URBAN FOREST STRATEGY

Ku-ring-gai Council

DRAFT

DRAFT - FOR PUBLIC EXHIBITION

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.

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 **Briony Williams** **Riley Faulds** **Dr Harry Eslick** **Naviin Hardy**	Briony Williams

Approved & Released by	Position	Approval Signature
Briony Williams	Consultant	

Revision Schedule

Revision	Report Description	Submission Date	Author(s)
A	Urban Forest Strategy – Revision A	22/03/2022	Gwilym Griffiths Briony Williams Riley Faulds Dr Harry Eslick Naviin Hardy
0	Urban Forest Strategy – Revision 0	29/04/2022	Gwilym Griffiths Briony Williams Riley Faulds Dr Harry Eslick Naviin Hardy

Disclaimer

ArborCarbon

GOOD CANOPY COMPANY

CONTENTS

1 Introduction

1.1 Executive Summary

Ku-ring-gai, known as Sydney's 'green heart', has developed its first Urban Forest Strategy to support the recently adopted Urban Forest Policy. This Strategy outlines how Ku-ring-gai will achieve the purpose set out in the Urban Forest Policy. Council is committed to protecting and enhancing this character and identity through sustainable management of its Urban Forest. This includes:

- Integration of green landscaping elements within built infrastructure
- Conservation of our magnificent environment for future generations
- Balancing benefits from the protection, health and growth of the urban forest against associated risks

Ku-ring-gai is committed to protecting its existing valuable and unique urban forest, as well as replenishing and expanding it. The four key principles are:

1. **Retain and Protect** - *Key to increasing urban tree canopy is protecting what you have.*
2. **Expand and Integrate** - *Expand tree planting programs and integrate capital programs to increase canopy on public land.*
3. **Monitor and Maintain -** *You need to know what you have to know how to manage it.*
4. **Collaborate and Incentivise** - *Raising awareness of the benefits of trees across the community will drive change.*

Ku-ring-gai is fortunate to have an established urban forest with good canopy cover. Priority will be given to protecting these existing assets, many of which have significant cultural and ecological importance, both on public land and private land. Council is also committed to increasing canopy cover where appropriate, focusing on areas where canopy is lower than average, in order to ensure that all of the community has equitable access to high quality green spaces. Council has identified areas that lack canopy, pinpointing road reserves that can accommodate trees, parks that lack sufficient tree cover, and active transport routes that lack shade, with the purpose of increasing canopy cover where it will benefit the community the most. This will also provide linkages between Ku-ring-gai's many pockets of remnant bushland, providing corridors for wildlife and numerous other ecological benefits. We will use utilize the latest technology and research available to ensure we are accurately monitoring our performance and ensuring we achieve our targets and goals. We will engage the community every step of the way. Partnering with and empowering local residents and organisations will help build urban forest awareness and support for the protection, management and increasing of urban canopy.

A five-year implementation plan paves the way for the Council to achieve the targets and goals set out in the Ku-ring-gai Urban Forest Strategy.

1.2 Purpose of this Strategy

Trees play an important role in defining the unique character of Ku-ring-gai. The Urban Forest Strategy will define how Council is currently managing its urban forest and will outline a pathway to facilitate improved urban forest outcomes, so that the benefits of a healthy urban forest can be maximised for current and future generations. The Urban Forest Strategy will be supported by the Urban Forest Replenishment Program and Urban Forest Monitoring Program, as outlined in Ku-ring-gai's Urban Forest Policy.

2 Vision Statement

To recognise that the Ku-ring-gai urban forest forms an important part of the cultural identity of Ku-ring-gai, where residents value trees and the natural landscape. Council will protect and enhance the urban forest to ensure this unique character and established canopy cover is preserved and improved for future generations.

PART ONE

Where did we come from?

3 Background

3.1 Strategic Framework

3.1.1 Council Policies and Strategies

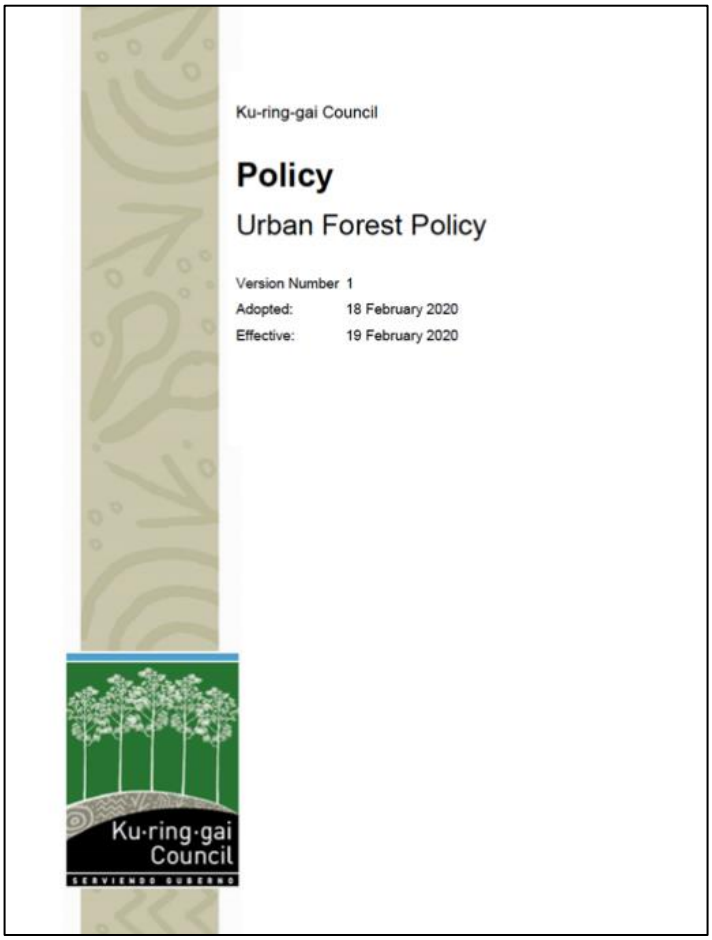
In 2020, Council adopted the Ku-ring-gai *Urban Forest Policy*, a policy that established Council's commitment to the improved holistic management of Ku-ring-gai's urban forest. This Urban Forest Strategy will provide the mechanism for implementing the Ku-ring-gai *Urban Forest Policy 2020*.

This Urban Forest Strategy will sit alongside other key Council documents and aims to align with State Planning Directions, 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 2020
- Ku-ring-gai Public Domain Plan 2022
- Biodiversity Policy 2022
- Climate Change Policy and Adaptation Strategy 2016
- Bushfire Management Policy 2020
- Weed Management Policy 2018
- Water Sensitive City Policy and Strategy 2022
- Green Grid Strategy (to be created 2022-2024)
- Local Character Background Study 2021
- Ku-ring-gai Play Space Strategy 2020

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 within 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 1 outlines where this Urban Forest Strategy sits within that framework.

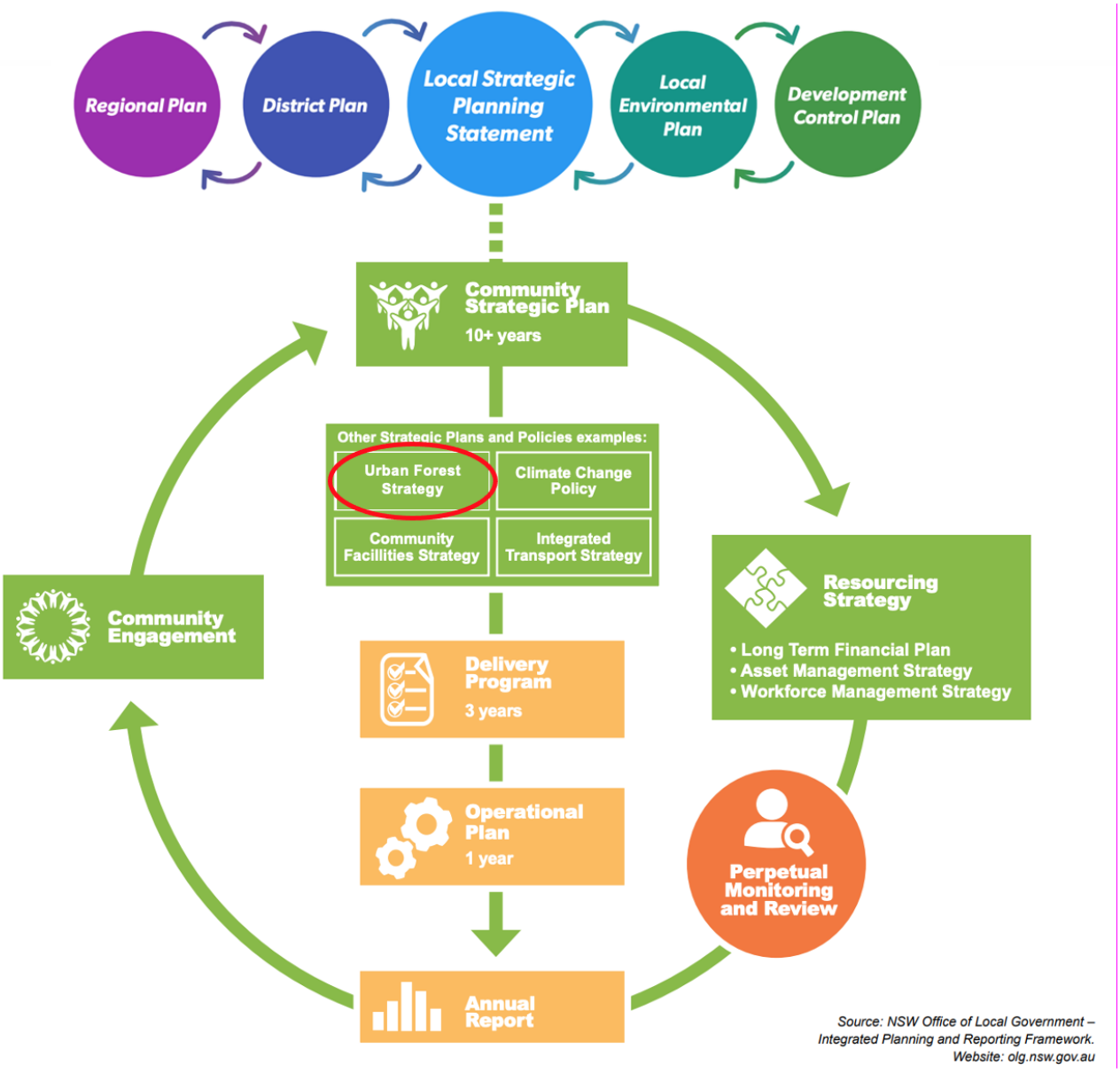
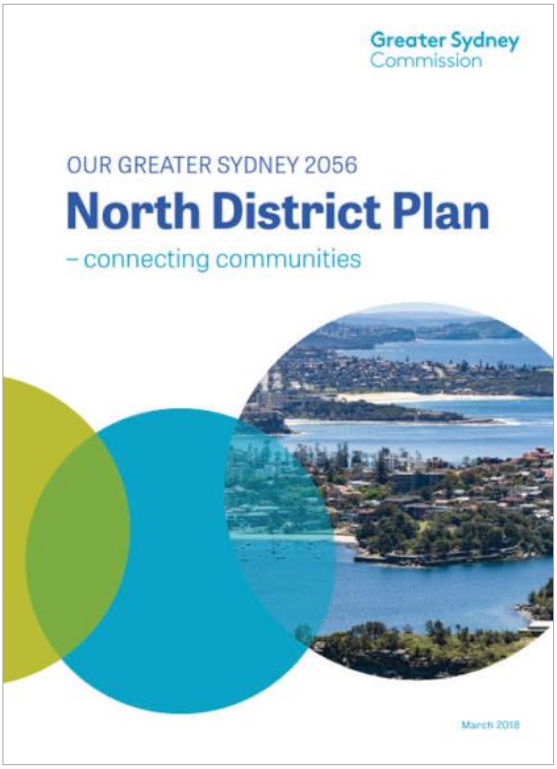


Figure 1: The Urban Forest Strategy within the IP&R Framework

3.1.2 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 1).

3.1.2.1 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:

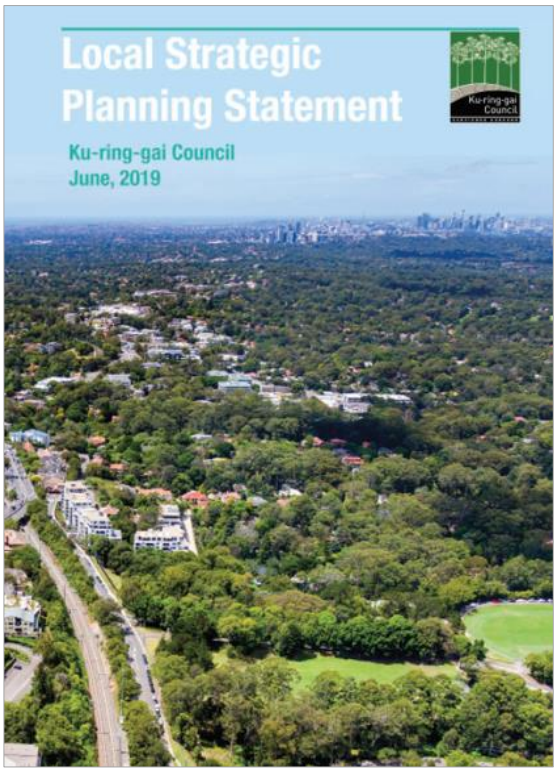
- Supporting initiatives that respond to the impacts of climate change; and
- Mitigating the urban heat island effect and reducing vulnerability to extreme heat.

3.1.2.2 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.

3.2 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.

3.3 Liveability and Benefits

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.

<u>Health and social</u>

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.** Shade 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.

Environmental

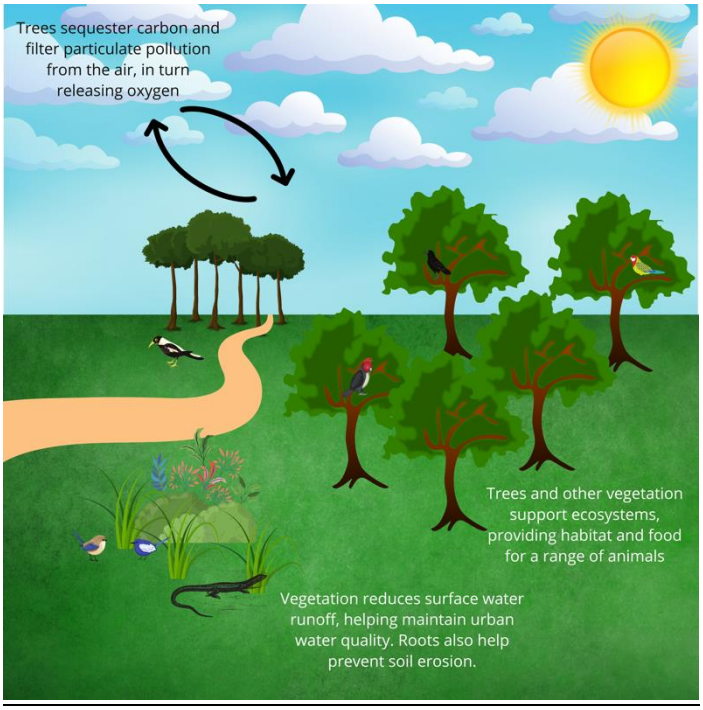
The environmental benefits of the urban forest include:

- **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. Retention of older trees also provides habitat hollows for various species.



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.

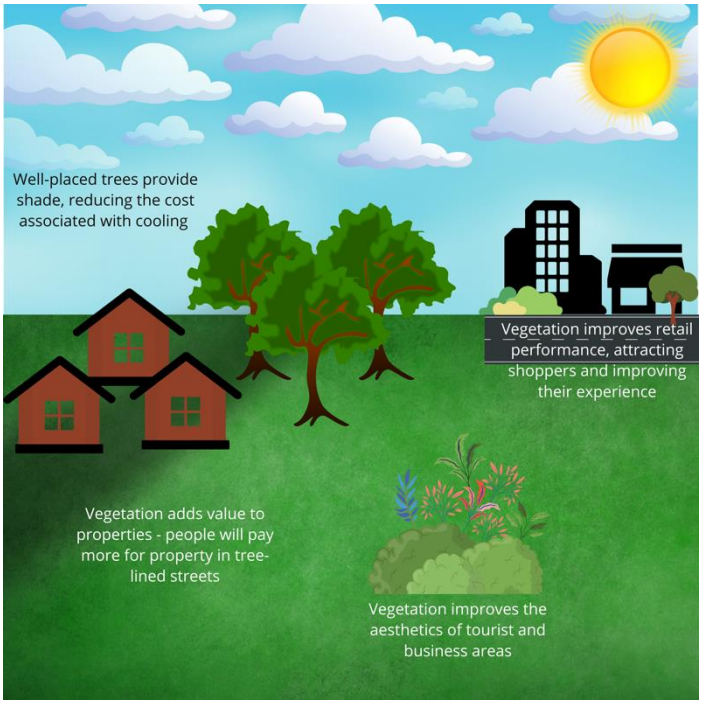
- **Increasing property values.** Areas with attractive and extensive urban forests have higher property values than similar areas with lower canopy cover. Tree-lined streets and gardens are attractive to potential buyers, with research demonstrating that a 10% increase in tree canopy for a suburb (Annandale, NSW) can result in a $61,000 increase in value of property (Aecom - Brilliant Cities Green Infrastructure Report, 2019).

- **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 area 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).



3.4 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 (Figure 2). 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.

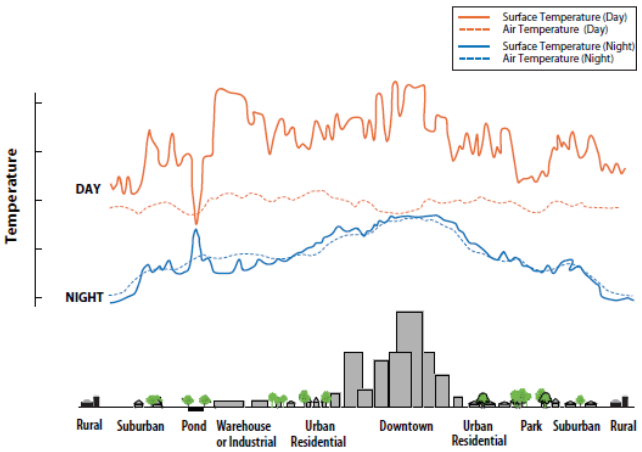


Figure 2: Schematic representation of changes in air temperature in relation to surface characteristic (EPA 2014).

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.

3.5 Historical Overview

3.5.1 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."

Figure 3: Scar Tree (Image credit: Ku-ring- gai Council)

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 a*cida). 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 4: Gulgadya and Wiriyagan are names in the Sydney language for *Xanthorroea* 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 Galgadya 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.

3.5.2 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) (Figure 5); and Sandstone Heaths, Woodlands and Forests (SHWF). There were also some scattered areas of Sydney Turpentine-Ironbark Forest (STIF) (Benson and Howell 1990).

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.

Figure 5: Example of an intact Blue Gum High Forest vegetation community in Dalrymple-Hay Nature Reserve (image credit G.Griffiths)

BGHF was found in the highest-rainfall areas; some of Sydney's highest-rainfall localities are found in the Ku-ring-gai LGA. The BGHF 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 understory 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 understory 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 *Corymbia 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 coronata*), Native Laurel (*Cryptocarya glauescens*) and various shrubs and vines.

Figure 6: Cabbage Palms (Image credit G. Griffiths)

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.

3.5.3 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 Cove 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.

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/08185tsdsbluegum.pdf

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.

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 Avenue in Gordon. The founding of the 'League' grew out of her concern at the destruction of the natural environment in the area.

3.5.4 Change Over Time

The changes over time in vegetation across the LGA can be observed in historical imagery. Figure 7 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.

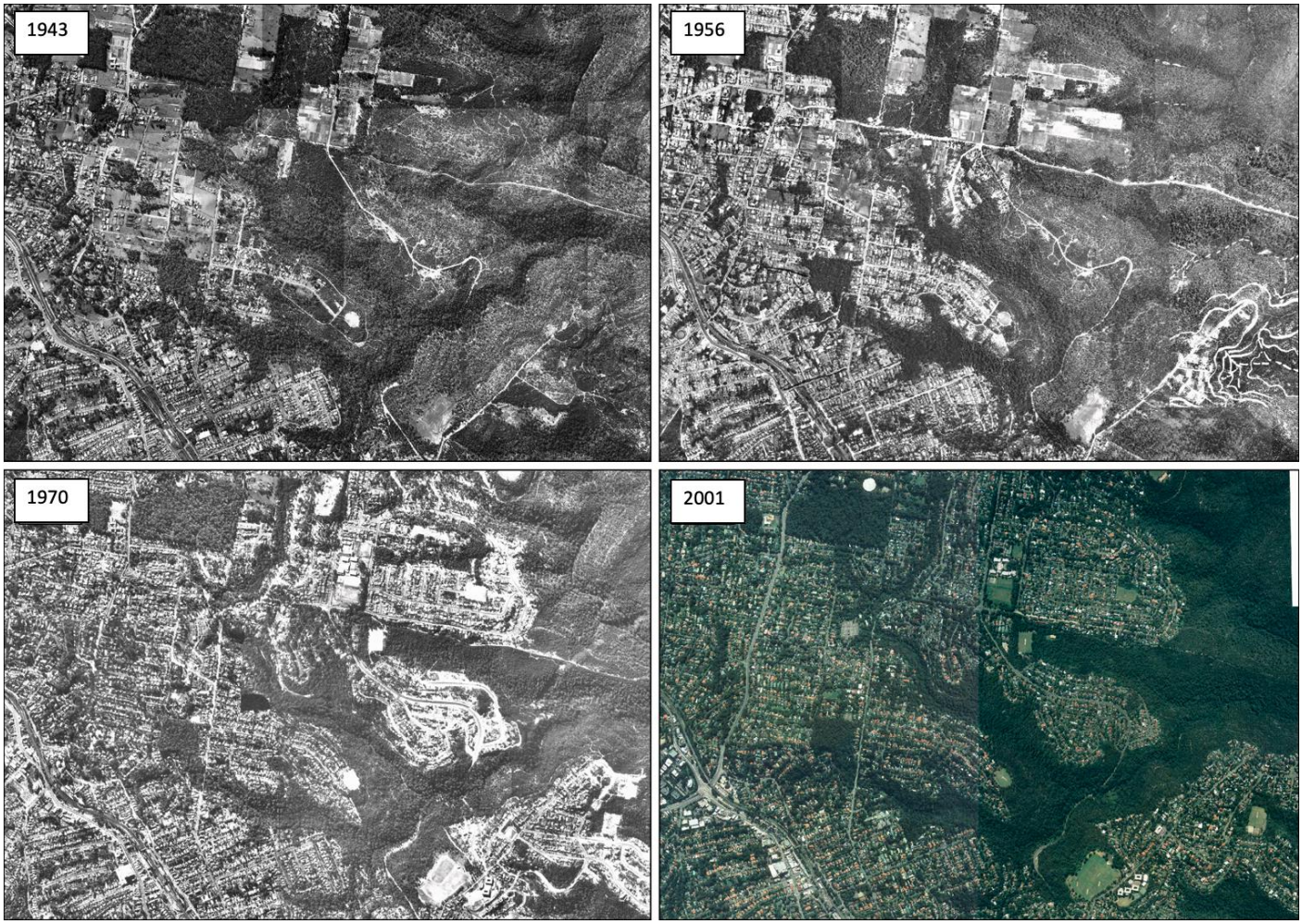


Figure 7: Development and land clearing evident in historical imagery over an area of St Ives, Gordon, and East Killara.

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' Figures 8, 9, and 10 below;

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.

Figure 8: Hill Street Roseville (image credit: Ku-ring-gai Historical Society https://www.khs.org.au/)

Figure 9: Coonanbarra Rd, Wahroonga (image credit: Kuringai Historical Society https://www.khs.org.au/)

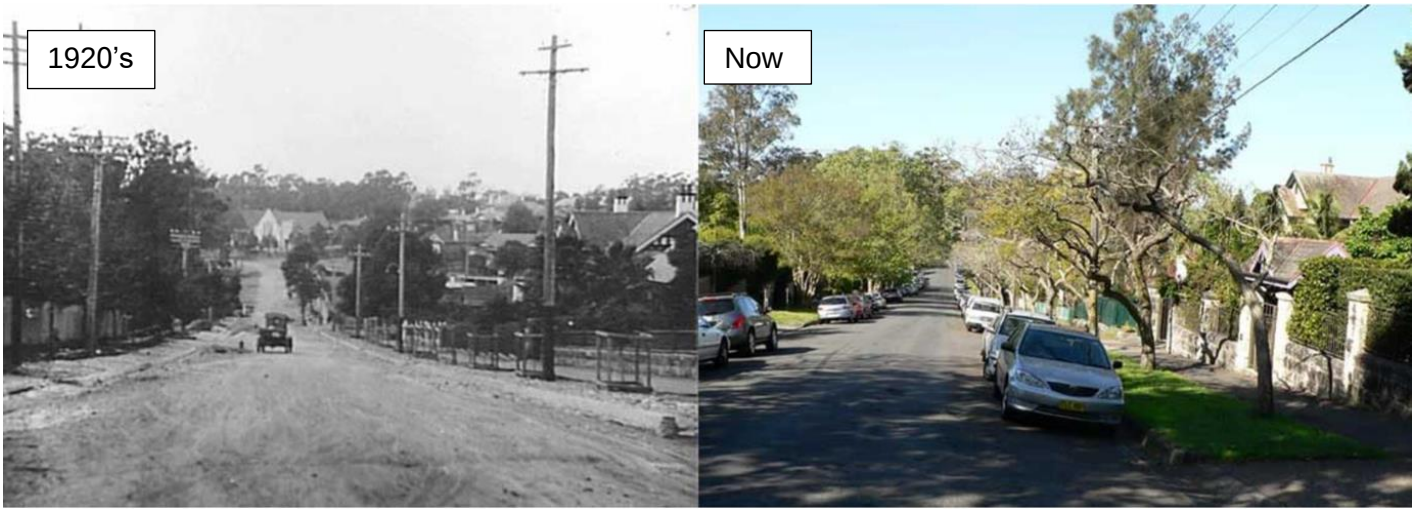


Figure 10: Locksly Street, Killara – note the early street tree planting with tree guards indicating the value placed on trees back then (image credit: Kuringai Historical Society https://www.khs.org.au/)

3.6 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 and Environment, are areas of land defined by particular topographies and soils. The soil map below, Figure 11, 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.

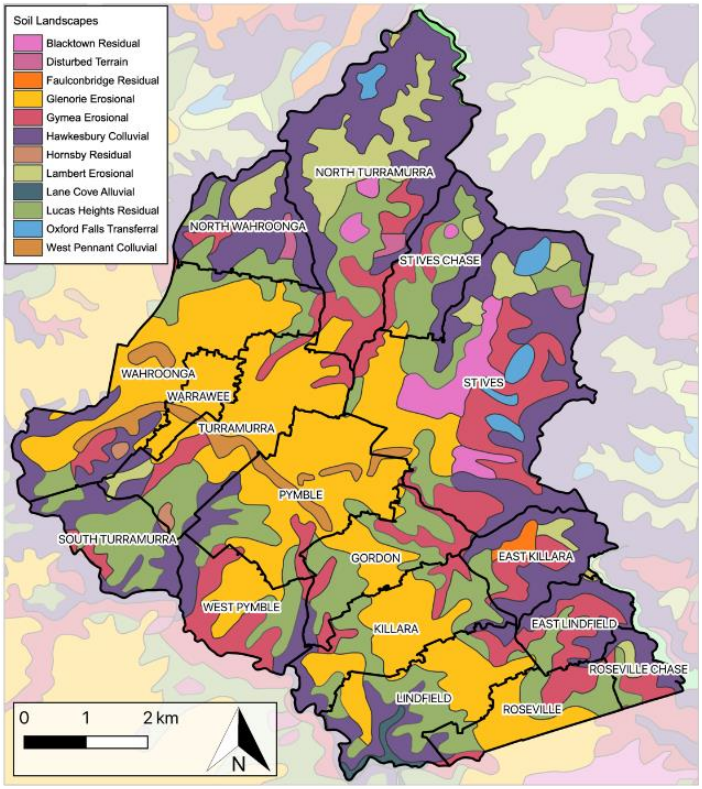


Figure 11: Soil map of the Ku-ring-gai LGA using the NSW Government's eSPADE data, illustrating the underlying soil types of the area (NSW Soil Landscapes).

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.

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.

PART TWO

Where are we at?

4 Current Vegetation

Canopy mapping was undertaken over the Ku-ring-gai LGA in 2020. Figure 12 shows high-resolution imagery of the Council area.

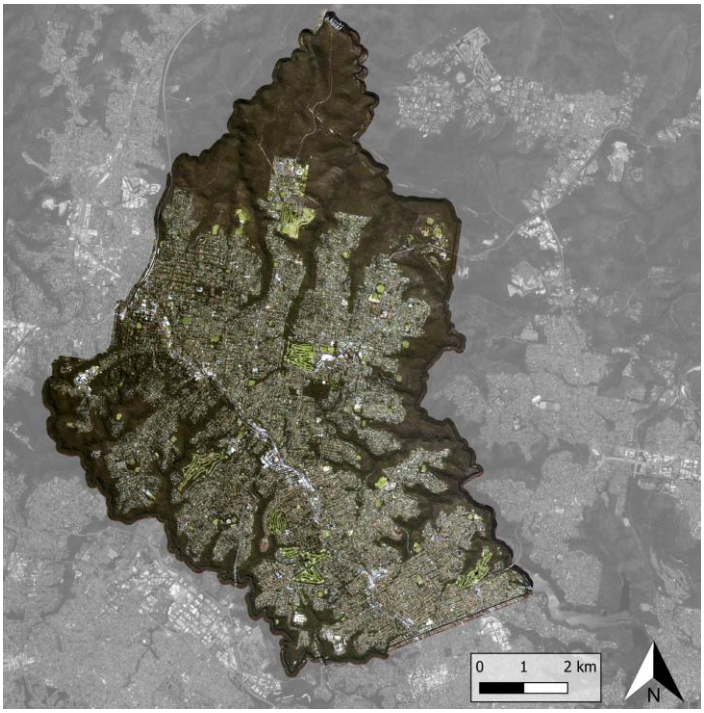


Figure 12: High-resolution RGB imagery of Ku-ring-gai Council (ArborCarbon 2020).

Canopy cover statistics were calculated for the ***urban area only*** – this was determined to be the LGA boundary, excluding land zoned as C1 – National Parks and Nature Reserves (Figure 13). National Parks and Nature Reserves are managed by the State Government, and while they are within the LGA boundary, they require different management approaches to urban areas of vegetation. Excluding National Parks and Nature Reserves from the analysis produces data that is relevant and useful for guiding management of land that is actually under the Council's control. C1 land is managed by the State government under the National Parks and Wildlife Act. Other areas of bushland which may be similar in management approach (fire, weed, erosion management etc.) to National Parks are included within the urban area of the LGA for analysis purposes, as they are managed by Council.

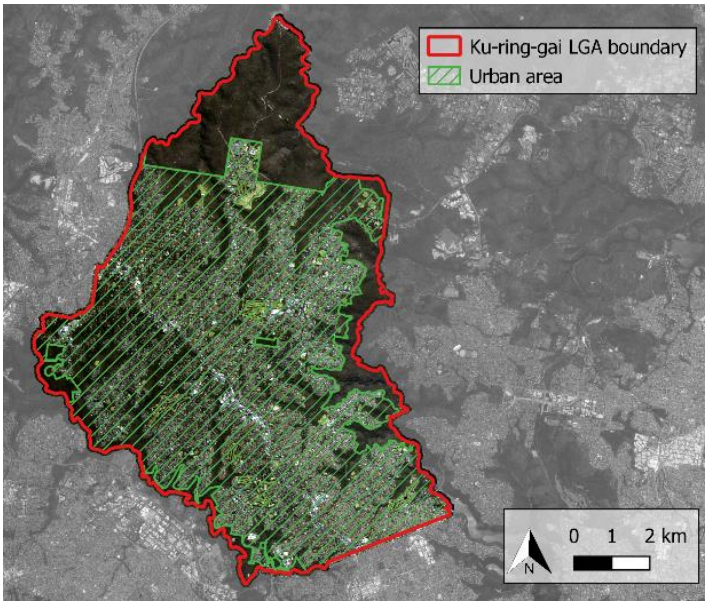


Figure 13: Urban boundary of Ku-ring-gai Council.

4.1 Suburb Canopy Cover

Average canopy cover in the urban area was 45%.

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 14). 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%).

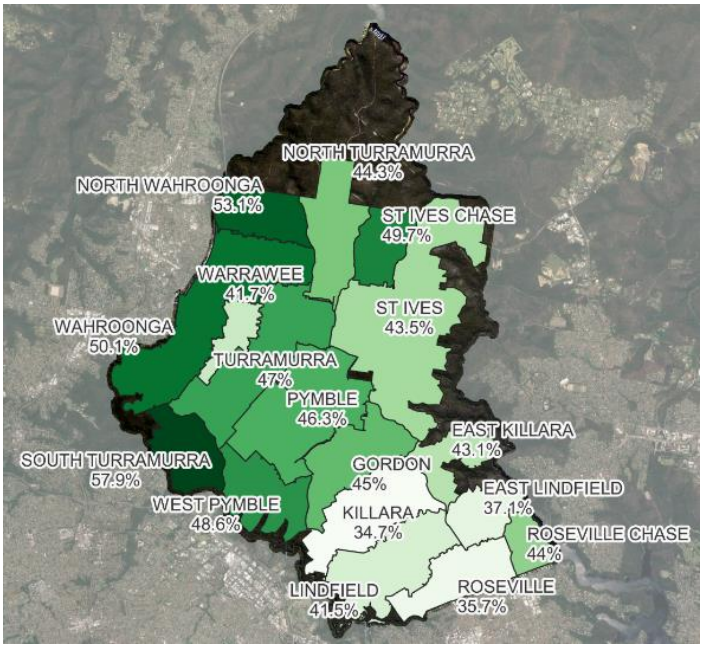


Figure 14: Thematic map showing canopy cover as a percentage of total suburb area (excluding C1 – National Parks and Nature Reserves). The darker green indicates higher relative canopy cover percentage.

4.2 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 15). 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.

4.3 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.

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;

- Burns Road, Wahroonga (London Plane Tree) (Figure 16)
- Roseberry Road, Killara (Tallow wood) (Figure 17)
- Winton Street, Warrawee (Liquidambar)

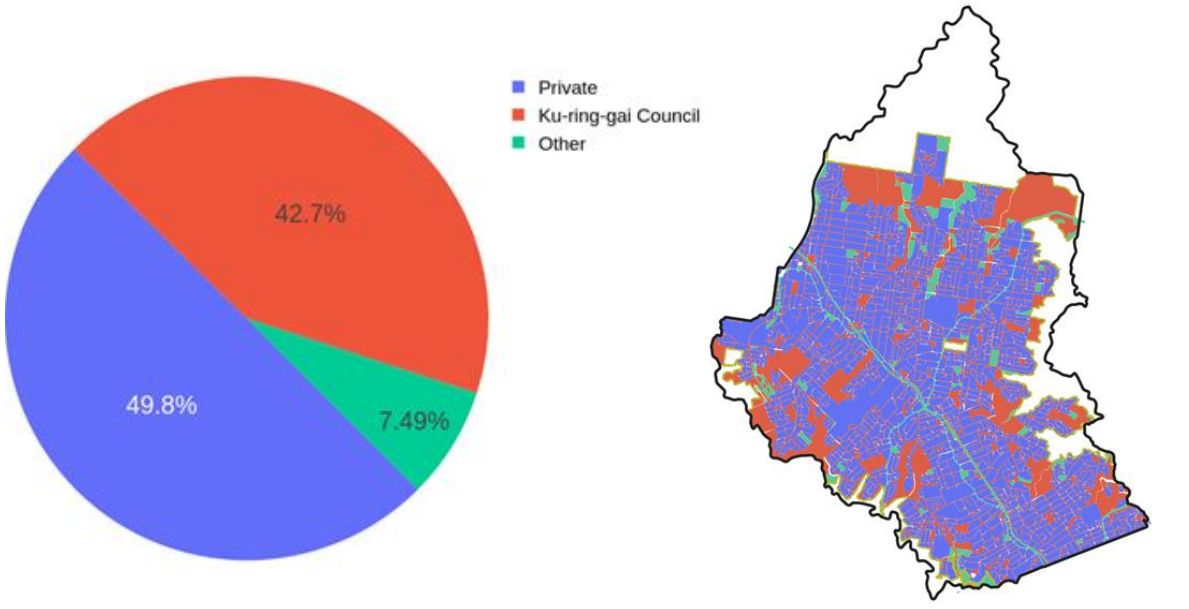


Figure 15: The proportion of tree canopy within the Ku-ring-gai Council and the distribution of land tenure classes. 'Ku-ring-gai Council' land includes council managed land such as local parks, road reserves and municipal buildings. Other includes state and federally managed lands, and all other land tenure classes.

Figure 16: Burns Road, Wahroonga – Iconic London Plane Tree street planting (image credit G.Griffiths).

Figure 17: 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. There 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 (Figure 18); several streets in east Killara and east Lindfield; and suburbs such as Turramurra, St Ives and Warrawee.

Figure 18: Mt William Street, Gordon – streetscpe 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 19: Wahroonga Park, Wahroonga – Iconic European style park with primarily exotic tree plantings (image credit G.Griffiths).

4.4 Tree Count

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 **286,097** trees were identified in this area. The majority (**213,184**) are on private land (Figure 20). Ku-ring-gai Council manages approximately **64,057** trees on public land, such as on streets and in parks. The remaining **8,856** trees are on land classified as 'other', primarily under state or federal management.

4.5 Council Operations

Fundamental to the delivery of improved urban forest and canopy outcomes is the organisational capacity to deliver these outcomes. Council is doing many things well when it comes to the management of their urban forest; however, there are some areas of potential improvement, as summarised below.

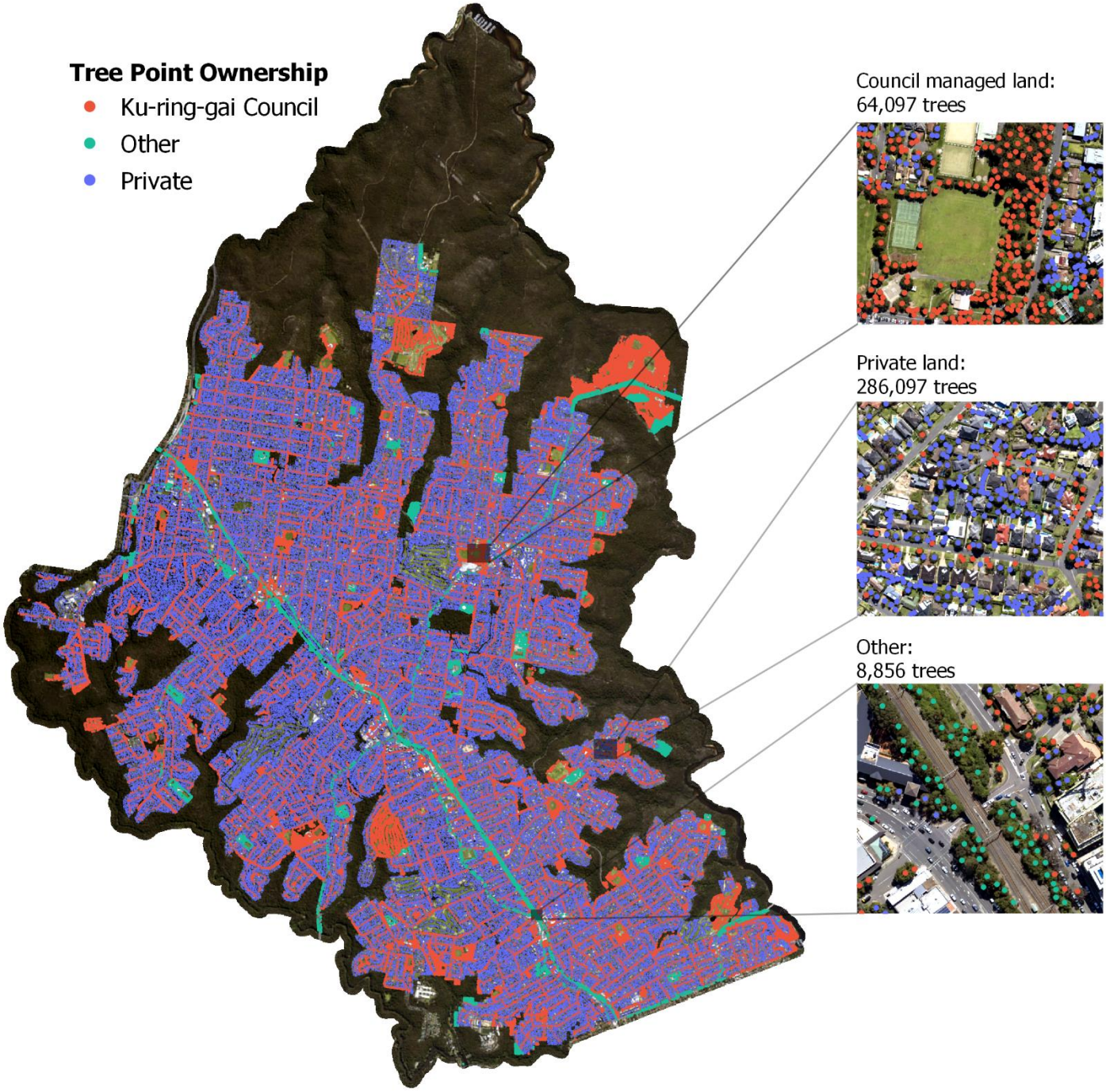


Figure 20: Tree location and count on Council managed land, private land, and land classified as 'other' (excluding land classified as C1 and C2).

4.6 Community Attitudes Towards Trees

During the development of this Strategy, a community survey was conducted to gauge public attitudes towards trees and how they feel they are managed in the Ku-ring-gai area. 138 responses to this survey were recorded. This survey was opt-in and therefore likely to attract respondents who are engaged and interested in Council's management of the urban forest. Therefore it may not be entirely representative of the full breadth of community attitudes towards trees, but it is still a useful initial indicator.

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).

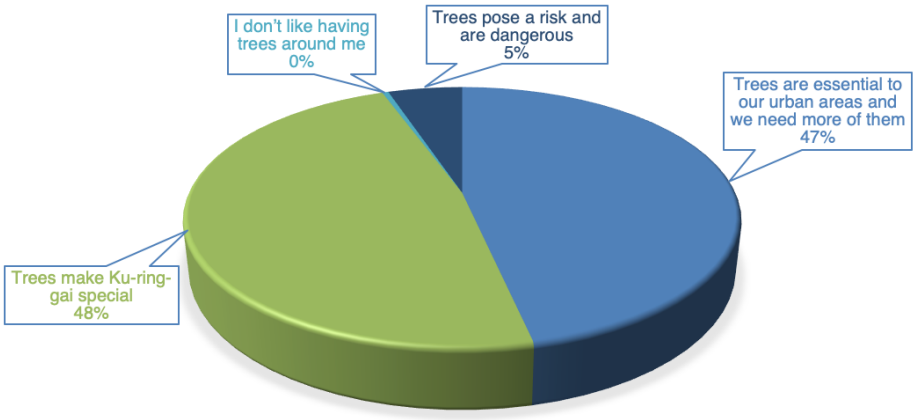


Figure 21: Pie-graph of community attitudes towards trees from 135 survey responses.

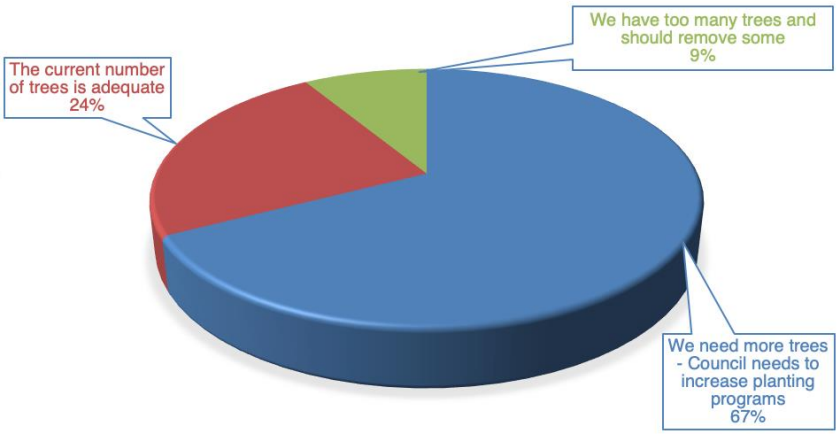


Figure 22: Pie-chart of survey responses to a question about the number of trees in the LGA.

5 Challenges and Drivers for Change

5.1 Aging 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. 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 23: Mature tree showing signs of decline, common among an aging tree population (image credit G.Griffiths).

Figure 24: Tree planting needs to be increased to offset aging tree population (image credit G.Griffiths).

5.2 Physical Challenges

The public realm is high contested space and finding room for trees can be an issue in urban areas. Trees did not evolve to deal with urban pressures, however, they have now become essential assets in our cities, and we need them to make our cities liveable and resilient.

Conflicts with infrastructure such as roads, buildings, footpaths and utilities are perhaps the most challenging issues. This combined with poor planning or species choices in the past can inevitably lead to trees being removed.

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 25. 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 25: Heavily pruned street tree with a limited future (image credit G.Griffiths).

5.3 Social Challenges

Living in close proximity to trees can cause issues. They can drop leaves, damage property, over shade and be potentially dangerous if not managed correctly. Pressure from community and negative attitudes towards trees can be major obstacle for Council when it comes to planting, maintaining and retaining trees.

Negative attitudes can range from an acute fear of trees, from a risk perspective or cultural barriers, and acceptance of trees from an aesthetics perspective.

Improved education and engagement around trees is often seen as the way to improve this issue. It is however very difficult to do well and needs a carefully considered approach to achieve any real improvement.

5.4 Climate Change and Urban Heat

Trees, have numerous benefits for addressing causes and effects of climate change. These include mitigating urban heat, temperature regulation, carbon capture and storage, and soil structure and erosion reduction.

The earth's atmosphere is predicted to warm 2.7 degrees above pre-industrial levels this century. This is going to result in more frequent, longer and intense heat waves, among other side effects, such as increased frequency of natural disasters like fires, floods and storms (Australian Academy of Science, 2021). If global temperatures rise 3 degrees, days above 50 degrees are likely to become a regular occurrence in Sydney. In addition, rising temperatures will seriously affect Australia's ecosystems, resulting in habitat degradation and increased species extinction rates. These ecosystem effects will in turn have flow on effects to human wellbeing.

As Australia's climate changes over the next 50 to 100 years, the species of trees and plants that exist in Ku-ring-gai Council today may not be suited to the range of conditions presented by the new climate. A study by Gallagher et al. (2019) indicated that 47% of vegetation in Australia is potentially at risk from increasing temperatures and showed low adaptability to climate change. Future planting programs throughout the Council will take this into account, and species selection will consider those that have been proven to withstand higher temperatures, drought, and are more tolerant to pollution. Species selection is a type of climate change adaptation, and is considered a form of risk management (Rychetnik et al. 2018). A targeted and comprehensive Urban Forest Strategy will support the Council's commitment to climate change adaptation, indicated by adoption of the Council's Climate Change Policy (2020) and Climate Change Adaptation Strategy (2018).

The urban heat island effect (UHIE) is the build up of heat within built up areas, such as cities, due to the higher occurrence of hard exposed surfaces which retain more heat than natural surfaces, such as water and vegetation. The UHIE will only be exacerbated by increasing environmental temperatures due to climate change, and urban areas will experience the consequences. The effects of climate change will be felt more in urban environments. It is important to mitigate the UHIE as much as possible. Ku-ring-gai must focus on the significant benefits of the urban forest if a more sustainable and resilient city is to be developed, particularly in the face of a changing, hotter climate. An extensive and well linked urban forest that incorporates all trees and other vegetation on public and private lands, and encompasses the mosaic of streets, parks, gardens, understorey and natural areas, watercourses and drainage banks and remnant vegetation and the environment that supports ecosystem services provided by soil and water, is the best strategy to mitigate future heat island impacts.

Setting targets for canopy and vegetation increases in the urban forest is the most important first step in reducing the UHIE. Mechanisms to reduce the UHIE through increased canopy and green-space cover include investment in and maintenance of the existing canopy cover and green space in the Council, including natural vegetation in reserves. Decreasing the loss of canopy from tree clearing on private property, renewal and revegetation of degraded watercourses and support of appropriately designed and maintained green-building developments will contribute to a reduction in UHIE.

It is extremely important that the community is engaged in the process of managing the Council's UHIE. This process of community involvement in the management of the Council's urban forest has continued through the development of the strategies and policies that contribute to and support the Council's Urban Forest Strategy.

5.5 Population Increase and Urban Consolidation

Population growth, subdivision of land and increasing densities of urban areas all place pressure on Council's capacity to maintain current canopy coverage on private lands. The NSW Department of Planning, Industry and Environment projects that Ku-ring-gai's population will increase by more than 25,000 people to a population of 140,809 in 2036. The council's Housing Strategy proposes housing provision of 3,000-3,600 new dwellings over the 15-year period 2021-2036 (Ku-ring-gai Council 2020). The majority of these new dwellings will be accommodated within the existing mixed use, medium and high-density zoned sites which are concentrated along the Pacific Highway corridor and around the Local Centres of Turramurra, Gordon, Lindfield and St Ives (Figure 26). This is seeing large mature trees removed, and less space available for large trees to be planted. Redevelopment of free-standing houses inevitably results in larger building footprints, less space for large trees to be planted and removal of mature trees (Figure 27). Residual capacity within current planning controls will be supplemented by the delivery of seniors housing developments and alternative dwellings such as secondary dwellings, group homes and boarding houses where permissible. Increased housing density in residential areas has the potential to negatively impact the Ku-ring-gai urban forest.

Figure 26: Medium density housing development alongside large mature trees (image credit G.Griffiths).

Figure 27: Increased size of building footprints (image credit G.Griffiths).

The main land use zones in these Local Centres that will experience population increase are R2 (Low-Density Residential), R3 (Medium Density Residential), and R4 (High-Density Residential).

The effects of increased housing density of the Local Centres were modelled by comparing the land parcels identified as having development potential to those which are already fully developed. Comparison of current canopy cover on developed and undeveloped land parcels revealed that undeveloped R3 and R4 parcels have similar canopy cover as the fully developed R2 parcels, ranging from 36.5 to 39.3% canopy cover (Figure 28). Developed parcels in R4 have 35% canopy cover, a similar proportion to R2 parcels. In contrast, proportional canopy cover considerably decreases on R3 zoned land following development (26%).

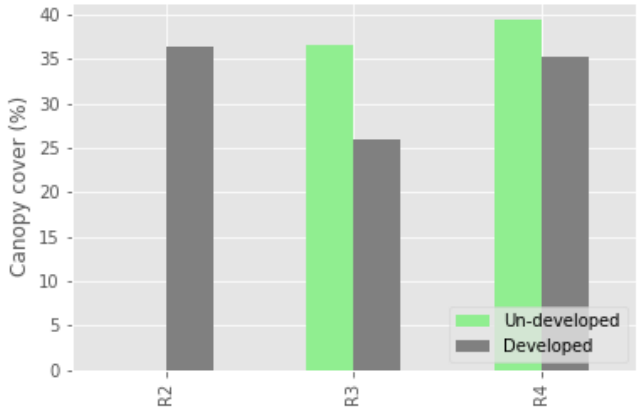


Figure 28: Comparison of canopy cover on developed and undeveloped residential areas within Ku-ring-gai Local Centres.

This suggests that future development uptake within R3 zoning is likely to result in a net reduction in canopy cover within the LGA, particularly within the Local Centres. The reason for this is possibly an effect of the reduced deep soil requirements and greater maximum building footprint/site coverage required within R3 areas compared with R4. However, many of the R3 developments within the LGA have only been developed within the last 10 years, therefore the median age of R3 developments is less than that of R4

developments which may also contribute to the observed reduction in tree canopy cover in the R3 zones.

Projecting these canopy cover reductions across all un-developed lots within the LGA is expected to have only a minimal impact on total canopy cover (Figure 29). This is not unexpected, given the short timeframe considered (5 years). In terms of change in canopy area (Figure 30), Turramurra Local Centre is projected to lose the most canopy area (approximately 7000m^2), while Roseville Local Centre is projected to lose the least (less than 1000m^2). Gordon Local Centre is projected to gain approximately 1150m^2 of canopy. The predicted canopy change appears more closely related to the current canopy cover than the number of undeveloped lots within each Local Centre. The most significant losses are expected in Pymble and Turramurra. These Local Centres have the greatest current canopy cover (both over 40% canopy). Conversely, Gordon Local Centre is predicted to increase in overall canopy cover, because the current canopy cover in the undeveloped lots is below the LGA average for these lots post-developed.

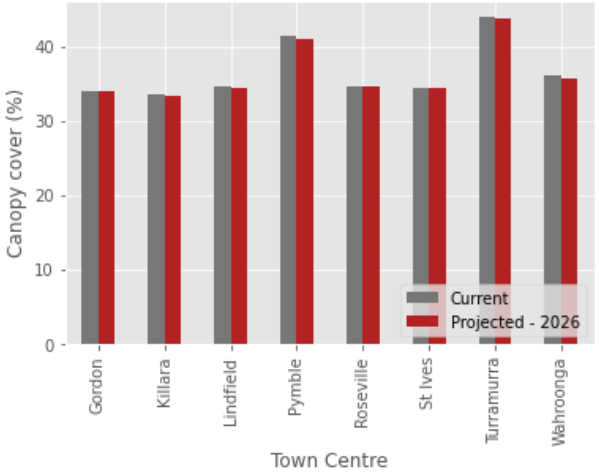


Figure 29: Current and projected canopy cover (%) for each Local Centre.

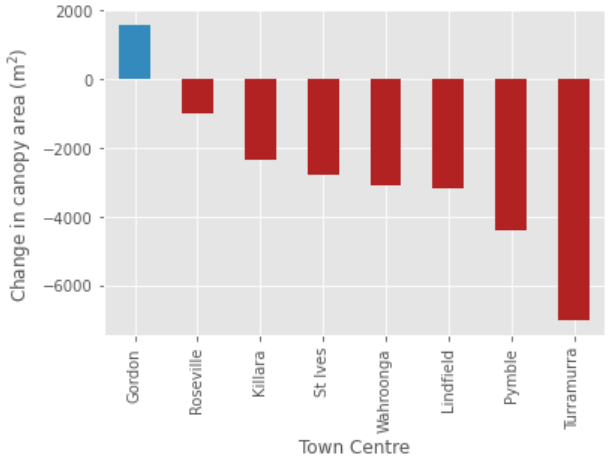


Figure 30: Projected loss of canopy area (m²) for each Local Centre in order of increasing canopy loss.

Current modelling does not account for the conversion of R2 areas into additional seniors housing, or the re-development of existing R2 lots. Redevelopment of R2 lots and replacement with modern R2 housing is likely to result in at least some temporary loss of tree cover during the development phase.

The addition of seniors housing in R2 zoned areas is likely to result in further canopy cover reductions. Seniors housing controls are set at the state government level and are less prescriptive that those set-out in the Ku-Ring-Gai DCP.

Case Study

154 Mona Vale Rd, St Ives

Seniors Living

Development date:	2005 - 2007
Lot size:	3753 m^2
Dwelling number:	12
Building footprint:	37 %
Canopy cover (2005):	41.6 %
(2020):	22.4 %

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

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

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

2005

41.6 % Canopy

2007

21.4 % Canopy

2020

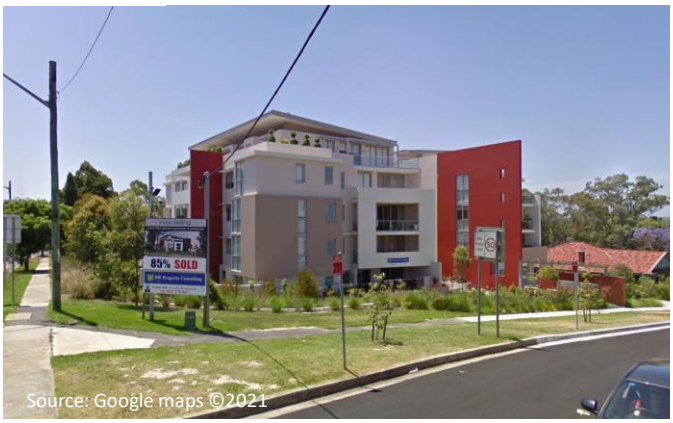
22.4 % Canopy

Case Study

2-8 Burleigh St, Lindfield

R4 – High Density Residential

2008



2021

Development date:	2005 - 2007
Lot size:	2790 m^2
Dwelling number:	31
Building footprint:	30 %
Canopy cover (2005):	30.6 %
(2020):	40.3 %

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

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

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

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

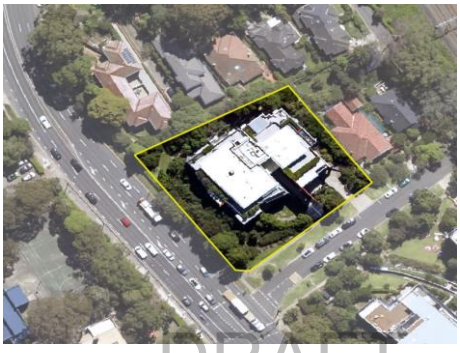
2005

30.6 % Canopy

2007

4.7 % Canopy

2020



40.3 % Canopy

Case Study

6 Shinfield Avenue, St Ives

R3 – Medium Density Residential

2009

2020

Development date:	2012
Lot size:	1943 m^2
Dwelling number:	11
Building footprint:	39 %
Canopy cover (2005):	35.8 %
(2020):	24.6 %

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

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

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

2005

35.8 % Canopy

2020

2020

24.6 % Canopy

PART THREE

What are we aiming for?

6 Canopy Cover Targets

Trees have been identified as providing exponentially more benefits than other types of vegetation. Therefore, targets have been set to increase canopy cover throughout the Ku-ring-gai LGA. These targets will be used to focus planting efforts and measure the success of the Urban Forest Strategy.

These targets have been developed using significant detailed analysis of current canopy cover across Land Zones, as identified in the NSW Local Environmental Plan (LEP), as well as road reserves and public open space (POS). The Council's capacity to achieve these targets was also considered. The targets were developed in line with canopy cover targets outlined in the DPE '*Draft Urban Design and Place Guide*', where possible, or using the current average canopy cover of that Land Zone. A detailed breakdown of the targets and their development is in Appendix A.

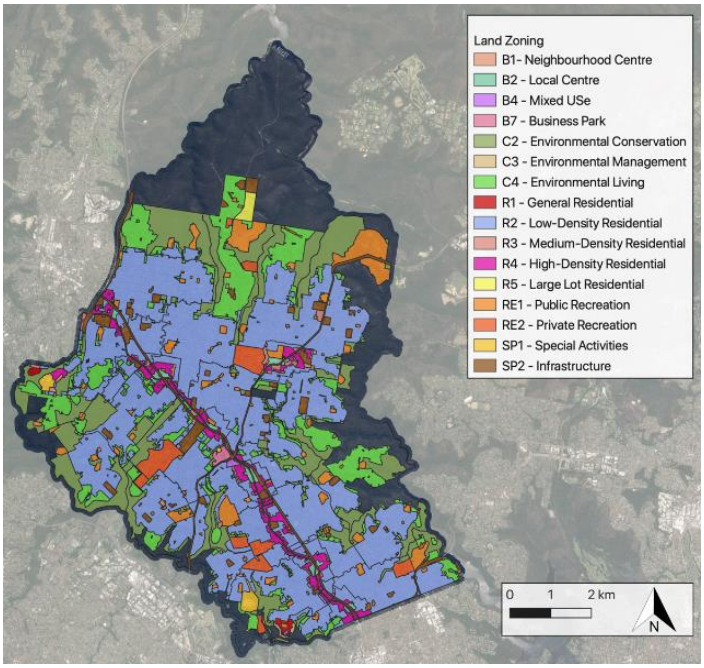


Figure 31: Land Zone classification (identified in the NSW LEP) of the Ku-ring-gai urban area.

Using this process to develop targets based on Land Zones, the resulting canopy target translates to a canopy cover increase of 287.3 ha in the urban area. This is approximately a 9.4% increase in canopy from 3059.0 ha (45% of the urban area) to 3346.3 ha (49%).

Ku-ring-gai aims to increase overall urban canopy cover from 45% to 49%.

This will include an increase of canopy cover on road reserves from 38.2% to 45%, and an increase in Public Open Space from 73.9% to 77%.

The number of trees required to be planted to achieve the canopy targets was estimated, based on the average crown area of a tree in Ku-ring-gai to be 70m^2.

To achieve 49% canopy cover, there needs to be an additional 44,043 trees planted throughout the urban area of Ku-ring-gai by 2036.

This will include at least 9,929 new plantings in road reserves and 8,243 new plantings in Public Open Space (POS).

Canopy cover targets were set for road reserves and POS (Table 1), as well as each Land Zone (Table 2) across the entire urban area. They were then broken down for each suburb (Table 3) and each Local Centre (Table 4), based on Land Zones.

It is imperative to note that Ku-ring-gai has a significant area of Bushfire Prone Land (BPL) within its boundary. As recent years have shown in various parts of Australia, the risk of catastrophic bushfire is increasing with a warming, drying climate. In BPL, expanding canopy cover and the many benefits that result, needs to be balanced with any increased fire risks that increased vegetation cover might pose. Land identified for planting to increase canopy cover that is identified as bushfire prone, will need to be assessed for its planting potential on a case-by-case basis. These areas will be investigated as part of the Urban Forest Monitoring program. Species selection will be especially important in these areas. Figure 32 below illustrates the areas of Ku-ring-gai classed as BPL.

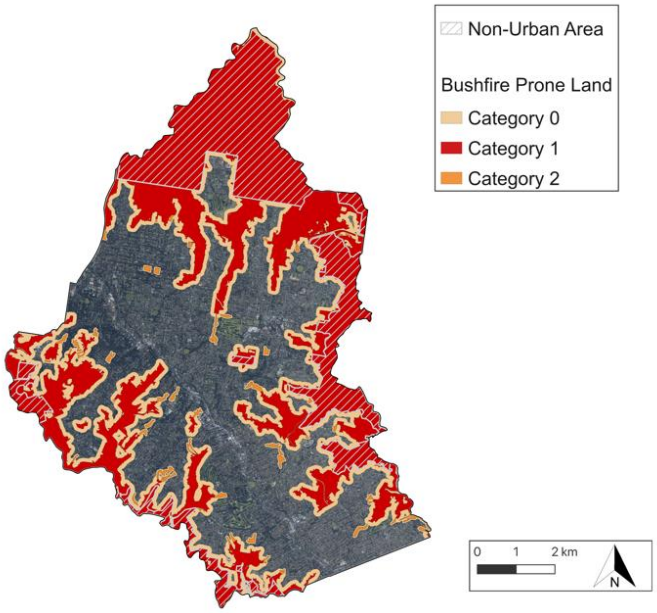


Figure 32: Map of Bushfire Prone Lands in the LGA (2017 data).

Table 1: Canopy targets for road reserves and Public Open Space (POS). *Average tree crown area of 70m²

Public Land	Current Canopy (%)	Canopy Target (%)	Trees* required to achieve target
Road reserves	38.2	45	9929
POS	73.9	77	8243

Table 2: Council-wide (urban area) Land Zone based canopy targets (excluding C1 – National Parks). *Average tree crown area of 70m²

Land Zone	Current Canopy (%)	Canopy Target (%)	Trees* required to achieve target
B1	23.2	27.7	86
B2	16.6	17.6	57
B4	12.4	12.4	0
B5	25.4	35	14
B7	22.6	35	229
C2	83.4	86.1	4914
C3	67	67	0
C4	41.3	46.7	6786
R1	29.1	40	114
R2	35.8	40	22400
R3	32.2	40	514
R4	32.9	40	1943
R5	26.8	40.1	400
RE1	40.9	45	3329
RE2	38.3	47.4	2314
SP1	37.1	37.1	0
SP2	29.6	31.7	929
W1	42.3	44	14
Total	**45**	**49**	**44043**

Table 3: Canopy targets for each suburb. *Average tree crown area of 70m²

Suburb	Current Canopy (%)	Canopy Target (%)	Trees* required to achieve target
EAST KILLARA	43.1	54.1	3286
EAST LINDFIELD	37.1	49.6	3657
GORDON	45	47.7	1443
KILLARA	34.7	41.7	4514
LINDFIELD	41.5	45.9	2843
NORTH TURRAMURRA	44.3	53.3	4814
NORTH WAHROONGA	53.1	65.1	4314
PYMBLE	46.3	46.5	186
ROSEVILLE CHASE	44	55.5	2043
ROSEVILLE	35.7	43.6	3357
SOUTH TURRAMURRA	57.9	60.4	1000
ST IVES CHASE	49.7	56.2	2043
ST IVES	43.5	49.2	8671
TURRAMURRA	47	47.2	171
WAHROONGA	50.1	50.4	329
WARRAWEE	41.7	42.1	86
WEST PYMBLE	48.6	51.4	1300

Table 4: Canopy targets for each Local Centre. *Average tree crown area of 70m²

Local Centre	Current Canopy (%)	Canopy Target (%)	Trees* required to achieve target
GORDON	34	38.4	1331
KILLARA	33.6	33.6	0
LINDFIELD	34.5	39.1	1396
PYMBLE	41.4	42.2	157
ROSEVILLE	35.1	39.7	649
ST IVES	34.5	44.3	3590
TURRAMURRA	43.9	44.9	344
WAHROONGA	36	36.5	76

6.1 Targeted Planting for Canopy Increase

A lack of planting space on public land has been identified as a limiting factor to increasing urban canopy. Available aerial imagery, land use boundaries and planting guidelines have been used to locate Available Planting Space (APS) on public land throughout the urban area of Ku-ring-gai, with the purpose of identifying the most suitable opportunities for planting investment. In addition, shade cast by canopy over existing and proposed Active Transport Routes (ATRs) throughout the LGA has been modelled and quantified, to further focus planting efforts to where the benefits and values provided by these new trees can be maximised.

Analysis of APS and identification of low-shade ATRs was conducted across the LGA using a range of geospatial datasets produced during ArborCarbon's airborne imagery acquisition of Ku-ring-gai in 2020 and vector datasets provided by the Ku-ring-gai Council.

Figure 33: Example of the shade modelling outputs, showing hours of afternoon shade with increasing intensity of blue on a high shade street (Moore St, above) and low shade street (Allan St, below) in Roseville Chase.

The identification of APS was limited to Council managed land, therefore the majority of APS identified was road verges and parks. A significant number of verges were identified as not having a tree, and the space available to plant one or more trees.

Figure 34: Space available for tree planting (blue) on public land on Allan St (Roseville Chase).

The analysis identified 157 ha of APSs managed by the Council, currently containing bare-ground, grass or shrubs, in the urban area of Ku-ring-gai. These APSs have the capacity to support approximately 23,552 additional trees, which is approximately 54% of the 44,043 trees required across the LGA to meet targets (Table 2).

The potential canopy increases from planting these areas is dependent on the tree species selected. Larger trees have the capacity to provide substantially more canopy area per tree planted, as well as the associated values such as shade and habitat etc. However, a range of constraints exist which limit the size of tree which can be planted at a given site, notably powerlines and other infrastructure requirements.

The average area of a tree crown within KRG was used to estimate the number of trees required to meet the canopy cover targets which was compared with the APS on public land within each suburb (Figure 7). In most suburbs, the canopy cover targets exceed the APS on public land, with the exception of Pymble, Turramurra, Wahroonga and Warrawee. This highlights the importance of community engagement in order to facilitate increasing canopy cover in private land.

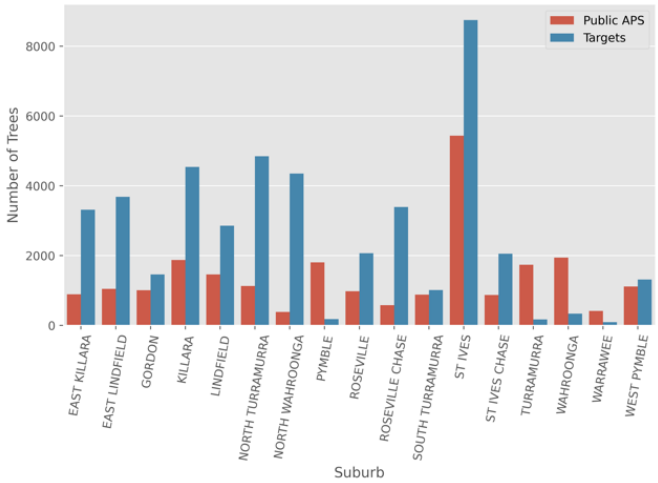


Figure 35: The number of new trees required to meet the canopy cover targets, compared with the Available Planting Spaces (APS) on public land. Assuming an average crown area on 70m².

Figure 36: Space available for new tree planting shown in red.

7 Principles

Council has developed a set of four Principles for the urban forest. These are key, overarching themes or values which will guide the implementation of the Urban Forest Strategy and guide Council's thinking around managing the urban forest.

The Principles are:

1. Retain and Protect
2. Expand and Integrate
3. Monitor and Maintain
4. Collaborate and Incentivise

Each of these addresses an important aspect of urban forest management, encouraging protection of existing trees and vegetation, expansion and strengthening of the urban forest, effective monitoring and management, and engagement with the community. A number of goals are attached to each Principle, addressing key aspects of the broader Principle. These Principles and Goals guide a range of Strategic Actions, which are important for the Council to undertake to ensure the health and robustness of the urban forest into the future.

7.1 Retain and Protect

Key to increasing urban tree canopy is protecting what you have.

Trees take many years to mature and provide valuable canopy. Ku-ring-gai is fortunate to have an established urban forest with good canopy cover (total urban LGA canopy area of 44%). Priority needs to be given to protecting these existing assets, both on public land and private land.

GOAL

1.1 PROTECTION OF EXISTING TREES ON PRIVATE LAND

60.8% of the land in Ku-ring-gai's urban area is privately owned, and this land contributes 49.6% of total canopy to the urban forest.

Considering that tree canopy on privately owned land contributes nearly half of the overall total canopy of the Council's urban forest, focus must be given to protecting trees on private land, in order to meet urban forest targets and maintain a high level of canopy cover.

The majority (73%) of privately owned land in Ku-ring-gai is classified as Residential. The remaining private land is mostly zoned as Business and Local Centres, Infrastructure and Special Activities.

The minimum canopy cover target for Residential-zoned land is 40% (Table 2). This would require an additional 175 ha of canopy, a 13.2% increase on the current canopy cover level of 1318 ha (35.6% of total Residential land zoned area). This translates to an additional 25,000 trees (note: Residential Zoned land includes adjacent Road Reserves and therefore that additional tree figure is likely to be partly within Council-managed Road Reserve areas).

Protecting trees on private land is a complex practice as there are multiple legislated controls that are relevant beyond the jurisdiction of Council, such as State Environmental Planning Policies (SEPPs), which allow for significant development to occur with limited Council oversight. Development has been identified as a major threat to protecting and increasing canopy cover on privately owned land, as has the 10/50 Vegetation Clearing Scheme, which bypasses Council tree protection controls.

Council can control certain aspects of the management of trees on private land via their Local Environment Plans and Development Control Plans. The actions below aim to achieve canopy cover protection and increase via these mechanisms.

ACTIONS

1.1.1 Undertake a holistic review of Council LEP and DCP controls to improve the protection of trees and provision of new trees on private land, including deep soil and planting requirements.

1.1.2 Develop a suite of standard Development Approval (DA) conditions to ensure consistency and application of best-practice tree management on private land.

1.1.3 Develop a range of tree protection and tree planting specifications in line with industry best practice for use by developers on private land.

GOAL

1.2 PROTECTION OF TREES ON PUBLIC LAND

32.9% of the land in Ku-ring-gai's urban area is Council owned, and this land contributes 42.7% of the Council's urban canopy.

Urban public trees provide many essential benefits for Kur-ring-gai and its residents, from temperature reduction to

improved health and wellbeing. To ensure these benefits are maximised it is vital that existing established trees are retained and protected.

Ku-ring-gai Council values and maintains their public tree population and aims to only remove trees if they are dead, dying or dangerous. Much of the pressure on public trees can come from the interface with private development and from infrastructure and utility service providers (including Sydney Water, Ausgrid and Transport for NSW).

ACTIONS

1.2.1 Manage public trees to their full Useful Life Expectancy (ULE) and only remove trees when all other options to retain the tree are exhausted. Develop an assessment criteria or framework to facilitate a consistent approach to removal and provide the public with clarity around processes.

1.2.2 Implement the use of 'Tree Bonds' on publicly owned trees to protect and maintain the health of these trees as part of any future development applications. Develop a public tree valuation framework to allow placement of monetary values against tree assets. Development of this framework should be considered as part of the broader LEP and DCP review (Action 1.1.1).

1.2.3 Investigate mechanisms (LEP and DCP controls) to require developers to bundle power cables adjacent to new developments and provide expanded soil volumes/vaults for new public domain tree plantings (in built-up areas).

1.2.4 Develop a range of tree protection and tree planting specifications in line with industry best practice for use by developers and utility service providers on public land.

1.2.5 Maintain clear lines of communication and establish processes with utility service providers in the area to ensure value is placed on protecting trees. Advocate for improved processes and practices.

1.2.6 Prioritise the protection and health of existing mature trees when infrastructure conflicts arise. Budget for the implementation of alternative designs or engineering solutions to allow for trees to be retained.

GOAL

1.3 ENSURE URBAN FOREST DIVERSITY AND PROTECT AGAINST PESTS AND DISEASES

A key potential threat to any urban forest is attack from pests and diseases. Effective management of pest and diseases is becoming even more of a focus due to climate change. With increased temperatures and altered weather events conditions may favor various pathogens and allow them to thrive. If mechanisms are not in place to manage these outbreaks our urban forest could be at risk.

Ensuring species diversity within the urban forest is an important way to protect against the impact of pest and diseases. A highly diverse urban forest is a resilient urban forest.

ACTIONS

1.3.1 Develop a 'Plant Pest and Disease Management Plan' with a focus on appropriate weed and pest hygiene practices for horticultural and arboricultural staff and contractors, and pest and disease monitoring and control guidelines. Set benchmarks of acceptable levels of pest/disease and establish actions for management within this Plan.

1.3.2 Integrate regular inspections and disease testing of significant street and park trees with the urban forest monitoring program.

1.3.3 Assess canopy species diversity within the urban forest, with an emphasis on priority areas (this action is linked to Action 3.2.4 'Develop a public tree inventory database'.)

7.2 Expand and Integrate

Expand tree planting programs and integrate capital programs to increase canopy on public land.

Key to any successful urban forest program is the planting of trees. Presently, Council removes more trees on average (due to a range of factors including pests/diseases, tree decline and death, conflict with infrastructure) than it replants. This will inevitably result in a decrease of tree canopy cover on public land. Public land increasingly needs to accommodate more trees as pressure on private trees increases, and it is essential that Council has a well-resourced tree planting program to facilitate an increase in canopy on public land.

Aligning tree planting programs and integrating capital project delivery is necessary to achieve improved canopy outcomes. All parts of Council should be actively seeking to incorporate tree planting in their projects where possible. Integrated project delivery leads to greater cost efficiencies and improved services for the community.

GOAL

2.1 INCREASE TREE PLANTING ON COUNCIL LAND

In 2020, average canopy cover of road reserves was 38.2%. Our target is to increase average canopy cover on road reserves to a minimum of 45% (Table 1). Road reserves with

below ground power services can achieve greater canopy cover and should aim for 50%. To increase canopy cover on all roads to 40% will require 69.5 additional ha of canopy.

The average canopy cover of Public Open Space (POS) (zoned as RE1) was 40.9%. The minimum canopy target for POS is 45% (Table 2). To achieve this, the Council must plant an additional 14.6 ha of canopy in Public Open Space.

Town Centres will need to accommodate the majority of the increasing population within the Council, and therefore are likely to experience canopy loss from development. Figure 3 shows the loss of canopy in m^2 from current canopy cover levels to projected canopy cover in 2026. To compensate for the loss of canopy as a result of private development, increased planting on public land will be required.

ACTIONS

2.1.1 Develop, fund and deliver an expanded ongoing 'Urban Forest Replenishment Program' to increase canopy cover and offset projected tree losses. Ensure the 'Urban Forest Replenishment Program' allows for adequate establishment maintenance of trees.

2.1.2 Implement tree planting replacement ratios in line with Council's 'Environmental Impact Assessment Process'.

2.1.3 Prioritise, fund and align planting programs with the Ku-ring-gai 'Public Domain Plan' precinct plans for each Local Centre.

2.1.4 Develop a 'Street Tree Master Plan' (STMP) or similar to guide future tree planting programs. This plan should incorporate a tree planting prioritisation framework that incorporates heat, canopy mapping, Local Centres, major cycle and pedestrian routes and social vulnerability mapping. Reference STMP to Council's 'Green Grid Strategy'.

2.1.5 Develop a program to convert above-ground powerlines to bundled cables or underground services in areas where existing high value trees are being impacted and in areas with lower-canopy cover to make room for larger sized trees. Work with service providers to form a partnership to achieve this.

GOAL

2.2 INTEGRATE DELIVERY OF GREEN, BLUE AND GREY INFRASTRUCTURE CAPITAL PROGRAMS

Integration of blue, green and grey infrastructure will provide mutual benefits to all. Opportunities to enhance and reconnect Ku-ring-gai's blue, green and grey infrastructure exist at all scales, from large public infrastructure projects to small private developments.

ACTIONS

2.2.1 Establish a culture and processes that promote collaboration and best-practice urban forest management.

2.2.2 Integrate capital delivery programs to ensure all projects consider opportunities for improved urban forest outcomes. All new capital or infrastructure renewal works should incorporate and appropriately budget for new tree planting and greening where practical.

2.2.3 Embrace innovative civil infrastructure design solutions such as structural soil and soil vaults for built-up areas where soil volume is limited, and green roofs or green walls for areas where building footprints restrict traditional plantings.

2.2.4 Incorporate WSUD principles (such as passive irrigation) as established in the Ku-ring-gai 'Water Sensitive City Policy and Strategy', for new tree planting projects.

GOAL

2.3 INTEGRATE URBAN ECOLOGY VALUES INTO PROGRAMS

Biodiverse and ecologically rich urban areas promote resilient and livable cities. When appropriately integrated, urban ecology values can enhance the benefits of the urban forest and provide improved soil and water quality and pollution mitigation, and support overall tree health.

ACTIONS

2.3.1 Ensure the planning, design and management of public open spaces, including through private development, considers and incorporates ecological values, such as use of native species and use of understorey planting to promote multi-layered ecosystems with good vertical complexity.

2.3.2 Continue to incorporate 'habitat trees' in the landscape where appropriate. Habitat trees are trees (live or dead) that are retained or modified to include (fauna) species-specific habitat hollows. Develop an assessment framework in collaboration with Council's ecology team to determine where and when to retain or incorporate these habitat trees.

3.4.3 Develop a 'Timber Reuse' policy and investigate opportunities to utilise wood from urban trees as a timber resource. Kur-ring-gai is home to many high-value timber tree species and when these trees require removal, they are usually turned into wood chips, the lowest value product possible. Timber could be used in Council projects (e.g. logs in playgrounds) or milled and provided to the community. Proceeds from timber sales could be used to fund tree planting projects and contribute to the circular economy.

GOAL

2.4 IMPROVED MANAGEMENT OF TREES IN BUSHFIRE PRONE LAND

Bushfires pose a significant threat to establishment, retention and management of trees. Much of the Ku-ring-gai area is designated as 'bushfire prone land' and comes under state legislation that impacts how trees are managed.

ACTIONS

2.4.1 Investigate/develop guidelines for tree planting in bushfire prone lands, for both public and privately owned land.

2.4.2 Collaborate with research institutions, agencies and relevant stakeholders in the trial of bushfire resistant species in bushfire prone areas.

2.4.3 Develop processes for assessing future greening initiatives to ensure they align with the *Ku-ring-gai Council Bushfire Management Policy 2020* and other related legislation.

2.4.4 Deliver tree planting programs in Bushfire Prone Land in coordination with Council's Bushfire Technical Officer and in line with best practice knowledge determined as part of action 2.4.2.

7.3 Monitor and Maintain

You need to know what you have to know how to manage it.

Having good data on the urban forest is critical for day-to-day decision-making and high-level strategic planning. It can provide valuable insights into the quality and value of your tree assets and uncover underlying issues or barriers to achieving targets. It will ensure resources are being directed to where they are required the most.

Vegetation extent and condition are necessary factors to know in order to maintain it throughout its life cycle. It is important to identify and quantify trees and record tree maintenance and planting activities. This will help to minimise resource use and minimise losses when investing in urban forestry programs.

While the present focus of this Strategy is urban canopy cover, there are many other quantitative and qualitative measures and targets that can be included in regular monitoring and reporting, which relate to the development and management of a healthy and resilient urban forest. Health and condition of the urban forest are as important as canopy cover. Urban forest composition, structure and age class are important measures of urban forest success, as a diverse forest is a resilient forest. Mapping urban forest landscapes and habitat values will help to identify opportunities for the creation and enhancement of corridors through targeted planting of particular species as informed by the Biodiversity Policy, Green Grid Strategy and Council's LEP and DCP biodiversity controls. Monitoring air quality and temperature can also be used to assess the health and success of the urban forest. In addition, the contribution of the forest to soil and water resources and the carbon cycle, and its socioeconomic impacts can be used as other methods of evaluation.

GOAL

3.1 MONITOR VEGETATION AND CANOPY COVER

Accurately monitoring changes in canopy cover will enable evaluation of the effectiveness of the management interventions and greening programs and will help to achieve targets and objectives.

ACTIONS

3.1.1 Acquire airborne imagery of the Council on a biennial basis (every two years) throughout the implementation of the Strategy (10 years) to identify changes in cover. Acquisitions should use the same metrics and parameters each time and assess canopy cover based on 3m and 10m height stratification.

3.1.2 Use acquired airborne imagery to accurately record the number of trees removed on public and private land, as a cross-reference to Council's record-keeping and monitoring of illegal tree removal.

GOAL

3.2 MONITOR LAND SURFACE AND AIR TEMPERATURE

Spatial analysis of urban heat islands is an important tool to measure the success of the urban forest. Investigating the relationship between vegetation and canopy cover, and land surface temperature can be used to develop a framework to prioritise green infrastructure and mitigate high urban temperatures.

ACTIONS

3.2.1 Acquire airborne thermal imagery data on a biennial basis (every two years) throughout the implementation of the Strategy (10 years) to identify urban heat islands and the relationship between vegetation cover and land surface temperature.

3.2.2 Focus planting efforts in areas identified as urban hot spots (in conjunction with action 2.14 – 'Develop a tree planting prioritisation framework').

3.2.3 Use thermal imagery to inform urban design, such as street width and building height, building and surface material used, and new park placement.

3.2.4 Invest in and trial innovative smart technologies for real-time monitoring of air temperature in different streetscapes to quantify the effect of street design and planting on air temperature. Consider collaborating with research agencies and other local governments. Use this data to feed back into planting efforts and urban design.

GOAL

3.3 MANAGE THE CONTRIBUTION OF THE URBAN FOREST TO SOIL AND WATER RESOURCES

The interaction between urban trees, surrounding infrastructure, soils and water is complex. There are positive correlations between the growth rate of trees, fine-root biomass and water infiltration rates. Appropriate and considered planting of trees has the potential to intercept stormwater runoff and reduce the requirement for additional irrigation. Trees have great potential for urban stormwater management, and research is required to develop policy mechanisms to encourage their cost-effective implementation.

ACTIONS

3.3.1 Trial innovative smart technologies for real-time monitoring of soil moisture and plant growth for targeted water application and early mitigation of tree disorders.

3.3.2 Consider waterways and stormwater runoff with new plantings, in order to appropriately intercept runoff.

3.3.3 Develop policy mechanisms to encourage cost-effective implementation of urban stormwater management.

GOAL

3.4 IMPROVE ASSET AND DATA MANAGEMENT

Most Councils are recognising trees as assets in their operational planning and maintenance programs and managing their trees with a 'whole of life' asset management approach. This ensures that risks from trees are managed and that costs associated with maintaining trees over their life cycle are accounted for.

A tree inventory is the most powerful and accurate method of collecting and analysing urban forest data in the public realm; it will provide metrics such as species diversity, tree health and condition, useful life expectancy and risk profile, in an easily accessible format.

Council manages approximately 64,057 public trees. Currently, the maintenance of these trees is carried out on a reactive basis according to risk.

ACTIONS

3.4.1 Audit trees in priority areas on Council-managed land (excluding bushland) and develop a tree inventory database. Utilise existing aerially acquired tree data as a base for this inventory. Collect additional fields such as species, condition, risk profile and Useful Life Expectancy via ground-based assessment. Priority areas for data collection include a number of District Parks throughout the LGA, as well as Green Grid Links, and can be seen in Appendix B.

3.4.2 Opportunistically collate audit data on trees outside priority areas on private and public land.

3.4.3 Investigate options to incorporate the tree inventory database for priority areas into Council's asset management system. If Council's system is not suitable for recording tree data, a proprietary tree asset management software may be appropriate.

3.4.4 Ensure the inventory is maintained as a 'live' asset management database. This includes adding newly planted trees into the database and recording all removals and maintenance works on Council trees as they happen.

3.4.5 Develop and implement an internal auditing tool to monitor the success of annual planting programs. Incorporate tree planting targets into delivery program KPIs.

3.4.6 Improve record keeping for private tree applications and DAs to enable accurate monitoring of tree removal on private land.

GOAL

3.5 IMPROVE TREE MAINTENANCE PRACTICES

As previously discussed, Ku-ring-gai has a well-established urban forest. Properly maintaining this existing urban forest is an essential part of protecting what exists, and ensuring it's continuation into the future.

ACTIONS

3.5.1 Identify a budget source and implement a proactive tree maintenance program to enable improved risk management. The proactive program should be based on priority areas determined by volume of traffic (pedestrian and vehicle) and the risk profile of trees, and be scheduled on a cyclic basis.

3.5.2 Undertake a whole-of-life cost analysis for tree maintenance based on tree inventory findings (action 3.2.1) and ensure future operational maintenance budgets align with increased tree planting programs.

3.5.3 Undertake an operational service review to assess and make recommendations regarding best use of tree maintenance and tree planting resources.

7.4 Collaborate and Incentivise

Raising awareness of the benefits of trees across the community will drive change.

Bring the community along for the journey – a strong relationship with your community will improve how well Council can deliver on these urban forest goals.

One of the biggest barriers to achieving improved urban forest programs is limited community awareness and understanding of the need for improved urban forest planning and greening outcomes.

Partnering with and empowering local residents and organisations will help build urban forest awareness and support for the protection, management and increasing of urban canopy.

GOAL

4.1 ENABLE, SUPPORT AND EMPOWER THE COMMUNITY TO ACTIVELY PARTICIPATE IN THE PLANNING AND MANAGEMENT OF TREES

Ku-ring-gai encourages the community to have a sense of ownership and acceptance of the City's community greening initiatives. Involving and enabling the community with each step of the Urban Forest Strategy will ensure a sense of connection with the urban forest. It's crucial that the Council provides opportunities for active participation in greening activities throughout the City, including ongoing education and awareness activities, hands on activities such as planting programs, and encouraging citizen science.

ACTIONS

4.1.1 Develop and fund a tree giveaway program. These programs can help to increase tree canopy on private land while also providing the opportunity to positively engage with the community and promote the benefits of trees. Align these programs with established tree events such as 'National Tree Day', or local community events like farmers' markets or festivals.

4.1.2 Develop and expand on existing community education programs such as 'Smart Schools'.

4.1.3 Increase involvement by Traditional Owners in decision making and management of public spaces and explore opportunities to re-introduce cultural practices into the urban landscape.

4.1.4 Conduct regular community planting days to involve and engage with the community. Continue to deliver corporate planting days. Align these programs with established tree events such as 'National Tree Day'.

GOAL

4.2 INCENTIVISE INCREASED CANOPY ON PRIVATE LAND

One of the most important things that the community can do is green their own property. As previously discussed, 60.8% of the land in Ku-ring-gai's urban area is privately owned. Private land holds significant influence over Ku-ring-gai's overall canopy cover, and residents can have a huge impact. The community is one of Ku-ring-gai's greatest resources for increasing canopy and green cover.

ACTIONS

4.2.1 Investigate a new grant/subsidy program for residents to assist with the ongoing maintenance of trees on private land. This could include subsidies towards gutter cleaning, additional green waste collections, tree inspections and/or subsidised pruning of trees on private land.

4.2.3 Provide community information and support relating to tree maintenance and planting on private land. Develop a list of suitable tree species for use by the community.

GOAL

4.3 ADVOCATE FOR GREATER RECOGNITION OF GREEN INFRASTRUCTURE

Advocacy is an important part of building urban forest awareness and support for trees. This advocacy needs to occur both externally and internally.

Ku-ring-gai Council has a positive history of engaging and collaborating with infrastructure agencies and providers such as Ausgrid, Transport for NSW, Sydney Water, utilities providers, and individuals and should continue to do so.

ACTIONS

4.3.1 Continue to actively participate in working groups and forums that seek to improve the recognition of trees as essential assets.

4.3.2 Advocate for BASIX and other sustainability tools to be updated and strengthened to incorporate green infrastructure.

4.3.3 Identify champions within Council to advocate and lead the implementation of this Strategy and associated urban forest programs. Form an Urban Forest Working Group of staff who share responsibility for the Urban Forest Strategy and establish clear lines of communication and processes.

8 Appendices

8.1 Appendix A – Canopy Target Development

Minimum target levels for each Land Zone were devised based on either the DPE 'Draft Urban Design and Place Guide', where possible, or using the current average canopy cover of that Land Zone. Canopy Targets were then set for Streets and Public Open Space (POS) (Table 5), and by Land Zone across the LGA (Table 6) using these minimum target levels.

Specific hectare targets for Land Zone by suburb (Table 7) and by Local Centre (Table 8) were also calculated, using a more complex process. This process involved calculating what the total canopy cover for each Land Zone would be if every land parcel in that Zone was brought up to at least the DPE or mean target level for that Zone. In this analysis, land parcels with canopy cover already at or above the target level were left as-is for the purposes of the analysis, while parcels with current canopy cover lower than the target had an estimated canopy level calculated based on bringing canopy cover up to the target level as a new minimum. The results of this analysis are outlined by suburb in Table 3 and for local centres in Table 4. These Tables illustrate how much canopy should be planted in each Land Zone by suburb or local centre, in order to reach targets.

An average tree canopy area of 70 m^2 was then used to determine approximately how many trees would need to be planted to meet targets (Table 2, Table 3).

Although targets were set by modelling increases in low-canopy land parcels and assuming no change in canopy for those parcels already above set minimum levels, the final canopy targets in Tables 3 and 4 may be achieved by planting wherever space is available within that Land Zone and suburb/local centre. Furthermore, some canopy loss is likely to occur in particular land parcels. The process of modelling and calculating targets for Tables 3 and 4 did not directly include canopy loss. Rather, the process was an indicative one based on current canopy levels, with the assumption that Council can use the calculated final targets to target plantings flexibly and with the ability to counteract canopy losses with increased plantings to meet targets.

Table 5: Canopy targets for streets and Public Open Space (POS).

Land Zone	Area (ha)	Canopy (ha)	Current Canopy (%)	Canopy Target (%)	Additional canopy required (ha)
Road Reserves	1020.1	389.5	38.2	45.0	69.5
POS	1609.2	1189.4	73.9	77	57.7

Table 6: City-wide Land Zone based canopy targets (excluding C1 – National Parks).

Land Zone	Area (ha)	Canopy (ha)	Current Canopy (%)	Canopy Target (%)	Additional canopy required (ha)
B1	12.3	2.8	23.2	27.7	0.6
B2	36.8	6.1	16.6	17.6	0.4
B4	5.2	0.6	12.4	12.3	0.0
B5	1.2	0.3	25.4	35.0	0.1
B7	12.8	2.9	22.6	35.0	1.9
C2	1250.4	1042.5	83.4	86.1	34.4
C3	5.7	3.8	67.0	67.0	0.0
C4	866.1	357.3	41.3	46.7	47.5
R1	14.0	4.1	29.1	40.0	0.8
R2	3453.3	1237.3	35.8	40.0	156.8
R3	43.4	14.0	32.2	40.0	3.6
R4	191.9	63.1	32.9	40.0	13.6
R5	21.4	5.7	26.8	40.1	2.8
RE1	358.8	146.8	40.9	45.0	23.3
RE2	176.4	67.5	38.3	47.4	16.2
SP1	33.9	12.6	37.1	37.1	0.0
SP2	302.5	89.5	29.6	31.7	6.5
W1	4.9	2.1	42.3	44.0	0.1
Total	6790.8	3059.0	45.0	49	287.3

Table 7: Breakdown of Suburbs into Land Zone based canopy targets.

Suburb	Land Zone	Area (ha)	Canopy (ha)	Canopy (%)	Target (%)	Additional canopy required (ha)	Current suburb canopy cover (%)	Overall target for suburb (%)
EAST KILLARA	B1	0.5	0.1	19.9	23.2	0.0	43.1	54.1
	C2	65.9	53.1	80.6	83.4	1.8		
	C3	83.7	21.5	25.7	41.3	13.0		
	R2	42.9	10.8	25.3	40.0	6.3		
	RE1	10.0	2.7	26.5	45.0	1.9		
	SP2	3.7	1.1	30.0	29.7	0.0		
	W1	1.8	0.5	25.7	22.7	-0.1		
EAST LINDFIELD	B1	0.1	0.0	11.2	23.2	0.0	37.1	49.6
	C2	45.2	31.4	69.4	83.4	6.3		
	C3	13.0	4.2	32.1	41.3	1.2		
	R2	132.8	35.9	27.0	40.0	17.3		
	RE1	9.0	3.2	35.9	45.0	0.8		
	RE2	0.3	0.1	38.5	45.0	0.0		
	SP2	3.5	0.8	23.4	23.4	0.0		
GORDON	B2	7.1	1.2	17.6	16.6	-0.1	45.0	47.7
	B4	4.0	0.6	15.4	12.4	-0.1		
	B5	0.5	0.2	40.0	25.4	-0.1		
	C2	65.4	56.4	86.3	83.4	-1.9		
	C3	35.4	17.4	49.1	41.3	-2.8		
	R2	191.3	71.7	37.5	40.0	4.8		
	R3	4.8	1.3	27.9	40.0	0.6		
	R4	23.7	6.7	28.3	40.0	2.8		
	RE1	29.3	11.3	38.4	45.0	1.9		
	RE2	0.0	0.0	0.0	45.0	0.0		
	SP1	0.4	0.2	38.5	39.0	0.0		

Suburb	Land Zone	Area (ha)	Canopy (ha)	Canopy (%)	Target (%)	Additional canopy required (ha)	Current suburb canopy cover (%)	Overall target for suburb (%)
	SP2	16.2	3.1	19.0	18.4	-0.1		
KILLARA	B1	0.7	0.4	57.9	23.2	-0.2	34.7	41.7
	B2	0.9	0.2	19.9	16.6	0.0		
	C2	15.3	12.4	80.9	83.4	0.4		
	C3	10.1	4.2	42.1	41.3	-0.1		
	R2	316.7	103.3	32.6	40.0	23.4		
	R3	0.8	0.4	45.1	40.0	0.0		
	R4	30.2	11.1	36.7	40.0	1.0		
	RE1	10.4	5.4	51.9	45.0	-0.7		
	RE2	43.3	12.7	29.4	45.0	6.8		
	SP2	17.0	4.3	25.6	25.2	-0.1		
LINDFIELD	B1	0.8	0.1	16.5	23.2	0.1	41.5	45.9
	B2	6.8	1.1	16.3	16.6	0.0		
	B4	1.2	0.0	3.4	12.4	0.1		
	B5	0.3	0.1	21.6	25.4	0.0		
	C2	55.6	48.2	86.7	83.4	-1.8		
	C3	5.7	3.8	67.6	67.0	0.0		
	C3	29.8	11.0	37.0	41.3	1.3		
	R1	9.3	1.9	20.4	29.1	0.8		
	R2	256.7	87.6	34.1	40.0	15.1		
	R3	3.6	1.5	40.4	40.0	0.0		
	R4	28.4	9.4	33.1	40.0	2.0		
	RE1	13.0	5.4	41.2	45.0	0.5		
	RE2	6.2	4.1	66.4	45.0	-1.3		
	SP1	20.5	9.9	48.5	42.5	-1.2		
	SP2	15.1	3.7	24.4	22.6	-0.3		
	W1	1.1	0.6	57.8	57.8	0.0		

Suburb	Land Zone	Area (ha)	Canopy (ha)	Canopy (%)	Target (%)	Additional canopy required (ha)	Current suburb canopy cover (%)	Overall target for suburb (%)
NORTH TURRAMURRA	B1	1.0	0.1	10.7	23.2	0.1	44.3	53.3
	C2	92.8	81.5	87.9	83.4	-4.2		
	C3	169.8	50.0	29.5	41.3	20.0		
	R2	2.8	1.1	37.8	40.0	0.1		
	R5	21.4	5.7	26.7	40.0	2.8		
	RE1	50.1	12.3	24.6	45.0	10.3		
	RE2	10.8	6.1	56.3	45.0	-1.2		
	SP2	18.8	5.9	31.3	33.3	0.4		
NORTH WAHROONGA	C2	141.8	99.8	70.4	83.4	18.4	53.1	65.1
	C3	69.0	22.4	32.4	41.3	6.1		
	R2	21.7	6.7	31.2	40.0	1.9		
	RE1	12.2	1.7	13.9	45.0	3.8		
	SP2	7.0	3.0	43.3	43.4	0.0		
PYMBLE	B2	3.0	0.7	24.1	16.6	-0.2	46.3	46.5
	B4	0.0	0.0	0.0	12.4	0.0		
	B5	0.3	0.0	0.1	25.4	0.1		
	B7	12.8	2.9	22.5	22.6	0.0		
	C2	58.5	55.0	94.0	83.4	-6.2		
	C3	39.9	26.0	65.2	41.3	-9.6		
	R2	399.2	160.6	40.2	40.0	-0.9		
	R3	4.0	1.4	35.6	40.0	0.2		
	R4	14.5	4.8	33.3	40.0	1.0		
	RE1	12.0	7.3	60.4	45.0	-1.8		
	RE2	50.8	23.7	46.6	45.0	-0.8		
	SP1	1.2	0.5	42.6	42.5	0.0		
	SP2	56.9	19.4	34.1	34.1	0.0		
ROSEVILLE CHASE	C2	0.4	0.0	8.4	83.4	0.3	44.0	55.5

Suburb	Land Zone	Area (ha)	Canopy (ha)	Canopy (%)	Target (%)	Additional canopy required (ha)	Current suburb canopy cover (%)	Overall target for suburb (%)
	C3	29.8	24.2	81.1	41.3	-11.9		
	R2	24.1	10.3	42.9	40.0	-0.7		
	RE1	42.6	10.2	24.0	45.0	8.9		
	RE2	19.2	6.6	34.6	45.0	2.0		
	SP2	1.4	0.4	25.8	43.1	0.2		
	W1	7.1	3.0	42.7	83.6	2.9		
ROSEVILLE	B1	0.1	0.0	10.1	23.2	0.0	35.7	43.6
	B2	3.2	0.5	15.0	16.6	0.0		
	B5	0.1	0.0	8.0	25.4	0.0		
	C2	13.1	12.3	93.6	83.4	-1.3		
	C3	0.0	0.0	76.9	67.0	0.0		
	C3	15.0	8.9	59.4	41.3	-2.7		
	R1	0.0	0.0	0.0	40.0	0.0		
	R2	215.3	69.2	32.2	40.0	16.9		
	R4	17.1	5.5	32.4	40.0	1.3		
	RE1	7.0	3.2	45.6	45.0	0.0		
	RE2	15.4	4.8	31.2	45.0	2.1		
	SP2	12.9	2.4	18.7	43.1	3.2		
	W1	0.1	0.1	95.5	83.6	0.0		
SOUTH TURRAMURRA	B1	0.7	0.2	22.9	23.2	0.0	57.9	60.4
	C2	119.2	102.4	85.9	83.4	-3.0		
	C3	23.5	10.5	44.5	41.3	-0.8		
	R2	115.0	39.5	34.3	40.0	6.5		
	RE1	11.2	4.5	40.6	45.0	0.5		
	SP2	4.4	1.5	35.4	35.2	0.0		
ST IVES CHASE	B1	0.4	0.1	23.9	23.2	0.0	49.7	56.2
	C2	77.5	65.2	84.1	83.4	-0.6		

Suburb	Land Zone	Area (ha)	Canopy (ha)	Canopy (%)	Target (%)	Additional canopy required (ha)	Current suburb canopy cover (%)	Overall target for suburb (%)
	C3	74.8	24.9	33.3	41.3	6.0		
	R2	59.3	16.8	28.3	40.0	7.0		
	RE1	6.1	1.4	23.2	45.0	1.3		
ST IVES	B1	0.8	0.2	21.7	23.2	0.0	43.5	49.2
	B2	6.3	0.8	12.8	16.6	0.2		
	C2	205.3	163.7	79.7	83.4	7.5		
	C3	85.5	38.2	44.7	41.3	-3.0		
	R2	529.6	170.5	32.2	40.0	41.3		
	R3	19.5	5.6	28.4	40.0	2.3		
	R4	21.4	6.1	28.5	40.0	2.4		
	RE1	118.0	58.2	49.3	45.0	-5.1		
	RE2	40.9	11.4	27.9	45.0	7.0		
	SP2	53.2	16.0	30.0	30.1	0.0		
	W1	0.5	0.1	16.6	11.9	0.0		
TURRAMURRA	B1	0.7	0.1	15.7	23.2	0.1	47.0	47.2
	B2	7.1	1.2	17.1	16.6	0.0		
	C2	82.6	70.5	85.4	83.4	-1.7		
	C3	41.8	24.2	57.8	41.3	-6.9		
	R2	407.6	163.2	40.0	40.0	-0.1		
	R3	3.9	1.4	36.5	40.0	0.1		
	R4	26.4	9.9	37.4	40.0	0.7		
	RE1	19.0	8.2	43.4	45.0	0.3		
	RE2	0.0	0.0	27.9	45.0	0.0		
	SP2	12.2	4.0	32.5	31.9	-0.1		
WAHROONGA	B1	4.2	1.0	24.6	23.2	-0.1	50.1	50.4
	B2	2.5	0.3	13.6	16.6	0.1		
	C2	110.9	102.9	92.8	83.4	-10.5		

Suburb	Land Zone	Area (ha)	Canopy (ha)	Canopy (%)	Target (%)	Additional canopy required (ha)	Current suburb canopy cover (%)	Overall target for suburb (%)
	C3	114.5	66.5	58.1	41.3	-19.3		
	R1	4.7	2.1	46.0	40.0	-0.3		
	R2	429.2	181.4	42.3	40.0	-9.7		
	R3	4.7	2.0	43.4	40.0	-0.2		
	R4	26.1	8.2	31.4	40.0	2.2		
	RE1	15.1	6.9	45.8	45.0	-0.1		
	SP1	11.8	2.0	16.7	16.6	0.0		
	SP2	50.0	14.4	28.9	24.3	-2.3		
WARRAWEE	C2	1.2	1.1	94.0	83.4	-0.1	41.7	42.1
	C3	5.0	3.9	77.6	41.3	-1.8		
	R2	109.8	45.3	41.3	40.0	-1.4		
	R3	2.0	0.4	19.0	40.0	0.4		
	R4	4.2	1.4	34.7	40.0	0.2		
	RE1	0.8	0.6	74.2	45.0	-0.2		
	SP2	12.3	3.6	29.6	29.5	0.0		
WEST PYMBLE	B1	1.9	0.5	25.5	23.2	0.0	48.6	51.4
	C2	69.2	62.2	89.8	83.4	-4.5		
	C3	31.4	13.3	42.5	41.3	-0.4		
	R2	180.6	63.2	35.0	40.0	9.0		
	RE1	16.3	8.0	49.4	45.0	-0.7		
	RE2	7.1	4.1	57.4	45.0	-0.9		
	SP2	12.2	3.3	27.2	27.2	0.0		
	W1	1.5	0.8	54.4	59.9	0.1		

Table 8: Breakdown of Town Centres into Land Zone based canopy targets.

Town Centre	Land Zone	Area (ha)	Canopy (ha)	Canopy (%)	Target (%)	Additional canopy required (ha)	Current Town Centre canopy cover (%)	Overall target for Town Centre (%)
Gordon	**B2**	7.37	1.26	17.09	16.57	-0.04	34.0	38.4
	B4	3.97	0.61	15.35	12.35	-0.12		
	B5	0.54	0.21	39.98	25.42	-0.08		
	C2	1.28	1.16	90.21	83.37	-0.09		
	C3	12.26	6.66	54.34	41.25	-1.60		
	R2	132.83	47.48	35.74	40.00	5.65		
	R3	3.45	0.98	28.39	40.00	0.40		
	R4	29.15	8.47	29.06	40.00	3.19		
	RE1	3.08	1.30	42.27	45.00	0.08		
	SP1	0.41	0.16	38.48	38.97	0.00		
	SP2	16.49	3.40	20.62	12.12	-1.40		
Killara	**B1**	0.65	0.38	58.97	58.97	0.00	33.6	33.6
	B2	0.60	0.17	27.58	27.58	0.00		
	C2	0.00	0.00	0.00	0.00	0.00		
	R2	62.20	20.14	32.38	32.38	0.00		
	R3	0.78	0.35	45.10	45.10	0.00		
	R4	21.01	8.32	39.61	39.61	0.00		
	RE1	0.63	0.51	80.13	80.13	0.00		
	SP2 Water Supply System	8.73	1.93	22.14	22.14	0.00		
Lindfield	**B2**	6.83	1.12	16.32	16.57	0.02	34.5	39.1
	B5	0.34	0.06	18.91	25.42	0.02		
	C2	1.98	1.85	93.40	83.37	-0.20		
	C3	7.35	2.94	39.98	41.25	0.09		
	R2	151.01	53.02	35.11	40.00	7.38		
	R3	3.60	1.45	40.39	40.00	-0.01		

Town Centre	Land Zone	Area (ha)	Canopy (ha)	Canopy (%)	Target (%)	Additional canopy required (ha)	Current Town Centre canopy cover (%)	Overall target for Town Centre (%)
	R4	28.86	9.69	33.56	40.00	1.86		
	RE1	0.86	0.61	70.42	45.00	-0.22		
	SP2 Railway Infrastructure	14.56	3.68	25.27	28.00	0.40		
Pymble	**B2**	2.95	0.71	24.06	16.57	-0.22	41.4	42.2
	B5	0.28	0.00	0.07	25.42	0.07		
	B7	7.03	1.67	23.81	22.58	-0.09		
	C2	2.92	2.82	96.65	83.37	-0.39		
	C3	10.82	6.48	59.89	41.25	-2.02		
	R2	76.20	31.56	41.41	40.00	-1.08		
	R3	3.76	1.40	37.17	40.00	0.11		
	R4	12.98	4.27	32.94	40.00	0.92		
	RE1	2.49	1.63	65.30	45.00	-0.51		
	SP1 Defence	1.18	0.50	42.55	42.54	0.00		
	SP2 Water Supply System	19.08	6.76	35.44	28.74	-1.28		
Roseville	**B2**	3.17	0.48	15.03	16.57	0.05	35.1	39.7
	B5	0.02	0.00	4.80	25.42	0.00		
	C3	4.75	2.93	61.64	59.89	-0.08		
	R2	64.92	22.86	35.21	40.00	3.11		
	R4	16.58	5.26	31.70	40.00	1.38		
	RE1	0.95	0.56	59.16	45.00	-0.13		
	SP2 Classified Road	1.72	0.26	14.99	14.99	0.00		
	SP2 Railway Infrastructure	2.28	0.76	33.21	33.21	0.00		
St Ives	**B2**	6.29	0.80	12.77	16.57	0.24	34.5	44.3
	C2	6.79	6.57	96.77	83.37	-0.91		

Town Centre	Land Zone	Area (ha)	Canopy (ha)	Canopy (%)	Target (%)	Additional canopy required (ha)	Current Town Centre canopy cover (%)	Overall target for Town Centre (%)
	C3	10.38	6.83	65.83	41.25	-2.55		
	R2	131.66	43.68	33.18	40.00	8.98		
	R3	15.52	4.28	27.60	40.00	1.92		
	R4	21.37	6.10	28.54	40.00	2.45		
	RE1	11.56	5.19	44.88	45.00	0.01		
	RE2	40.92	11.43	27.93	45.00	6.98		
	SP2 Water Supply System	13.21	4.10	31.05	65.50	4.55		
Turramurra	**B2**	7.05	1.21	17.14	16.57	-0.04	43.9	44.9
	C2	3.92	3.75	95.58	83.37	-0.48		
	C3	17.89	11.81	66.03	41.25	-4.43		
	R2	172.18	75.88	44.07	40.00	-7.01		
	R3	6.07	1.83	30.16	40.00	0.60		
	R4	30.99	11.50	37.10	40.00	0.90		
	RE1	7.54	3.33	44.16	45.00	0.06		
	SP2 Railway Infrastructure	14.89	5.14	34.55	40.24	0.85		
Wahroonga	**B1**	0.29	0.14	47.01	23.16	-0.07	36.0	36.5
	B2	2.51	0.34	13.62	16.57	0.07		
	C2	0.03	0.00	7.79	16.57	0.00		
	R2	60.70	25.14	41.42	40.00	-0.86		
	R3	0.25	0.19	75.35	40.00	-0.09		
	R4	19.17	7.21	37.60	40.00	0.46		
	RE1	3.33	1.62	48.62	45.00	-0.12		
	SP2 Water Supply System	34.65	8.95	25.84	9.28	-5.74		

8.2 Appendix B – Priority Areas for Tree Inventory Data Collection

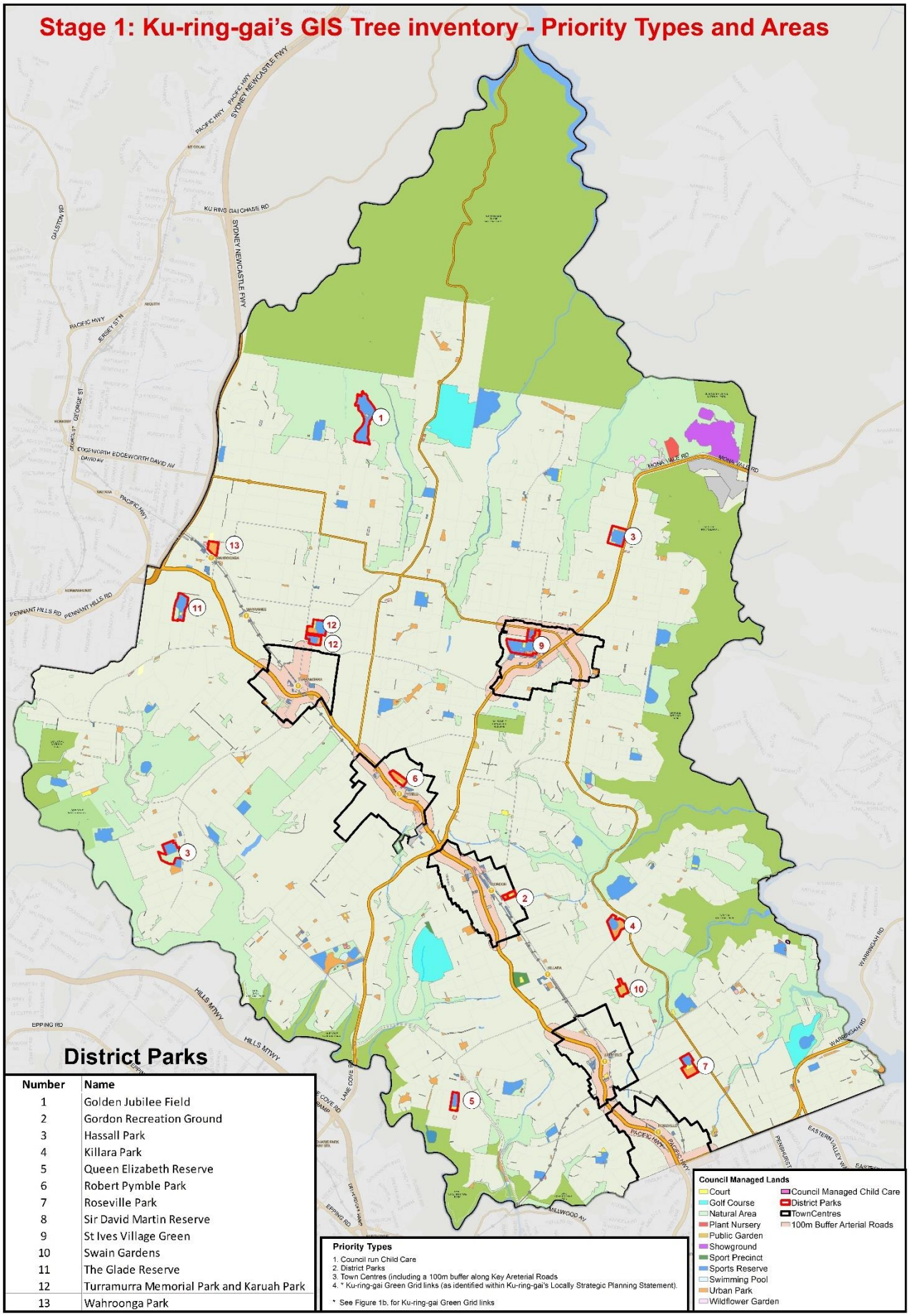


Figure 1b. Ku-ring-gai Green Grid Links

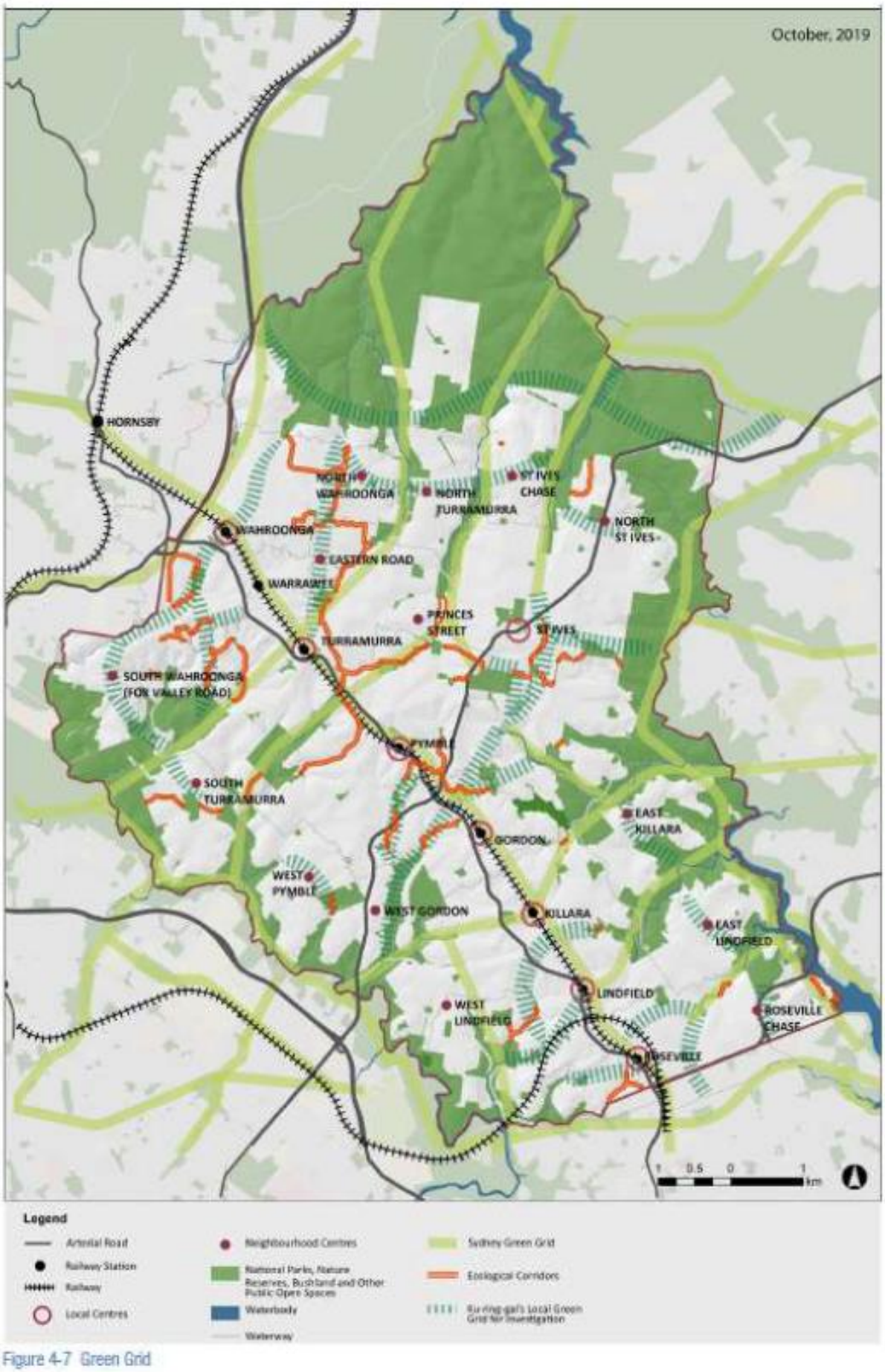


Figure 4-7 Green Grid

Source: Local Strategic Planning Statement Ku-ring-gai Council (Adopted 17 March 2020)

9 References

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.

AECOM. (2019). Green Infrastructure: A vital step to Brilliand Australian cities. https://aecom.com/content/wp-content/uploads/2017/04/Green-Infrastructure-vital-step-brilliant-Australian-cities.pdf

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

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

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., Gatziolis, 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

Frumkin, H. (2003). Healthy Places: Exploring the evidence. American journal of public health, 93 (9), 1451-1456. https://doi.org/10.2105/ajph.93.9.1451

Gallagher, R. V., Allen, S., & Wright, I. J. (2019). Safety margins and adaptive capacity of vegetation to climate change. Scientific Reports, 9(1), 8241. https://doi.org/10.1038/s41598-019-44483-x

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

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

Kondo, M. C., Fluehr, J. M., McKeon, T., & Branas, C. C. (2018). Urban Green Space and Its Impact on Human Health. International Journal of Environmental Research and Public Health, 15(3), 445. https://doi.org/10.3390/ijerph15030445

Konijnendijk, C., Nilsson, K., Randrup, T., & Schipperijn, J. (2010). Urban Forests and Trees: a reference book. Springer.

Kuo, F. E., & Sullivan, W. C. (2001). Environment and Crime in the Inner City: Does Vegetation Reduce Crime? Environment and Behavior, 33(3), 343–367. https://doi.org/10.1177/0013916501333002

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

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

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

Matthers, P. (1978). *Ku-ring-gai: Living With Trees.* The Currawong Press, Sydney.

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.

Mouratidis. (2019). Compact city, urban sprawl, and subjective well-being. Cities, 92, 261–272. https://doi.org/10.1016/j.cities.2019.04.013

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.

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.

Rychetnik, L., Sainsbury, P., Stewart, G., Rychetnik, L., Sainsbury, P., & Stewart, G. (2018). How Local Health Districts can prepare for the effects of climate change: An adaptation model applied to metropolitan Sydney. Australian Health Review, 43(6), 601–610. https://doi.org/10.1071/AH18153

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.

Troy, Jakelin. (2019). The Sydney language. Canberra, ACT: Aboriginal Studies Press

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

Velarde, M.D., Fry, G. and Tveit, M. (2007) Health Effects of Viewing Landscapes: Landscape Types in Environmental Psychology. Urban Forestry and Urban Greening, 6, 199-212.

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