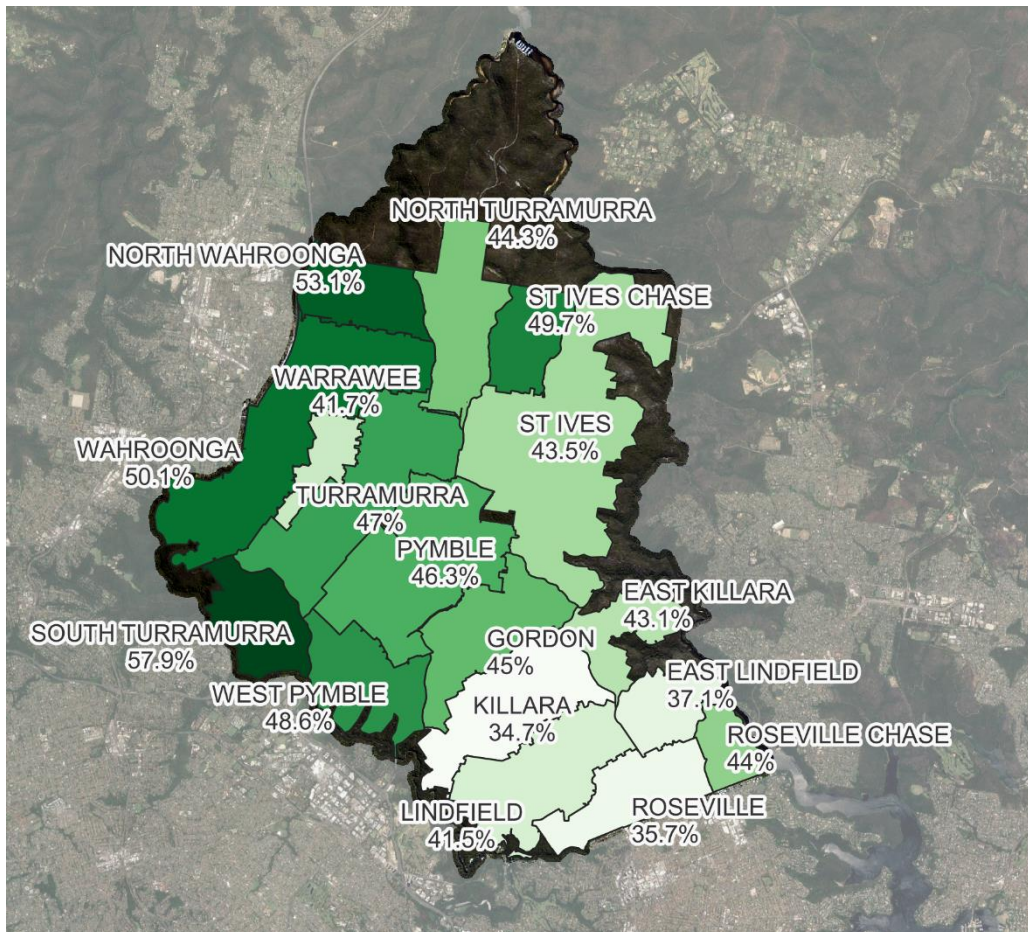


Figure 17: Thematic map showing canopy cover as a percentage of total suburb area (excluding C1). The darker green indicates higher relative canopy cover percentage.

Tall canopy (vegetation >10m in height)

In urban forestry, canopy is defined as all vegetation above 3m in height. However, Ku-ring-gai has a significant amount of older and larger trees. These trees contribute more benefits to the urban environment than smaller trees. Therefore, Ku-ring-gai Council is interested in tall canopy cover as well.

The three suburbs with the most canopy also had the most tall canopy cover (Figure 18). 39.1% of South Turramurra is covered by tall canopy, while Wahroonga and North Wahroonga have 37.1 and 34.8% tall canopy cover respectively. Similarly, the suburbs with the lowest canopy cover, also had the lowest tall canopy cover. Roseville had 17.7% tall canopy cover, while East Lindfield and Killara had 19 and 19.5% respectively.

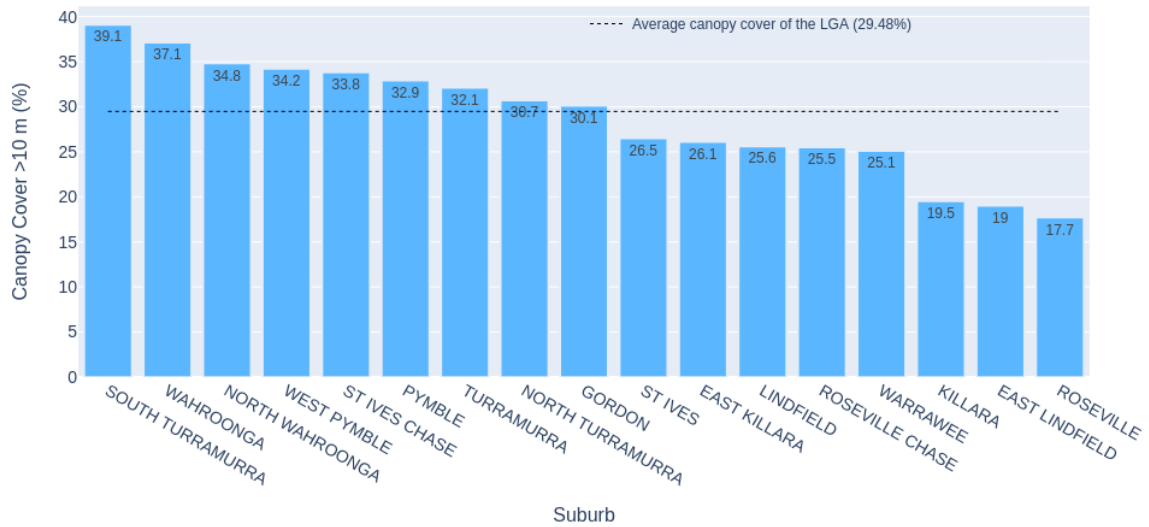


Figure 18: Tall canopy cover (vegetation >10m in height) of each suburb in the Ku-ring-gai Council urban area (excluding C1) by percentage of total suburb area. The average tall canopy cover of the urban area was 29.5%.

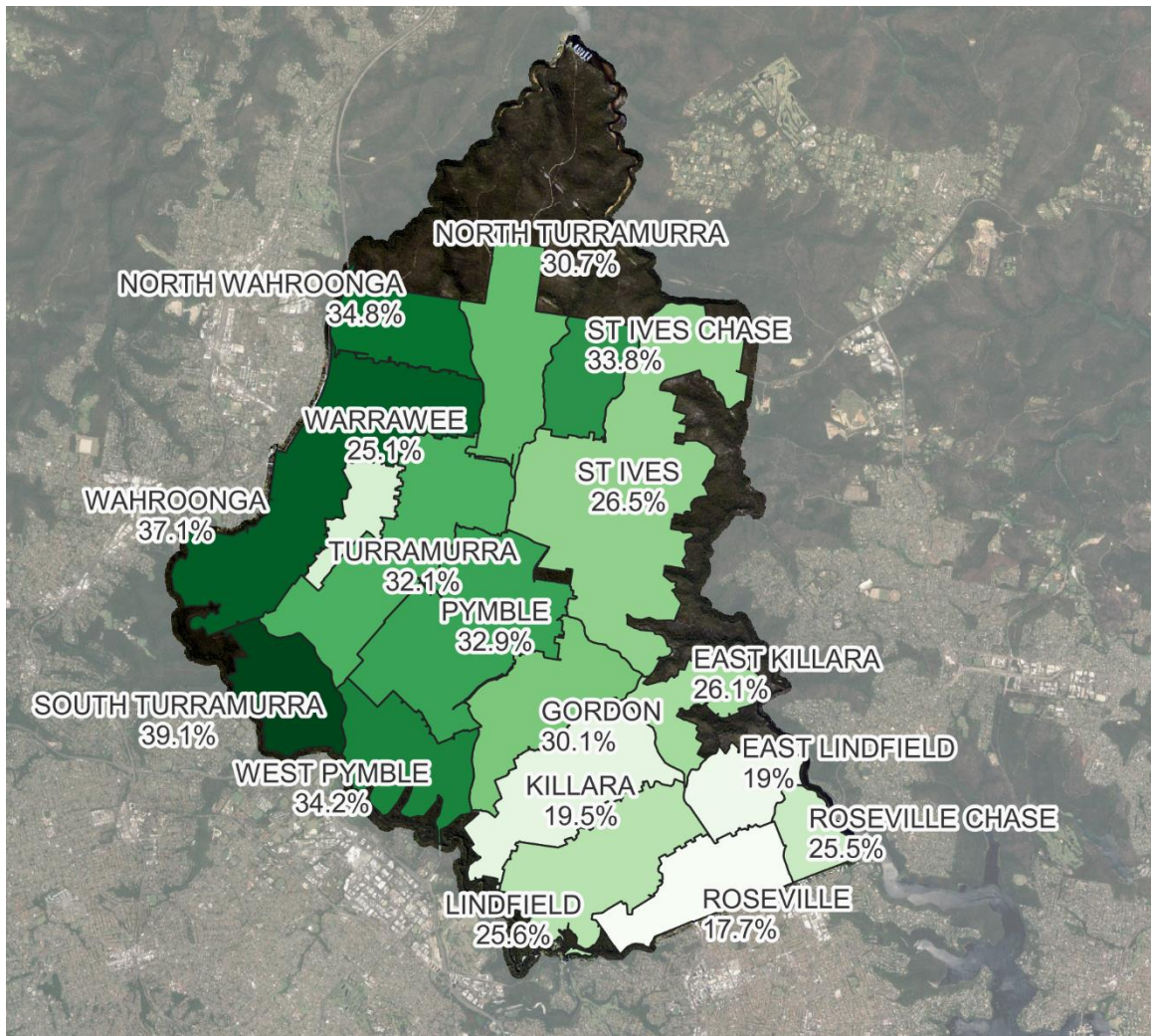


Figure 19: Thematic map showing tall canopy (vegetation >10m in height) cover as a percentage of total suburb area (excluding C1). The darker green indicates higher relative canopy cover percentage.

3.1.3 Public vs private land ownership

Of the 3024.8 ha of canopy within the urban LGA boundary, nearly half (49.8%) is within privately owned land (Figure 20). Another 42.7% falls on land managed by Ku-ring-gai Council, which includes local parks, road reserves and municipal buildings. The remaining 7.5% of canopy falls on land classified as 'Other', such as state and federally managed land

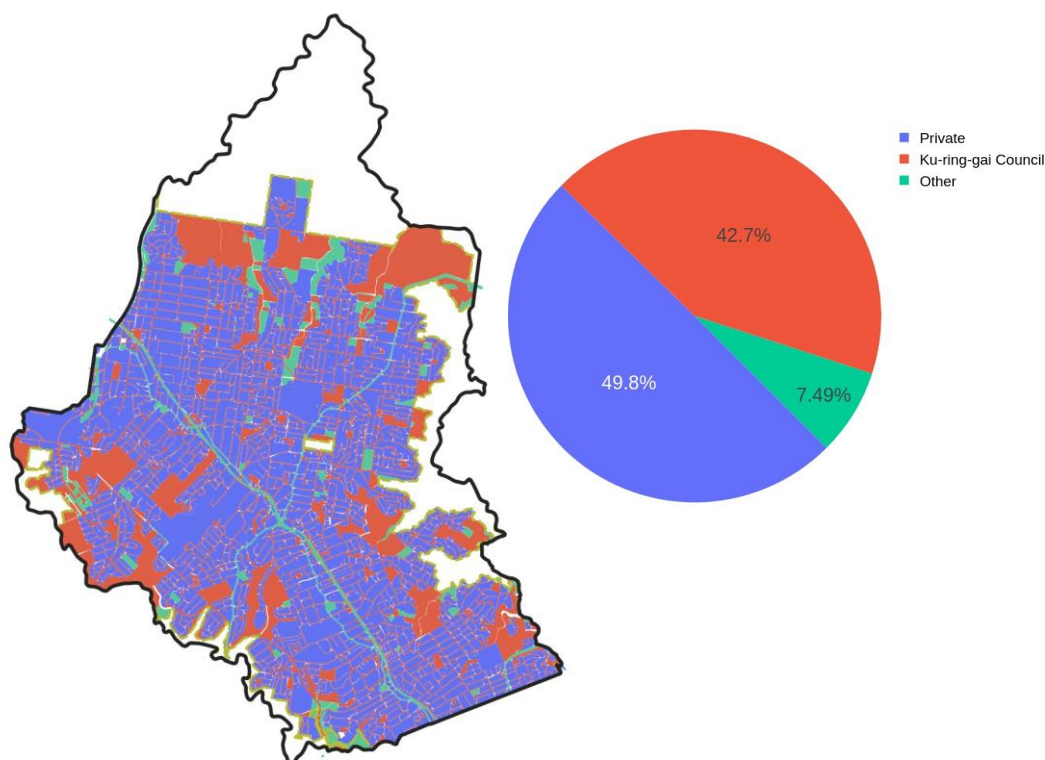


Figure 20: The Distribution of land tenure classes (left) and the proportion of tree canopy within the Ku-ring-gai Council (right). 'Ku-ring-gai Council' land includes council managed land such as local parks, road reserves and municipal buildings. Other includes state and federally managed lands, and all other land tenure classes.

3.1.4 Land Surface Temperature

On the day of acquisition, the maximum air temperature recorded in Sydney was 35°C. Land surface temperature (LST) recorded in the thermal imagery ranged from 25 to 40°C (Figure 21). The cooling effect of vegetation is clearly visible in the thermal imagery. Areas of dense vegetation in the north and south-west, particularly in the suburbs Wahroonga, North Wahroonga, North Turramurra, St Ives and St Ives Chase, appear to have the lowest land surface temperatures. Golf courses, which have high canopy cover and areas of irrigated turf, also have very low surface temperatures. Different materials absorb and retain heat at different rates, resulting in different surface temperatures. In general, impervious surfaces, such as buildings, roads, carparks, synthetic turf, dead grass and bare earth have higher land surface temperatures. The Council has high canopy cover, with little area of bare earth and dead grass. Most of the hot spots throughout the Council are buildings, roads and synthetic playing fields, which were scattered throughout the Council.

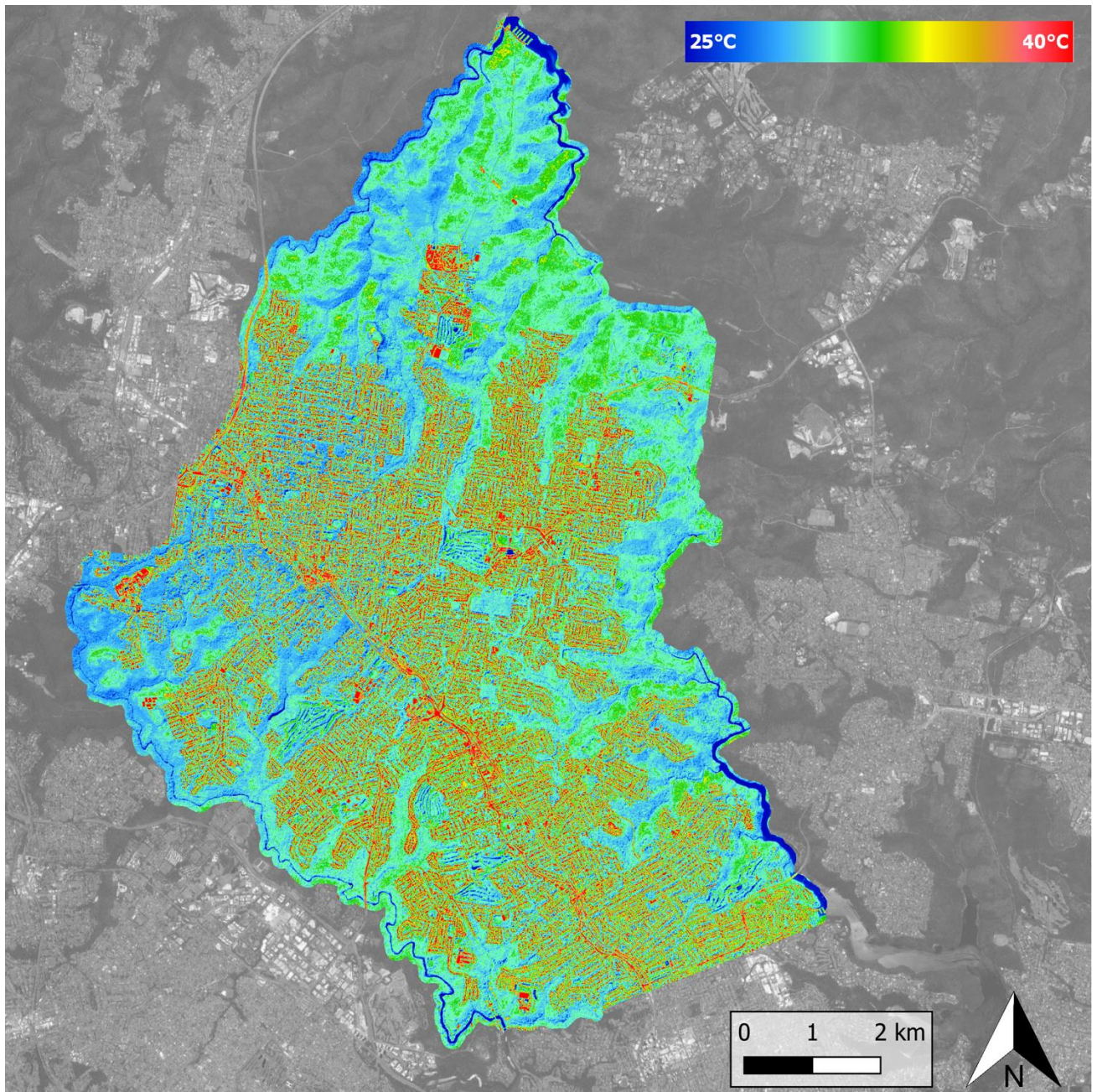


Figure 21: Radiometrically corrected thermal ortho land surface temperature of Ku-ring-gai Council ranging from 25°C (blue) to 40°C (red).

3.2 Soils Topography and Climate

Soil type is influenced by many factors, including the underlying geology, the topography, and the forces that have led to soil formation. The Soil Landscapes of the Ku-ring-gai LGA are diverse. These Soil Landscapes, as defined by the NSW Department of Planning, Industry and Environment, are areas of land defined by particular topographies and soils. The soil map below, Figure 22, illustrates the many Soil Landscapes of the LGA, and it is apparent from this that the topography of the area has a notable influence on soil distribution; soils along the ridgelines are distinct from those in gullies and valleys, and along waterways. However, this is just one of the many factors that influences the characteristics and distribution of soils, along with differences in the forces of formation like wind and water erosion of rock, and the forces of deposition like gravity or river flow.

Soil, as the growth medium that contains water and nutrients and acts as a structural base for roots, is a naturally crucial aspect of plant establishment, survival, and growth. Soil type affects

the success of particular plant species, influencing the distribution of species and ecological groupings. Major Soil Landscapes in the LGA include Glenorie Erosional, Hawkesbury Colluvial, and Lucas Heights Residual. Each of these soil types is defined by different underlying geology and different formation and deposition processes. As a result of these differences, vegetation growing in these Landscapes varies. The Glenorie Erosional soils, formed from shales, are dominated by Blue Gum forest (BGHF), which has been extensively cleared, leaving scattered areas of bushland and dispersed individual trees; the Hawkesbury Colluvial soils are formed from sandstone and support sandstone open woodlands along crests and ridgelines (SHWF woodlands) and wet closed forests (BGHF and SHWF forests) in sheltered gullies; meanwhile, Lucas Heights Residual soils are formed in an intersecting zone of the shale and sandstone of the aforementioned Landscapes, supporting low open forests and woodlands of eucalypts and turpentine, which have been mostly cleared.

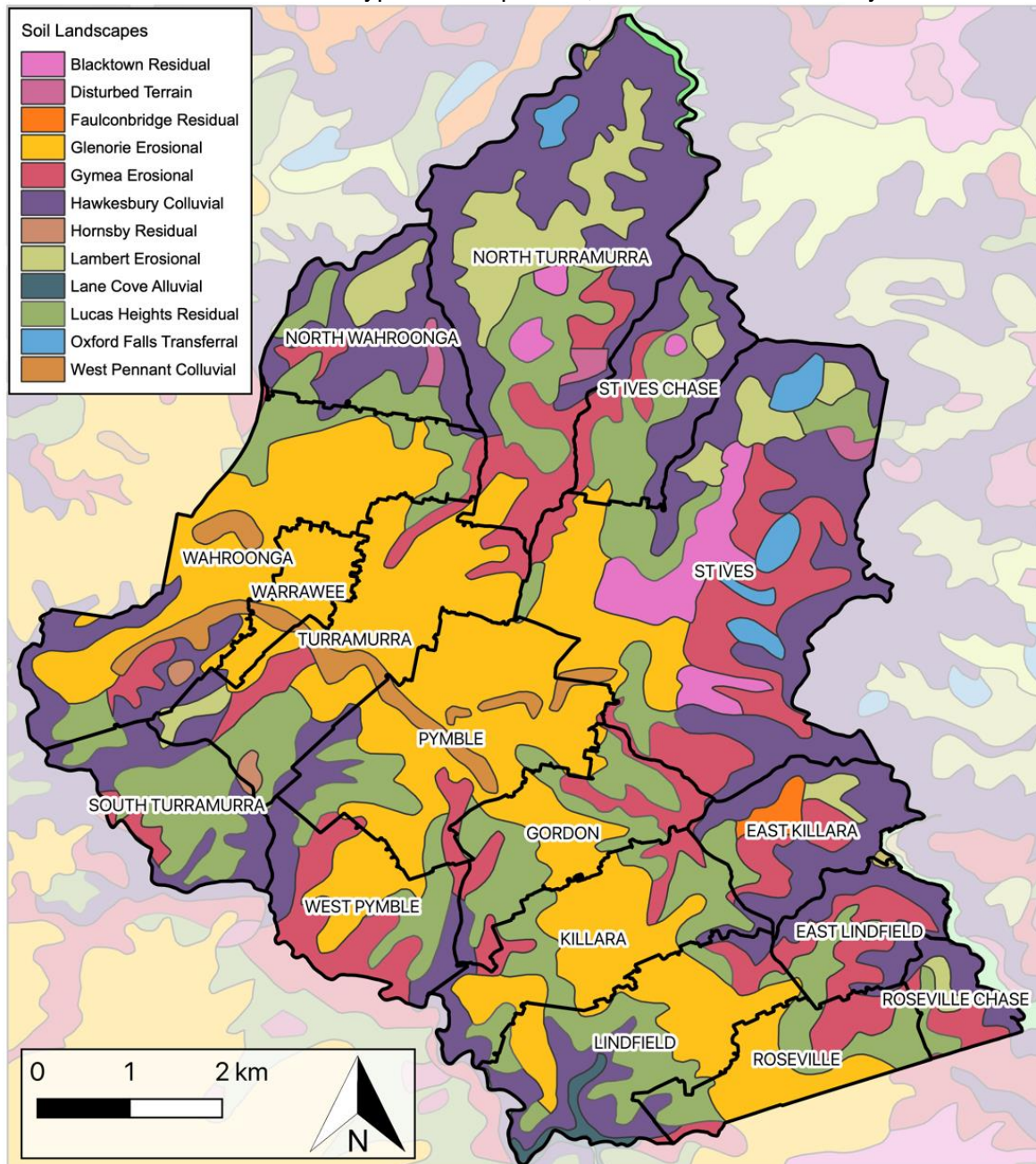


Figure 22: Soil map of the Ku-ring-gai LGA using the NSW Government's eSPADE data, illustrating the underlying soil types of the area (NSW Soil Landscapes).

It is likely that much of the areas soil landscape has been highly altered. Human activities, such as the practices of importing and excavating soil, amending soils with fertilisers, soil

wetters, and other treatments, mean that soils have had their characteristics altered in many locations. Therefore, soils in broad Landscapes can vary significantly from site to site, from garden to garden; it also means that some species can successfully grow in soils they otherwise might not have been able to.

The Ku-ring-gai area can be described as a landscape of ridges and valleys. It is also one of Sydney's highest-rainfall areas; Bureau of Meteorology data from weather stations across the LGA demonstrate that average rainfall over the previous few decades ranges from just over 1200 mm to around 1400 mm per annum. This high rainfall was one of the key factors allowing the extensive Blue Gum forest that existed prior to colonisation to flourish in the area; this rainfall continues to support the diverse vegetation types in the LGA.

Severe weather events like storms and bushfires are a concern for the LGA. The risk of heatwaves, catastrophic bushfires, flooding, and extreme storms is increasing with climate change. Recent examples like the November 2019 storms that hit the LGA, the more recent October 2021 storm, and the 2019-20 extreme bushfires across NSW demonstrate the level of damage that natural disasters can cause in and around the LGA. Natural disasters like storms and bushfires threaten vegetation, damaging trees and reducing canopy cover.

Ku-ring-gai is upon the Hornsby Plateau, with high ridges cut into by waterways, feeding Middle Harbour and the Lane Cove River. Deep gullies have formed over millennia. Ridgelines slope down to the three National Parks around the LGA – Ku-ring-gai Chase to the north, Lane Cove to the west, and Garigal to the east. Residential areas are concentrated along these ridges and higher areas, with the Pacific Highway following the broad ridgeline that transects the LGA. The northern parts of the LGA (north of Pymble) are particularly elevated, with elevations surpassing 200 metres despite being quite close to waterways. The diversity of vegetation in the Council area is partly due to the diverse topography and the soil conditions that result from this.

3.3 Existing tree population

Ku-ring-gai's urban tree population is a unique blend of exotic and native tree species. These trees contribute significantly to the character and identity of Ku-ring-gai and form an important part of the cultural and historic landscape of the area.

Despite the major historical logging and land clearing in Ku-ring-gai, the area retains a relatively high level of native vegetation compared to many other urban LGAs in Sydney, and elsewhere in Australia.

In 2021, ArborCarbon undertook analysis to determine a preliminary tree inventory based on the 2020 aerial imagery datasets. The analysis was conducted on LGA boundary, excluding land classified as C1 (National Parks and Nature Reserves) and C2 (Natural Areas). The analysis resulted in a tree asset database for trees in the 5540 ha of remaining land. A total of **279,642** trees were identified in this area. The majority (**213,137**) are on private land. Ku-ring-gai Council manages approximately **58,216** trees on public land, such as on streets and in parks. The remaining **8,289** trees are on land classified as 'other', primarily under state or federal management.

Dominant street tree species include:

- *Angophora costata* (Sydney Red Gum)
- *Eucalyptus pilularis* (Black butt)
- *Eucalyptus saligna* (Sydney Blue Gum)
- *Eucalyptus microcorys* (Tallow wood)
- *Jacaranda mimosifolia* (Jacaranda)
- *Liquidambar styraciflua* (Liquidambar)
- *Lophostemon confertus* (Brush Box)

- *Platanus x acerifolia* (London Plane Tree)
- *Syncarpia glomulifera* (Turpentine)

There are several well-known iconic mature street tree boulevard plantings in Ku-ring-gai. These are generally formal planted streetscapes, some of which include;

- Burn Road, Wahroonga (London Plane Tree)
- Roseberry Road, Killara (Tallow wood)
- Winton Street, Warrawee (Liquidambar)



Figure 23: Burns Road, Wahroonga – Iconic London Plane Tree street planting (image credit G.Griffiths)



Figure 24: Roseberry Road, Killara – impressive stand of native Tallow wood trees (image credit G.Griffiths)

There are numerous examples within the LGA where the streetscape is dominated by less formal native remnant style planting. These areas are characterised by ‘towering giant’ eucalypt species such as Sydney Blue Gum and Black Butt. Some of these areas include; Mt William Street, Gordon; several streets in east Killara and east Linfield; and suburbs such as Turramurra, St Ives and Warrawee.



Figure 25: Mt William Street, Gordon – streetscape dominated by towering eucalypts (image credit G.Griffiths)

Parks and open space within the area are predominately characterised by native bushland style tree plantings and/or remnant vegetation; some of these include Turramurra Memorial

Park, Turramurra; Killara Park, Killara; and Golden Jubilee Park, Wahroonga. There are however several parks with a more European tree planting style, the most notable of these is Wahroonga Park, Wahroonga; Pymble Soldiers Memorial Park, Pymble; and Swain Gardens, Linfield.



Figure 26: Wahroonga Park, Wahroonga – Iconic European style park with primarily exotic tree plantings (image credit G.Griffiths)

3.4 General Observations and challenges

Dominance of private tree canopy over public – In many instances there is limited capacity for Council to plant trees within the streetscape due to a dominance of trees overhanging from private property. This is not necessarily a bad thing; however it does pose an issue for Council in identifying available planting locations to increase canopy cover on public land. This dominance of private vegetation over public vegetation is most notable in the upper north shore suburbs such as Turramurra, Wahroonga and Waitara (Figure 27).

Conflict with powerlines – Impacts from powerline clearance pruning to street trees can be observed throughout the LGA. This pruning significantly impacts on the ability to establish good canopy cover and severely limits available tree planting locations. The repeated pruning and resulting stress it imposes on trees can also predispose trees to infection by plant disease pathogens and attack from pests.

Some of these locations are exacerbated by poor tree species selection, as demonstrated in Figure 28. Installation of bundled cables (ABC) in strategic areas would enable improved tree planting outcomes. However, this is associated with high cost which is often not shared by the utility provider.



Figure 27: Bangalla Street, Wahroonga – tree canopy from private land limiting options for street tree planting (image credit G.Griffiths)



Figure 28: Heavily pruned street tree with a limited future (image credit G.Griffiths)

Vacant sites – Numerous locations exist where wide verges are available for planting, but no trees have been planted. In some examples there are verges that have recently been re-turfed and trees not considered. This may highlight issues with integrated project delivery or coordination/timing within Council projects.

As part of the 'Ku-ring-gai Stage Two Mapping Analysis Report', an analysis of vacant sites was undertaken using remote sensing and aerial imagery, this identified 17,000 vacant sites available for planting on public land throughout the LGA, including many verges.



Figure 29: Lost opportunity to integrate tree planting with other Council projects (image credit G.Griffiths)

Ageing tree population – Ku-ring-gai is fortunate to have many large mature street trees providing excellent canopy cover. Many of these are trees remnant from the Blue Gum High Forest and Sydney Turpentine Ironbark Forest and are considered key components of the urban forest. This, in combination with an observed lack of recently planted, younger or semi-mature trees will cause issues with age diversity. Many of Ku-ring-gai's trees, including those in the iconic boulevards and parks, are close to 100 years old and approaching the end of their useful life. An ageing tree population requires increasing resources to manage and sustain, and with fewer trees in the lower age categories the Council will inevitably see a decline in canopy on public land if not well managed.



Figure 30: Aging tree population (image credit G.Griffiths)



Figure 31: Tree planting needs to be increased to offset aging tree population (image credit G.Griffiths)

Population growth and urban consolidation – Large trees that dominate many parts of Kuring-gai are under pressure from increased population and consolidation of residential land. The State Government’s mandate for increased medium density housing along growth corridors such as the Pacific Highway (Figure 32), is seeing large mature trees removed, and less space available for large trees to be planted. Large block with traditional free-standing houses are being developed, and the building footprint increased (Figure 33).



Figure 32: Medium density housing development alongside large mature trees (image credit G.Griffiths)



Figure 33: Increased size of building footprints (image credit G.Griffiths)

Local centres – Local centres are often the least treed areas in an LGA. In correlation, they are often the hottest areas (Figure 34). Increased canopy cover will provide shade and reduce the UHIE in Ku-ring-gai local centres, improving liveability. These local centres are difficult places to establish trees as they are physically highly contested spaces, due to infrastructure such as awnings, services, street furniture and signage, resulting in little room available for trees, (Figure 35). Establishing trees in these areas needs to be considered as part of public domain upgrades and/or conditions imposed on any development in these areas. Significant planting of trees (other than in-fill planting) in these areas is beyond the capacity of current Council tree planting programs as it requires substantial investment in modification of infrastructure. It is possible, but requires proper planning and design. Figure 36 shows Rohini Street in Turramurra local centre, and is a good example of well-considered planning and design, incorporating trees.

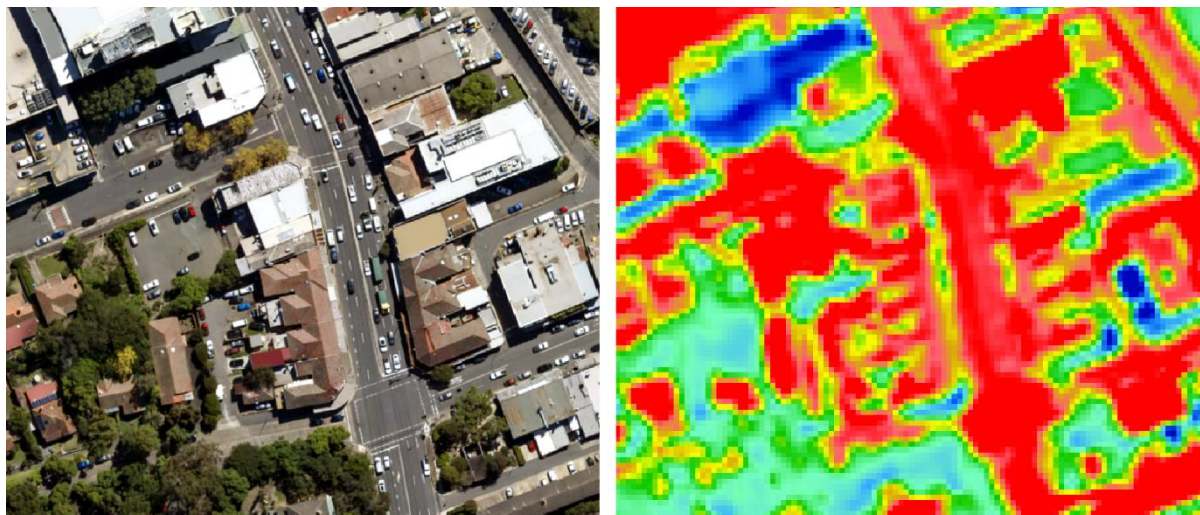


Figure 34: RGB (left) and thermal (right) imagery of Gordon Lown Centre, showing the Pacific Hwy, buildings and carparks as hot (red) while nearby vegetation is showing as significantly cooler (blue and green).

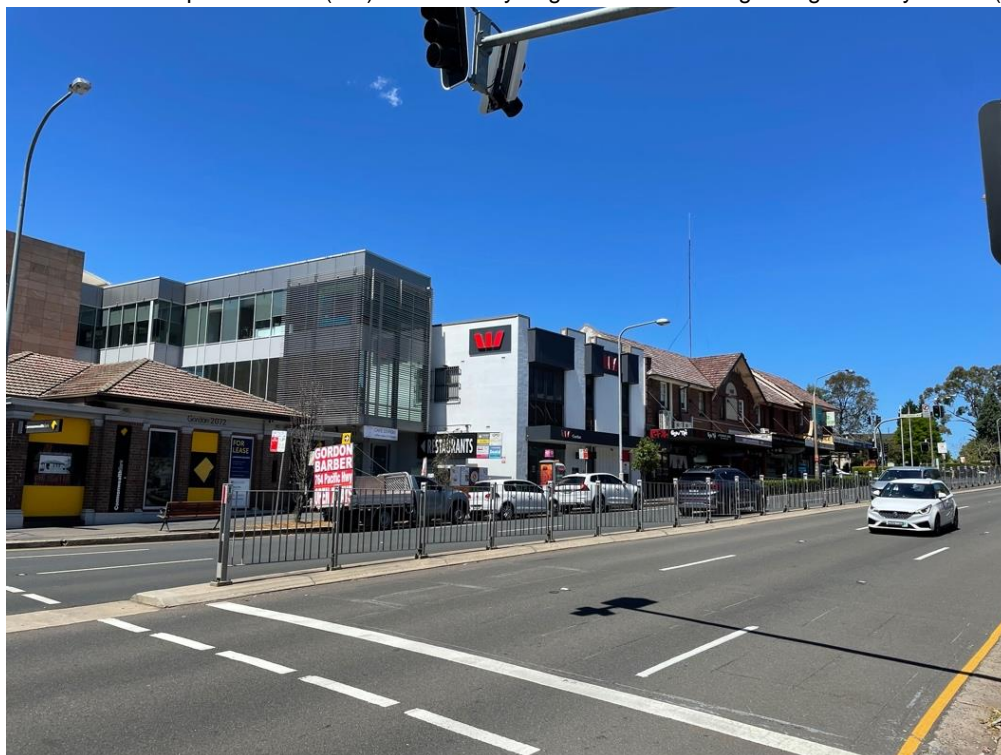


Figure 35: Gordon local centre – high heat with limited opportunity for tree planting (image credit G.Griffiths)



Figure 36: Rohini Street, Turramurra – example of a well treed local centre (image credit G.Griffiths)

4

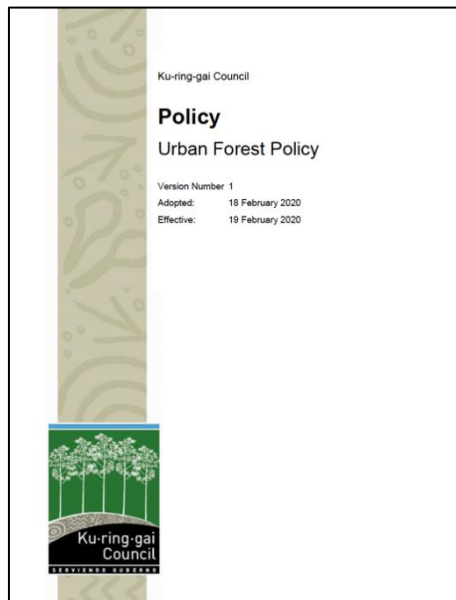
STRATEGIC FRAMEWORK



4 Strategic Framework

4.1 Council Policies and Strategies

In 2020, Council adopted the Ku-ring-gai *Urban Forest Policy*, a policy that established Council's commitment to the improved holistic management of Ku-ring-gai's urban forest. This Urban Forest Strategy will provide the mechanism for implementing the Ku-ring-gai *Urban Forest Policy 2020*.



This Urban Forest Strategy will sit alongside other key Council documents and aims to align with State Planning Directions (Section 4.2), including the North District Plan and the Ku-ring-gai Local Strategic Planning Statement, as well as recent policies and strategies that have been prepared for and by Council. Some of these key documents are:

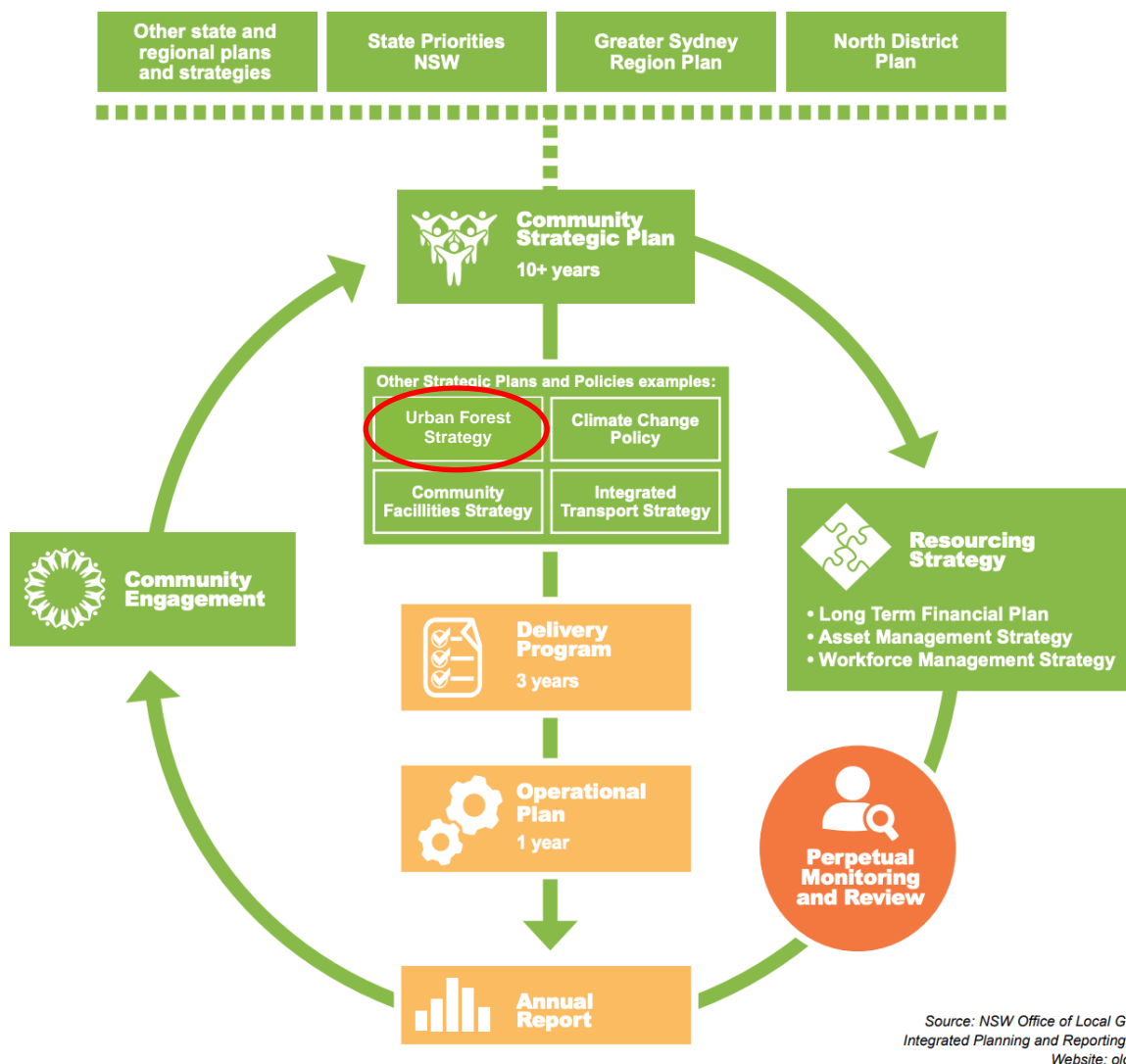
- Urban Forest Policy 2020
- Urban Forest - Strategic Directions Paper
- Ku-ring-gai Public Domain Plan 2021 (draft)
- Biodiversity Policy 2021 (draft)
- Climate Change Policy and Adaptation Strategy 2016
- Bushfire Management Policy 2020
- Weed Management Policy 2018
- Water Sensitive City Policy and Strategy (Updated 2021)
- Green Grid Strategy (to be created 2022-2024)
- Local Character Background Study 2021
- Playground Strategy Scenic and Cultural Landscape Study (to be created 2021)
- Ku-ring-gai Play Space Strategy 2020
- Scenic Cultural Landscape Study (TBA)

Urban forest management is supported by the Ku-ring-gai Community Strategic Plan 2038 in **Theme 3: Places, spaces and infrastructure - Issue P1: Preserving the unique visual character of Ku-ring-gai**. It is also recognised in **Theme 2** which identifies the importance of 'enhancing our tree canopy and green corridors'.

Council's Operational Plan and Delivery Program 2018-2022 sets out priority *P1.1.1: Strategies, plans and processes are in place to protect and enhance Ku-ring-gai's unique*

visual and landscape character. This is the strategic driver for the preparation of this Urban Forest Strategy.

Strategic urban forest planning in the Council is driven by the Ku-ring-gai Community Strategic Plan 2038 and Council's Operational Plan and Delivery Program. Community Strategic Plans are required by all Councils in NSW under the Integrated Planning and Reporting (IP&R) Framework. Figure 37 outlines where this Urban Forest Strategy sits within this framework.



Source: NSW Office of Local Government – Integrated Planning and Reporting Framework. Website: olg.nsw.gov.au

Figure 37: The IP&R Framework and where the Urban Forest Strategy sits in relation

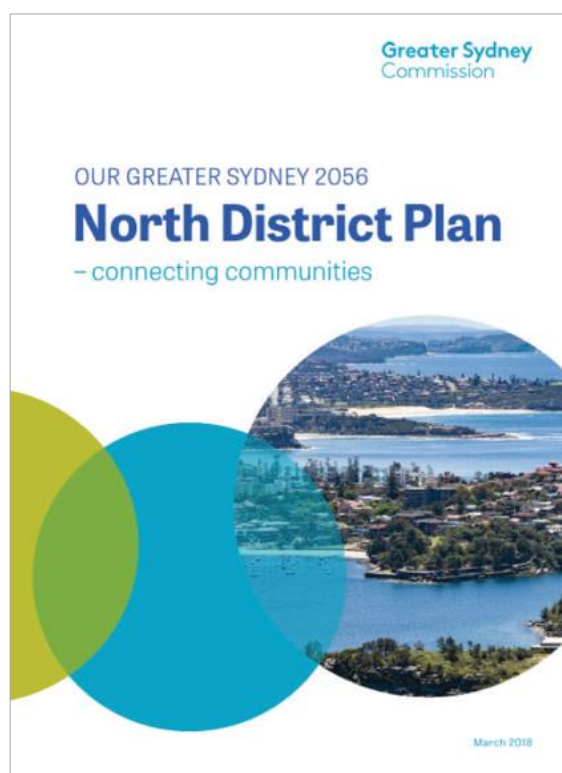
4.2 State Planning Directions

The NSW strategic planning framework connects key planning priorities identified at regional or district scale with the finer-grained planning at the local level (Figure 38).



Figure 38: NSW strategic planning framework as it relates to the Local Strategic Planning Statement

Greater Sydney Commission North District Plan



The North District Plan Priorities that are relevant to the Ku-ring-gai Urban Forest Strategy are summarised below.

Planning Priority N19

Increasing urban tree canopy cover and delivering Green Grid connections. Increasing the Green Grid means:

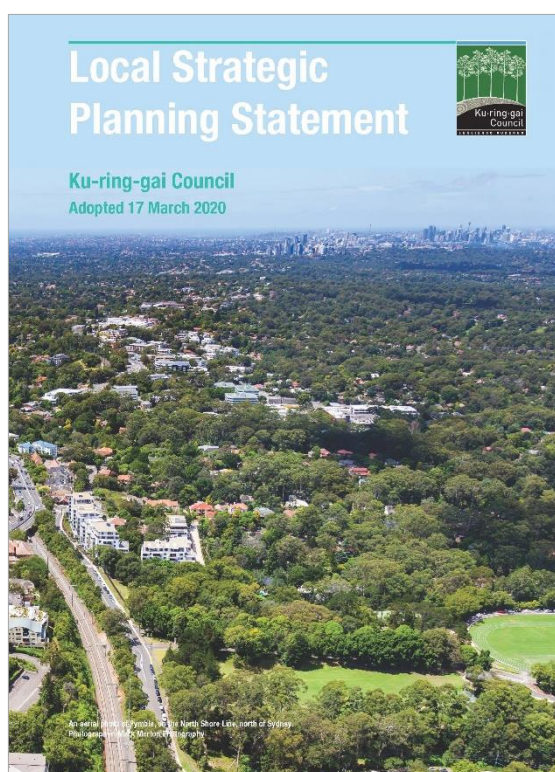
- expanding canopy in the public realm;
- providing opportunities for connections that form the long-term vision of the network; and
- walking and cycling links for transport as well as recreational trips.

Planning Priority N22

Adapting to the impacts of urban and natural hazards and climate change, such as:

- supporting initiatives that respond to the impacts of climate change; and
- mitigating the urban heat island effect and reducing vulnerability to extreme heat.

Ku-Ring-Gai Local Strategic Planning Statement



The Local Strategic Planning Statement Priorities that are relevant to the Ku-ring-gai Urban Forest Strategy are summarised below;

Urban Forest

- K30. Improving the quality and diversity of Ku-ring-gai's urban forest.
- K31. Increasing, managing and protecting Ku-ring-gai's urban tree canopy.

Green Grid

- K32. Protecting and improving Green Grid connections.
- K33. Providing a network of walking and cycling links for leisure and recreation.

Water Sensitive City

- K35. Protecting and improving the health of waterways and riparian areas.
- K36. Enhancing the liveability of Ku-ring-gai's urban environment through integrated water infrastructure landscaping solutions.
- K37. Enabling water resource recovery through the storage and reuse of water, alternate water

and increased water efficiency.

Change and Resilience

K40. Increasing urban tree canopy and water in the landscape to mitigate the urban heat island effect and create greener, cooler places.

Bushland and Biodiversity

K28. Improving the condition of Ku-ring-gai's bushland and protecting native terrestrial and aquatic flora and fauna and their habitats.

K29. Enhancing the biodiversity values and ecosystem function services of Ku-ring-gai's natural assets.

5

ORGANISATIONAL CAPACITY



5 Organisational Capacity

Fundamental to the delivery of improved urban forest and canopy outcomes is the organisational capacity to deliver these outcomes.

At the commencement of this project two workshops were carried out with key internal staff to determine the organisation's capacity and identify the current challenges and barriers that may exist in achieving improved urban forest outcomes. The workshops were designed to cater for the two main urban forest functions within Council 1) Public trees and operations and; 2) Private tree management and planning. These workshops were facilitated online using an interactive whiteboard platform to enable collaboration and visual representation of ideas, see Figure 35 for an example output from this workshop.

Each workshop focused on key areas of consideration within that function, for public trees these areas were:

- Tree Maintenance;
- Tree planting;
- Capacity to deliver.

For private trees these key areas were:

- Tree and Vegetation DCP;
- State Planning Framework;
- Capacity to deliver.

To assist with the assessment of organizational capacity to deliver improved urban forest outcomes each workshop contributed to the assessment matrix known as the Greening Success factor Tool (Croeser 2020). This assessment looks at functions of Council and provides a final ranking out of 10 to identify strengths and highlight where there may be issues. These functions, also referred to as 'success factors', include:

- Stable executive and political support;
- Suitable internal processes;
- Staff time, technical skill and capacity;
- Engagement skills and organisational culture;
- Alignment of internal departments .

Generally, Ku-ring-gai Council scored well in this assessment with no score in either workshop being below 8 (out of a possible 10). Minor issues were identified with staff resourcing and internal alignment of departments (integration). Issues with barriers posed from state and infrastructure agencies such as DPIE, Ausgrid and RMS were also identified.

The final output from these workshops were the identification of 'key focus areas'. These were issues or topics determined by the group as being the most important areas to be improved and/or developed further.

5.1 Key Focus Areas - Public Trees

1. **Council tree asset management** – It was identified that Council's publicly maintained trees are not currently recorded within a tree inventory and trees are not managed as operational assets. This poses issues at several levels, but primarily from a data collection and operational programming point of view. *It is impossible to know how to manage what you have unless you know what you have.*

Lack of information on public trees has implications on risk management but also best practice urban forest planning. An inventory can give you accurate data on, but not limited to, tree health and condition, species diversity, age distribution, and risk profile. Access to this data allows for accurate decision making and effective public tree management.

2. **Tree maintenance** – Council currently undertakes only reactive tree maintenance. There are no proactive or cyclic tree maintenance programs. Only high-risk reactive maintenance works are undertaken, these are primarily generated from customer requests. Low risk customer requests are generally not carried out.

Lack of resources and budget was identified as being the barrier to increasing levels of tree maintenance. Current annual maintenance budgets are approximately **\$1.94 m** (inclusive of contractor budgets, internal crew and fleet budgets).

3. **Risk management approach** – The current tree maintenance service level has implications on tree risk management. Having no proactive tree maintenance program means that tree risk is not being identified until it is already an issue. Trees that are inspected by Council staff under the reactive program are assessed using the TRAQ risk assessment framework which is an internationally recognised risk framework.

It was also identified that there is a low degree of organisational tolerance to risk, including by the Council's insurers. It is logical to draw conclusions between the current risk management approach and the low tolerance to risk, they inevitably go hand in hand.

It must be acknowledged that all trees carry some degree of risk and that a tree risk-benefit management approach should be adopted. This approach recognises that the risk from trees must also be balanced by the benefits they provide to achieve a tolerable level of risk.

4. **Tree planting program** – It was identified that more public trees are removed annually than planted by Council. This will inevitably result in a decrease in tree canopy on public land.

Public land increasingly needs to accommodate more trees as private space is developed, and it is essential that Council has a well-resourced tree planting program to facilitate an increase in canopy.

Budget for tree planting is approximately **\$200k** and is delivered primarily through external contractors, as there is limited internal resources to support planting programs.

5. **Social issues around trees** – Pressure from community and negative attitudes towards trees was identified as a major obstacle to improving urban forest outcomes. These negative attitudes can range from a fear of trees, from a risk perspective or cultural barriers, and acceptance of trees from an aesthetics perspective. Improved education and engagement around trees were seen as the way to improve this issue. It was however recognised that this is difficult to do well and needs a carefully considered approach to achieve any real improvement. Education was also identified as a barrier in the Private tree management workshop summarised below.

5.2 Key Focus Areas - Private Tree Management

1. **Reporting and benchmarking** – There is currently limited ability within Council to accurately record tree permit or DA figures to keep track of tree removal numbers on private land. This was largely determined to be a system/technology issue. The more data that can be collected in this area the better, as accurate data informs enhanced decision making.

This highlighted the need for improved monitoring and benchmarking of canopy cover and urban forest data across the board. Metrics need to be established in order to set targets for canopy, diversity and age distribution etc.

2. **State NSW planning conflicts** – Population growth, housing targets and complying development provisions were identified as barriers to achieving increases in canopy. These planning frameworks see existing valuable canopy removed and a reduction in the physical space for planting large canopy trees.

It was however acknowledged that there were other state planning initiatives such as DPIE Greener Places and Council's LSPS/ Green Grid work that were providing mechanisms for improved canopy outcomes. This contradiction of priorities from the state government was highlighted as a problem.

3. **DCP controls** – It was recognised that the current DCP controls pertaining to trees on private land could be improved. There is potential to set mandated canopy targets and tighter controls in relation to tree removal. The current stage one community engagement will provide some valuable feedback data on whether there is community support for this.
4. **Bushfire** – perceived threat from bushfires and zoning for bushfire prone areas was identified as being a significant obstacle to protecting and increasing trees in certain areas. The 10/50 Vegetation Clearing Scheme allows for trees within 10m of a property to be cleared in certain areas without approval from council. In some instances, this has allowed for effective bushfire management practices however in some areas it has seen the unnecessary removal of valuable trees. Not requiring Council approval also means there is no record of how many trees have been removed under this scheme.

The workshop also revealed that community pressure around trees and bushfires causes significant barriers retaining trees. There is a fear of trees (dendrophobia) and the potential threat they may pose from a bushfire perspective.

5. **Education** – This was identified as being key to success on many fronts. Approximately 70% of land within the LGA is privately owned, hence the impact of changes in canopy on private land is significant. Negative community attitudes towards trees often results in poor urban forest outcomes. Council Tree Management Officers are undoubtedly the 'front line' of urban tree management and good or bad decisions often come down to individual conversations with residents; the more aware the community are of tree benefits the easier these conversations are.

There are several current Council-led urban forest engagement initiatives underway however it was identified that more could be done in this area, including a regular community tree giveaway program. This would provide for increased tree planting on private land and the opportunity to meaningfully engage with the community on the benefits of trees.

These key focus area topics will be considered during the development of the project and will lead to the formation of the recommendations and actions in the final Urban Forest Strategy document.

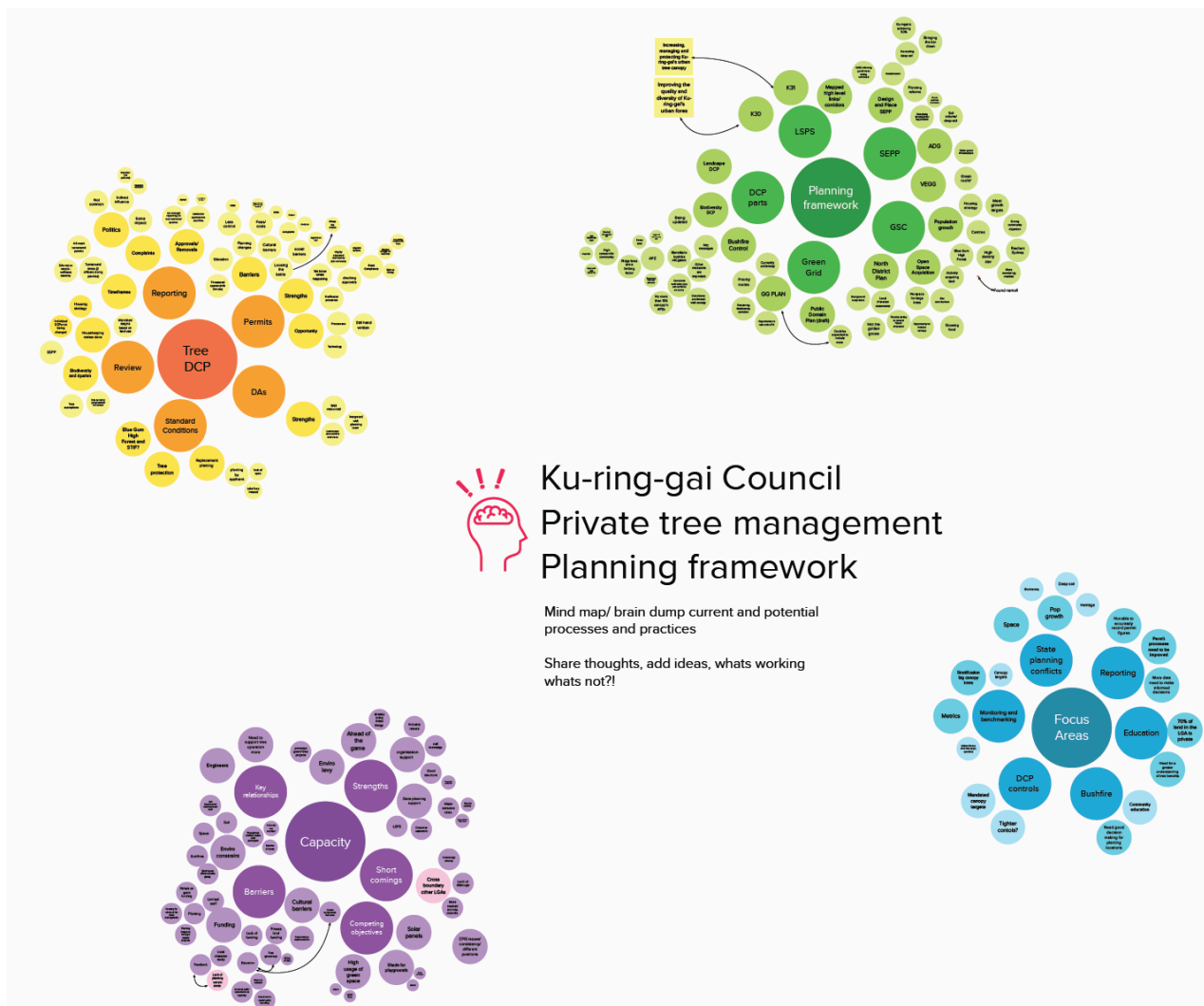


Figure 39: Example output of the internal staff workshop mind mapping exercise

6

COMMUNITY ENGAGEMENT



6 Community engagement

6.1 Background

This Urban Forest Strategy will define how Council manages and improves the urban forest for current and future generations. To support the development of the Strategy, the community's input was sought to ensure their opinions and insights were considered, and to assist Council to deliver an urban forest that considers the needs of its residents and provides maximum benefits to all.

Community consultation and engagement for the Urban Forest Strategy sits within the 'consult/inform' brackets on the IAP2 spectrum for public participation, and is to be delivered as a two-phase process. **Phase one** will align with Stage 1 (Background Studies) and Stage 2 (Mapping) of the strategy development process, and will initiate the conversation about the strategy and what its goals are. It will inform, register opinions and ascertain the current level of understanding about the urban forest in the community. **Phase two** of the engagement process will take place once the draft Urban Forest Strategy has been prepared and the document is placed on exhibition for community comment, in mid 2022.

6.2 Engagement methods

An online survey was developed using Council's online engagement portal (Engagement Hub) with a range of questions designed to gauge the following:

- Level of understanding in the community regarding tree benefits;
- Attitudes towards Council's management of urban trees (on private and public land);
- Issues of concern with urban trees;
- Preference towards native or exotic trees and preferred size of tree.

The specific questions and the summary of responses can be seen below in Section 6.3 - Engagement Outcomes.

The screenshot shows the online engagement hub portal for the Ku-ring-gai Urban Forest Strategy. The page has a dark header with navigation links: Home, Council Website, Contact Us, and a search bar. Below the header is a large image of trees. The main content area is titled 'Ku-ring-gai Urban Forest Strategy' and is divided into three sections: 'What's happening', 'Project Information', and 'Project Timeline'. The 'What's happening' section includes a video player and text about the development of the strategy. The 'Project Timeline' section lists the phases of community engagement and the adoption of the strategy.

Project Timeline
Phase 1 Community Engagement - COMPLETE
Development of draft Urban Forest Strategy - November 2021 - February 2022 Informed by Phase 1 community engagement
Phase 2 Community Engagement - February 2022 Public exhibition of draft Urban Forest Strategy
Urban Forest Strategy adopted by Council - April 2022

Figure 40: The online Engagement Hub portal

Q.1 We want to know about community attitudes towards trees. Please indicate your level agreement with each of the following statements.

	Strongly agree	Agree	Neither agree or disagree	Disagree	Strongly disagree	Don't know/NA
Trees are essential to our urban areas and we need more of them	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Trees make Ku-ring-gai special	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I don't like having trees around me	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Trees pose a risk and are dangerous	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I don't really think about trees at all	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Figure 41: Example question from the Engagement Hub online survey

The survey was promoted using the following platforms:

- Council social media channels (Facebook);
- Media release;
- Ku-ring-gai E-news lists: Sustainability, Smart schools and Bush care;
- Council's registered email distribution lists: Bush care volunteers, Wild Things, Pool to Pond, Native Bees, Fauna Monitoring;
- Direct emails to residents who had provided submissions on the Urban Forest Policy;
- Council's Environmental volunteers;
- Environmental groups (FOKE, STEP, NTAG);
- Other contacts through Council's operation tree management team.

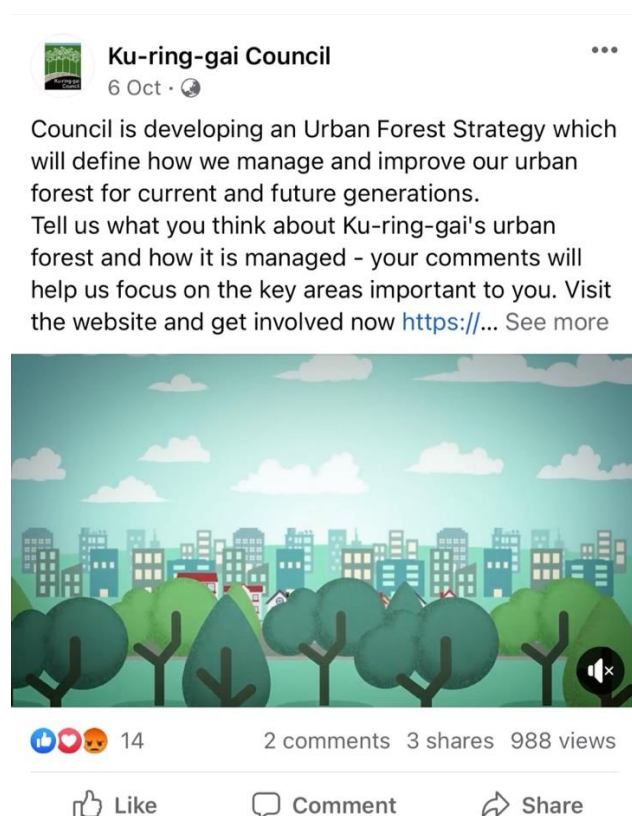


Figure 42. Facebook promotion of the online survey

6.3 Engagement outcomes

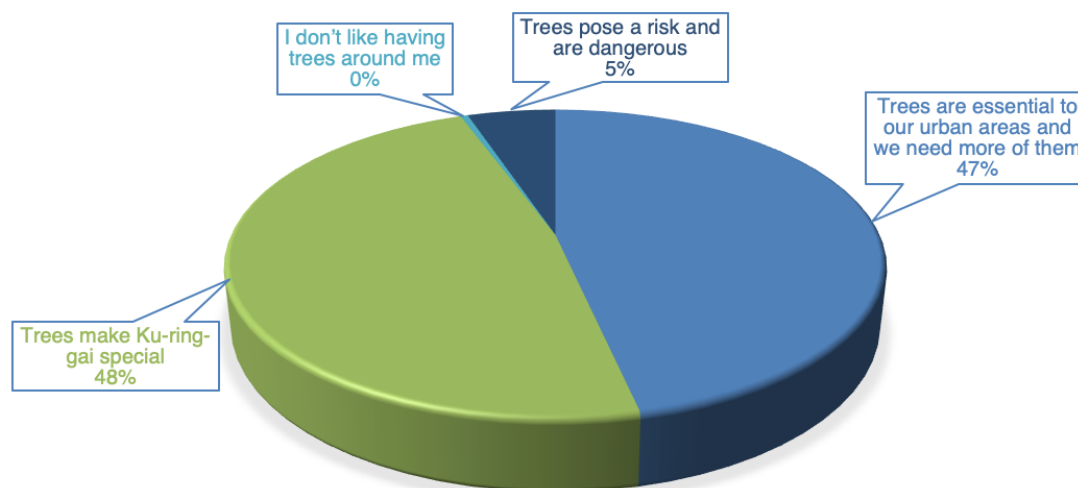
A total of **138** respondents completed the online survey. Individual submissions were received from the following organisations:

- Friends of Ku-ring-gai Environment Inc (FOKE)
- Wild Things NSW committee
- STEP Inc
- Ku-ring-gai Bushcare Association (KBA)

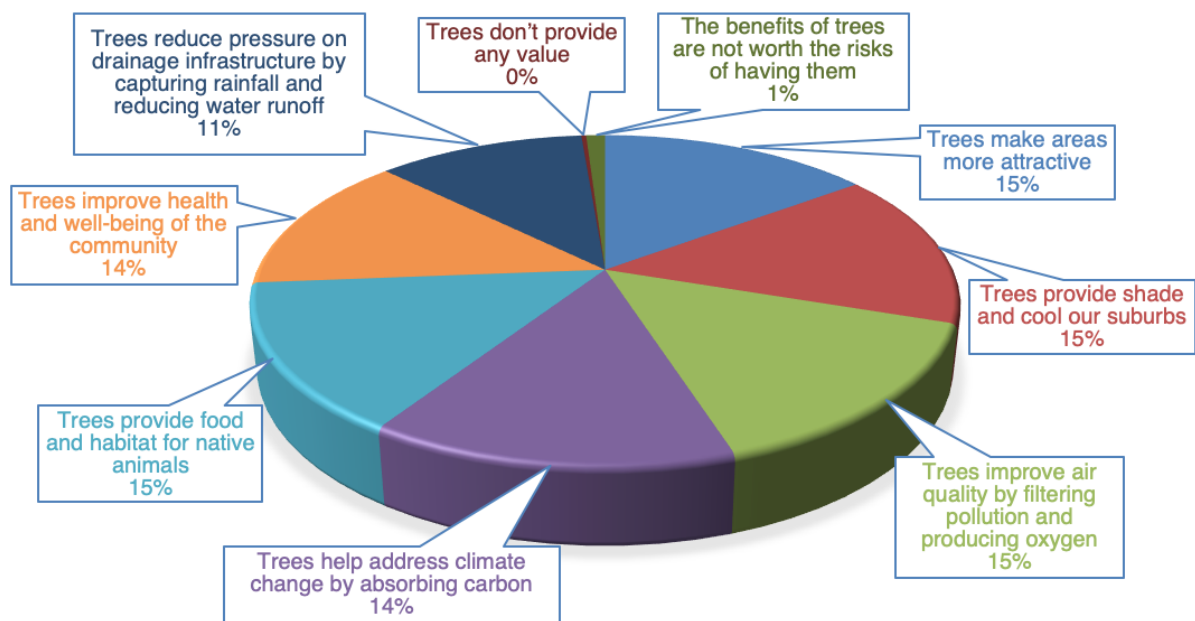
Survey responses

Respondents were asked a series of 10 questions designed to achieve the outcomes outlined above. These questions were grouped into three main categories: 1) Attitudes towards trees; 2) Council's management of public trees; 3) issues surrounding private trees. These questions and the responses are provided below.

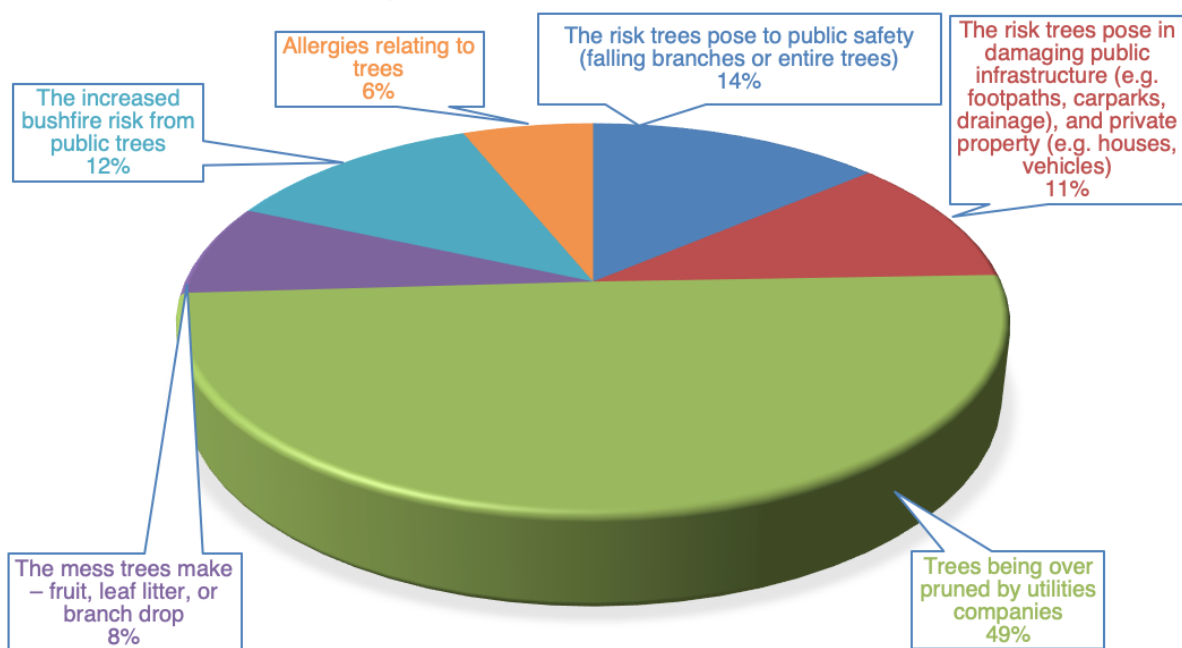
- 1. QUESTION ONE** - *"We want to know about community attitudes towards trees. Please indicate your level agreement with each of the following statements."*



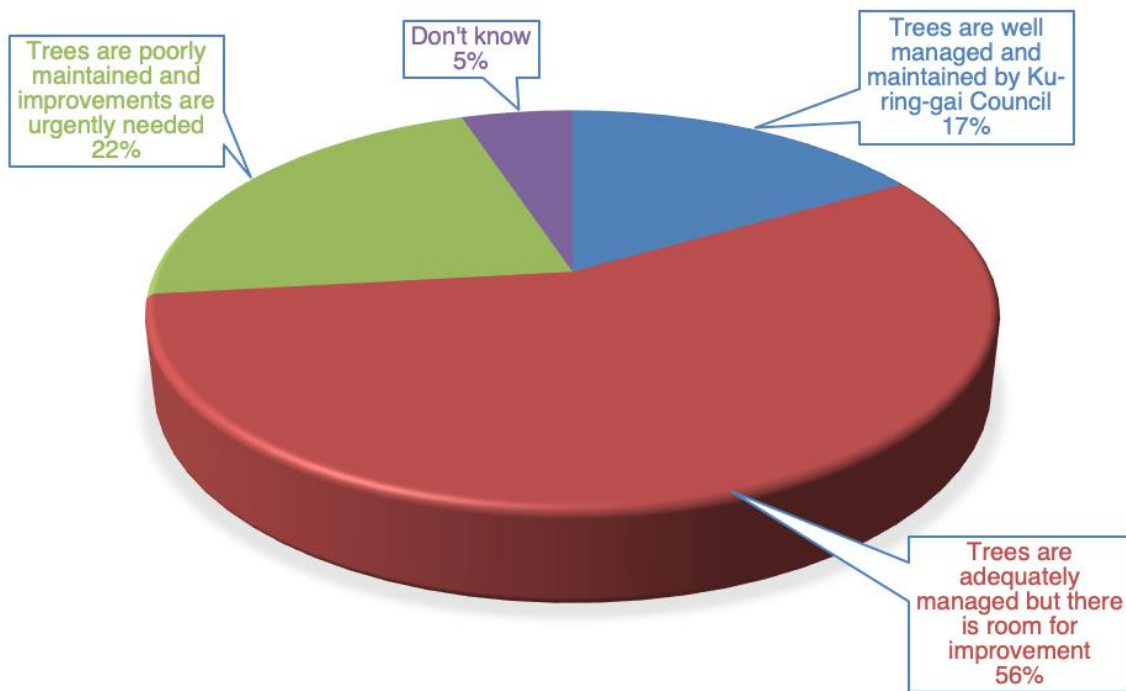
- 2. QUESTION TWO** - *"Below is a series of statements about how trees can impact our environment and local area. Indicate your level of agreement with these statements."*



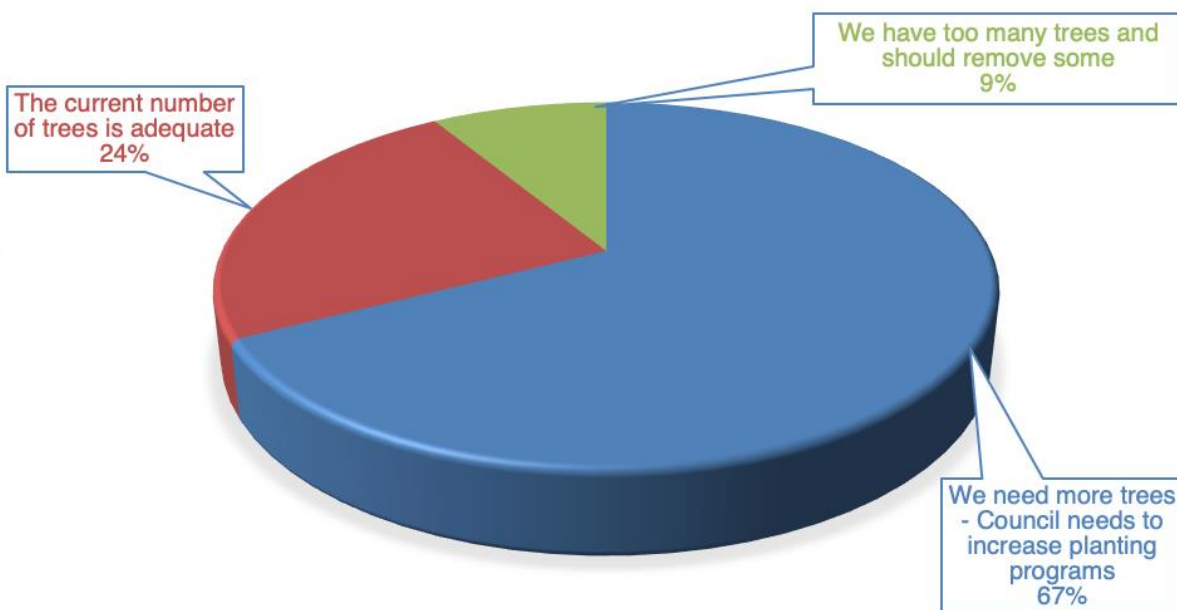
3. QUESTION THREE - "Please read the following statements about possible impacts of trees and indicate relevant levels of concern to you"



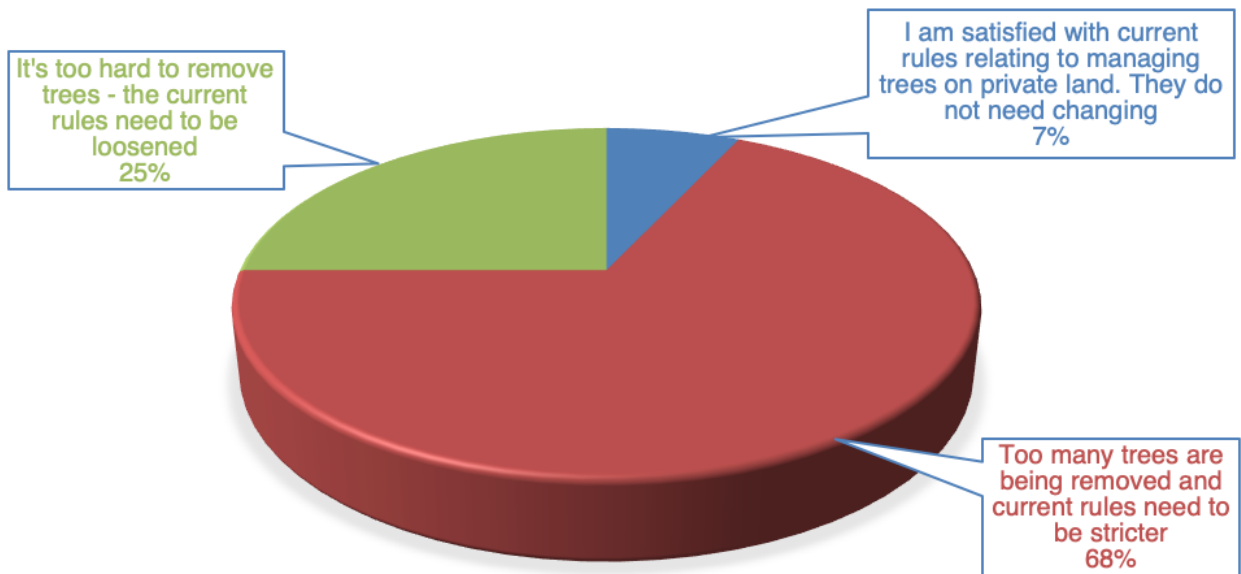
4. QUESTION FOUR - "In relation to the management of trees in PUBLIC AREAS (streets and parks/sports grounds) indicate below how you feel Ku-ring-gai Council is performing"



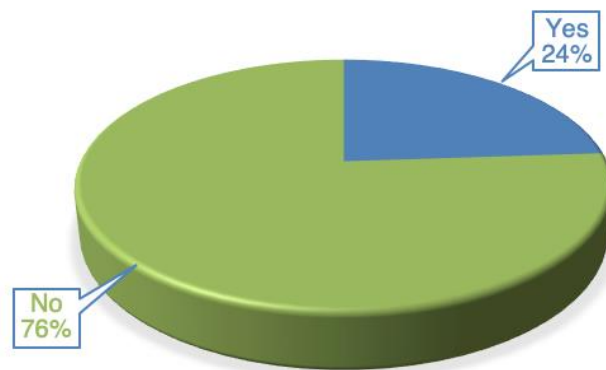
5. QUESTION FIVE - *“Tell us about the number of trees you think we need to have in PUBLIC AREAS across Ku-ring-gai?”*



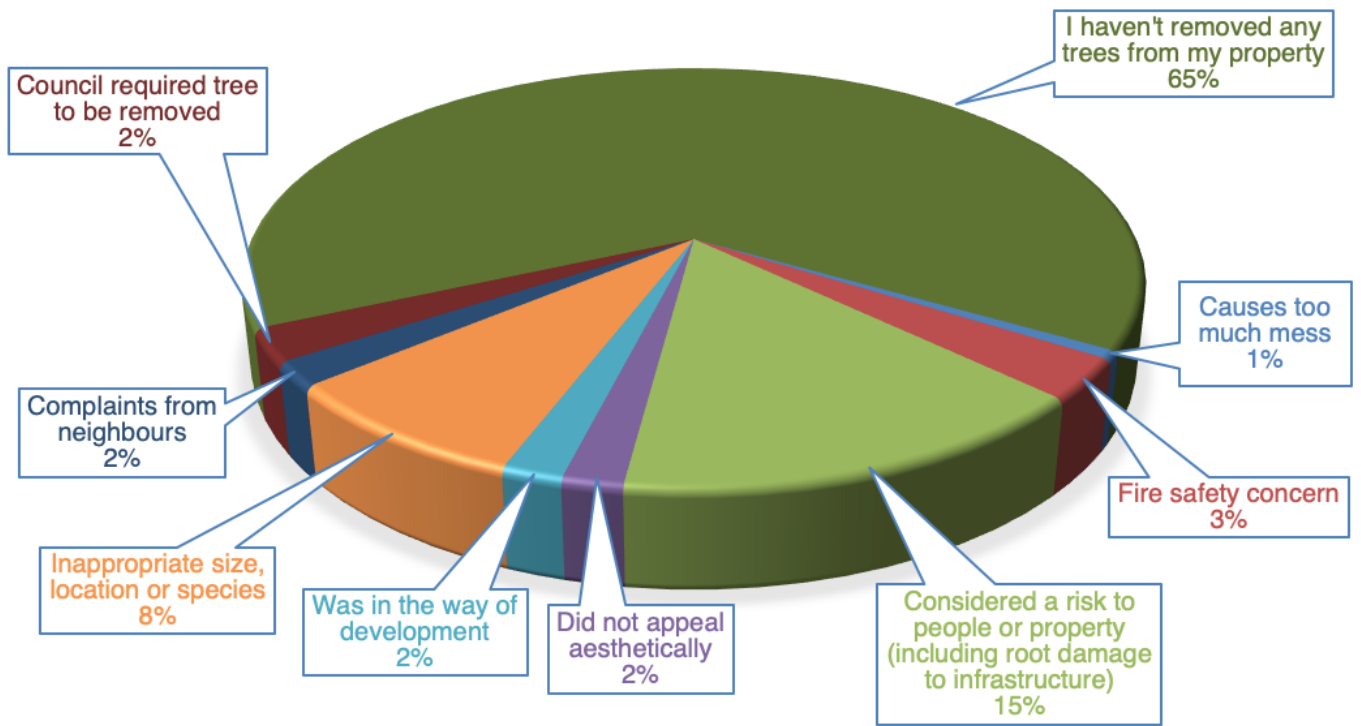
6. QUESTION SIX - *“In relation to the management of trees on PRIVATE LAND in Ku-ring-gai, indicate your level of agreement with the following statements.”*



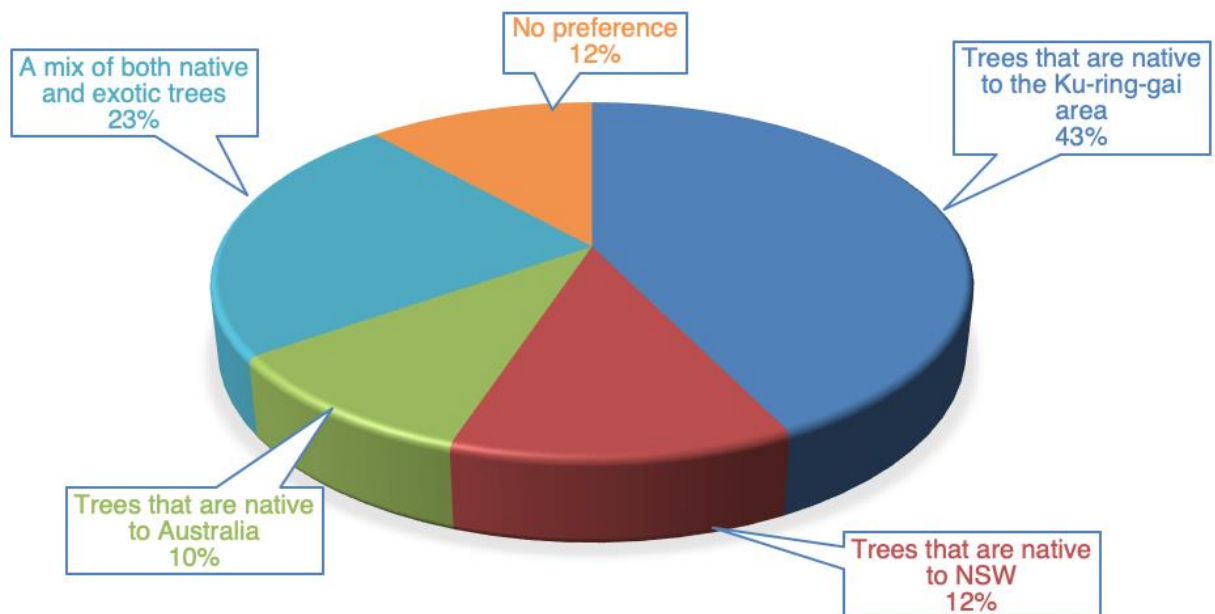
7. QUESTION SEVEN - *“Have you recently removed a tree/s on your property?”*



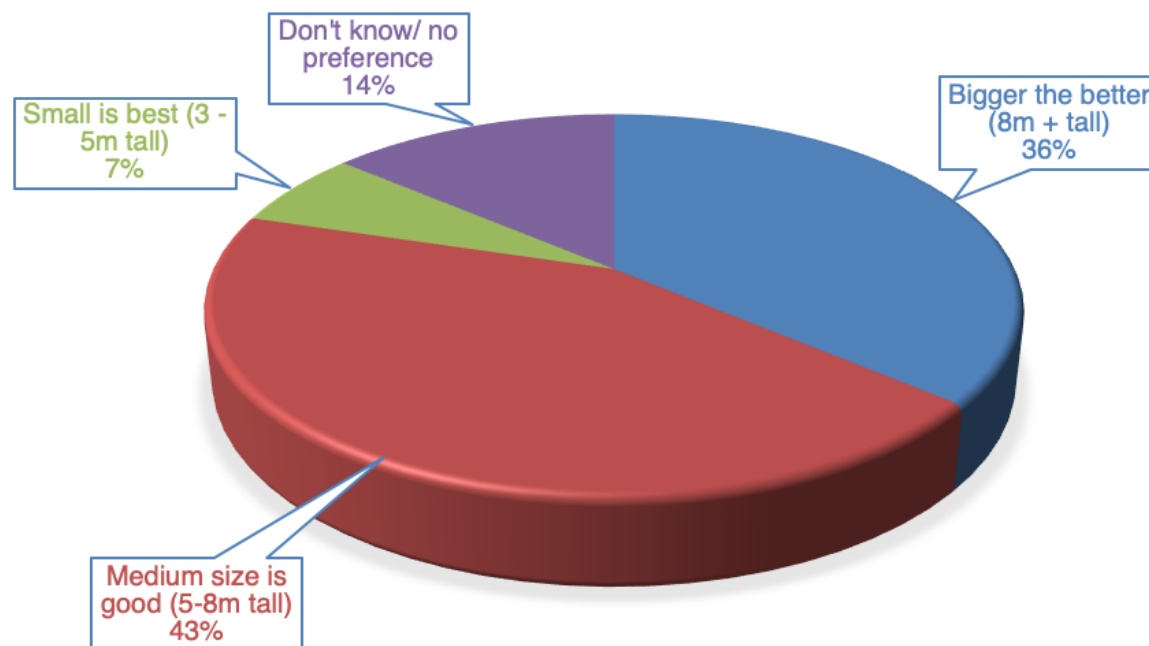
8. QUESTION EIGHT - *“If you have recently had a tree/s removed from your property please tell us why (click all that apply)”*



9. QUESTION NINE - "In terms of the origin of the trees you would like to see in Ku-ring-gai, would you prefer"



10. QUESTION TEN - “Generally what size of tree do you prefer?”



Individual comments

Respondents to the survey were also asked for general comments regarding urban trees in Ku-ring-gai. This gave residents an opportunity to expand on the questions asked throughout the survey, or provide comments on topics not covered by the survey.

Tree removal and development

A common concern raised throughout the comments was the lack of strict guidelines for removal and replacement of trees on development sites. Overdevelopment is a big concern for the community. Many respondents commented that it is too easy for developers to remove trees, that there is not enough of a requirement for large, mature trees to be retained on development sites, or for the replacement of trees post development. Multiple responders commented that fines for tree removal are too low, don't deter developers and that the fines are simply considered as part of the cost of development. The community is concerned that too much native forest, such as the Sydney Turpentine and Ironbark forest in Wahroonga, is being cleared for development, and that this will negatively impact ecological flora and fauna communities. Many respondents also feel that there is a disparity between tree removal on private land for developers versus residents. Residents feel that it is too easy for developers to remove significant trees, yet difficult for a resident to have a non-native tree removed on their own property that is considered unsuitable for the area and could be replaced with a more appropriate native tree. In general, residents indicated that DA regulations around tree removal were too rigid, and that individual case-by-case context needed to be considered. In general, comments support protecting existing trees, and that looking after the current tree population was important.

In addition, tree removal on Council owned land was raised as a concern. Residents feel that well-established significant trees are removed from streets and parks at a rate that they are not replaced. Furthermore, residents want to see more 'unique' and ecologically significant trees retained for aesthetic or habitat value, once they have died. Concern was expressed that these significant trees are currently not protected enough.

Conflicting issues

The majority of comments supported increasing the number of trees. However, a number of comments did not support increasing the number of trees or did not see it as a priority. For example, some respondents commented that increasing canopy was counter intuitive to the sustainability movement. Some residents commented that too many large trees in their local area are inhibiting the use of solar panels to generate household energy. In addition, some comments identified too much shade as an issue, increasing the requirement for indoor heating. Others commented that retaining trees took precedence to other issues, such as damage to footpaths caused by trees or public safety, therefore inhibiting their use of the footpaths and their preference to drive instead of walk.

Bushfire

A number of comments brought attention to the 10/50 rule for clearing of vegetation. Residents want to see the rule relaxed or removed in certain areas. Comments have indicated that the rule has resulted in too much unnecessary clearing of native forest and disconnectedness between areas of bush.

Planting trees on public land

Comments indicate that residents are very supportive of increasing the number of plantings on nature strips. However, size and species selection need to be well considered. For example, planting smaller trees under powerlines and along streets, as current pruning is resulting in unaesthetic streetscapes.

A number of specific locations were mentioned as particularly lacking canopy cover or requiring tree replacement, such as St Crispins Green and Jinkers Green.

Planting trees on private land

In addition, many residents remarked on their desire to plant suitable trees on their own property and requested that the Council provide easily accessible planting guidelines and recommendations on their website. For example, respondents want to plant a tree that is suitable for their soil type. It was commented that the current information on the Council's website for managing vegetation on private land is too long and complex, and should be simplified so that residents have a better understanding.

Resident education

Community education around the benefits of the trees is conserved an important element of the urban forest strategy by many respondents. Many members of the community are aware that much of the urban forest falls on private land, and that it's everyone's responsibility to protect the urban forest, and it's important that the Council provides easily accessible resources to educate the general community about the value of trees.

Weed management on public land and a preference for small and medium trees around infrastructure were also commonly received comments.

6.4 Summary (key takeaways)

The majority of respondents generally support trees and understand the benefits they provide:

- 95% of respondents have a positive attitude towards trees, this is a clear majority and an impressive result. They feel “they make Ku-ring-gai special”, “that they are essential to our urban areas and we need more of them.”
- Respondents generally seem to understand the benefits of trees with only 1% saying that the benefits of trees are not worth the risk of having them.
- The top concerns regarding issues caused by trees were the over pruning of trees by Ausgrid and tree risk and safety concerns.
- The majority of respondents feel that “trees are adequately managed but there is room for improvement” while a reasonable proportion (22%) feel that “trees are poorly maintained and improvements are urgently needed”.
- The majority of respondents (67%) feel that Council should increase tree planting programs on public land.
- 68% of respondents feel that the protection of trees on private land is not effective and that the rules should be tighter, while 25% felt that it was too hard to remove trees and that the rules need to be loosened.
- Only 24% of respondents had recently removed trees on their land and the majority of these were removed due to risk or property damage.
- The majority of people (43%) want trees that are native to the Ku-ring-gai area and that are medium in size (5-8m).

Phase 1 of the community engagement has provided some clear direction regarding the views of residents towards trees. The results of the survey and individual submissions will be used to formulate the strategic objectives of the Urban Forest Strategy and guide decision making throughout the process.

7 Reference list

Aboriginal Heritage Office. (2018). *Aboriginal Heritage and History Within the Ku-ring-gai Local Government Area*, https://www.krg.nsw.gov.au/files/assets/public/hptrim/information-management-publications-public-website-ku-ring-gai-council-website-environment/aboriginal_heritage_and_history_within_the_ku-ring-gai_local_government_area_-_july_2018.pdf.

Aboriginal Heritage Office. (2015). *Filling a Void: a Review of the Historical Context for the Use of the Word 'Guringai'*, <http://www.aboriginalheritage.org/wp-content/uploads/Filling-a-Void-Guringai-Language-Review-2015.pdf>.

Alvey, A.A. (2006). Promoting and preserving biodiversity in the urban forest. *Urban Forestry and Urban Greening*. 5: 195-201.

Attenbrow, V. (2010). *Sydney's Aboriginal Past: Investigating the archaeological and historical records*. UNSW Press, Sydney.

Australian Academy of Science. 2021. *The Risks to Australia of a 3°C Warmer World*. Canberra: Australian Academy of Science. Accessed online <https://www.science.org.au/files/userfiles/support/reports-and-plans/2021/risks-australia-three-deg-warmer-world-report.pdf>. Viewed October 19, 2021.

Benson, D., & Howell, J. (1990). *Taken for Granted: the Bushland of Sydney and its Suburbs*. Royal Botanic Gardens, Sydney.

Bi, P., Williams, S., Loughnan, M., Lloyd, G., Hansen, A., Kjellstrom, T., & Dear, K. (2010). 'The effects of extreme heat on population health in Australia'. Discussion Paper Series: State of the Science and Policy.

Bolund, P. and Hunhammar, S. (1999). Ecosystem services in urban areas. *Ecological Economics*. 29: 293-301.

Bowler, D.E., Buyung-Ali, L., Knight, T.M. and Pullin A.S. (2010a). Urban greening to cool towns and cities: A systematic review of the empirical evidence. *Landscape and Urban Planning*. 97:147-155.

Bowler, D., Buyung-Ali, L., Knight, T. and Pullin, A. (2010b). How effective is 'greening' of urban areas in reducing human exposure to ground level ozone concentrations, UV exposure and the 'urban heat island effect'. *Systematic Review - Collaboration for Environmental Evidence* 2010. 41: 52.

Brack, C.L. (2002). Pollution mitigation and carbon sequestration by an urban forest. *Environmental Pollution*. 116: s195-s200.

Bratman G.N., Hamilton J.P., Hahn K.S., Daily G.C. and Gross J.J. (2015). Nature experience reduces rumination and subgenual prefrontal cortex activation. *Proceedings of the National Academy Sciences*. 112:8567-8572. doi:10.1073/pnas.1510459112

Burden, D. (2006) *Urban Street Trees: 22 Benefits*. Retrieved from http://www.walkable.org/download/22_benefits.pdf p2. 2

Chapin, F. S., & Knapp, C. N. (2015). Sense of place: A process for identifying and negotiating potentially contested visions of sustainability. *Environmental Science & Policy*, 53, 38–46. <https://doi.org/10.1016/j.envsci.2015.04.012>

- Chmura, G.L., Anisfeld, S.C., Cahoon, D.R. and Lynch, J.C. (2003). Global carbon sequestration in tidal, saline wetland soils. *Global Biogeochemical Cycles*. 17:22-1 – 22-12. <https://doi.org/10.1029/2002GB001917>
- Craig, M.D. (2004). The value of unlogged buffers for vulnerable bird species. In: *Conservation of Australia's Forest Fauna* (Ed: D. Lunney). NSW Zoological Society, Sydney. Pp 774-782.
- Croeser, T. (2020). Diagnostic tool - success factors for urban Greening (Version 1). RMIT University. <https://doi.org/10.25439/rmt.12859502.v1>
- Donovan, G. H., Butry, D. T., Michael, Y. L., Prestemon, J. P., Liebhold, A. M., Gatzliolis, D., & Mao, M. Y. (2013). The Relationship Between Trees and Human Health: Evidence from the Spread of the Emerald Ash Borer. *American Journal of Preventive Medicine*. 44(2): 139–145. <https://doi.org/10.1016/j.amepre.2012.09.066>
- Dwyer, J.F., McPherson, E.G., Schroeder, H.W. and Rowntree, R.A. (1992). Assessing the benefits and costs of the urban forest. *Journal of Arboriculture* 18: 227-234.
- Dwyer, J.F., Schroeder, H.W. and Gobster, P.H. (1991). The significance of urban trees and forests: toward a deeper understanding of values. *Journal of Arboriculture* 17:276-284.
- Egorov A.I., Griffin S.M., Converse R.R. and Styles, J.N. (2017). Vegetated land cover near residence is associated with reduced allostatic load and improved biomarkers of neuroendocrine, metabolic and immune functions. *Environmental Research*. 158: 508-521. doi:10.1016/j.envres.2017.07.009
- Gibson, L.A., Wilson, B.A. and Aberton, J.G. (2004). Landscape characteristics associated with species richness and occurrence of small native mammals inhabiting a coastal heathland: a spatial modelling approach. *Biological Conservation*. 120: 75-89.
- Grant R.H., Heisler, G.M. and Gao, W. (2007). Estimation of Pedestrian Level UV Exposure Under Trees. *Phytochemistry and Phytobiology*. Published Wiley On-line. [https://doi.org/10.1562/0031-8655\(2002\)0750369EOPLUE2.0.CO2](https://doi.org/10.1562/0031-8655(2002)0750369EOPLUE2.0.CO2)
- Heisler G.M and Grant, R.H. (2000). Ultraviolet radiation in urban ecosystems with consideration of effects on human health. *Urban Ecosystems*. 4: 193-229.
- Jacobs, B., Mikhailovich, N., & Delaney, C. (2014). Benchmarking Australia's Urban Tree Canopy: An i-Tree Assessment (p. 49).
- Jerrett, M. and van den Bosch, M. (2018). Nature exposure gets a boost from a cluster randomized trial on the mental health benefits of greening vacant lots. *JAMA Network Open*. 1(3):e180299. doi:10.1001/jamanetworkopen.2018.0299
- Joye, Y., Willems, K., Brengman, M. and Wolf, K. (2003). The effects of urban retail greenery on consumer experience: Reviewing the evidence from a restorative perspective. *Urban Forestry & Urban Greening*. 9: 57-64.
- Keniger, L.E., Kevin J. Gaston, K.J., Irvine, K.N. and Fuller A.A. (2013). What are the Benefits of Interacting with Nature? *International Journal of Environmental Research and Public Health*. 10: 913-935.
- Ko, Y. (2018). Trees and vegetation for residential energy conservation: A critical review for evidence-based urban greening in North America. *Urban Forestry & Urban Greening*, 34, 318–335. <https://doi.org/10.1016/j.ufug.2018.07.021>

Ku-ring-gai Historical Society. (Accessed 2021). Roseville Local History. <https://www.khs.org.au/roseville-local-history/>

McPherson E.G and Rowntree R. (1993). Energy Conservation Potential of Urban Tree planting. *Journal of Arboriculture* 19: 321-331.

McPherson, E.G. (2009). Urban Forest Impacts on Carbon, Water and Urban Heat Islands. Center for Urban Forest Research, USDA Forest Service, USA.

McPherson, E.G. Nowak, D.J. and Rowntree, R.A. (1994). Chicago's urban forest ecosystem: results of the Chicago Urban Forest Climate Project. General Technical Rep. NE-186. Radnor, PA: U. S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 201 p.

McPherson, E.G., Nowak, D.J., Heisler, G., Grimmond, S., Souch, S. and Rowntree, R.A. (1997). Quantifying urban forest structure, function, and value: the Chicago Urban Forest Climate Project. *Urban Ecosystems* 1: 49-61.

Nowak, D.J., Hirabayashi, S., Doyle, M., McGovern, M. and Pasher, J. (2018). Air pollution removal by urban forests in Canada and its effect on air quality and human health. *Urban Forestry and Urban Greening*. 29: 40-48.

Pandit, R., Polyakov, M., Tapsuwan, S., & Moran, T. (2013). The effect of street trees on property value in Perth, Western Australia. *Landscape and Urban Planning* 110: 134–142.

Roy, S., Byrne, J. and Pickering, C. (2012). A systematic quantitative review of urban tree benefits, costs, and assessment methods across cities in different climatic zones. *Urban Forestry and Urban Greening*. 11: 351-363.

South, E.C., Hohl, B.C., Kondo, M.C., MacDonald, J.M. and Branas, C.C. (2018). Effect of Greening Vacant Land on Mental Health of Community-Dwelling Adults: A Cluster Randomized Trial. *JAMA Network Open*. 1(3): doi:10.1001/jamanetworkopen.2018.0298

Steffensen, V. *Fire Country : How Indigenous Fire Management Could Help Save Australia*, Hardie Grant Publishing, 2020.

Strehlow, K.H., Bradley, J.S., Davis, J.A. and Friend, G.R. (2004). Seasonal invertebrate communities in multiple use jarrah forest. Implications for conservation and management. In: *Conservation of Australia's Forest Fauna* (Ed: D. Lunney). NSW Zoological Society, Sydney. Pp. 830-844.

Ulrich, R.S. (1984). View through a window may influence recovery from surgery. *Science*. 224:420–421.

Wolfe, K.L. (2007). The environmental psychology of shopping: assessing the value of trees. *International Council of Shopping Centers Research Review*. 14: 39-43.

