



Central Coast Council

ORDINARY COUNCIL MEETING

ENCLOSURES

Monday, 8 July, 2019

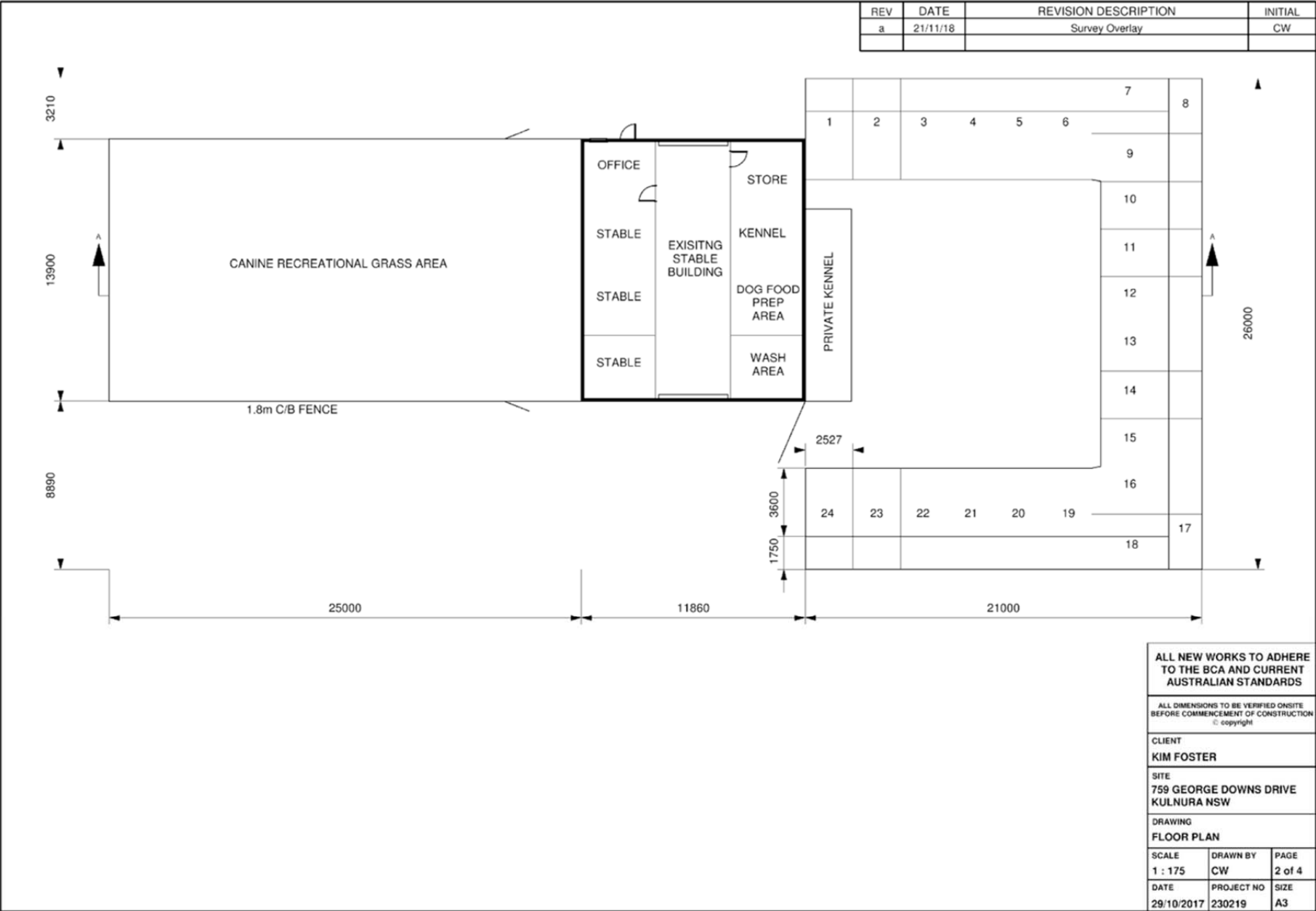
CENTRAL COAST COUNCIL
ENCLOSURES TO THE
ORDINARY COUNCIL MEETING
TO BE HELD IN THE COUNCIL CHAMBER,
2 HELY STREET, WYONG ON MONDAY, 8 JULY 2019 ,
COMMENCING AT 6.30PM

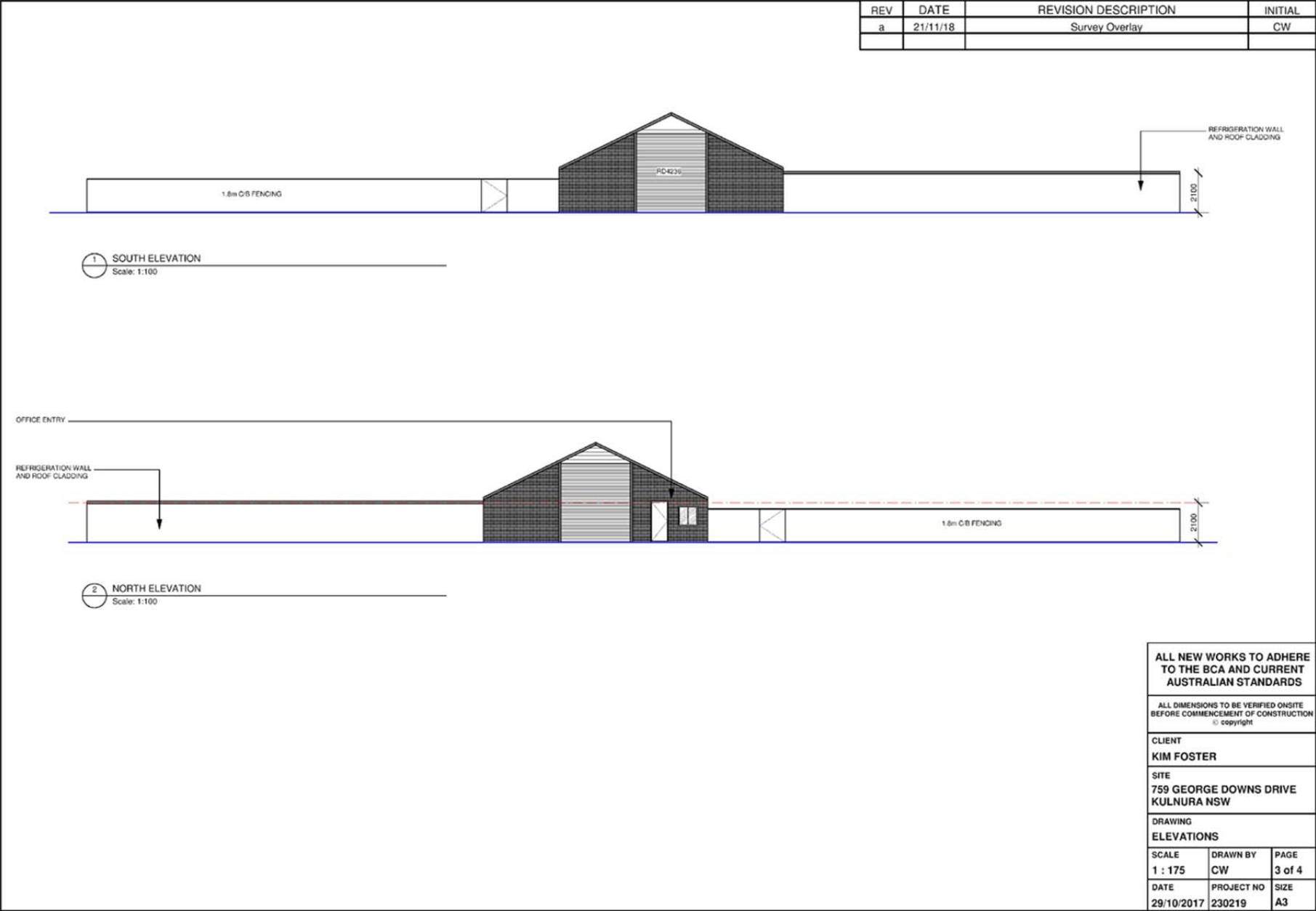
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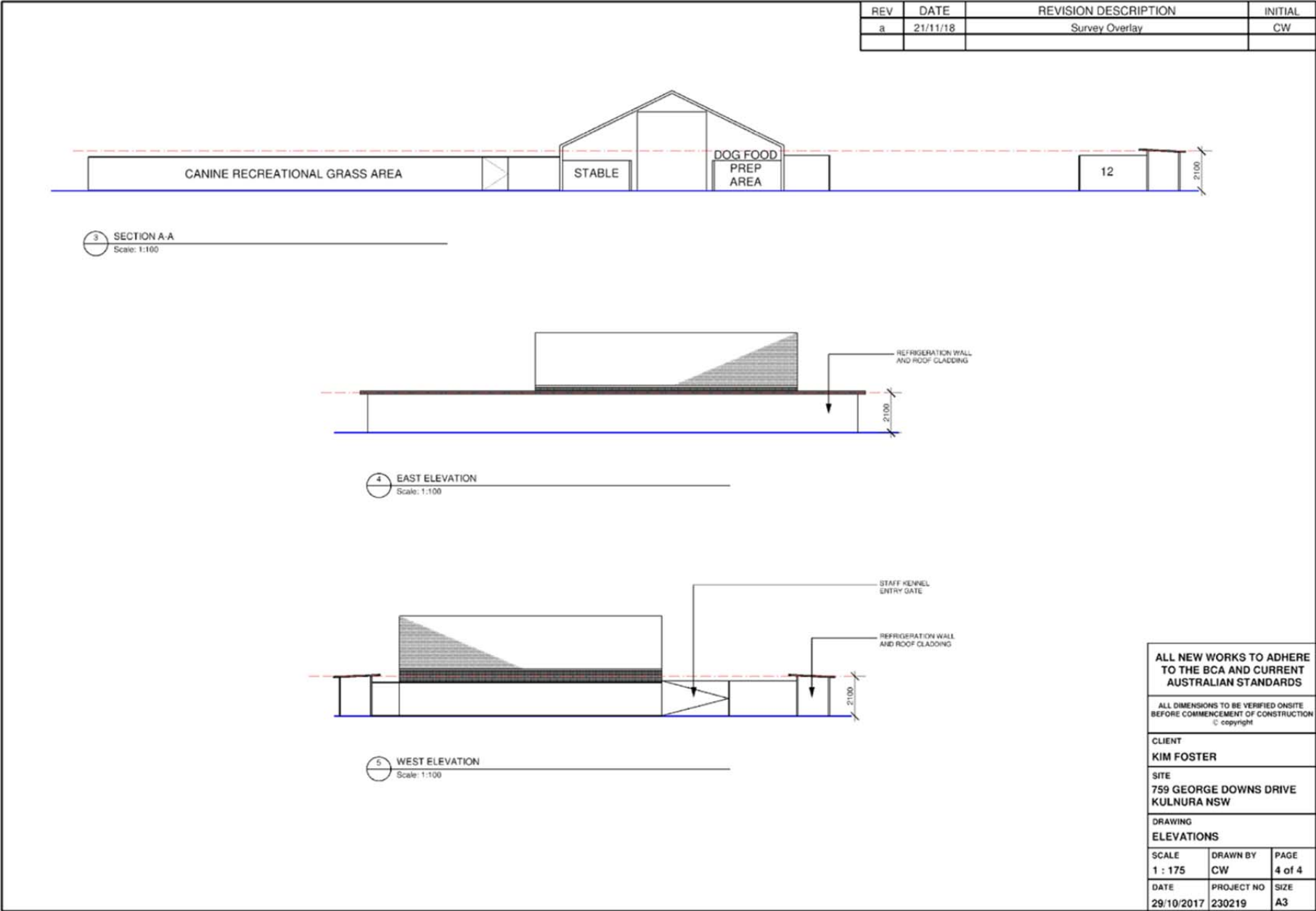
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Central Coast Council Landcare Program Strategy



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Cover photo – Shelly Beach Coastcare and visiting volunteers at work

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1. Executive Summary

This review and strategy provides an analysis and evaluation of Councils environmental volunteering program, the Central Coast Council Landcare Program (CCCLP).

The analysis included a review of Council documents, policies and procedures; a survey of volunteers within the program; a workshop where Councillors were invited to discuss their expectations for the program review and strategy development; benchmarking with other external environmental volunteering programs; and an analysis of the requirements in terms of Council resources to deliver the program under its current and expanded forms, including staff and financial resourcing.

The program, for the most part, is similar to other environmental volunteering programs on offer. The groups within the program carry out a range of activities that broadly fall within the areas of land conservation and park maintenance and are similar in nature to programs such as Bushcare, Landcare and Keep Australia Beautiful which are run by many other NSW Local Government Councils.

The current levels of support for the program have seen it capped at 80 volunteer groups. This has resulted in a program that is running at capacity, with a wait list of an additional 10 new groups. The report has found that the program is diverse in nature, supporting groups that can be defined in terms of 4 distinct sub-programs:

1. Conservation groups – volunteers carrying out bush regeneration activities
2. Amenity groups – volunteers carrying out maintenance, rubbish and graffiti removal, etc.
3. Technical groups – volunteers carrying out nursery volunteering, seed collection, citizen science.
4. Short-term groups – volunteers carrying out one off activities e.g. National Tree Day planting events, Floating Landcare, corporate events, etc.

A number of opportunities have been identified to expand the existing program. These include increasing the involvement of existing volunteers and groups in the program as well as introducing new volunteers and groups. With a program already at capacity, expanding the program could only realistically be achieved by increasing the resources allocated to the program from Council.

The report identifies strategic principles to guide management of the program and actions for the future including the following recommendations:

- To rename the program to Central Coast Council EnviroCare.
- To distinguish the 4 distinct sub-programs, developing and delivering more specialised support to the groups working within each, through specific procedures, objectives and work techniques.
- To prioritise the expansion of the program through developing additional conservation, technical and short-term groups in preference to additional amenity groups.

2. Introduction

Council-supported environmental volunteering has a long history on the Central Coast. Since the late 1990's local residents have been helping to care for the environment through the former Wyong Shire Council Landcare and Gosford City Council Bushcare programs.

Since amalgamation of the two former Councils in 2016, the two programs have continued to run together under the title of the Central Coast Council Landcare Program (CCCLP). This has brought together approximately 600 volunteers working with a total of 83 Bushcare, Dunecare, Friends Of, Landcare and Tidy Towns groups throughout the local government area. Volunteers are almost entirely residents of the Central Coast, most often volunteering at sites within the suburbs where they live.

On most days of the month there is at least one CCCLP volunteer session taking place, with as many as 10 sessions taking place simultaneously across the LGA on busy days. Within each month, weather permitting, there are over 140 scheduled volunteer sessions, each running for at least 2 hours.

The CCCLP supports volunteers carrying out activities including ecological restoration and land conservation in bushland and coastal natural reserves, recreation area maintenance in open space parks, garden and road verge maintenance, and rubbish and graffiti removal. Volunteers are also involved with native plant seed collection and plant propagation through Council's nursery, take part in citizen science activities such as flora and fauna monitoring, and participate in one off events such as annual National Tree Day plantings and floating Landcare.

Since amalgamation there has been a continuation of administrative and management approaches for the groups working within their respective former Council areas. There is an opportunity to now better align these programs, taking into consideration the conservation, social, amenity, community and citizen science aspects that are already in place and bringing these together through an overarching program to support the community, Council and environmental needs of the Central Coast into the future.

3. Vision and Purpose

Vision: The community partnering with Council to care for our environment.

Purpose: For Council to support these partnerships with the community in caring for our environment.



Figure 1: Kevin Shipman, partnering with Council through Wamberal Dunecare

4. Program background and origins

Origins of environmental volunteering in Australia

To understand how and why the CCCLP exists today it is necessary to have an understanding of the history of community based natural resource management, and environmental volunteering, in Australia, and from the former WSC and GCC.

Landcare began in 1986 as a Victorian initiative to encourage a sustainable, integrated approach to agriculture and environmental management. The national Landcare movement commenced in 1989 and has grown and evolved to be a community owned and driven initiative with the vision of 'all Australians actively caring for the land and water that sustains us'. The keystones of the Landcare model are that it encourages integrated management of environmental assets including productive farmland and a sustainable approach to private land management. Landcare has expanded into many sub-programs including Coastcare, Dunecare, Swampcare, etc.

Bushcare, sometimes called Urban Landcare, formed in 1989 in the suburbs of Sydney as a program to support environmental volunteer work on public land managed by local councils or NSW government agencies. Activities include bush regeneration, weed removal, habitat restoration, tree planting, monitoring and surveying of native wildlife, water quality monitoring, community education and growing native plants at community nurseries.

Keep Australia Beautiful (KAB) is a national program which was established in 1971 with a vision for a litter free and sustainable Australia, following the 1968 commencement of Tidy Towns in Western Australia. The objectives of KAB were to lead, influence and advocate for environmental sustainability, deliver partnerships and programs ensuring mutually beneficial environmental outcomes. Programs developed and supported through KAB include Tidy Towns, Clean Beaches, Sustainable Cities and Adopt a Patch.

Origins of environmental volunteering on the Central Coast

WSC established the Wyong Shire Landcare Program in the late 1990's with an aim to encourage volunteer participation in the care of lands under the management and control of Council and other approved lands. The WSC program included volunteer groups carrying out bush regeneration works through Landcare (and other care) groups and later expanded to include Tidy Towns and Friends Of groups carrying out work to improve the amenity of the area. The program also supported one off events such as National Tree Day planting activities within the Wyong Shire LGA, an education and training program for volunteers, and floating Landcare.

GCC established the Gosford City Council Bushcare Program in the late 1990's to support volunteers carrying out conservation work (bush regeneration) on Council owned and/or managed bushland reserves. The program later expanded to include volunteers working in Council's nursery to assist with native plant propagation and a seed collecting group to collect native plant seed from Council's bushland reserves for supply to the nursery. Citizen science based activities associated with fauna and flora monitoring were supported through the program, as were one off events such as National Tree Day planting activities. There was also an education and training program for volunteers.

Following amalgamation in 2016 the Central Coast Council Landcare Program was adopted as the program name following staff consultation, as this was considered to encompass the various landscapes, land tenures and activities covered by the program. Existing groups retained their individual names, such as Budgewoi Beach Dunecare, Green Point Bushcare, Mount Alison Landcare, Mannering Park Tidy Towns.

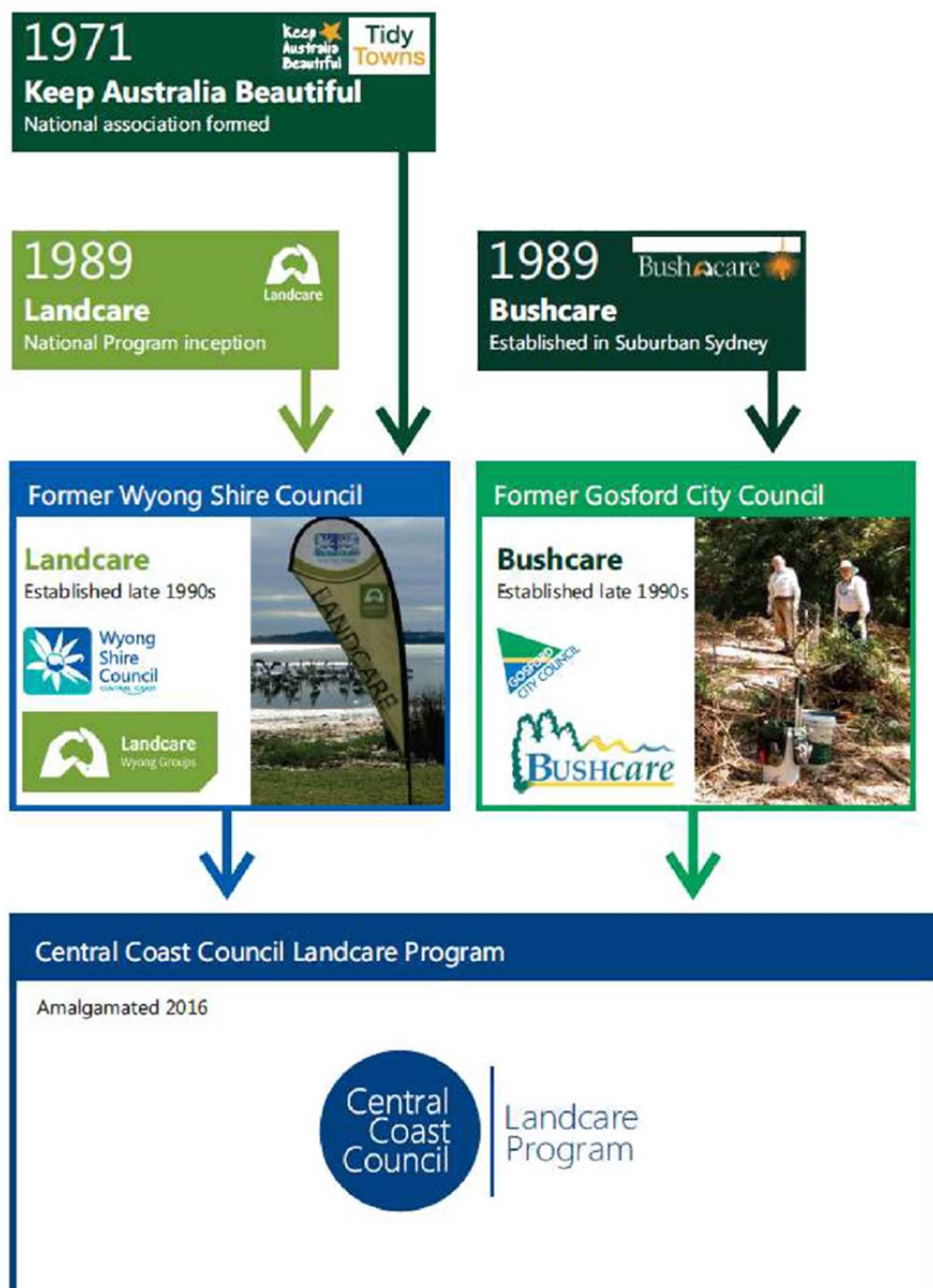


Figure 2: Flowchart showing the evolution of the current Landcare Program on the Central Coast

Differences between the former Council programs

The former Wyong Shire Council Landcare and Gosford City Council Bushcare programs had a number of notable differences.

Table 1: Differences between former WSC Landcare and GCC Bushcare programs

Program attribute	Former WSC	Former GCC
Types of volunteer groups	<p>Conservation groups (Landcare, Coastcare, Dunecare, etc.).</p> <p>Amenity Groups (Friends Of, Tidy Towns).</p> <p>Short-term groups (National Tree Day, corporate volunteering, etc.).</p>	<p>Conservation groups (Bushcare, Dunecare, etc.).</p> <p>Technical groups (nursery volunteers, seed collectors).</p> <p>Short-term groups (National Tree Day, corporate volunteering, etc.).</p>
Where the volunteers work	Council owned and/or managed land as well as other government land (e.g. RMS land, education land).	Council owned and/or managed land.
Volunteer records and reporting requirements	Volunteers record sessions and submit records to Council every 6 months.	Volunteers record sessions and submit records to Council monthly.
Site management	Restoration action plan for each volunteer group, 3 to 5 year review period.	Site strategy for each volunteer group, annual review and update.
Insurance coverage for volunteers	<p>Council funded an umbrella policy through Wycare Incorporated to cover all unincorporated volunteer groups working through the Landcare program.</p> <p>Council funded individual insurance policies for each</p>	Volunteer work on Council managed land covered through Council's insurance.

	incorporated group, this enabled them to carry out work within the Landcare Program and also covered them for work that they did in addition to the Landcare program.	
Herbicide use by volunteers	Volunteers permitted to spray in accordance with restoration action plans, glyphosate and other herbicides used.	Direct application methods with glyphosate only (no spraying by volunteers).
Power tool use by volunteers	Power tools including brush-cutters, ride-on mowers and powered spray equipment permitted in accordance with restoration action plans.	Power tools not permitted for use by volunteers.

5. The Central Coast Council Landcare Program

5.1 Overview of current Program

The CCCLP is managed by a Council team consisting of a Team Leader, four Bushcare/Landcare Officers to support volunteers, and a part time administration assistant to help manage the large quantity of information and volunteer records.

Each officer within the Landcare team currently has responsibility for a maximum of 20 groups and the volunteers associated with them. Requests from groups for assistance, tools and materials, training, etc. are managed by each officer for their respective groups.

The current CCCLP can be divided into four sub-programs:

- Conservation groups include those whose primary objective is to conserve and regenerate natural reserves. The reserves include bushland areas and coastal dune areas. Volunteers achieve these objectives through controlling exotic weed species and native planting activities where required.
- Amenity groups are those whose primary objective is to help improve the amenity of public spaces. Volunteers achieve these objectives through carrying out ongoing maintenance such as litter and graffiti removal, lawn mowing and garden maintenance.



Figure 3: Friends of Noraville Cemetery carrying out maintenance work at their site.

- Technical groups are those whose primary objective is to carry out specialist tasks or activities that support other CCCLP or Council functions. Examples of these are the seed collectors and plant propagators. Citizen science groups collecting fauna and flora information would also fit within this sub program.



Figure 4: Seed collection, for supply to Council's nursery, is one of the activities carried out within the Technical sub-program.

- Short-term groups are formed to undertake a specific activity or event e.g. a planting activity organised as a National Tree Day event. These groups are often open to residents who are otherwise not registered and active within the Landcare Program. Sessions are managed to record attendance and to provide appropriate training and risk assessment for the activity. Other examples of short-term groups include corporate volunteering, Floating Landcare sessions, and community education events that the Landcare Team deliver, such as the Pioneer Dairy Day for school students, Bioblitz events and Youth Week events.



Figure 5: Volunteers and staff participating in a Helping Hands planting event at Shelly Beach.

There are also groups within the program whose current objectives and activities don't strictly fall within a single sub-program. They often carry out a combination of conservation and amenity type works, for example there are Landcare groups that manage part of their conservation site through bush regeneration techniques but also carry out lawn mowing, tree pruning and garden maintenance. These groups have been given a name that suggests that they fall within one of the sub-programs however they are really a hybrid group. The number of these won't be clear until all

group Site Strategies have been reviewed, but is likely to be less than 10, comprising some Landcare groups that also undertake mowing and some Amenity groups that also undertake bush regeneration.

Table 2: Central Coast Council Landcare Program group and volunteer information

Sub program	Group type	Group number	Volunteer number	Volunteer hours July 2018 to March 2019	Objectives
Conservation	Bushcare	36	508	7,119	Help conserve and regenerate natural areas, including bushland and coastal dune reserves.
	Coastcare	5			
	Dunecare	6			
	Landcare	24			
Amenity groups	Friends Of	3	21	219	Improve the amenity of public spaces, mainly parks
	Tidy Towns	7	59	3,005	
Technical	Nursery volunteers	1	9	268	To provide specialist assistance and support for conservation activities
	Seed collectors	1	8	161	
Short-term groups *	e.g. National Tree Day	1	300*	600*	To provide opportunities for residents to participate in one off events.

*Estimates based on available event documentation and staff observations

Note: The volunteer report form and definition of active volunteers changed early in 2018, preventing easy comparison with previous years.

5.2 Volunteer Profile

Members of the program were surveyed in April 2019 to better understand who they are, aspects of the program they consider important, and how the program could be improved. There were 233 respondents to the survey, representing approximately 38% of the volunteers within the program. A summary of the survey results is included in the Appendix.

The vast majority of current volunteers were volunteering with one of the former Wyong or Gosford programs, bringing with them an expectation that Central Coast Council will continue to support them in a similar fashion. Changes in legislation (including Biodiversity Conservation and listing of endangered ecological communities) and internal procedures (e.g. personal protective equipment, risk assessment) mean that there is a need to change at least some aspects of each of the former programs as the Central Coast Council program further develops.

Introducing a unified program for the Central Coast Council will affect existing volunteers to some degree. Carrying out a review of the current situation in developing this strategy, and understanding the expectations of the volunteers for the future, will help Council develop a program to meet the future needs of the region.



Figure 6: Chris Anderson and Sue Bradfield are volunteers with Peninsula Dunecare at Ettalong

The results of the survey, which was designed to capture information about who the volunteers were, and how they volunteer, are summarised in Table 3 below. The responses showed the majority of the programs members were older in age and are retirees. This is consistent with research and demonstrates that people become more active in volunteering as they age, attributed mainly to lifestyle factors such as employment, career status and family life.

Table 3: Summary of survey results - volunteer profile information

	Results summary
Volunteer age	The program in its current form appeals to older members of the community, with almost half (47%) of the volunteers in the program aged between 60-69, and another 33% being over 70. Volunteers under the age of 35 only represent 3% of the program.
Volunteer employment status	The majority of volunteers within the program are retirees (66%), with the remainder in full time (9%), part time (9%) or other forms of employment.
Period volunteering with Council?	Approximately 30% of the volunteers have been volunteering for less than 3 years, representing those who have joined since Council's amalgamation. Just over 45% of the volunteers have been volunteering for 3 to 9 years, and over 20% of the volunteers in the program have been volunteering for more than 10 years.
Frequency of activity?	Most of the groups within the program have one regular session per month, reflected by the number of members who volunteer monthly (37%). A small number of volunteers are active less often (6%). Many of the programs members are more active, volunteering at least weekly (29%) or fortnightly (15%).
Number of groups for each volunteer	The majority of the volunteers in the program volunteer with one group (68%). However there are many volunteers who volunteer with 2 groups (15%) and some volunteers who are very active in volunteering with 3 or more groups (5%).

The survey questions presented 12 aspects of the program, asking volunteers to rate these from Not At All Important to Very Important. Table 4 lists these aspects from highest to lowest in overall importance to the volunteer respondents. These results are also presented in graphical form in the appendix.

Table 4: Program aspects in order of importance to volunteers

Program aspect	Ranking of importance from volunteer responses
<i>Helping look after bushland areas and the environment</i>	The highest scoring aspect of the program. 66% of respondents scored this as Very Important with another 31% scoring this as Important. For this aspect of the program only 2% of responses were Neutral and there were no responses as either Not Important or Not At All Important.
<i>Community satisfaction and belonging, feeling like I am working with my neighbours and contributing to the local community</i>	48% of respondents scored this aspect as Very Important and 44% as Important, making this the second highest scoring aspect overall. 8% of responses were either Neutral or Not Important.
<i>Personal satisfaction, I feel good when I volunteer</i>	The third highest scoring aspect of the program, 46% of respondents scored this as Important and 41% as Very Important. Only 1% of the responses were rated as Not Important.
<i>Spending time outdoors</i>	This aspect was the fourth highest scoring for the volunteers with the majority of responses rating this as Important (41%) or Very Important (40%). 17% of responses were Neutral and 1% of the ratings were as either Not Important or Not At All Important.
<i>Helping to keep the community clean and tidy, through rubbish and graffiti removal, garden maintenance, mowing, etc.</i>	Another important aspect for many volunteers, with 44% rating this as Very Important and 31% as Important. 22% of respondents were Neutral on this aspect and 3% were either Not Important or Not At All Important.
<i>Education, learning about plants and animals, Aboriginal and European culture/history</i>	Important to 47% of respondents, with 35% rating this as Very Important. Almost 4% of respondents rated this aspect as either Not Important or Not At All Important while 14% of the responses were Neutral.

<i>Helping look after public parks and recreation areas</i>	Compared to the similar aspect of helping to look after bushland areas and the environment (the highest scoring aspect), helping to look after public parks and recreation areas was seen as being much less important to the respondents (7 th place overall). Rated as Important (36%) or Very Important (39%) by the majority of respondents, with the remaining responses being Neutral (22%) or Not Important and Not At All Important (3%).
<i>Socialising, meeting other people and making friendships</i>	59% of respondents listed this as an Important aspect of the program. Others rated this as Very Important (23%) or Neutral (17%). A small number of respondents rated this as Not Important (1%).
<i>Physical health and exercise benefits, the way I feel from the physical activities I do as a volunteer</i>	Seen as Important to 48% of respondents. Of the other volunteers there was an almost equal split between those who found this aspect Very Important (25%) with those who were Neutral (22%). It was rated as Not Important by 4% of respondents.
<i>Mental health benefits, wellbeing, stress/anxiety relief that I feel from my volunteering</i>	Similar to the physical health benefits aspect, this was seen as Important to 45% of respondents. Seen as Very Important to 26% and Neutral to 25%. Not Important or Not At All Important to 4% of respondents.
<i>Teaching other people, through sharing my skills and expertise with them</i>	Seen as Important to 39% and Very Important to 25% of respondents. 32% of respondents were Neutral. 4% of respondents rated this aspect as Not Important or Not At All Important.
<i>Citizen science projects, helping with research and monitoring activities, plants and animals, waterways</i>	This was the lowest scoring aspect of the program with 23% of responses as Very Important, 35% as Important and 33% as Neutral. 9% of respondents rated this aspect as Not Important or Not At All Important.

The volunteers were asked to rate a number of areas where the program might be improved, including a free text section. The results are summarised in Table 5.

Table 5: Volunteer responses to areas for improvement within the program

Area for improvement	Volunteer response
<i>Promotion for groups and the program</i>	82% of respondents said that they would like more promotion for the program and for the groups within the program
<i>Workshops and learning opportunities</i>	63% of respondents said that they would like more workshops and learning opportunities
<i>Visits from Landcare staff to groups and sites</i>	62% of respondents said that they would like more visits from Landcare staff
<i>Communication to volunteers</i>	54% of respondents said that they would like more communication to volunteers
<i>Tools and equipment</i>	54% of respondents saying that they did not need more tools and equipment than was already being supplied through the program
<i>No changes required</i>	46% of respondents indicated that no changes were required, that the program already addressed their needs and expectations
<i>Volunteer surveys</i>	72% of respondents said No to more volunteer surveys*

* Note: This was the third survey to be sent to volunteers within the Central Coast Council and former Councils within the last 10 years.

The final question of the survey asked the volunteers to indicate their preference for the name of Council's program:

- 35% of the volunteers did not have any preference for the overall program name.
- 31% of the volunteers chose one of the new program names that were suggested, either CCC Envirocare or CCC Environmental Volunteer Program.
- 30% of the volunteers chose a name consistent with the former Council program names, either CCC Bushcare Program or CCC Landcare Program.

Note: Advice from Council's Communication and Engagement section suggested that EnviroCare would be the preferred naming option for branding purposes.



Figure 7: Alternative names for Council's environmental volunteering program

5.3 Landcare Program management and procedures

Volunteer group formation

New volunteer groups have historically formed when members of the community contact Council to request the establishment of a new group in a particular area. An Expression Of Interest (EOI) form captures information including how many people want to establish the group, the type of group that the community want to establish, the land ownership and management including future plans for the site, constraints and risks associated with the site.

In some instances Council has facilitated interest from the community and developed a new group in an area, for example Doyle Street Bushcare was formed after Council promoted and ran National Tree Day planting events at the site over a number of years. Other past attempts by Council to establish groups in priority conservation areas without an initial interest from the community have been less successful.

Council currently prioritises the EOI's received on the basis of:

- Number of initial volunteers
- Land tenure
- Type of group (eg conservation, amenity)
- Council plans for and use of the site

Commencement of a new group is dependent on the capacity of the Landcare team to manage and supervise it. As at May 2019 there was a waiting list to form 10 new groups of which five are conservation groups.

Group work sessions

Each group within the program is dedicated to working on a particular site or sites e.g. Pearl Beach Bushcare has three sites within the suburb of Pearl Beach. Groups take on a name that has significance or meaning to them e.g. Allagai Dunecare (working at MacMasters Beach).

Groups have regular work session times e.g. the first Saturday morning of the month, with some groups meeting at least once a month and many much more frequently. Groups are open to membership from the public and are promoted through Council's webpage and other CCCLP promotional activities. A Landcare program officer is appointed to each group as their primary point of contact with Council.



Figure 8: Members of the Vietnam Veterans Tidy Towns group carrying out a planting activity at their site.

Volunteer management

An active volunteer is defined as someone who is registered in the program and who has volunteered within the last 12 months.

Volunteers are considered to be inactive if they have not volunteered within the last 12 months. At this time staff contact them to find out why they are no longer active and they are encouraged, where possible, to become active again in the program.

New volunteers are required to complete a site induction and fill out a registration form when first attending a work session. Within 6 months of joining the program new volunteers are required to complete an introductory training session. New volunteers are provided with education and training about the CCCLP through the introductory training session and also through site based work session training. This includes record keeping requirements, Council's Code of Conduct, site training, risk assessment, personal safety and protective equipment requirements, native and weed plant identification and weed control techniques.



Figure 9: Terry Dicks of the Summerland Point/Gwandalan Tidy Towns group carrying out maintenance work within the Summerland Point Community Centre.

Group supervision

Most groups have a qualified supervisor working with them during at least one session each month. However, there are too many groups and sessions to allow program Officers to supervise every group.

Supervisors are either a staff member from Council's Landcare Team, a staff member from another section of Council, or someone who is engaged externally through a bush regeneration or labour hire company.

All supervisors are suitably qualified and experienced in land conservation and management. They have first aid and chemical use qualifications, as well as skills and experience in plant identification appropriate to guide the volunteers and their activities at the sites where they are appointed.

Table 6: Central Coast Council Landcare Program group supervision.

Group Supervision	Number of groups
Directly supervised by Landcare team staff	11
Supervised by other Council staff	1
Supervised by contractor staff	3
Supervised by Labour Hire staff	33
Groups approved to work without direct supervision	35

Insurance

Volunteers working on Council owned or managed land are covered for their program-related works through Council's personal accident and public liability insurance.

A small number of groups from the former WSC Landcare Program are incorporated and undertake additional activities that are not included in the CCCLP on land that is not under the ownership and/or management of Council or is not within the approved site. In these cases, following a resolution of WSC on 12 March 2003, Council provides funds to identified groups so that they can arrange their own insurance cover. Insurance support is currently provided to such incorporated conservation and amenity groups in the former WSC area.

Site Risk Assessment

An annual risk assessment is completed by each group within the program, guided by the group Supervisor or Landcare program officer. Tool box talks are carried out at the beginning of each work session to consider the works that will be performed on the day and plan safe work practices to eliminate or reduce any associated risks.

Site strategy development and review

Each site is unique and a detailed site assessment is completed for the conservation sites as a reference document. In addition, a Site Strategy template has been developed to identify the site-related objectives and authorised volunteer activities for the coming year. Site Strategies are reviewed and updated regularly, with volunteers and supervisors consulted by the program officer throughout.

A number of sites still have detailed Action Plans which in large part combine both the assessment report and the site strategy and these are continuing to be reviewed to fit the new format.

Some Site Strategies and Action Plans have previously included activities that volunteers completed outside the CCCLP or on non-Council land, however after the next review these will either not be included or will be clearly identified as additional to Council's program and approved activities to clarify legal responsibility.

Minimum criteria to remain in program

A set of minimum criteria has been developed for the conservation and amenity groups within the program:

- Groups are to complete a report sheet for each volunteer session and submit this to Council within one month of the session
- Groups are to meet on a regular basis throughout the year, with a minimum of 6 sessions per year
- Groups are to achieve a minimum of 50 volunteer hours at their site each year
- Groups are to operate on Council owned and/or managed land (existing groups that currently work on other public land will continue to be supported as at present, however new groups will need to comply with this requirement)

The Landcare Team works closely with groups that do not meet these criteria, offering additional training, support and promotion to help them remain in the program.

Communication with groups/volunteers

Communications occur between group members directly, and between the group and members of Council's Landcare team.

Each group nominates a convenor, a volunteer who is the primary point of contact for the group. Most of the communications between Council and the groups are through the group convenor however individual volunteers are also able to contact Landcare team staff directly if they wish to.

Communications from the Landcare team are sent out to individual volunteers, to specific groups, or to the whole program depending on the nature of the communication. This includes periodic information about education and training events and newsletters with useful or interesting information.

Promotion

Individual groups within the program are encouraged to develop promotional activities with the assistance and support of their dedicated officer. A template is being developed for use by all groups to streamline this process. Program wide promotions are also developed by the Landcare Team with the assistance of Council's communications section. Some incorporated groups also maintain their own websites and social media pages.



Figure 10: Display banners are one way that groups are promoted within their local area, displaying these in prominent locations while the volunteers are working at their site.

Education, training, knowledge and skills development

Education and training within the CCCLP gives volunteers opportunities to increase their skills and knowledge in areas related to environmental management. An ongoing education and training program is offered to active members of the program which is delivered through several frameworks:

- Compulsory training (Introduction to Bushcare/Landcare)
- Optional training (Chemical certification, first aid certification)
- Educational Workshops (snake safety awareness, Aboriginal culture and heritage, importance of bees, plant propagation, fungi)

Volunteers also learn and develop practical skills through the program, for example which techniques to use to most effectively and efficiently control the weed species on their sites and how to safely use the variety of tools that they have available to carry out their work. Work practices and methods are demonstrated by staff and supervisors during volunteer sessions and through workshop and training events.

As volunteers increase their skills and knowledge they are encouraged to contribute to the development of site strategies and take more responsibility for the work at their sites. In time, as the level of competence and confidence grows through education, training, knowledge and skills development groups may be encouraged and approved to work without supervision at their sites.

Workshops and training events provide the added opportunity of bringing together members from different groups within the program, offering opportunities for them to network and share their ideas and experiences.



Figure 11: Aboriginal cultural heritage workshop for program volunteers.



Figure 12: Weed identification workshop for program volunteers.

Resourcing

All tools and materials to support the work of volunteers and groups within the program are supplied by Council. Groups are able to request additional tools and materials, or replacements for consumable and/or broken items, through the report sheets that are submitted for their volunteer sessions.

Plants are provided to groups where revegetation is needed to help restore their sites. All plants supplied to groups within the program are sourced from Council's nursery at Erina, with a preference for stock that is of local provenance, having been collected by the seed collection volunteers and grown at Council's nursery by staff and nursery volunteers.

Achievements

Some of the achievements of the CCCLP over recent years include:

- Blue Star Sustainability Awards for environmental achievement and individual volunteer recognition through The Centre for Volunteering, NSW
- In excess of \$500,000 in external funding to support the works of volunteers groups within the program
- The support of and partnership in Green Army projects at multiple sites across the Central Coast to provide training and skills development to under-employed youth
- Floating Landcare events throughout the Central Coast to provide conservation actions at difficult-to-access sites
- National Tree Day events with annual attendances in excess of 300 residents
- Improving Your Local Park and Environment funding of \$30,000 annually to Landcare works that contribute to the improvement of Tuggerah Lakes
- Financial support from private sector organisations e.g. Delta Electricity provides \$10,000 annually to support volunteer groups working near Munmorah Power Station

Celebration

The Landcare Program holds an annual event to celebrate the achievements of the volunteers over the previous year and to thank them for their efforts within the program.



Figure 13: Landcare officer promoting Council's program at a Youth Week event

5.4 Benefits of the program

Environmental Benefits

Conservation initiatives such as the Central Coast Council Landcare Program provide a significant role in the management, conservation and rehabilitation of natural habitats in an ever increasingly urban-centric world. Conservation volunteers offer services that would otherwise not be provided by Council, but which add value to the environment for all Central Coast residents.

Primarily, the CCCLP addresses environmental degradation, habitat loss and decreased biodiversity at a local scale. The Central Coast environment directly benefits from the Program's 83 groups through the reduction of weed species within local ecosystems and the increase of quality habitat for local native fauna. The program also aligns with the Central Coast Community Strategic Plan (CSP) which highlights the community's value of the natural environment and sustainability statement of '*leaving a positive legacy for future generations through responsible stewardship of our natural areas*'. CCCLP does this by encouraging groups to work within areas of key ecological importance such as Endangered Ecological Communities (EECs) and connecting corridors of remnant bushland.

Environmental benefit is also reflected in volunteer motivations. Studies show that one of the key motivators for volunteer activities are ecosystem conservation. At a local scale the 2010 GCC Bushcare volunteer survey found that 85.6% of respondents indicated that they had a '*personal satisfaction in helping the environment*'.



Figure 14: Corporate volunteers enjoy a day out of the office contributing through Council's environmental volunteer program.

The CCCLP also plays a crucial role as an enabler of citizen science which leads to beneficial environmental outcomes. Fauna surveys on the Central Coast by Landcare groups are a key component of the program and have been critical in the collection of data for several state, national and internationally listed species. The data collected also assists in the rehabilitation and management of sites, an example being community data (not Landcare) which informs the maintenance of Little Tern breeding sites at North Entrance.

Physical, mental and social health

The health benefits for volunteers undertaking conservation activities outdoors have been well documented. Significant research has shown that those participating in volunteering have better health outcomes in relation to physical and mental health, self-esteem, happiness and lower psychological stress. In broad terms it has been suggested that humans have a tendency to seek connection to nature (Wilson, E. O., 1984). This would suggest that environmental volunteering fulfils basic human requirements deeply entrenched in our biology.

The physical health benefits associated with environmental volunteering are intuitive but supported by scientific rhetoric. A 2004 study by Deakin University reported that participants benefited from physical exercise and activity. Physical activity contributed to increased cardiovascular benefits and the management of weight. The opportunity to breathe 'fresh air' and associated respiratory health improvement are also recognised. The study also supports early research undertaken in 1997 by Deakin University showing that contact with nature had positive influence on immunity and cardiovascular function, a reduction of heart rate, muscle tension, blood pressure and skin conductance.

A previous GCC Bushcare Program survey (2010) found that 65% of its volunteers were over the age of 61. Current CCCLP registrations show this number is still typical for the program in

2019. Research demonstrates that an average of 3 hours volunteering per month leads to a significant improvement in life expectancy for older volunteers.

The United Nations World Urbanization Prospects (2015) predicts that loss of biodiversity will increasingly lead to the loss of wellbeing in urban centres. Wellbeing is not only defined as a lack of illness but also includes mental health and social wellbeing.

Studies conducted by Pryor et al. (2006) show that *'individuals experiencing chronic physical, mental and social ill health'* respond positively to *'active and social nature-based intervention'*. The study Feel Blue Touch Green (Deakin University, 2006) also highlights the benefits of volunteering in environmental conservation with respondents suffering from chronic depression reporting their involvement was *'uplifting'* and resulted in them *'feeling more positive'*.

Volunteering in conservation activities has also been shown to improve skills and employability of many of the participants. Contributing to communities and environment practical volunteer hours has been investigated and implemented by some universities as Workplace Integrated Learning for Natural Science students. Currently a very small number of volunteers in Central Coast Landcare commence programs for this reason. Moving forward this may prove to be a reliable source of participation for future groups.



Figure 15: Budgewoi Beach Dunecare winning a clean beach challenge.

6. Links to other Council strategies

The Central Coast Community Strategic Plan 2018-2028, *One Central Coast*, identifies community priorities and provides a roadmap for the future. Based on extensive community consultation, several themes and related focus areas are relevant to Council's Landcare Program:

Belonging - Our community spirit is our strength; Creativity, connection and local identity

Green - Environmental resources for the future; Cherished and protected natural beauty

Liveable - Out and about in the fresh air; Healthy lifestyles for a growing community

In order to determine the success of *One Central Coast*, a range of indicators were identified to be reported annually. Council's Landcare Program could potentially contribute measurement to a number of these, such as:

- Sense of Community on the Central Coast
- Opportunities to be part of community life
- Community events that bring people together
- Volunteering Activities
- Healthy Lifestyle choices
- Access and enjoyment of local environment
- Community organisations, boards, and committees
- Participation in community engagement

Council's Landcare Program directly or indirectly relates to themes and actions identified in other Council strategies and plans (either completed or in preparation), including:

- Biodiversity Strategy
- Greener Places Strategy
- Climate Change Strategy
- Sustainability Strategy
- Plans of Management for Council Reserves

As a result, Council's Landcare Program regularly liaises with other areas within Council to discuss ideas and actions, and to share information and de-personalised data of relevance.

7. Comparison with other Councils and Programs

Information was recently obtained about the environmental volunteering programs at eight other Councils and the Central Coast branch of the National Parks and Wildlife Service. Blue Mountains City Council was unable to be contacted during the comparison project but online information was available for their program.

Table 7 below summarises the information relating to each of these programs.



Figure 16: Partnership - Green Corp youth training group assisting to restore dunes at North Shelly Beach.

Table 7: Environmental volunteering program information for other NSW Councils and NPWS

Attribute	Blacktown City Council	Cessnock City Council	Hornsby Shire Council	Ku-ring-gai Council	Lane Cove Council	Lake Macquarie City Council	Newcastle City Council	Port Macquarie-Hastings Council	Blue Mountains City Council	CC National Parks and Wildlife Service	Central Coast Council
Program name	Bushcare Program	X		X		X					X
	Landcare Program					X	X				
	Environmental Volunteer Program				X						
	Community Conservation Program		X					X	X		
Program objectives	No formal program name									X	
	Environmental conservation and habitat restoration.	X	X	X	X	X	X	X	X		X
	Community engagement/education.	X	X	X	X	X	X	X	X		
	Litter collection and gardening.	X									X

Attribute		Blacktown City Council	Cessnock City Council	Hornsby Shire Council	Ku-ring-gai Council	Lane Cove Council	Lake Macquarie City Council	Newcastle City Council	Port Macquarie-Hastings Council	Blue Mountains City Council	CC National Parks and Wildlife Service	Central Coast Council
Types of groups within program	Conservation Groups:											
	• Bushcare	X	X	X	X	X	X					X
	• Creekcare						X					
	• Dunecare						X					X
	• Harbourocare					X						
	• Landcare		X				X	X	X			X
	• Treecare			X								
	Technical Groups:											
	• Backyard Habitat					X						
	• Bush Friends					X						
	• Bush Kids					X						
	• Native Bees				X							
	• Nursery volunteers	X		X								X
	• Pool To Pond				X							
	• Seed Collectors											X
	• Stream Watch					X						
Amenity Groups:	• Adopt A Park	X										
	• Community Gardens				X							
	• Friends Of								X			X
	• Parkcare				X							
	• Streetcare				X							

Attribute		Blacktown City Council	Cessnock City Council	Hornsby Shire Council	Ku-ring-gai Council	Lane Cove Council	Lake Macquarie City Council	Newcastle City Council	Port Macquarie-Hastings Council	Blue Mountains City Council	CC National Parks and Wildlife Service	Central Coast Council
		12	9	65	65	100	230	21	6	NA	20	71
Number of groups	Conservation:	12	9	65	65	100	230	21	6	NA	20	71
	Technical:	1									22	2
	Amenity:	10	15		33							10
Group structure	Each group has a representative, one of the volunteers who acts as the leader or convenor and is the primary point of contact with Council.	X	X	X	X	X	X	X	X	X		X
							X					
		X	X	X	X	X		X	X	X		X
	There must be at least 2 volunteers for a session to run.											

Attribute		Blacktown City Council	Cessnock City Council	Hornsby Shire Council	Ku-ring-gai Council	Lane Cove Council	Lake Macquarie City Council	Newcastle City Council	Port Macquarie-Hastings Council	Blue Mountains City Council	CC National Parks and Wildlife Service	Central Coast Council
Land tenure	Volunteers only work on Council owned and/or managed land	X	X		X			X	X		X	X
	Volunteers also work on other state government land			X	X		X				X	
	Volunteers also work on private land					X	X			X		X
Group selection/ approval process	Community driven	X	X	X	X		X	X	X	X	X	X
	Council initiates groups at priority sites					X						X
Group supervision	Sessions supervised by Council staff	X		X		X				X	X	X
	Sessions supervised by non-Council staff, contractors	X		X	X	X				X		X
	Supervision is not provided for groups		X				X	X	X			

Attribute		Blacktown City Council	Cessnock City Council	Hornsby Shire Council	Ku-ring-gai Council	Lane Cove Council	Lake Macquarie City Council	Newcastle City Council	Port Macquarie-Hastings Council	Blue Mountains City Council	CC National Parks and Wildlife Service	Central Coast Council
Volunteer education and training	Compulsory introduction/induction training for new volunteers	X		X	X	X	X	X				X
	Optional introduction/induction training						X				X	
	Work site induction	X		X		X					X	X
	Optional courses: <ul style="list-style-type: none">Plant identification, fauna, bush regeneration relatedFirst aid – optionalChemical use – optionalSnake SafetyAboriginal Cultural Awareness	X	X	X		X	X		X		X	X
Program resources	Bush regeneration works at sites to support volunteers	X		X	X		X					X
	Tools and materials supplied to groups	X	X	X	X	X	X	X			X	X

Attribute	Blacktown City Council	Cessnock City Council	Hornsby Shire Council	Ku-ring-gai Council	Lane Cove Council	Lake Macquarie City Council	Newcastle City Council	Port Macquarie-Hastings Council	Blue Mountains City Council	CC National Parks and Wildlife Service	Central Coast Council
Herbicide application	Volunteers not permitted to use herbicides	X		X	X	X	X	X		X	X
	Volunteers have restricted herbicide use, direct application methods only, limited range of herbicides										
	Volunteers have broad use of herbicides, including ability to spray/splatter gun/cordless drill and use wide range of herbicide products						X	X		X	X
Power Tool Usage	Not permitted	X	X	X	X	X	X				
	Permitted by Conservation groups										
	• Chain saws							X			
	• Ride on mowers							X			X
	• Brushcutters							X			X
	• Splatter guns										X
	• Other unspecified small plant items							X		X	X

Attribute		Blacktown City Council	Cessnock City Council	Hornsby Shire Council	Ku-ring-gai Council	Lane Cove Council	Lake Macquarie City Council	Newcastle City Council	Port Macquarie-Hastings Council	Blue Mountains City Council	CC National Parks and Wildlife Service	Central Coast Council
Power Tool Usage	Permitted by Amenity groups											
	• Chain saws											
	• Ride on mowers											X
	• Brushcutters											X
	• Other unspecified small plant items											X
Site plans - management	Plan developed at establishment of group	X			X	X	X	X	X		X	X
	Annual Review and update of site plans	X				X					X	
	3 year review of site plans			X	X		X					
	Volunteer plans included within broader reserve management plans, reviewed every 7-10 years	X		X		X			X			

8. Demand for, and constraints on, Council's Landcare Program

Community demand

Council's programs are well established with continued demand and interest. Applications have been received to establish an additional five Bushcare / Landcare and five Amenity groups. Consideration of these at the present time is not possible due to staff limitations in the program. Efforts have not been made to attract new groups into the program in recent years due to the inability to meet the current wait list.

Ongoing community interest in participating in technical areas is also evident, for example assisting with flora and fauna surveying and pre and post fire monitoring.



Figure 17: Volunteers are encouraged to learn about fauna monitoring through a bat workshop.

The current Central Coast population of 345,000 is forecast to grow to 415,000 by 2036, an expansion of approximately 20%. Most of the current volunteers within the CCCLP are retirees (66% from survey) and age demographics indicate a growing number of residents transitioning into retirement in the next decade, which is expected to translate into increased demand for Council's program.

One-off events, such as National Tree Day, have also increased in popularity in recent years, indicating that short-term volunteering opportunities may attract residents who may not be able to commit to ongoing attendance. Managing a single event can require the same staff time as

managing an ongoing group for a year (say 70 hours), and can produce up to 600 volunteer hours which is equivalent to the annual volunteer hours for one of the top 10 groups in the program.

Increased program promotion is likely to increase demand and attract new interest from the community.

Conservation and Amenity sub-programs

The Conservation sub-program fits best with the purpose of Council's Natural and Environmental Assets Unit which is responsible for implementing the Landcare program, and this sub-program has been identified as a high priority when assessing new applications, given the limitation of staff and budget resources.

The Amenity sub-program also addresses needs and interests of some residents while providing the social and health benefits of volunteering in general. Additionally, Amenity groups enable Council's Open Space and Recreation Unit to provide a higher level of service in relation to park maintenance. At present there is no intention to accept applications from groups wishing to establish new park areas. Amenity groups generally require a higher level of establishment and ongoing resourcing for small plant purchases and maintenance (ride-on mowers, brushcutters), risk management, and at some locations, also the need for additional training and traffic control plans. As a result, Amenity groups are not as high a priority and this is considered when prioritising requests to form new groups as detailed in the program procedure.

Technical sub-program

The Technical sub-program is also a high priority due to its support relationship to the Conservation sub-program, however this is currently only a small part of the overall program. There is great potential for this area to expand, with volunteers assisting to collect information or provide specialist services e.g. frog monitoring groups for Green and Golden Bell Frog populations at North Avoca and Davistown. Other potential volunteer opportunities include fauna and flora monitoring and survey work, and monitoring sites pre and post fire which will also help to identify emerging issues such as weeds.

Short-term sub-program

Short-term groups give members of the community the ability to participate in environmental volunteering activities without needing to commit to ongoing involvement in the program. Observations from staff suggest that these types of events, such as National Tree Day, attract younger members of the community, such as parents with children. These events give Council the ability to engage these community members in environmental volunteering where the other types of groups do not appeal to them for reasons of work/family life commitments.

Land tenure

In general terms the priority is to undertake activities on Council-managed land while acknowledging that flora and fauna do not recognise property boundaries. There can be landscape and community benefit in also providing support for activities on other public land, including

schools, crown land, and land owned by Roads and Maritime Services, however these are not currently supported as this would reduce capacity to support volunteer conservation activities on Council-managed land. WSC previously had a schools Landcare sub-program which has since lapsed in part due to changes in school and Council staff over time.

Site Access

Actual and potential program sites are nominally the responsibility of a specific unit within Council, most frequently the sections responsible for bushland reserves, natural open spaces, recreation spaces, beaches and waterways. Some sites may include operational land, Council-owned residential land, road reserves, and drainage reserves. The establishment of new sites involves securing the approval of the internal property manager.

New groups are now advised that Council cannot guarantee access to the program site in perpetuity. Issues that may influence this includes availability of resources, Council policy, current legislation, new information about the site, and Council plans for the property.

Council need

Maintenance of Council's many Reserves by volunteers is of benefit where volunteer groups assist to improve prioritised site outcomes. However the key drivers in group establishment are the level of community interest on a site by site basis, and the Council resources available to initiate, manage, supervise, and resource new groups.

The most effective and cost-efficient method to identify new sites considers a range of factors and these are assessed from individual applications from the community to form new groups. Although site prioritisation is based on these factors when establishing new groups at new sites, it is important to note that Council and staff do not view eager new volunteers as an opportunity for cheap resources and labour to be directed to areas of greatest perceived need. The needs of the site are balanced with the needs and passions of the volunteers and the groups that are committed to helping manage them.

Resourcing limitations

Staff

Council's existing program provides for a Team leader and 4 full time officers, with a part time administration assistant (0.6 of a full time position).

Each individual Officer can manage a limited number of groups which is currently capped at 20, as this enables officers to offer the level of support to groups to meet administrative and management requirements. This provides an average of around 1.5 hours per week allocation to support each group, including travel time for site visits. Reducing the cap to 18 groups per officer would allow an additional 10 minutes allocated per group per week (a 10% increase).

Citizen science technical groups and one-off events both require a similar level of staff and resource support as ongoing program groups, but these are not counted within the cap at the present time.

Providing direct supervision of group activities is one challenge in establishing new groups. Many groups meet at the same time including on weekends and it is not possible for all of the required supervision to be provided directly by Landcare officers. For example, 10 groups meet simultaneously on the first Saturday of each month.

At present Council relies on external staff though contractors and labour hire to provide supervision for 36 of the 83 groups in the program. Some groups are authorised to work without supervision due to the specific sites and skills and experience of the volunteers, however many groups require a qualified bush regenerator to guide their activities.

Due to supervision requirements an identified limitation to expanding the program is the availability of suitably qualified personnel.

Budget

Council's existing program requires an allocation of about \$900,000 per year to fund 5.6 staff with vehicles and support equipment, external group supervisors and bush regeneration contractors, and materials such as plants, replacement tools, herbicide, mulch and signs.

Overall, the average cost of managing each group in the program is \$12,500 per year. Of this approximately 57% is allocated to internal staff (but not external supervisors), vehicles and corporate overheads. Most groups require little in the way of materials, around \$1,200 per group. An exception is that the establishment of any new Amenity groups would require the purchase of items of small plant such as ride-on mowers and brushcutters, ongoing lease fees to cover equipment maintenance and replacement costs and (for a few groups) licence arrangements over Council storage areas.

An expansion of the program to meet existing and expected demand, while maintaining the current service levels, would require an increase in the associated budget. In simple terms, increasing the number of groups by 22-25%, or 18 to 20 groups, would require approximately \$250,000 in additional annual funding as well as approval to recruit another officer.



Figure 18: Saltmarsh regeneration achieved by volunteers at Killarney Vale over three years

9. Realistic options for expansion

Specific interest has been expressed to identify the best opportunities to expand the current program are these are described in the Table 8 below.

Table 8 – Expansion opportunities and constraints

Opportunity	Constraint	Approvals and requirements
<p>Increase the number of groups by up to 20 to cater for current and expected demand. The 5 Conservation group applications currently on the waitlist can be progressed in the short term, while additional short-term volunteering opportunities are investigated and developed as relevant.</p>	<p>Insufficient staff to manage new groups including developing specific procedures for any 'Technical' groups. May require a promotional campaign to attract new applications; due to unfulfilled waitlist no promotion to attract new group applications has occurred in recent years. Starting a new group is significantly more labour-intensive than managing an existing group. Note that the 5 Amenity groups on the wait list are a lower priority for commencement and require more resources.</p>	<p>Requires:</p> <ul style="list-style-type: none"> • additional Landcare Officer including office provision • budget increase of \$250,000 per year • one-off Capital vehicle purchase of about \$40,000 • Including technical and short-term groups within the cap of 20 groups per officer
<p>Increase short-term volunteer opportunities including planting events, citizen science and flora/fauna surveys to cater for a broader audience.</p>	<p>Staff capacity is an issue as each event requires considerable effort to organise and this increases when developing new events. Extra resources are also required (eg plants, tools, portable toilets, etc).</p>	<p>Additional staff and budget included in the above Review effectiveness regularly.</p>

Facilitate participation of relevant public and private schools and TAFE (including Indigenous and youth conservation courses) in Landcare-related activities which could include specific Landcare groups or work experience type programs; youth are currently under-represented.	Likely to require additional Landcare Officer to liaise with stakeholders and identify sites and procedures (eg work experience, short term arrangements, specific supervision, etc)	Develop new procedures Additional staff and budget included in the above Review demand and procedures regularly.
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In addition to the above, other opportunities were identified but found not to be practical or effective; these are listed in Table 9 below.

Table 9 – Ineffective or non-practical opportunities

Opportunity	Constraint	Approvals and requirements
Increase the number of volunteers per group. Could include encouraging volunteers to participate in more than one group.	Requires ongoing promotion including site events; experience shows that this is rarely successful. Dependent on willingness of local volunteers.	Dependent on capacity of Landcare officers; reducing cap to 18 groups per officer may be required as larger groups usually require additional support.
Increase the number of years volunteers remain in the program.	Dependent on willingness of volunteers. May require incentives such as additional workshops and other events.	Nil. Initiating an exit survey will help understand the reasons volunteers leave the program.
Increase the number of hours per volunteer.	Dependent on willingness of volunteers, some may be interested. Likely to require additional group meeting times and supervision.	Will require additional resources for those groups that require site supervision .

10. Strategic principles and Action Plan

Strategic management of the program into the future is best supported by a decision framework to inform flexible and responsive management choices that are aligned to Council and community needs.

The following principles guide management of the program at the present time:

1. The number of groups managed by each Officer will not exceed 20 (this does not include the program Team Leader who may manage a small number of additional groups)
2. Groups may be one of four sub-programs:
 - a. Conservation – to undertake bush regeneration
 - b. Technical – to undertake specialist technical activities which may include seed collection, plant propagation, scientific surveys and data collection, and advanced bush regeneration
 - c. Short-term groups - for specific activities and events
 - d. Amenity – to maintain public parks
3. The current priority is to support the Conservation sub-program on Council-managed land and also Technical and Short term groups that support the Conservation sub-program or conservation activities on Council's priority natural reserves.
4. The Amenity sub-program :
 - a. Only applies to designated parks as approved by Council's Open Space and Recreation unit
 - b. Will not increase significantly as a proportion of all groups (currently 8.3%)
5. Procedures or guidelines will be developed and reviewed regularly for:
 - a. Each sub-program
 - b. Assessing an expression of interest to form a new group
 - c. Potential high risk activities which may include - herbicide use; activities related to protected species and vegetation communities; use of small plant and specialised equipment; working near roadsides, waterways, steep slopes; and use of power tools. In general terms use of small plant is not usually consistent with conservation activities and use of power tools is not encouraged, however variations may be considered.
 - d. Minimum reporting and other requirements for groups to remain in the program
 - e. Managing Incorporated groups that undertake activities additional to, and/or on sites not included in, Council's program
6. Regular liaison with groups and communication with volunteers and groups is considered a priority
7. Group supervisors will have suitable qualifications and experience and may be either Council program Officers, other suitable Council staff, bush regeneration contractors or labour hire staff
8. Consult with 'hybrid' groups that do not easily fit into one of the identified sub-programs and provide options to each to assist their transition into the program structure

Table 10 - Action Plan

Action	Description	Budget changes
1.	Change Council's environmental volunteering program title to the Central Coast Council Envirocare Program.	Nil
2.	Provide 4 sub-programs, in order of priority being: <ol style="list-style-type: none"> 1. Conservation program 2. Technical program 3. Short-term volunteer program 4. Amenity program 	Nil
3.	Continue to develop, and periodically review, procedures to support the program.	Nil
4.	Ensure the Site Strategy or Plan for each group is compliant with current policy and legislation, and is reviewed at least every 2 years.	Nil
5.	Continue to engage external contractors and labour hire staff to provide suitable supervision for approved group activities, where suitable internal staff are not available	Nil
6.	Develop exit questionnaire for volunteers/groups leaving the program to better understand turnover dynamics	Nil
7.	Pursue opportunities to recruit an additional Officer and provide sufficient budget allocation to allow expansion of the program	\$250,000 per year (plus one-off Capex vehicle purchase of approximately \$40,000)
8.	Continue to review and identify groups that may justify consolidation or retirement from the program in order to allow new groups to establish that may yield greater	Nil

	environmental and social outcomes with existing resources.	
9.	Establish branding and marketing of new program to attract new volunteers and to acknowledge existing volunteers within the program	Nil
10.	Determine and establish threshold levels where the cost of supporting a group and the outcomes being realised remain sustainable	Nil
11.	Develop a set of indicators to track growth and success of the program in order to guide future approaches for continuous improvement	Nil
12.	Review criteria for prioritisation of new group requests when program expansion is constrained by resources.	Nil



Figure 19: Results of mound planting by Friends of Noraville Cemetery.

11. References

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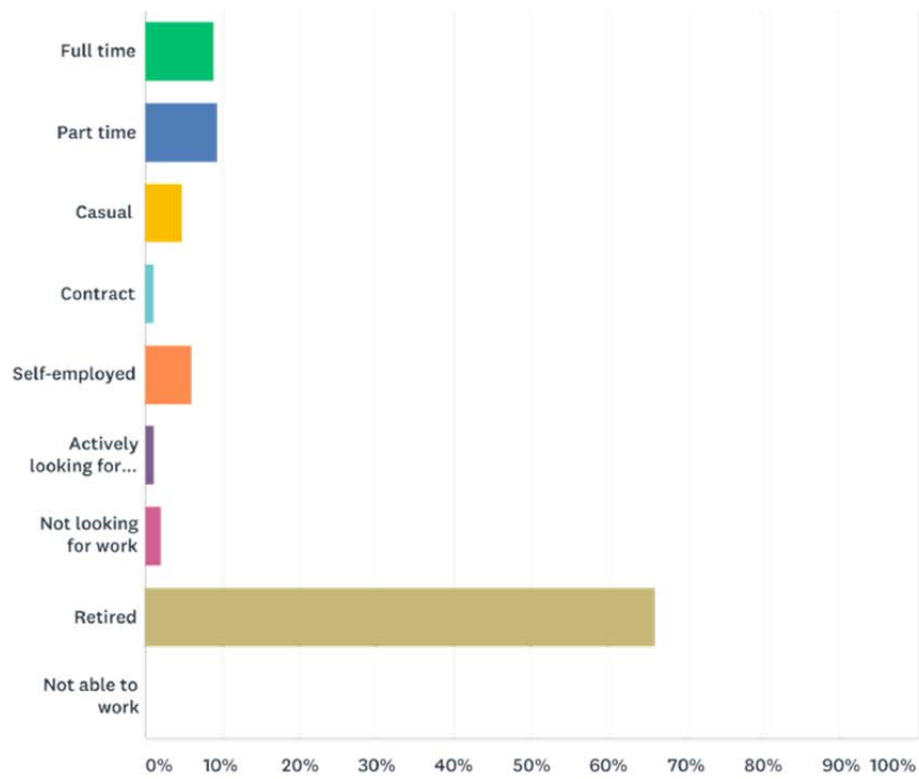
12. Appendices

1. Summary of Landcare Program Volunteer Survey 2019

Landcare Program Volunteer Survey 2019

Q1 What is your employment type?

Answered: 233 Skipped: 0

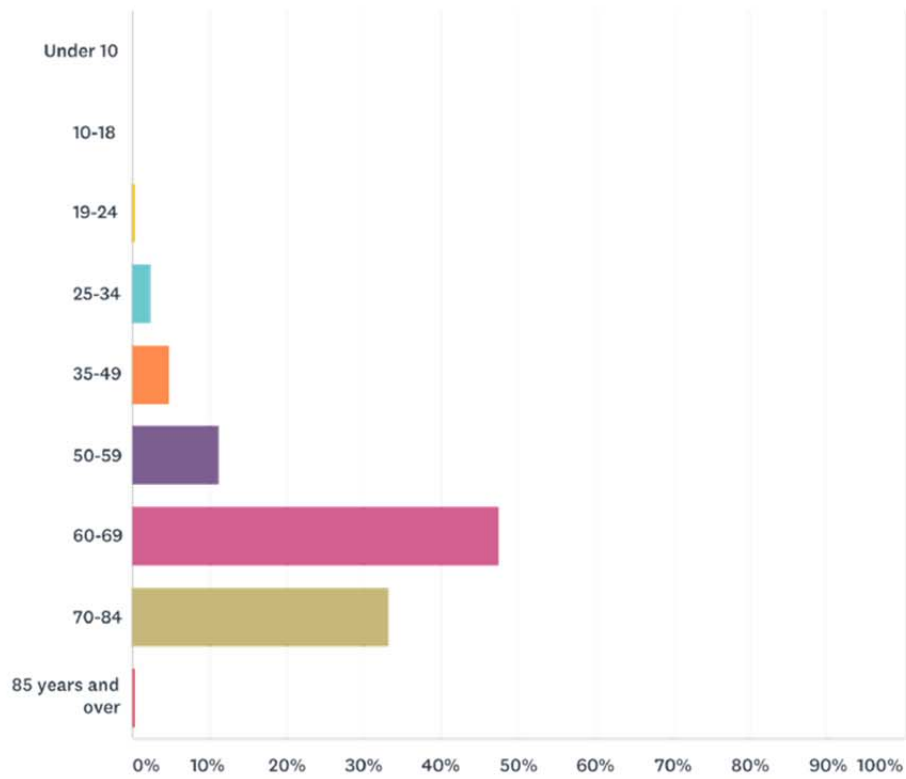


ANSWER CHOICES	RESPONSES	
Full time	9.01%	21
Part time	9.44%	22
Casual	4.72%	11
Contract	1.29%	3
Self-employed	6.01%	14
Actively looking for work	1.29%	3
Not looking for work	2.15%	5
Retired	66.09%	154
Not able to work	0.00%	0
TOTAL		233

Landcare Program Volunteer Survey 2019

Q2 What is your age?

Answered: 232 Skipped: 1

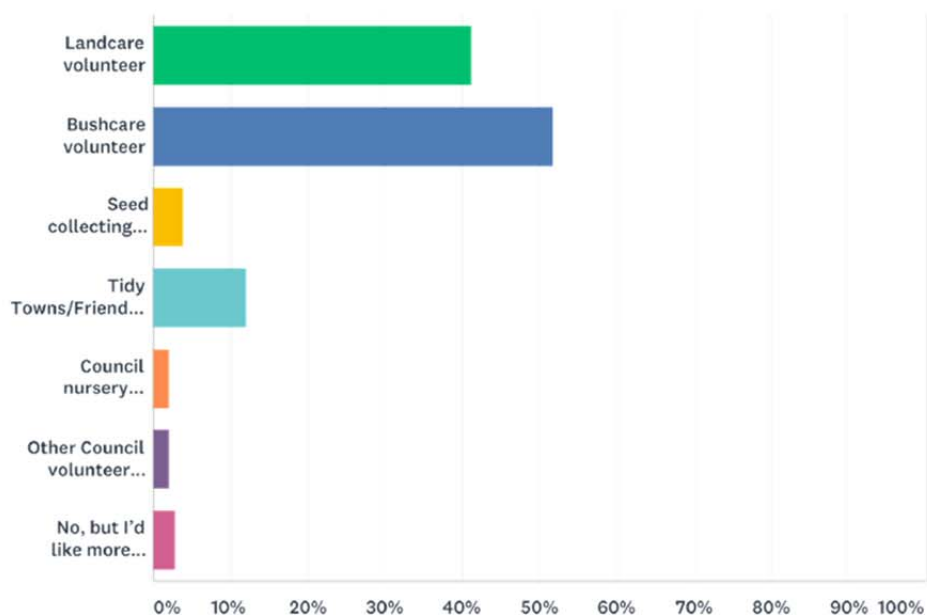


ANSWER CHOICES	RESPONSES	
Under 10	0.00%	0
10-18	0.00%	0
19-24	0.43%	1
25-34	2.59%	6
35-49	4.74%	11
50-59	11.21%	26
60-69	47.41%	110
70-84	33.19%	77
85 years and over	0.43%	1
TOTAL		232

Landcare Program Volunteer Survey 2019

Q3 Do you volunteer with Council?

Answered: 231 Skipped: 2



ANSWER CHOICES	RESPONSES	
Landcare volunteer	41.13%	95
Bushcare volunteer	51.95%	120
Seed collecting volunteer	3.90%	9
Tidy Towns/Friends Of volunteer	12.12%	28
Council nursery volunteer	2.16%	5
Other Council volunteer programs, e.g. library, art gallery, etc.	2.16%	5
No, but I'd like more information about volunteering	3.03%	7
Total Respondents: 231		

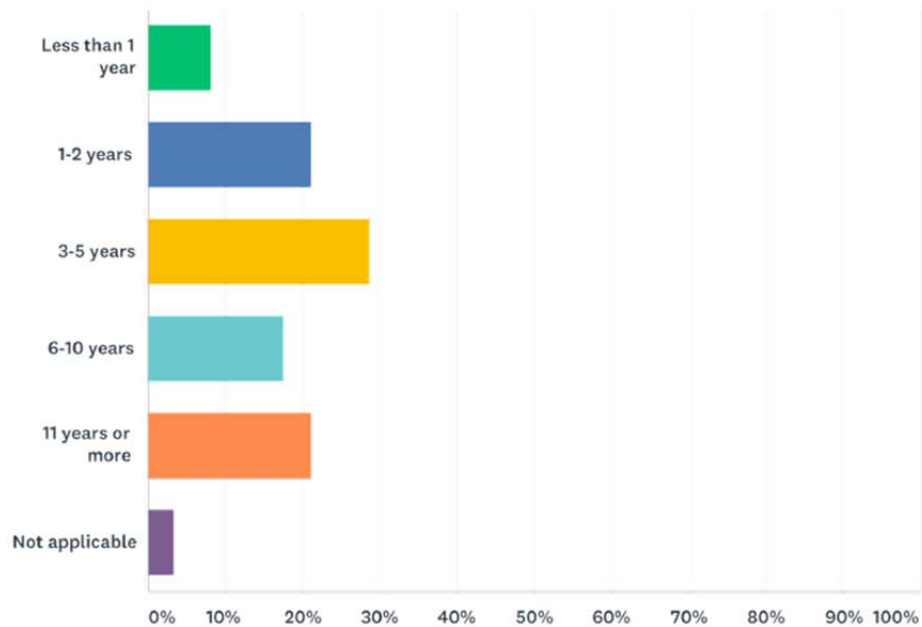
Q4 Please provide your email address below

Answered: 7 Skipped: 226

Landcare Program Volunteer Survey 2019

Q5 How long have you been volunteering with Council's Landcare Program?

Answered: 233 Skipped: 0

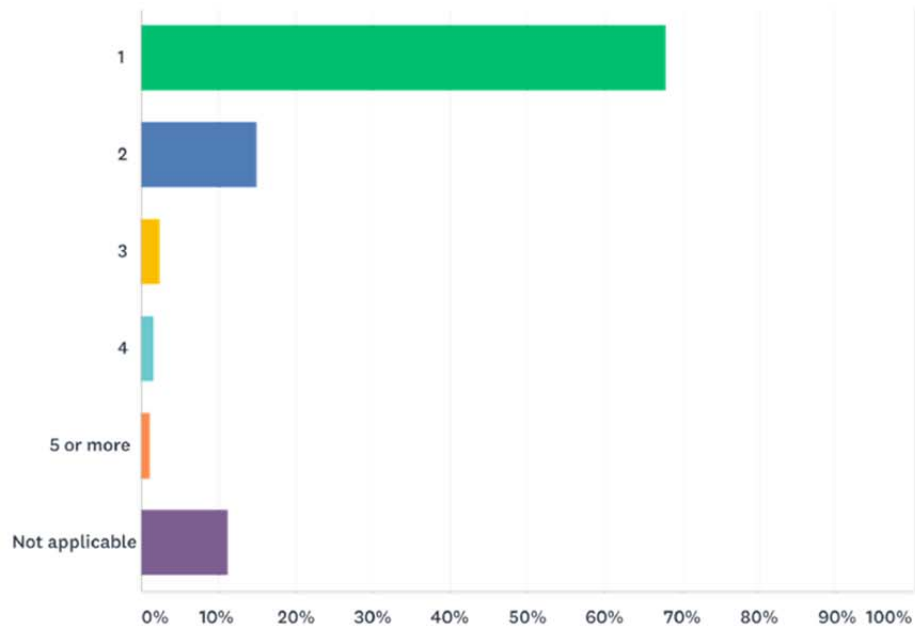


ANSWER CHOICES	RESPONSES	
Less than 1 year	8.15%	19
1-2 years	21.03%	49
3-5 years	28.76%	67
6-10 years	17.60%	41
11 years or more	21.03%	49
Not applicable	3.43%	8
TOTAL		233

Landcare Program Volunteer Survey 2019

Q6 If you are a Landcare Program volunteer, how many groups do you volunteer with?

Answered: 231 Skipped: 2

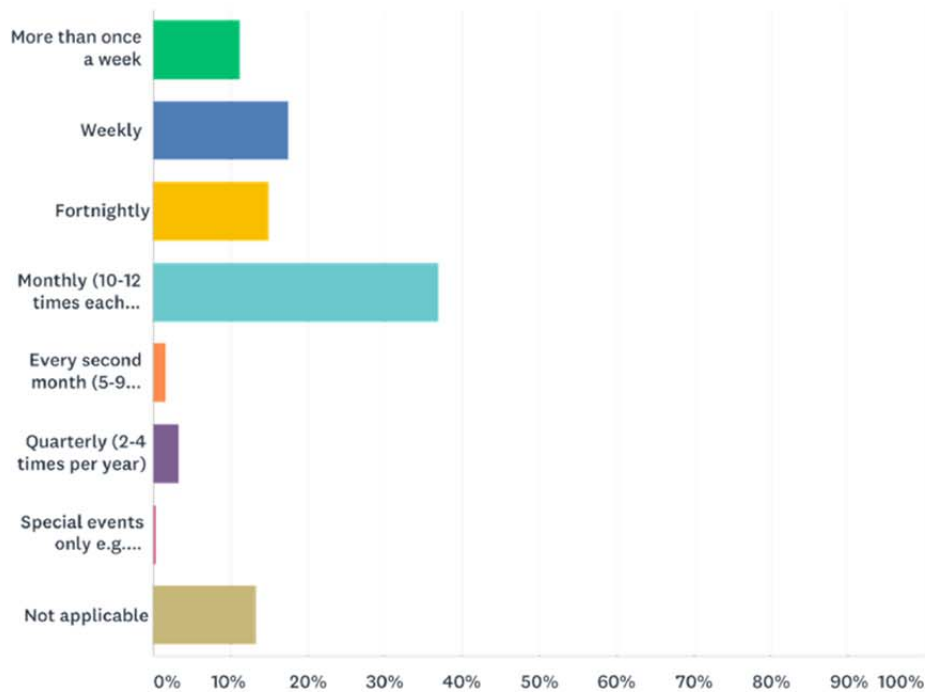


ANSWER CHOICES	RESPONSES	
1	67.97%	157
2	15.15%	35
3	2.60%	6
4	1.73%	4
5 or more	1.30%	3
Not applicable	11.26%	26
TOTAL		231

Landcare Program Volunteer Survey 2019

Q7 If you are a Landcare Program volunteer, how often do you volunteer?

Answered: 232 Skipped: 1

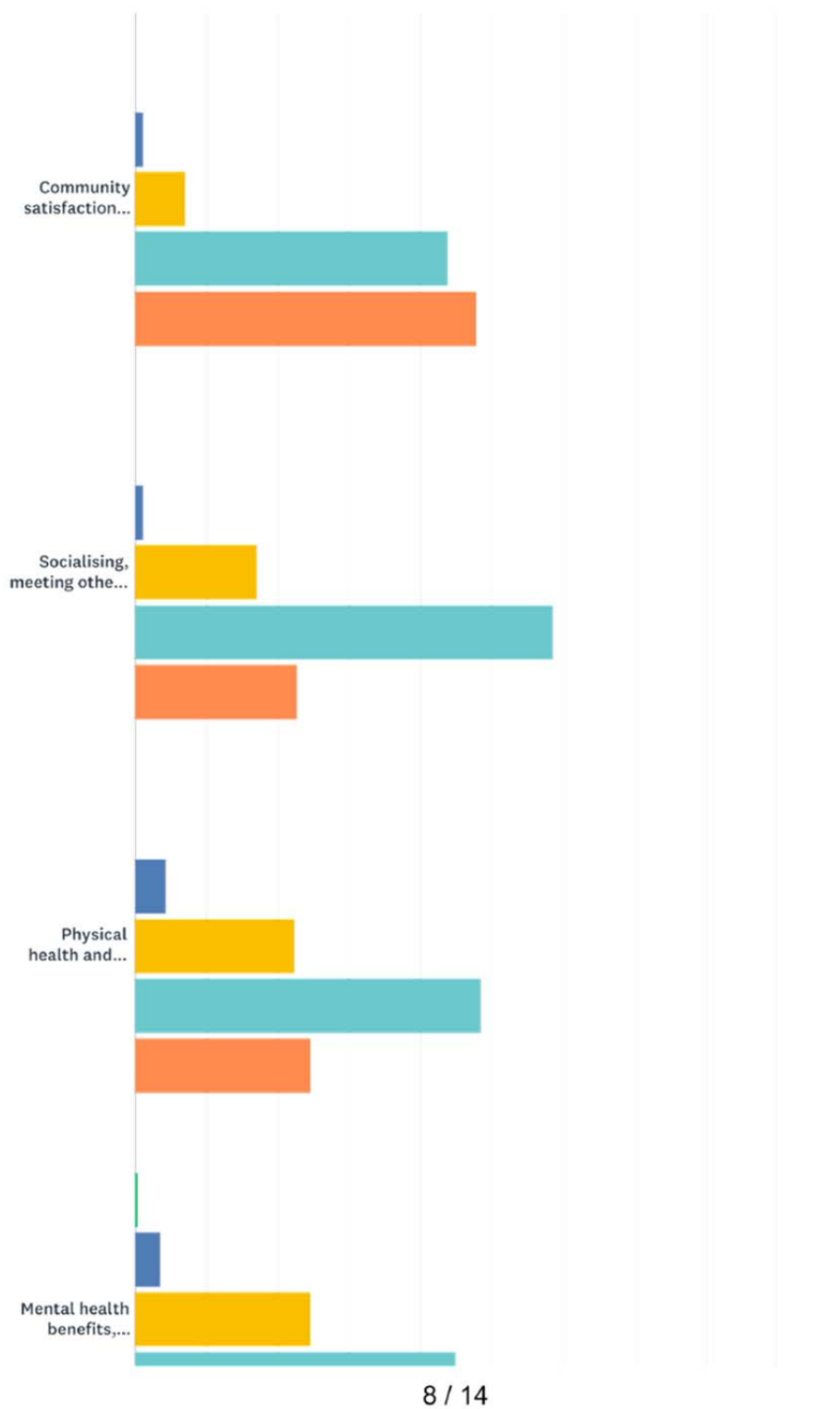


ANSWER CHOICES	RESPONSES	
More than once a week	11.21%	26
Weekly	17.67%	41
Fortnightly	15.09%	35
Monthly (10-12 times each year)	37.07%	86
Every second month (5-9 times each year)	1.72%	4
Quarterly (2-4 times per year)	3.45%	8
Special events only e.g. National Tree Day planting or other one off events	0.43%	1
Not applicable	13.36%	31
TOTAL		232

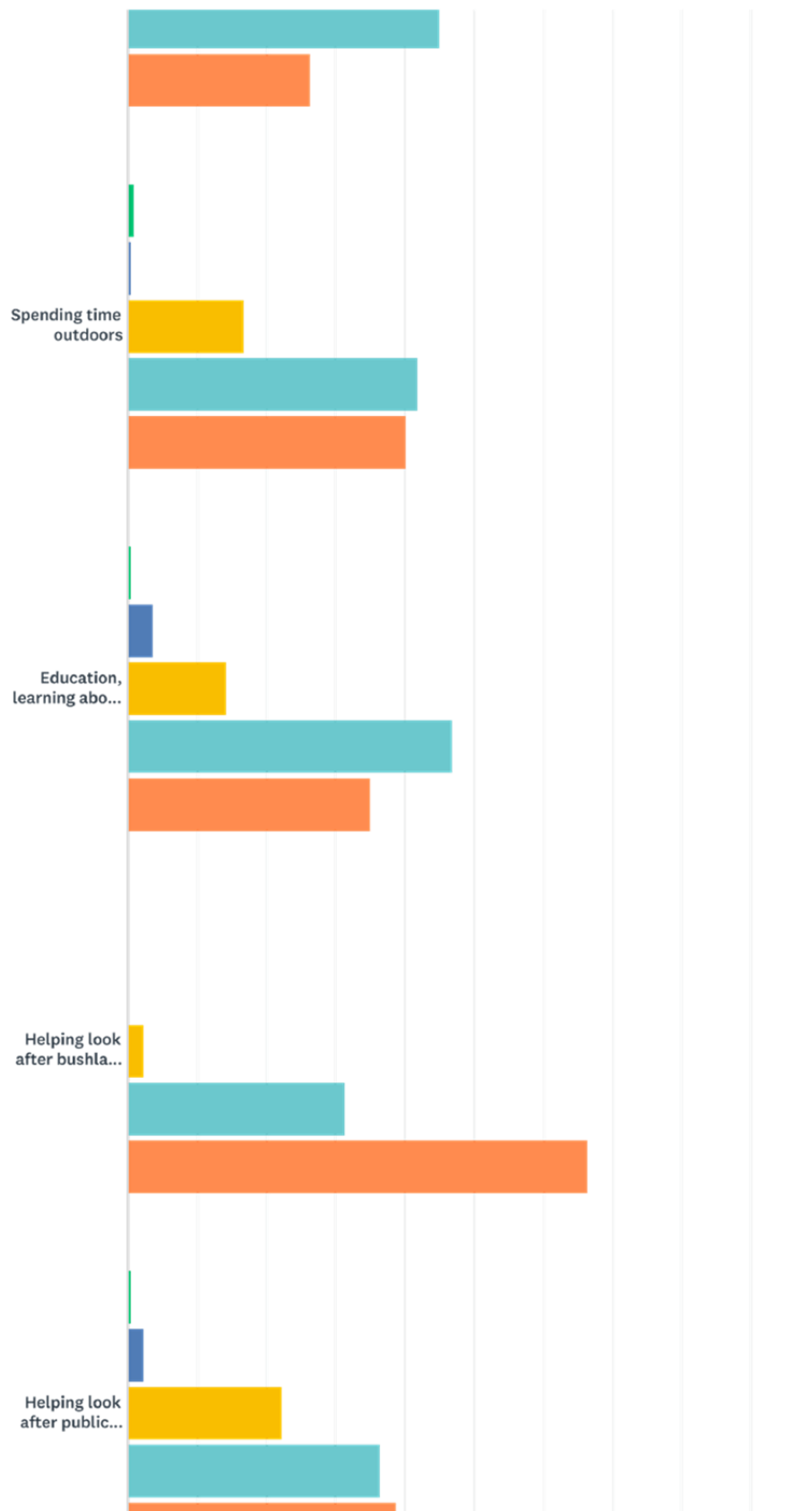
Landcare Program Volunteer Survey 2019

Q8 Please rate the importance of the following aspects of Council's Landcare Program to you.

Answered: 228 Skipped: 5

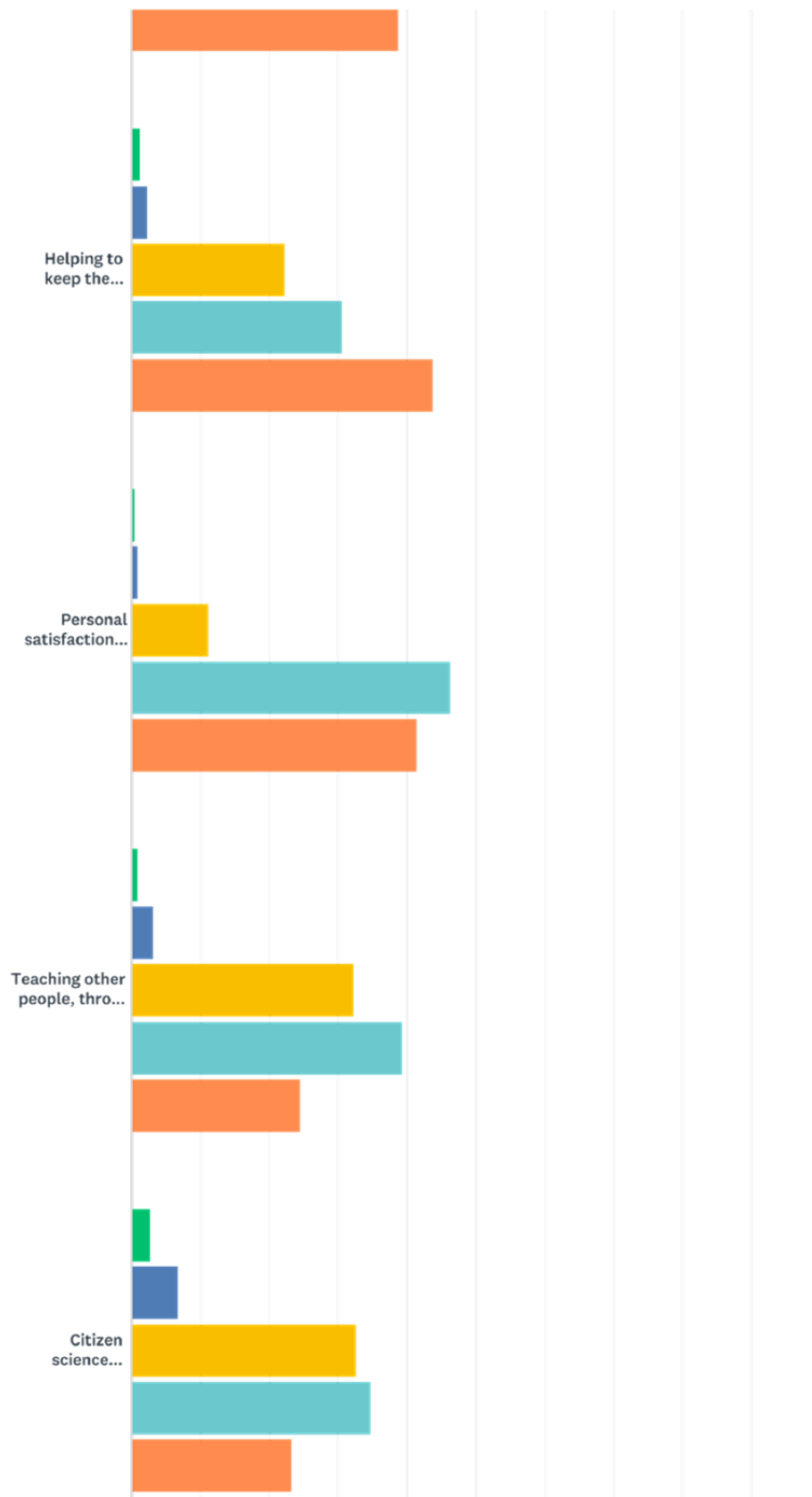


Landcare Program Volunteer Survey 2019



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Landcare Program Volunteer Survey 2019



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Landcare Program Volunteer Survey 2019

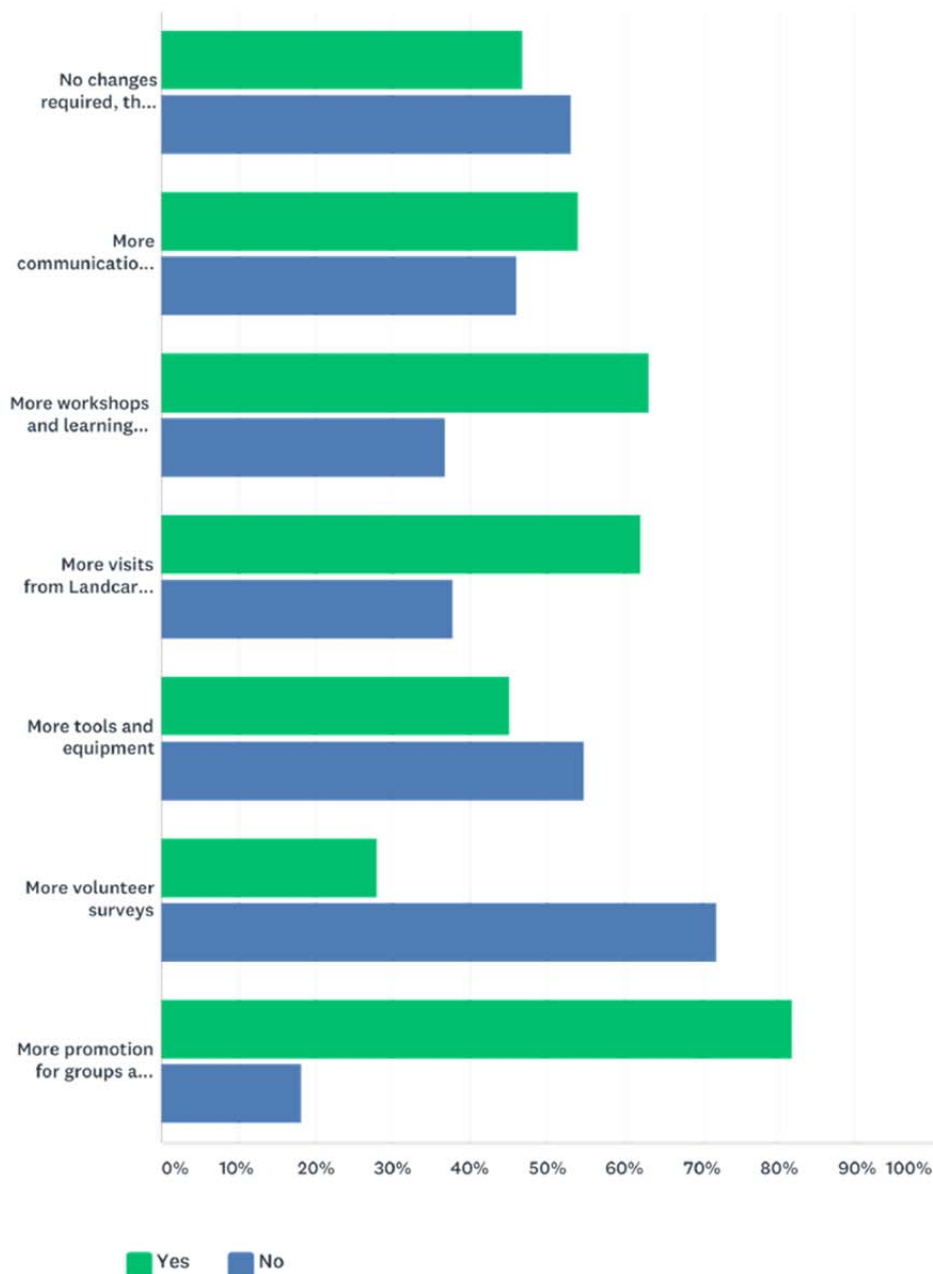


	NOT AT ALL IMPORTANT	NOT IMPORTANT	NEUTRAL	IMPORTANT	VERY IMPORTANT	TOTAL	WEIGHTED AVERAGE
Community satisfaction and belonging, feeling like I am working with my neighbours and contributing to the local community	0.00% 0	1.32% 3	7.02% 16	43.86% 100	47.81% 109	228	4.38
Socialising, meeting other people and making friendships	0.00% 0	1.32% 3	17.18% 39	58.59% 133	22.91% 52	227	4.03
Physical health and exercise benefits, the way I feel from the physical activities I do as a volunteer	0.00% 0	4.41% 10	22.47% 51	48.46% 110	24.67% 56	227	3.93
Mental health benefits, wellbeing, stress/anxiety relief that I feel from my volunteering	0.44% 1	3.52% 8	24.67% 56	44.93% 102	26.43% 60	227	3.93
Spending time outdoors	0.88% 2	0.44% 1	16.74% 38	41.85% 95	40.09% 91	227	4.20
Education, learning about plants and animals, Aboriginal and European culture/history	0.44% 1	3.54% 8	14.16% 32	46.90% 106	34.96% 79	226	4.12
Helping look after bushland areas and the environment	0.00% 0	0.00% 0	2.21% 5	31.42% 71	66.37% 150	226	4.64
Helping look after public parks and recreation areas	0.44% 1	2.22% 5	22.22% 50	36.44% 82	38.67% 87	225	4.11
Helping to keep the community clean and tidy, through rubbish and graffiti removal, garden maintenance, mowing, etc.	1.35% 3	2.25% 5	22.07% 49	30.63% 68	43.69% 97	222	4.13
Personal satisfaction, I feel good when I volunteer	0.44% 1	0.89% 2	11.11% 25	46.22% 104	41.33% 93	225	4.27
Teaching other people, through sharing my skills and expertise with them	0.89% 2	3.13% 7	32.14% 72	39.29% 88	24.55% 55	224	3.83
Citizen science projects, helping with research and monitoring activities, plants and animals, waterways	2.68% 6	6.70% 15	32.59% 73	34.82% 78	23.21% 52	224	3.69

Landcare Program Volunteer Survey 2019

Q9 Do you have any suggestions for changes that we could make to improve the program?

Answered: 221 Skipped: 12



	YES	NO	TOTAL	WEIGHTED AVERAGE
No changes required, the program already addresses my needs and expectations	46.84% 89	53.16% 101	190	1.53

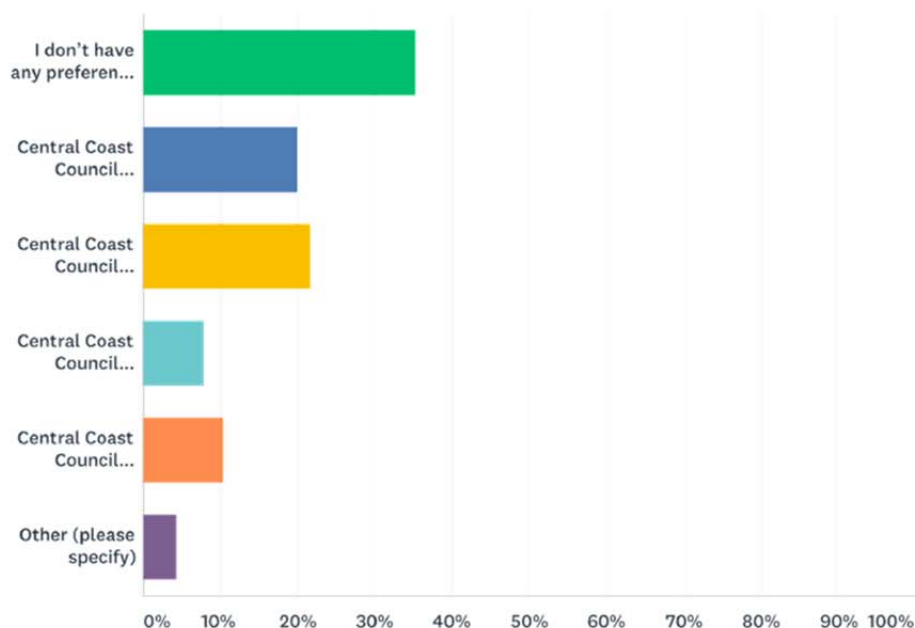
Landcare Program Volunteer Survey 2019

More communication to volunteers	53.97% 102	46.03% 87	189	1.46
More workshops and learning opportunities	63.13% 125	36.87% 73	198	1.37
More visits from Landcare staff to groups and sites	62.11% 118	37.89% 72	190	1.38
More tools and equipment	45.26% 86	54.74% 104	190	1.55
More volunteer surveys	27.98% 54	72.02% 139	193	1.72
More promotion for groups and the program	81.86% 167	18.14% 37	204	1.18

Landcare Program Volunteer Survey 2019

Q10 Since amalgamation 'Central Coast Council Landcare Program' has been used as the overall program name covering all of the Landcare, Bushcare, Tidy Towns and Friends Of groups from the former Wyong Shire Council and Gosford City Council. Do you have a preference, or a suggestion, for the overall program name in the future?

Answered: 229 Skipped: 4



ANSWER CHOICES	RESPONSES	
I don't have any preference for the overall program name	35.37%	81
Central Coast Council Environmental Volunteer Program	20.09%	46
Central Coast Council Landcare Program	21.83%	50
Central Coast Council Bushcare Program	7.86%	18
Central Coast Council Envirocare Program	10.48%	24
Other (please specify)	4.37%	10
TOTAL		229

CENTRAL COAST GREENER PLACES STRATEGY 2019-2030

DRAFT



Central
Coast
Council

CENTRAL COAST GREENER PLACES STRATEGY

DRAFT





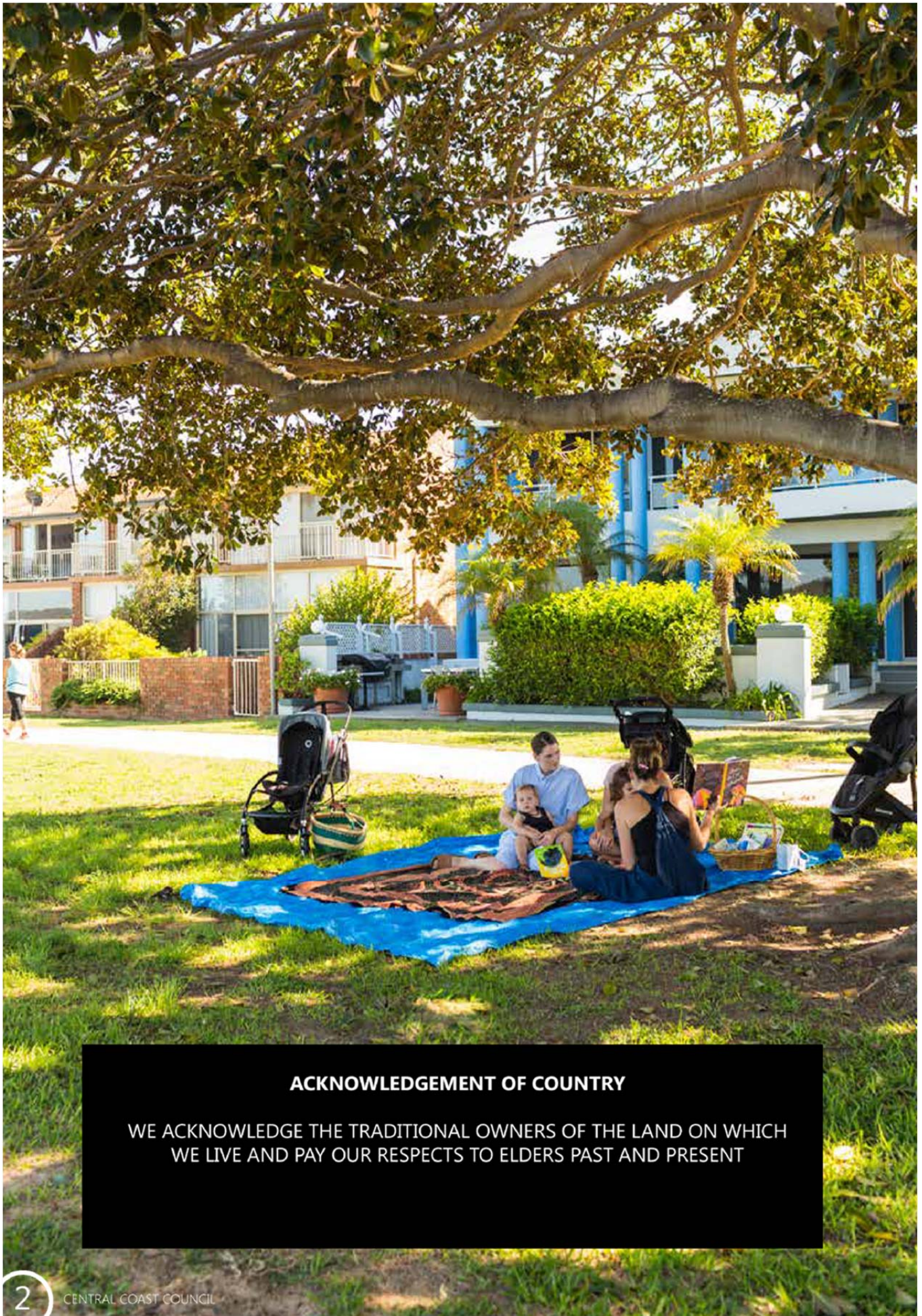
Executive summary

The draft Central Coast Greener Places Strategy (the Strategy) is the first greening strategy for the Central Coast Council since its formal declaration in 2016. The Strategy is informed by the former Council's greening strategies and the Urban Heat Island and canopy mapping technical studies that guide the vision for greening the region. The vision for greening and a liveable Central Coast is reflected within the One Central Coast -Community Strategic Plan 2018-2028 which identifies a strong desire in our community to maintain the unique environmental attributes of the Central Coast.

Whilst the Central Coast region is characterised by green ridges and surrounded by national parks, the loss of canopy cover and green corridor in urban centres and neighbourhoods need to be better managed. In response to the loss of canopy cover, the Strategy provides a framework for enhancing and managing the Central Coast's urban forest and promotes urban greening over the next 10 years.

The Central Coast contains many unique urban ecosystems and places like Pearl Beach or Budgewoi foreshore are great examples. These places include parks that are dappled with tree cover that provide shade to residents while picnicking or swimming and reinforce the value and beauty of vegetation. Such urban forests play a vital role in the health, social wellbeing and economic sustainability of a region. Trees in our parks, streets or in our backyards provide services to us every day, improving our environment and quality of life. This Strategy acknowledges that trees often require removal, however without replacement planting nearby, a loss of the urban forest canopy will occur. As such, across the Central Coast trees and shrubs need to be managed in a strategic way, ensuring that any removed trees or shrubs are adequately replaced. This Strategy proposes a framework for the replacement of removed shrubs and trees, also identifying suburbs that are very hot or that contain low levels of tree canopy cover which over time will receive increased urban greening.

The Strategy also acknowledges the need for greening and managing urban health effects through other methods such as green walls and roofs and urban food gardens, to maintain liveability in urban centres, many of which are currently undergoing renewal which is resulting in higher population density. Maintaining functional urban ecosystems is a shared responsibility across all land tenure. Hence, more rigorous requirements on new development will be implemented in order to effectively improve landscaping and associated green infrastructure. It is important that we all work together to protect and enhance urban greenspace. To do this, it is also proposed that community engagement programs will be developed. Importantly once implemented, the Strategy will ensure that tree canopy cover and green space is maintained in a way that improves the liveability of the Central Coast region.



ACKNOWLEDGEMENT OF COUNTRY

WE ACKNOWLEDGE THE TRADITIONAL OWNERS OF THE LAND ON WHICH
WE LIVE AND PAY OUR RESPECTS TO ELDERS PAST AND PRESENT

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INTRODUCTION



Central Coast Council was formed in 2016, forming one of the largest regions in NSW with a total area of 168,000 ha. Both the former Wyong Shire Council and Gosford City Council had strong position on urban greening and maintaining the green character of the region. The need for a harmonized approach for greening the region to enhance local livability resulted in the development of the Central Coast Greener Places Strategy (the Strategy).

Approximately 74 per cent of the region contains native vegetation wooded which comprise of National Parks, State Forest, Aboriginal lands and Council owned and managed natural areas, including the Coastal Open Space System (COSS). Despite this high level of tree canopy cover, developed coastal areas, such as on the Woy Woy peninsula and south of The Entrance contain less than 10% tree canopy cover.

The Central Coast is currently home to 325,000 people, which is expected to increase to 415,000 by 2036, placing an urgent need to meet the demand housing and employment. This will result in increased housing density, such as the construction of medium density housing in existing suburbs, along with the development of greenfield housing sites. The projected level of urban intensification and expansion requires careful planning for the development, maintenance and expansion of urban forest cover.

This Strategy builds on from the Greening Wyong Strategy which was adopted in early 2016 and aimed at:

- guiding proactive management of public trees, such as those located in streets and parks.
- identifying priority planting areas and identifying detailed precinct based objectives.
- developing relevant procedures and technical guidelines for tree planting along roads and identifying hazardous trees.

This Strategy provides a harmonized strategic direction for the management of urban greening in the region and expands beyond public land to incorporate all land tenure. The specific objectives of the Strategy are to:

- Identify areas affected by Urban Heat Islands, opportunities for greening and to prioritise areas for future greening activities.
- Undertake an audit for opportunities for public tree planting in priority suburbs and all areas of open space to facilitate tree planting operational planning.
- Strengthen tree removal and replacement processes to avoid the net loss of tree canopy cover.

- Establish processes for the replacement of removed private trees wherever practicable.
- Develop operational plans for public tree planting across the key priority suburbs.
- Develop education programs to promote community involvement in greening initiatives.
- Where the planting of trees is not possible, encourage the use of smaller shrubs and groundcovers as they make significant contribution towards mitigating heat island effects and enhancing urban biodiversity
- Implement other provisions for urban greening such as community garden green walls and green roofs.

PLANNING FRAMEWORK

Legal and policy framework guiding documents

A range of legislative instruments, policies and strategies, referred to as guiding documents, relate directly to the Greener Places Strategy. These guiding documents can either assist or limit the ability of Council to effectively implement the Greener Places Strategy. A summary of the guiding documents is provided below.



Biodiversity Conservation Act 2016

The Biodiversity Conservation Act 2016 aims to, among other things, protect common and threatened species and to regulate harm to these entities. The urban forest provides habitat for a range of common and threatened species, such as parrots and flying foxes which may forage on fruits and blossom provided by the urban forest. The urban forest may also provide landscape connectivity among patches of bushland for these species. It is an offence to harm Endangered Ecological Communities, protected and threatened species protected under this Act without obtaining appropriate development consent or a biodiversity conservation licence.

Rural Fires Act 1997

The Rural Fires Act 1997 establishes the NSW Rural Fire Service and define its functions and makes provision for the prevention, mitigation and suppression of rural fires. Specific to this Strategy, the Rural Fires Act 1997 requires adequate bushfire mitigation measures. The Act is supported by, among other things, the Planning for Bushfire Protection Code which determines the density of trees around built infrastructure. Of particular importance to this Strategy is the 10/50 Code of Practice which allows for the removal of trees within 10 metres and slashing within 50 metres of an approved dwelling without Council consent on certain bushfire prone land.

New South Wales

planning policies, guidelines and plans State Environmental Planning Policy (Vegetation in Non-Rural Areas) 2017

The State Environmental Planning Policy (Vegetation in Non-Rural Areas) 2017, aims to protect the biodiversity and amenity values created by trees and other vegetation in non-rural areas. The SEPP aims to protect vegetation in non-rural areas and allows for Councils to act as the Consent Authority for determining tree removal in these areas. The SEPP also allows for removal of vegetation that Council is satisfied is dead or dying or provides a risk to life or property.

Local Government Act 1993

The Local Government Act 1993 requires, among other things, for Plans of Management to be prepared for all community land. The Act has objectives for the management of land classified as parkland, which encourage, provide, promote and facilitate recreational, cultural, social and educational pastimes and activities and to improve how land can meet these objectives.

Local Land Services Act 2013

The *Local Land Services Act 2013*, among other things, regulates clearing of vegetation on rural lands. Many of the provisions contained within the *Local Land Services Act 2013* are similar to that of the recently repealed *Native Vegetation Act 2013* in that agricultural management activities such as the felling of trees for construction timber and the clearing of fencelines are classified as complying development that do not require Council consent. Importantly in areas where the Local Land Services Act 2013 apply the State Environmental Planning Policy (Vegetation in Non-Rural Areas) 2017 and Council's Tree and Vegetation DCP do not apply.

State Environmental Planning Policy (Infrastructure) 2007

The State Environmental Planning Policy (Infrastructure) 2007 provides for limited tree removal and pruning as exempt development in health precincts if the pruning or removal is approved by an AQF 5 qualified Arborist. The SEPP allows for other tree removal or pruning only if a permit or development consent is granted by a consent authority.

Roads Act 1993

The *Roads Act 1993* primarily deals with matters regarding public roads, however provides for a range of exemptions in which trees can be removed or pruned without completing impact assessments or applying for permits if a tree is deemed to be a traffic hazard or for the purposes of completing road maintenance.

State Environmental Planning Policy No 65— Design Quality of Residential Flat Development

The State Environmental Planning Policy No 65— Design Quality of Residential Flat Development, aims to, among other things, enhance the natural environmental performance of residential flat buildings by co-ordinating water and soil management, solar access, micro-climate, tree canopy and habitat values.

NSW Government Apartment Design Guidelines

The NSW Government Apartment Design Guidelines, released in 2015, includes provisions for improved retention of existing trees and the establishment of quality landscaping in building setbacks. Provisions also occur for establishment of deep soil planting beds including on building roofspace.



Central Coast policies and strategies

Tree and Vegetation Management Development Control Plan (DCP)

The Central Coast Tree and Vegetation Management Development Control Plan (DCP) aims to protect trees on privately owned land in the Central Coast, allow for the removal of undesirable species and minimise unnecessary injury to or destruction of trees and vegetation. On non-rural land, the DCP requires that the removal of trees growing more than three metres from an approved structure require consent from Council.

Central Coast Regional Plan

The Central Coast Regional Plan 2036 includes actions to protect and enhance the existing amenity of the region, in particular within open space and to protect the region's scenic amenity. Specific to this Strategy are:

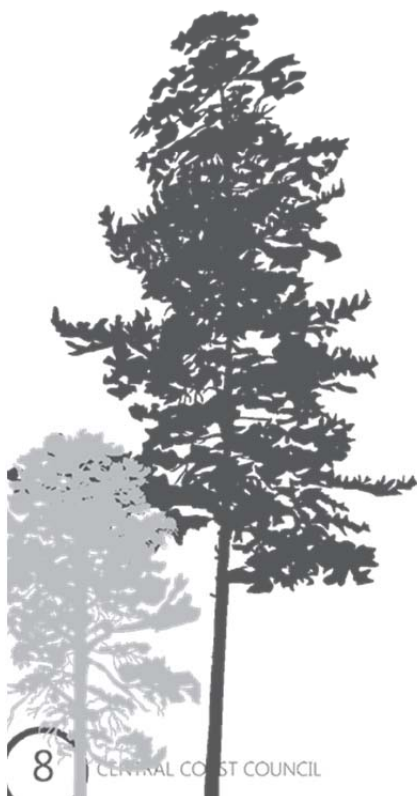
- **Action 8.1** Protect the Central Coast's scenic amenity by planning for development that respects the distinct qualities of different places.
- **Action 18.4** Enhance the amenity and attractiveness of existing places
- **Action 18.5** Implement strategies to invest in open space, sporting and recreational infrastructure.

One Central Coast Community Strategic Plan

The One Central Coast Community Strategic Plan (CSP) notes that residents of the Central Coast value urban trees and tree canopies. The CSP provides support for the protection of trees and vegetation, addressing climate change and ensuring ecologically sustainable development. Themes specific to the CSP are:

- **E1** Educate the community on the value and importance of natural areas and biodiversity, and encourage community involvement in caring for our natural environment.
- **F1** Protect our rich environmental heritage by conserving beaches, waterways, bushland, wildlife corridors and inland areas, and the diversity of local native species.
- **F2** Promote greening and ensuring the wellbeing of communities through the protection of local bushland, urban trees, tree canopies and expansion of the Coastal Open Space System (COSS).
- **F4** Address climate change and its impacts through collaborative strategic planning and responsible land management.
- **L3** Ensure land use planning and development is sustainable and environmentally sound and considers the importance of local habitat, green corridors, energy efficiency and stormwater management.

This Strategy aligns to these actions through specifically promoting urban greening, undertaking appropriate management of existing green space.





Draft Climate Change Policy

The Draft Climate Change Policy includes the need to plan for future impacts of future climate on biodiversity. This Strategy does this through increasing the level of tree cover, reducing Urban Heat Islands and providing informal wildlife corridors through the urban matrix.

Urban Sustainability Strategy

The Urban Sustainability Strategy (in preparation) will attempt to decrease the environmental footprint created on the Central Coast. The reduction of the effect of the Urban Heat Island Effect and increasing urban biodiversity are consistent with the Urban Sustainability Strategy.

Greenfield Housing Guidelines

The Greenfield Housing Guidelines (in preparation) will provide a framework for among other things, improved landscaping in greenfield subdivisions.

Central Coast Biodiversity Strategy

The Central Coast Biodiversity Strategy (in preparation) will aim to ensure the maintenance of biodiversity values across the Central Coast within areas of native vegetation. This Strategy supports the Biodiversity Strategy in providing a framework to enhance the provision of wildlife habitat in urban areas which may act as informal wildlife corridors.



Figure 1: Interaction among the Greener Places Strategy and other future plans, strategies and planning controls for the Central Coast.



What is an urban ecosystem?

In recent years, it has been increasingly recognised that cities and urban areas provide habitat for plants and animals. Humans are also part of this system, commonly referred to as urban ecosystems (Alberti et al. 2008).

As shown in Figure 2, the elements of the urban ecosystems are diverse, consisting of plants, animals and humans.

An urban ecosystem can occur at a variety of scales, from that of an entire region, such as the Central Coast, to an individual suburb. At a local scale, urban ecosystems may occur as an individual shrub or tree, a group of shrubs or trees or a whole park of trees, shrubs and garden beds. The urban ecosystem also provides ecosystem services to humans such as sequestration of carbon and other pollutants, provision of shade and increased amenity which are summarised below.

What is the difference between Urban Forestry and the Urban Forest?

Urban Forestry is the establishment, care, maintenance, and renewal of trees and tree populations in an urban context, collectively considered the urban forest (Miller et al. 2015).

The main focus of urban forestry is ensuring suitable species are chosen and appropriately maintained in order to maximise their longevity and benefits to users of adjacent areas (Miller et al. 2015). The urban forest may consist of trees that are remnants of native vegetation which formerly occurred or native and exotic trees planted in a landscaping context. Due to the diverse range of trees and large shrubs within an urban forest, it may contain exceptional diversity, representing several

hundred species, across a range of size classes and heights (Figueroa et al. 2018). Trees that form part of the urban forest will often require removal due to disease and decay (Brack 2016). However, it's important they are replaced (Brack 2016). Nevertheless, the urban forest is not a self-sustaining entity and as such, trees which are removed or die need to be replaced with careful consideration to the future maintenance requirements (Miller et al. 2015). Importantly in increasingly urbanising areas, planning for the urban forest of the future also needs to secure space for future planting which may be on either public or private lands.



Urban Ecosystems

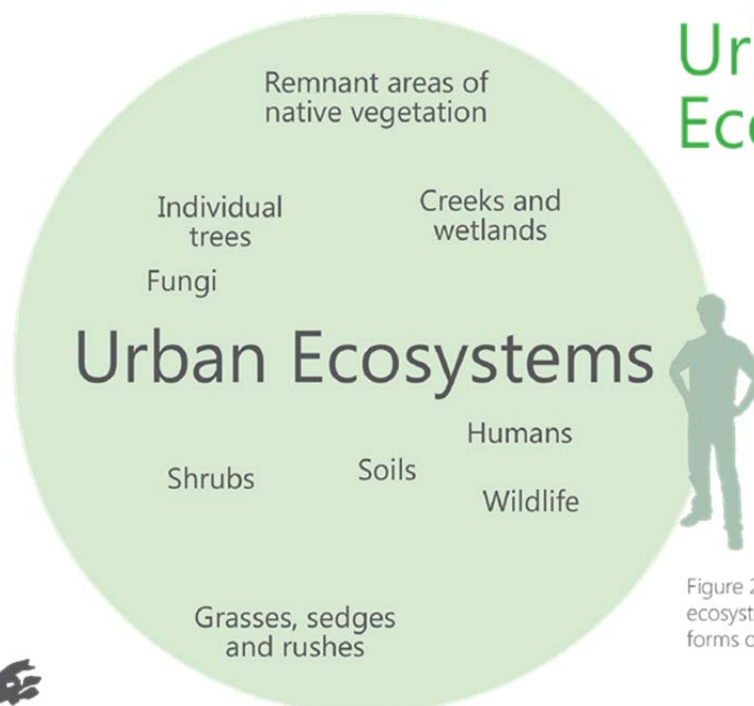


Figure 2: The elements of urban ecosystems are diverse, including all forms of life, including humans.

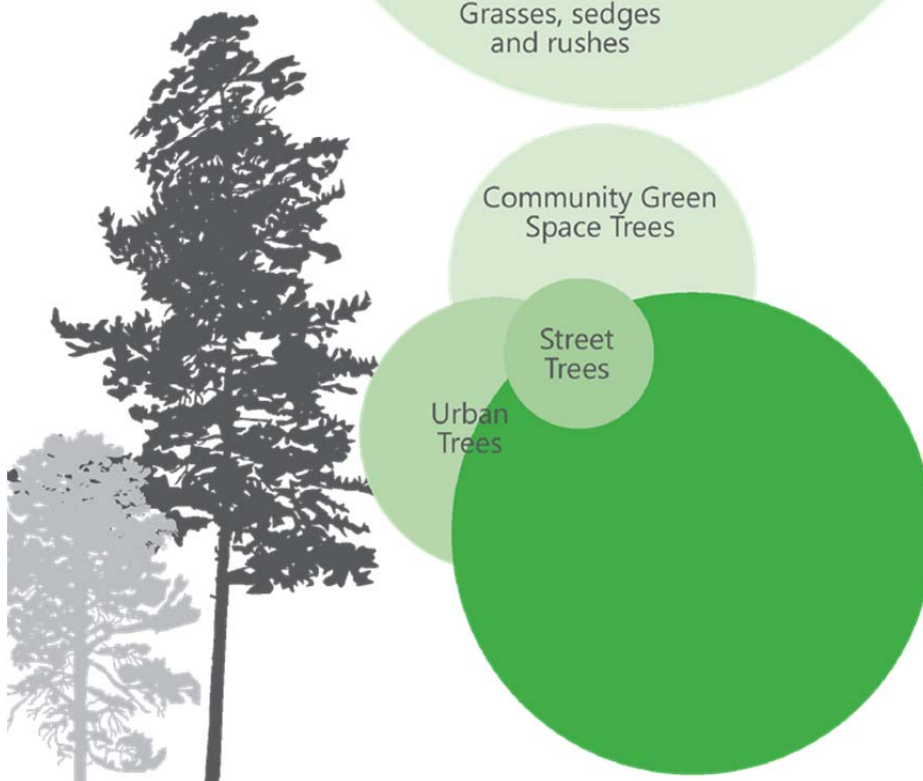


Figure 3: How the urban forest interacts with individual trees and what elements form part of the Urban Forest and how those interact together. Adapted from Roy et al. (2012).

What are the benefits of urban ecosystems?

While some negative effects may occur from vegetation in urban areas, primarily after storms, the benefits of urban vegetation far outweigh the negatives. Some of the benefits provided include:

Cooling effects

Urban trees provide shade to buildings, roads, along with private and public open space. This assists in reducing the impact of the Urban Heat Island Effect, especially during heatwaves (Amati et al. 2013, Elmes et al. 2017). Throughout the warmer months, having tree canopy shading the walls or roofs of buildings has been shown to reduce the cost of cooling. For example a study along a 19 km section of the Pacific Highway in Northern Sydney estimated energy savings from shade trees at over \$57,000 per year (Amati et al. 2003).



Carbon sequestration

The urban forest completes carbon sequestration through storage of carbon in tree stems, branches and the soil (Nowak et al. 2013). Research on urban forests in the United States have calculated whole tree carbon storage measures of around 7.7 kg of carbon per square metre of tree cover, with an annual sequestration rate of around 0.3 kg of carbon per square metre (Nowak et al. 2013). A study along a 11 km section of Parramatta Road, Sydney estimated that urban trees stored 22,600 tonnes of carbon and sequestered a further 573 tonnes of carbon per year (Amati et al. 2003). Thus the urban forest provides for a high level of carbon storage and is useful in combating climate change.

Absorption and storage of atmospheric pollutants

The absorption and storage of atmospheric pollutants in leaves and the stem and branches, such as Volatile Organic Compounds (VOCs) and benzene originating from car exhausts (Nowak et al. 2002). A study on the Greater London Metropolitan area found that the urban canopy removed between 0.7-1.4% of very small particulate matter, referred to as PM10 emissions, which can trigger health issues such as Asthma (Tallis et al. 2011). A study of urban trees in a congested area of Naples, Italy found elevated levels of heavy metals in the leaves of sampled Oak trees, suggesting that the urban forest potentially stores heavy metals (Alfani et al. 1996). In an experiment conducted by researchers from the University of Technology Sydney on the effectiveness of a green wall at removing volatile organic compounds (VOCs) such as benzene and formaldehyde found that such a wall could effectively remove over half of the VOCs (Torpy et al. 2018). As such the maintenance of vegetation within areas of high air pollution may reduce the concentration of air pollutants in urban areas.

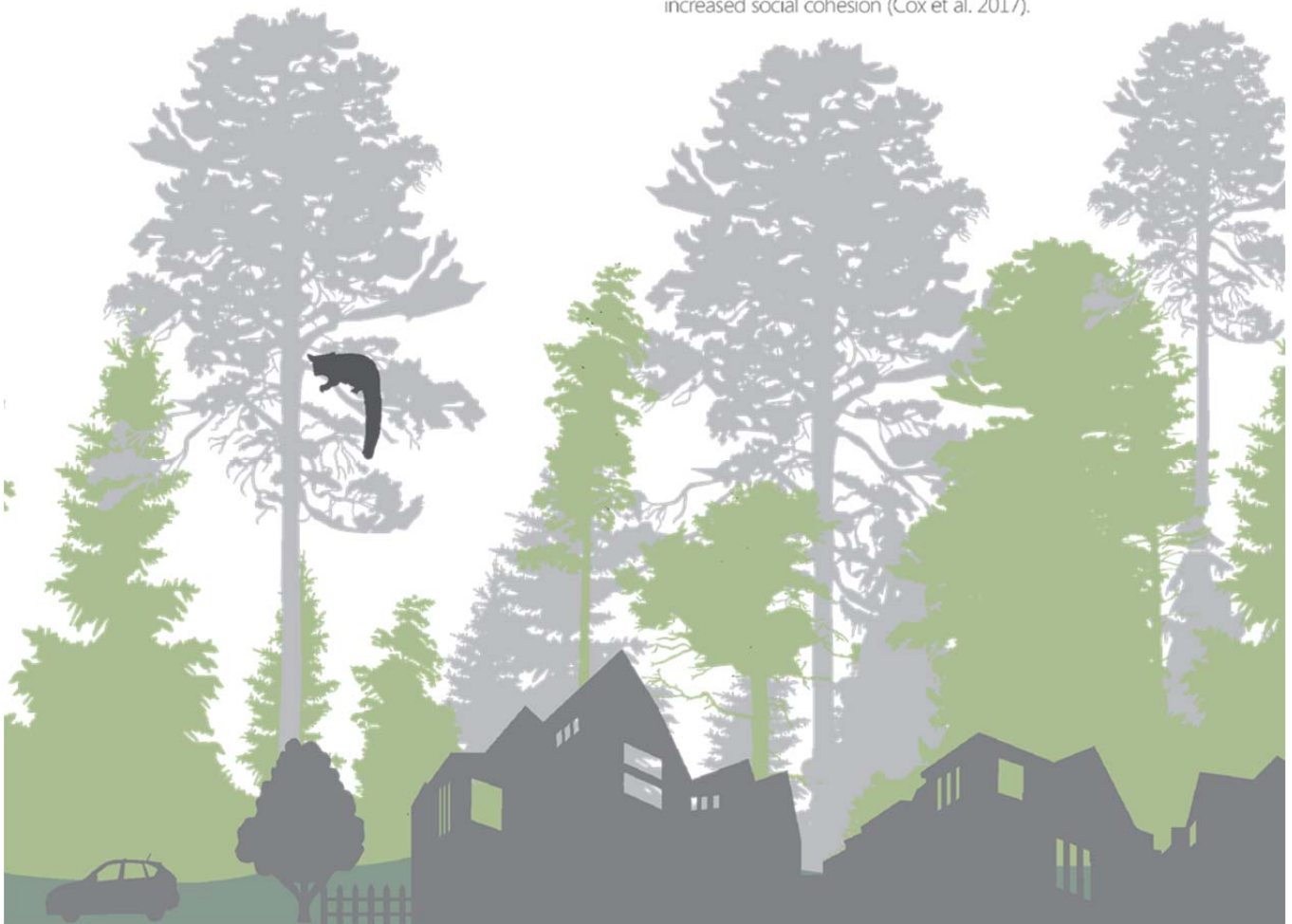


Crime prevention through environmental design aided by appropriate plantings

Areas with a high level of vegetation cover have been shown to have lower crime rates than areas with lower levels of vegetation cover (Troy et al. 2012). In a study of a highly urban area of Chicago in the United States, Kuo and Sullivan (2001) found that apartment buildings surrounded by trees had a lower reporting rate of crime than those that occurred in less vegetated areas. These findings are strongly linked to the principle of Crime Prevention through Environmental Design (CPTED) which argues that criminals make rational choices about crime targets, relating to the risk of being detected and the likely gain (Crowe 2000). Areas that have improved physical appearance are thought to be less likely to attract criminal elements as there is a strong perception that crime is correlated to areas that are less cared for (Crowe 2000).

Improved scenic amenity, health and wellbeing, enhancement of real estate values and consumer spending

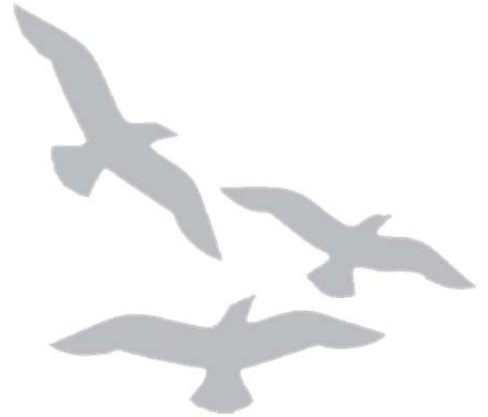
The urban forest can improve scenic amenity through softening vistas, which otherwise may be dominated by the built form (Orland et al. 1992). This in turn can improve real estate prices, with leafy suburbs generally selling for more than less leafy suburbs (Orland et al. 1992). A study of retail shoppers in the United States showed that having large trees adjacent to the shopping district consumers were more willing to pay for parking, visit the shopping district more often and for a longer period of time compared to areas that were devoid of trees (Wolf 2005). A study in the state of Georgia in the United States found that properties that contained mature trees sold for around 3.5-4.5% more than properties that were devoid of trees (Anderson and Cordell 1988). A study in Finland found that dwellings that had a leafy outlook were on average 4.9% more expensive than similar dwellings that did not have a leafy outlook (Tyrväinen and Miettinen 2000). In a study in Southern England, it was found that increased time spent in leafy areas decreased depression and increased social cohesion (Cox et al. 2017).



Provision of habitat for urban wildlife, including informal wildlife corridors

The urban forest provides habitat for a range of urban wildlife. Gardens in suburbia having been shown to provide habitat for a range of small native birds (Parsons et al. 2006) and some native mammals (Carthew et al. 2014). The urban forest provides habitat resources for wildlife such as flowering blossom, fruits and denning opportunities within tree hollows. The urban forest may also function as an informal wildlife corridor, providing stepping stones among patches of remnant native vegetation through which wildlife can move through.

Approximately 74% of the Central Coast consists of native vegetation, of which around half occurs in conservation areas managed as Council reserves, State Forests and National Parks. These areas are important habitat for a range of threatened species such as the Yellow-bellied Glider and Powerful Owl. However outside of these areas, urban trees may provide habitat for other threatened species, such as the Eastern Osprey which may roost or nest in very tall Norfolk Island pines in the Blackwall area or the Grey-headed Flying Fox, Swift Parrot and Little Lorikeet which may occasionally forage on flowering Eucalypts such as Swamp Mahoganies in parks. For protected wildlife, a wide range of birds may also utilise the urban forest for foraging, such as the Brown Cuckoo Dove, Laughing Kookaburra and Rainbow Lorikeet. Urban forests may act as a stepping stone between patches of bushland, allowing wildlife to disperse or migrate across the region.





Other benefits of Urban ecosystems

Over the past decade there has been a greater recognition of the contribution that structures such as constructed wetlands, raingardens and vegetated infiltration trenches towards enhancing the urban ecosystem. A study of the use of constructed wetlands by waterbirds in Melbourne found that they provided habitat for 35 species of waterbird and 91 types of phytoplankton (Murray et al. 2013).

While smaller structures such as raingardens and vegetated infiltration trenches may not provide this scale of benefits to the urban ecosystem, they still provide habitat for pollinators and reduce impacts of stormwater runoff on nearby wetlands, creeks and estuaries (Asleson et al. 2009).





Case study: what was the value of street trees along the Pacific Highway in Sydney?

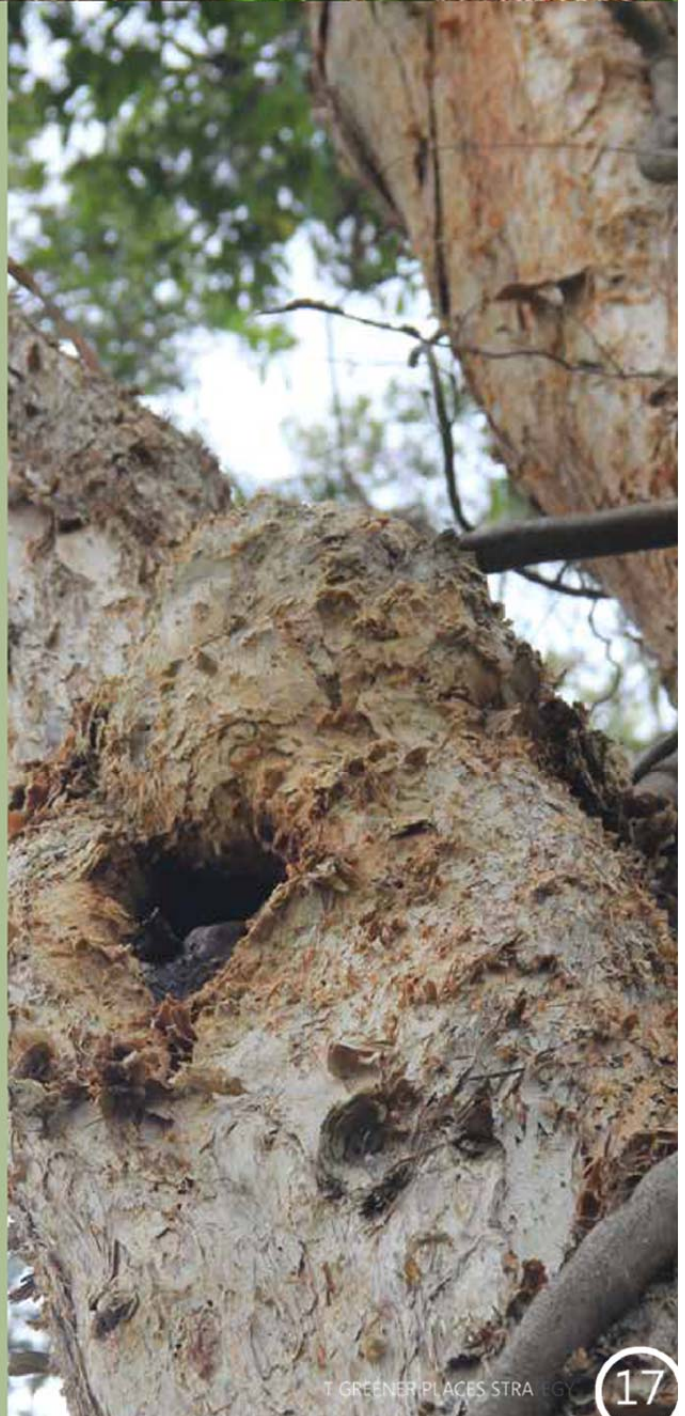
A study completed by Amati et al. (2013) along a 19km stretch of the Pacific Highway estimated 40% tree cover immediately adjacent to the road, covered by around 40,000 trees. This removed:

- 11 tonnes of pollutants per year
- Stored 71,700 tonnes of carbon across their life
- Sequestered 1220 tonnes of carbon across a year
- Produced 2110 tonnes of oxygen across a single year

This study shows the value of street trees at reducing pollution and increases the efficiency of cooling systems.

Case study: older trees have greater habitat value than younger trees in the urban forest

In the Australian environment, tree hollows are very important for wildlife, with a wide range of species such as parrots, gliders and owls all requiring hollows for breeding or denning (Gibbons and Lindenmayer 2002). However tree hollows take over 100 years to form and are found in very large trees rather than smaller trees (Gibbons and Lindenmayer 2002). Furthermore large trees generally produce more nectar than smaller trees, thus increase their value to nectar feeding wildlife such as parrots and Flying Foxes (Law and Chidel 2008). Due to these factors, old trees, in particular those that contain hollows have paramount importance in the urban forest and should be maintained and removal should only occur as a last resort. However it must also be remembered that young trees eventually become the next generation of old trees and smaller trees must also be valued and appropriately managed to ensure they are also only removed as a last resort.





Why does the Central Coast need a Greener Places Strategy?

The Central Coast is currently home to 325,000 people, which is expected to increase to 415,000 by 2036, with the growth being met by increased demand for housing and employment (NSW Department of Planning and Environment 2016).

This will result in housing intensification in existing areas, such as the construction of medium density housing in existing suburbs, along with the development of greenfield housing sites, in the area covered by the North Wyong Shire Structure Plan (NSW Department of Planning and Environment 2016). Industrial areas of the Somersby Plateau and North Wyong will also continue

to be developed (NSW Department of Planning and Environment 2016). The projected level of urban intensification and expansion will require careful planning for the development, maintenance and expansion of urban forest cover. The Gosford CBD will be subject to the extensive development of residential flat blocks and other medium to high density buildings. These developments may remove urban canopy cover and increase the Urban Heat Island effect and as such, require strategic management of urban forests to reduce these effects.

The Central Coast contains a unique environment with a high level of tree cover.

This level of tree cover contributes to a number of unique suburbs, such as Pearl Beach. The Central Coast Community Strategic Plan 2018-2028 (Central Coast Council 2018) notes that residents of the

Central Coast value urban trees and tree canopies. The Central Coast Regional Plan also aims to increase the amenity of existing urban areas and to protect the region's scenic amenity (NSW Department of Planning and Environment 2016). These can be achieved in part through the protection and expansion of the urban forest.

Urban Heat Island mapping has shown that on hot days, the Central Coast's 10 hottest suburbs are between 3.4 and 5.7°C above background levels (see Appendix). For example the forest within Blackwall Mountain is more than 4°C cooler than nearby urban housing in Ettalong Beach (see Appendix). Between 2013 and 2018, ten suburbs became more than 1.5°C hotter compared to background levels that occurred in bushland, including an increase of 2.6°C at Ettalong Beach, 1.9°C at Blue Haven and Woongarah, 1.8°C at East Gosford and Booker Bay and 1.72°C at Point Frederick (see Appendix). Over time unabated, the effects of the Urban Heat Island will continue and possibly intensify as a result of continued development intensification of the urban centres.



Suburb scale tree canopy coverage ranges from 7% in Booker Bay to 90% in Ourimbah, which includes areas of each suburb that are bushland (see Appendix). Across the 94 suburbs examined, there was an overall canopy level of 42% (see Appendix). While bushland is not considered as part of the urban forest for this Strategy, it offers a number of benefits in terms of reducing the Urban Heat Island Effect and as an area for conserving wildlife, thus was included in these calculations.

The urban forest often provides habitat for urban wildlife, which are valued by Central Coast residents. The expansion of the urban forest allows for greater use of flowering and fruiting trees and shrubs by wildlife. Urban wildlife is an important part of the environment and urban trees can assist in the migration of certain species, such as parrots and small honeyeaters. Other urban greening, such as gardens that contain low growing shrubs, grasses and groundcovers also increase biodiversity through providing habitat for insects and birds.

How will this Strategy enhance Urban Ecosystems?

This Strategy predominantly focuses on the maintenance and re-establishment of urban canopy, however on certain occasions the maintenance and re-establishment of urban canopy may not be possible, for example on road verges constrained by overhead cables or within small courtyards.

Furthermore rooftop gardens and green walls on residential flat blocks may also be possible where the required area of planting beds that allow for the establishment of trees is not possible. The reintroduction of low growing vegetation such as sedges, native grasses and small shrubs in these areas may mitigate the effect of the Urban Heat Island Effect and thus the investigation, planning and establishment of urban greening is included in this Strategy.

This Strategy does not include natural areas such as bushland which in the future will be considered by Council's Biodiversity Strategy and existing site-based Plans of Management for bushland reserves.

However, at times, tree planting may occur within areas of exotic grasses adjacent to natural areas or within natural assets which over time may develop into bushland. This Strategy does include a commitment to develop Citizen Science programs around urban greening. These programs also align to the actions of the draft Biodiversity Strategy and as such, these strategies will develop shared programs predominantly in the area of environmental education. Due to the diverse range of trees and large shrubs within an urban forest, it may contain exceptional diversity, representing several hundred species, across a range of size classes and heights (Figueroa et al. 2018). Trees that form part of the urban forest will often require removal due to disease and decay (Brack 2016). However, it's important they are replaced (Brack 2016). Nevertheless, the urban forest is not a self-sustaining entity and as such, trees which are removed or die need to be replaced with careful consideration to the maintenance requirements vs or enhancement tree cover for the future (Miller et al. 2015). Importantly in increasingly urbanising areas, planning for the urban forest of the future also needs to secure space for future planting which may be on either public or private lands.

The importance of maintaining sufficient urban space for the Urban Forest

Trees planted in urban sites are usually growing under conditions that are sub-optimal for maximum canopy and root system development (Moore 2001). If trees are planted in areas with insufficient space, they are not likely to fully develop and reach their full potential (Moore 2001). If trees are planted in areas with insufficient space, this may increase the likelihood of interaction between the tree and infrastructure (Ely 2010).

Regardless of the type of tree that occupies the space today, it is the space that is the most valuable commodity for the maintenance and enhancement of the urban ecosystem and urban forest. The conversion of space that may potentially host a tree, shrub or other type of vegetation to a land cover type such as concrete or a building that does not allow for vegetation to be established results in a loss of the potential of that space to contribute to urban vegetation cover.

The adage of planting the '*right tree in the right place*' is often stated although is not always applied in planting practice. Relatively few streets were originally designed to accommodate street trees, and subsequent planting periods have sought to fit popular and often quite large growing species into constrained spaces (Ely 2010). This has often resulted in significant conflict between trees, private property and infrastructure, reducing their useful life of both and increasing the likelihood of tree failures in storm events.

Ensuring the right tree is planted in the right place means that the chosen tree species

must be suitable for the space when fully grown. This requires a detailed analysis of site constraints, above and below ground spatial elements, risks and opportunities prior to selecting a species. In some instances increased space may need to be created to accommodate tree planting. Importantly however, where only small spaces are available, this does not mean that no planting should occur, instead the species with the greatest potential maximum height for the space should be selected which at times may be represent small shrubs or other groundcovers.





BACKGROUND AND CONTEXT

Urban forests from Australia and the world



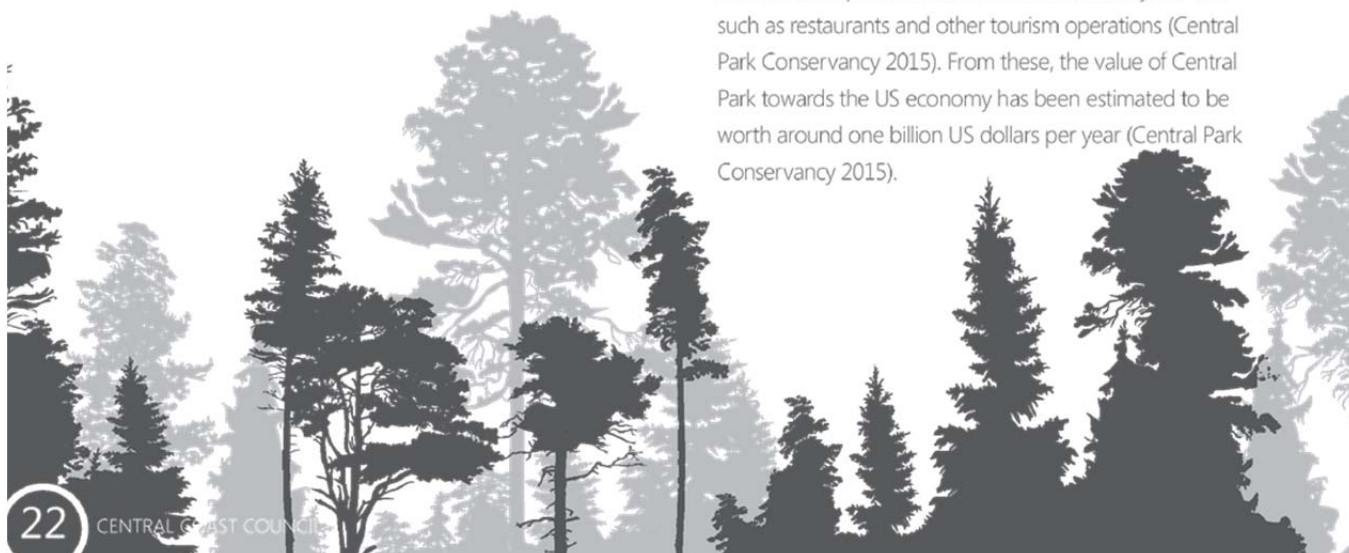
Melbourne's Urban Forest

The City of Melbourne's Urban Forest consists of open space areas such as the Royal Botanic Gardens and Fitzroy Gardens along with over 70,000 other public trees within road reserves and other Council managed spaces (City of Melbourne 2012). These areas are supported by the 2012-2032 City of Melbourne Urban Forest Strategy which aims to increase tree cover in the city to 40% by 2040.



Central Park, New York; an urban forest area in a metropolis

Central Park, located in Manhattan, New York is a 341 ha urban forest. It was officially opened in 1857 with almost every one of the 25,000 trees contained within being planted. Each year Central Park attracts over 37 million visitors who visit the park for walking, relaxing and attending concerts (Central Park Conservancy 2015). Central Park directly contributes to the employment of 453 people and indirectly a further 1345 full time positions associated with ancillary activities such as restaurants and other tourism operations (Central Park Conservancy 2015). From these, the value of Central Park towards the US economy has been estimated to be worth around one billion US dollars per year (Central Park Conservancy 2015).





Gothenburg's Urban Forest

Gothenburg is Sweden's second largest city, home to around half a million inhabitants. Around 70% of the Gothenburg urban area is open space, with those areas containing around 50% tree cover. It also contains numerous areas of open space and supports a large urban forest, as well as street trees. Examples of open space that forms part of the Gothenburg urban forest includes Slottskogen which is a 137 ha urban forest which was officially opened in 1874. It contains mature plantings of European trees such as Oak and Beech along with numerous walking trails. On a summers day Slottskogen is a favourite among locals who use the park for picnics under shady trees.



What is the Urban Heat Island Effect?

An Urban Heat Island occurs when the urban area is significantly warmer than the surrounding less developed areas, such as rural lands and forests (Oke 2011). Heat islands develop due to urban materials such as concrete, asphalt, tiled roofs and gravel absorbing rather than reflecting heat which occurs when the area is more heavily vegetated (Oke 2011).

The concept of the Urban Heat Island has been in existence for over 50 years (Bornstein 1968), however as society becomes more urbanised, greater emphasis needs to be placed upon the effect during urban planning. Figure 4 demonstrates the effect of development at Erina shows the heat island effect compared to surrounding vegetated areas, which were on average 3°C hotter. This means houses and other buildings will be hotter in areas where the Heat Island Effect is operating which will translate to higher cooling costs or alternatively less comfortable conditions indoors if cooling does not occur. Furthermore on hot days taking a

walk outdoors will be much warmer than if canopy cover is present over footpaths.



Figure 4: an example of the operation of the urban heat island effect at Erina where areas of vegetation are on average 3°C cooler than adjacent developed areas. Areas in red are hotter than areas that are blue.



Seed Consulting were engaged to determine the occurrence of Urban Heat Islands across the Central Coast. Open source Landsat imagery was used to determine differentials on a hot day in January 2018 and a hot day in March 2013. These analyses found that a number of urban and agricultural areas are more than 4°C above background levels (Figure 5). When considering change in the

operation of heat islands over the past five years, the analysis found that large areas of agricultural land in the west of the Central Coast had become significantly warmer, along with some isolated areas of greenfield residential subdivision across the Central Coast (Figure 6). However, minor warming differentials also occurred on the Woy Woy peninsula, Kariong, Gosford city and in the greenfield suburb of

Woongarah (Figure 5). Further information on the operation of heat islands on the Central Coast is included in Appendix.

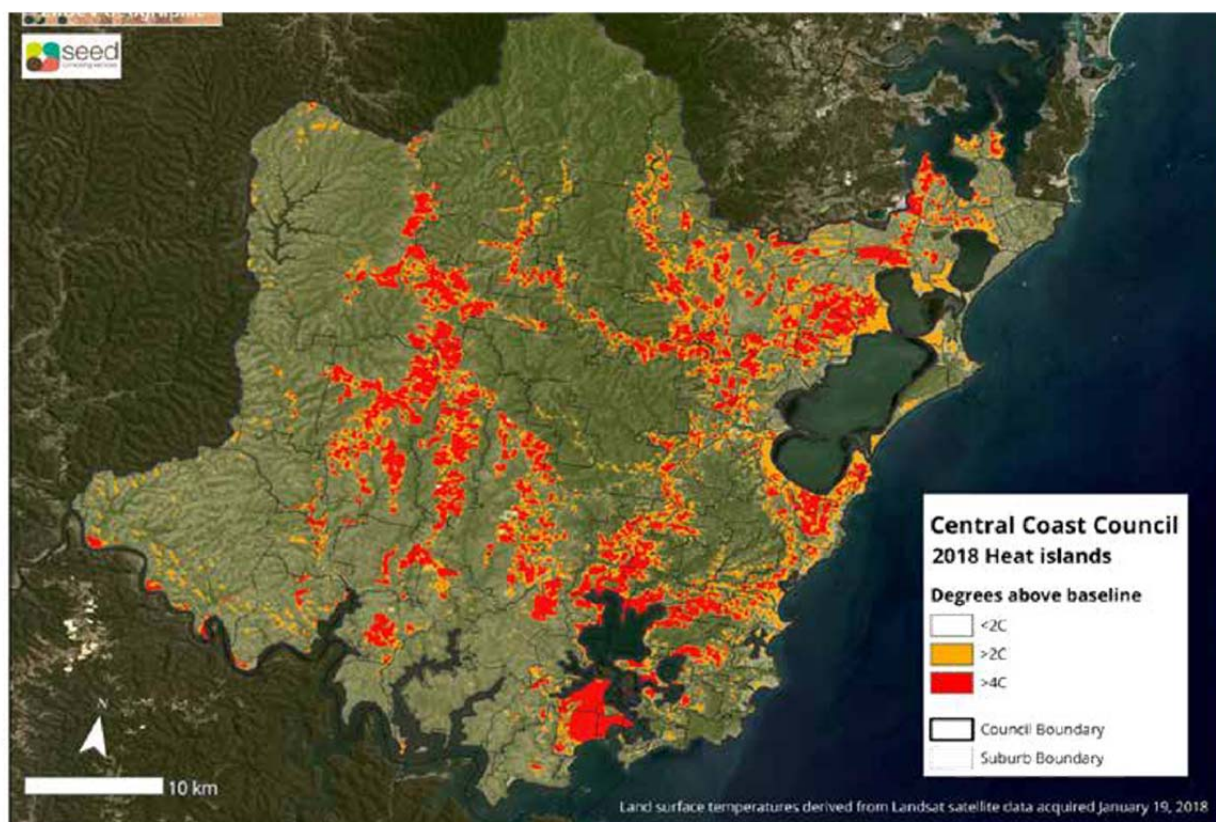


Figure 5: Areas where heat islands are more than 2°C and 4°C above baseline temperatures on a hot day in January 2018.

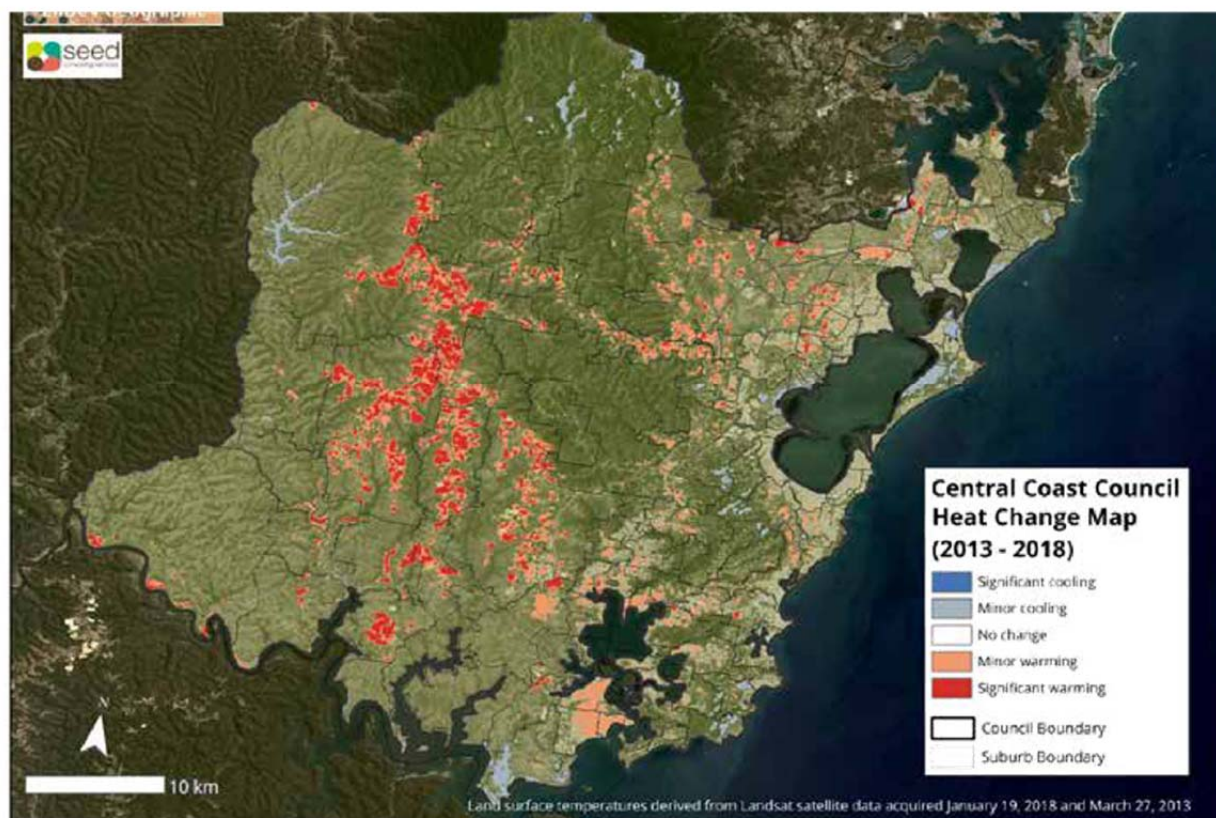


Figure 6: changes in heat islands between 2013 and 2018 for the Central Coast Local Government Area.

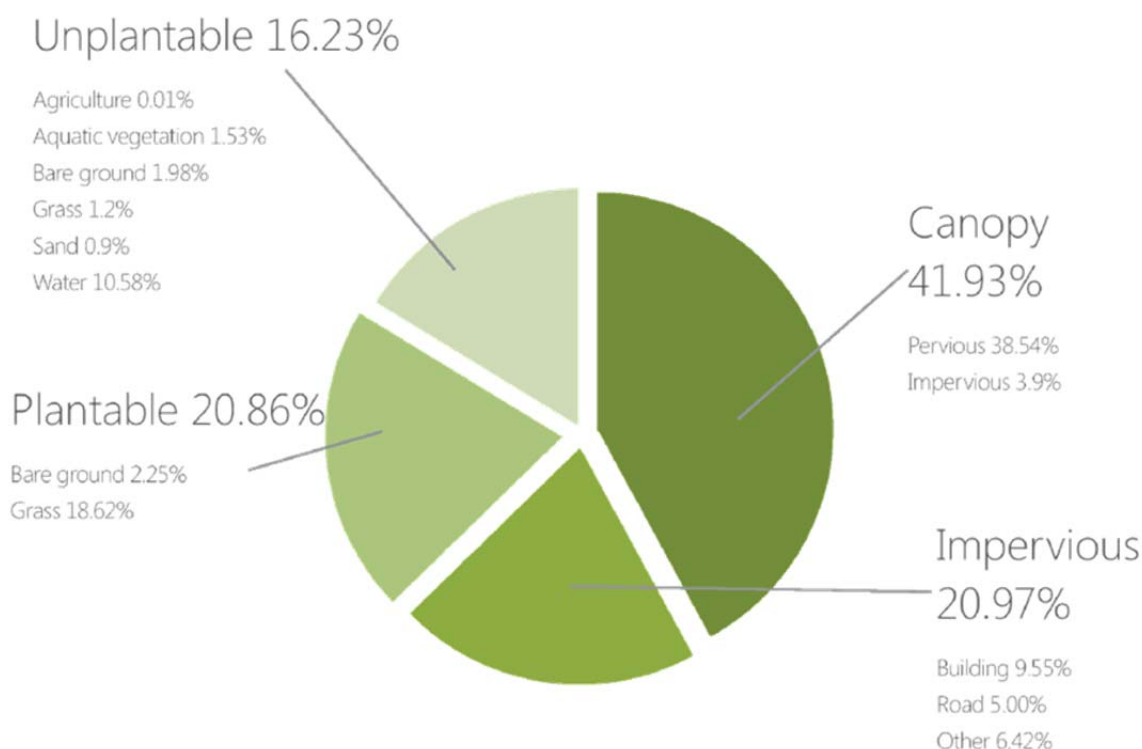


Figure 7: Overall land use breakdown for the 94 predominantly urban suburbs considered for urban canopy mapping.

Suburb scale vegetation cover

Seed Consulting were engaged to determine the level of vegetation cover for 94 suburbs that contain urban areas, with the full report being included as an Appendix to this Strategy. Seed Consulting used i-Tree, online open source software to determine the level of canopy cover in each suburb, along with the amount of impervious surfaces and opportunities for planting within grass. This process was tenure blind, meaning that the area of canopy in public compared to private ownership was not determined. One of the limitations

of the process of suburb based canopy mapping is some suburbs contain large areas of National Park or State Forest which may increase the relative level of tree cover. The example of this is the suburb of Woy Woy, which includes a large area of Brisbane Water National Park, however the urban area has relatively low levels of canopy cover, giving a higher level of canopy than would occur if the National Park lands were not included in the analysis.

Within the 94 suburbs considered, an overall canopy cover of 42% was determined, with a further 21% of land containing impervious surfaces (Figure 7). This is comparable to the national urban canopy which when assessed in 2014 had an average coverage of 39%, however is lower than northern Sydney Council areas such as Hornsby and Pittwater which recorded overall average canopy coverage of 59% (2020 Vision 2014).

Overall, 21% of Central Coast suburbs contained grass or bare ground that could be planted, which may include grazing lands, while 16% of these suburbs were unsuitable for planting, including around 1% that consisted of grass with other purposes such as sporting fields (Figure 7). On the individual suburb scale, tree canopy cover ranged from around 7% at Booker Bay through to almost 90% at Ourimbah, however this included a large proportion of Ourimbah State Forest. A number of suburbs recorded levels of canopy cover of less than 15% including Blue Bay, Davistown, Ettalong Beach, Gorokan, Point Frederick, St Hubert's Island, The Entrance and The Entrance North (Seed Consulting 2018). Generally these are suburbs that are relatively established and do not contain large areas of bushland. Further information on the level of tree cover in each suburb is



Case study: changes in canopy cover at Woy Woy between 2005 and 2014

An investigation occurred as to changes in tree canopy cover and number of impervious surfaces at Woy Woy between 2005 and 2014 (see Appendix). Over this time, canopy cover declined by 173 hectares, while the area of impervious surface increased by 84 hectares and unplantable space increased by 113 hectares (Figure 8). This effect may be difficult to counteract as the area of plantable space only increased by 24 hectares (Figure 8).

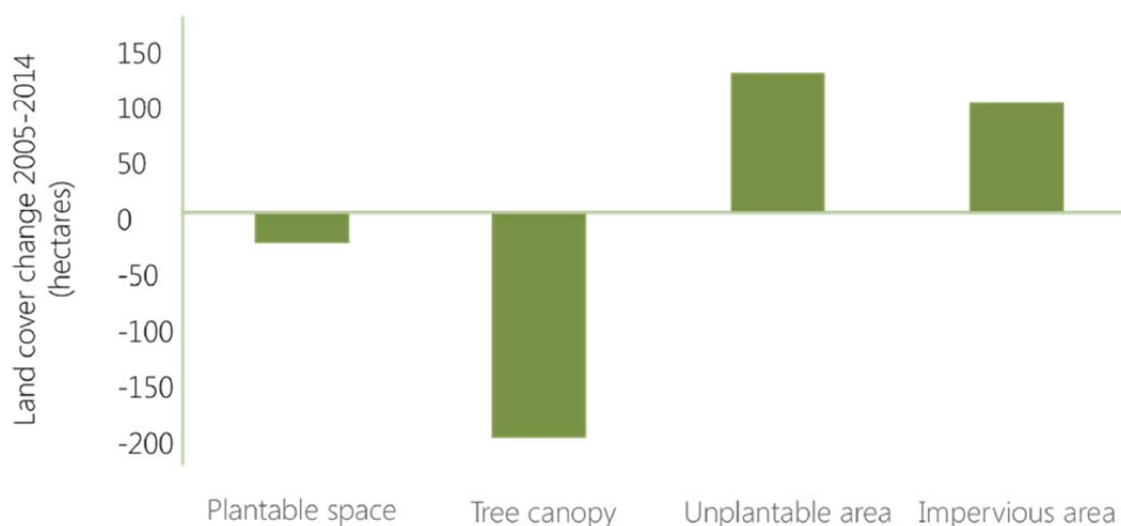


Figure 8: change in land cover categories between 2005 and 2014 for the suburb of Woy Woy.



How many public trees are there on the Central Coast?

This Strategy aims to inform broad scale strategic planning and has not attempted to estimate the number of public trees on the Central Coast.

Surveys did however occur in public recreation reserves which recorded a median tree density of 78 trees per hectare. As Council owns 663 ha of recreation reserves, it's likely that around 50,000 trees are contained within these reserves.

While an Urban Forestry Strategy or Greening Strategy may quantify the actual number of public trees within an individual local government area, such as the Melbourne City Urban Forest Strategy, these are usually determined for small local government areas and field based surveys for the Central Coast to determine the status of every tree is not practicable. Instead a

reactive approach to tree risk will occur where trees reported to be a risk will be assessed on a case by case basis.

What is the optimal density for street and park trees? What type of place should we be aiming to achieve for parks and streets?

The density for street trees and park trees will vary depending on the predominant purpose of the location and the type of species chosen. In general planting densities in this strategy will be at a maximum of around 150 trees per hectare, which is the density recorded in heavily vegetated parks that still maintain grass cover underneath. However, any planting program must occur through appropriate place based planning that considers all users of the park, how tree planting will complement those uses and enhance the user experience including considering the future size of planted trees. As such, parks should be assessed on a case by case basis by relevant subject matter experts before planting commences. This

may instead translate to a planting density of between 50-100 trees per hectare or through trees, shrubs and groundcovers being planted in defined mulched planting areas with surrounding land being maintained as lawn.

Street tree planting is often constrained due to the presence of underground services, powerlines, footpath and kerb and gutter, which may allow for less than 0.5 metres of planting width. In these situations, smaller trees and large shrubs should be considered to ensure that damage to infrastructure does not occur in the future, as long as lines of sight are maintained (see Figure 10). Alternatively, smaller shrubs, grasses and groundcovers may be used in areas of high visual prominence where taller trees and shrubs may not be suitable and in areas where future maintenance will not be excessive.





Figure 9: photo of a park that includes a high tree density which provides shade to park users.

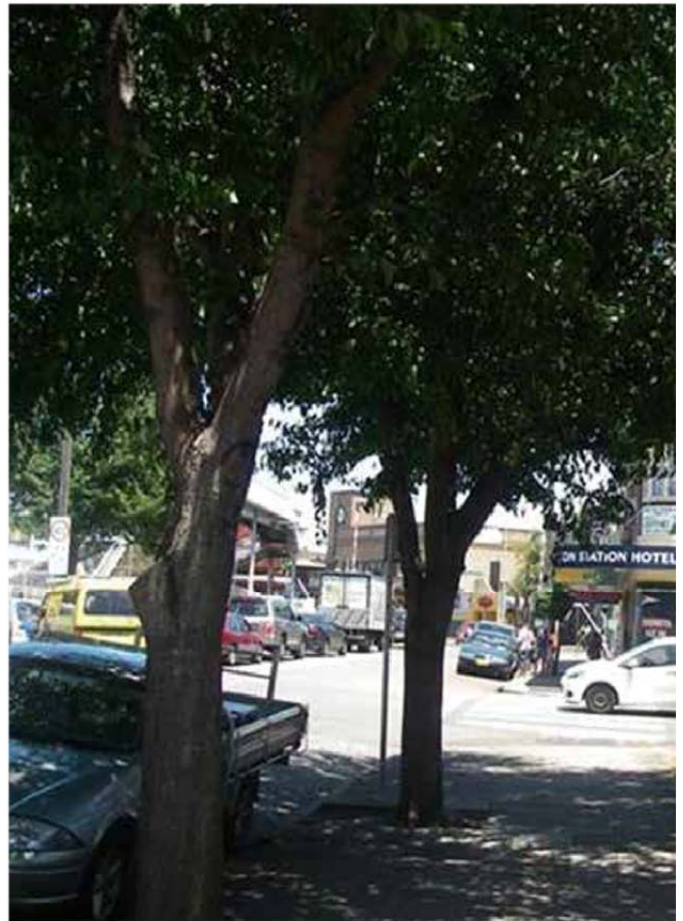


Figure 10: smaller street trees in Hamilton near Newcastle allow for canopy establishment in a paved footpath area while also providing shade to the footpath and parked vehicles.

Priority planting locations to increase canopy

A total of 18 suburbs have been identified for planting, based on either increasing canopy cover or mitigating urban heat island effects or to mitigate urban heat island effects in more heavily vegetated suburbs. For suburbs that have low levels of tree cover, it is anticipated that an aim of an increase of canopy cover by a further 5% will occur around 30 years after the initial installation. Where suitable public locations cannot be found for the specified number of trees, alternative mechanistic approaches such as providing trees and large shrubs to schools, health facilities, private open space providers such as golf courses and private residents where their land will strategically address the urban heat island effect and a guarantee can be provided that the tree will be maintained into the future.

Bateau Bay
Blackwall
Blue Bay
Booker Bay
Davistown
Ettalong Beach
Gorokan
Kariong
Killarney Vale
Lake Haven
Point Frederick
St Hubert's Island
The Entrance
The Entrance North
Toowoan Bay
Umina Beach
Woy Woy
West Gosford



ISSUES AND CHALLENGES

What challenges does the urban forest face?

The Central Coast Urban Forest faces a number of threats to its long-term survival, including:

- Urban infill development, which converts existing rural or larger lot residential areas to a more intensive landuse, including townhouse development. These types of developments often require extensive cut and fill excavation, which means existing remnant trees cannot be retained without compromising the tree protection zone or tree structural root zone.
- An ageing urban forest, as many of the trees of the Central Coast are remnant trees from the native vegetation that formerly occurred on the site. These trees are often mature or over-mature, thus towards the end of their Safe Useful Life Expectancy (SULE).
- The impacts from insect attack and emerging diseases. Urban trees may be stressed from insect attack, such as an overabundance of Psyllids that can cause severe dieback in Eucalypts (Hall et al. 2015). Pests and diseases can cause trees that are part of the urban forest to die or become severely stressed, which may require removal or significant pruning.
- The impacts of warming and heatwaves on tree death. Heatwaves are known to potentially result in tree death, especially if the tree is already stressed from drought (Choat et al. 2018).
- The impact on storms and floods on the urban forest. This includes trees failing due to wind throw, branch shear caused by strong winds. It is likely that storms will become more severe in the future as a result of climate change which will require consideration of which species are more resistant to storm events.
- Required clearance between trees and overhead services which require regular pruning. Pruning may reduce the structural integrity of trees and reduce their overall appearance. Ausgrid have been expanding the use of Aerial Bundled Cables for overhead services on the Central Coast which will reduce the level of required pruning in the future.
- The NSW Government's 10/50 Bushfire Code of Practice. This Code, on certain lands, permits the removal of canopy trees within 10 metres of approved dwellings, on bushfire prone land, unless their retention is required as part of a Plan of Management or development application Condition of Consent.
- Council's tree Development Control Plan (DCP) allowing the removal of any tree that occurs within 3 metres of an approved dwelling.
- The lack of appropriate replacement of trees removed for the above reasons, which may over time cause a decrease in the extent of the urban forest.



VISION AND PRINCIPLES

THE VISION

This Strategy aims to maintain and enhance tree canopy cover and green space across the Central Coast urban areas. The Strategy aims to have no loss of canopy cover across each residential suburb.

What are the overarching principles of the Strategy?

- 1. The Urban Forest is a valuable community asset, providing a range of benefits.** The Urban Forest on both private and public land benefits the Central Coast community through the provision of ecosystem services, for example through limiting the effects of urban heat islands. As such, the Urban Forest is a valuable community asset.
- 2. Public open space is enhanced by suitable plantings of large shrubs and trees and tree planting and replacement must be an integral part of all open space planning.** Open space planning must plan around existing plantings and supplement these as required. Trees and shrubs are an important component of open space and must be adequately included.
- 3. Existing trees, in particular the species canopy have a high replacement value and should be given precedence over conversion to alternative land uses.**
- 4. The urban forest canopy must be maintained at the suburb scale, with any loss being offset through supplementary planting nearby.** Despite the challenges to the maintenance of urban forest canopy cover in relation to increasing residential densities, Strategies must be put in place to ensure that the urban forest canopy is maintained at the suburb scale. This may include incorporation of appropriate planting areas for the establishment of medium-sized trees within higher density developments or greater emphasis on tree avoidance during the planning stage of individual developments.
- 5. Trees can contribute to a particular sense of place for individual locations or suburbs and as such, tree cover in those areas should be maintained or expanded.** Trees may make a particular location feel a particular way, such as Norfolk Island pines at Terrigal and The Entrance or canopy trees retained at Pearl Beach. In areas where trees provide a particular sense of place to a location, successful planning and retention of those elements should be considered to ensure



that they are maintained into the future. If the maintenance of these specific elements cannot occur, their replacement must be supported by appropriate evidence, community consultation and support.

6. Native trees and shrubs provide greater habitat value to wildlife than exotic species and as such, should be favoured over exotic species.

In general, native trees and shrubs provide greater habitat value to wildlife, such as rainforest trees that provide fruits and Eucalypts that provide blossom. Some exceptions do occur, such as exotic trees that produce extensive blossom or fruit; however some exotic species may become bushland weeds and should be avoided for use.

7. The Urban Forest can provide habitat for a range of urban wildlife and may function as a corridor for birds and other wildlife.

While the bushland areas of the Central Coast act as reservoirs for biodiversity, they are often fragmented by residential or other development. The maintenance and expansion of tree canopy will allow the movement of some species of wildlife to move among bushland areas.

8. The planting and maintenance of trees and large shrubs may not always be possible, but other urban greening can still contribute to the broad aims of urban forestry.

One of the main aims of this Strategy is to encourage the planting of trees in an urban context, however there are strong integrations with other green infrastructure such as rain gardens, green roofs and walls.

and median strips planted with midstorey vegetation rather than being filled with concrete. This Strategy supports an overall increase in urban greenspace irrespective of land tenure.

9. At times ageing or defective trees may need replacement, however their removal must be supported by appropriate expert opinion or analysis.

The Urban Forest is a living thing and as such, over time tree death, defects or disease may occur. This means that tree removal may be required, however their removal must be supported by expert opinion from an Arborist or other expert.

10. The engagement of the community is essential in the implementation of this Strategy.

This Strategy covers all land on the Central Coast and as such, requires the engagement of the community who are able to contribute to the success of this Strategy. Community engagement may include individuals planting trees and shrubs on private land, pruning rather than removing trees on private land or participation in Council's Landcare and development of the Backyard Habitat program.





Priority implementation actions

Specific targets for planting in each of the 18 priority suburbs have not been proposed as these numbers should reflect actual site conditions. It is therefore a priority to prepare suburb specific replanting plans that identify the location for each proposed tree, the most suitable size of tree and or species and from these, develop the required resourcing for implementing the suburb specific replanting plan.

At times planting may need to occur within the road reserve which may need to be reconstructed to allow for planting, such as through incursion into the pavement. In other suburbs where resources permit, available areas for replanting may also be determined and replanted where resources are available.

The field investigations completed as part of this Strategy identified an ageing canopy within Council's parks. This means that trees within the parks may require removal in the medium-term and as such successional planting needs to commence if current levels of canopy cover are to be maintained in

parks. Stormwater detention basins should be assessed to determine their suitability for the establishment of canopy trees basin to determine their suitability for the establishment of canopy trees. This may be through civil works that allow for replanting of moisture tolerant trees..

This Strategy requires the consideration of green infrastructure in the form of rooftop gardens and green walls as part of all development as well as possible minor changes to Council's existing planning controls as part of the Comprehensive Local Environmental Plan project. The updated planning controls must also specify that planting is part of all development applications that come before Council for consideration. These amendments to Council's planning controls will also specify that in new developments a particular calculated area of landscaping where larger shrubs and trees can be established is required. This will increase the level of urban amenity and mitigate contributions of developments to the Urban Heat Island

Effect.

This Strategy does not propose immediate planting and instead relies upon suburb scale assessments for planting opportunities in 18 priority suburbs. Along with an audit of all areas of passive open space planting plans will be developed by June 2021 with the first four suburbs being assessed by June 2020 to allow for planting to commence. The audit will consider the presence of underground and aboveground services and other constraints which will first be developed during a geographical information systems exercise which will prepare 'no go' areas before on ground assessments of possible planting locations are assessed. If a location is deemed suitable for planting, the location will be marked by a GPS and added to a database including recommended tree species.

Community education is an important part of this Strategy and as such a priority will be to develop a website informing the community on the numbers of field assessments that have been completed,



future planting locations, completed planting locations and how to become part of the Backyard Habitat program.

Council during the implementation of its work program removes trees and shrubs for the construction of roads, cycleways and other infrastructure. During these projects, this Strategy expects that the proponent of each project engage with Council's arboriculture staff to ensure the minimum number of trees and shrubs are removed for each project and the number of retained trees and shrubs are documented on Council's website. Council's Environmental Assessment method will also be modified to ensure the offset planting of removed trees at a ratio of 2:1 in a nearby suitable location.

This Strategy does not include specifications on species selection, stock selection and a procedure for determining the most appropriate species for an available location. Instead within one year of endorsement of this Strategy, Council is to prepare a species selection matrix which will be reviewed on a regular basis which will be prepared in

accordance with Tree Stock for Landscape Use or any subsequent Standard.





IMPORTANT CONSIDERATIONS

Ensuring the implementation of this Strategy does not significantly increase bush fire risk

Approximately 70% of the Central Coast is classified as bush fire prone and historically large bush fires have occurred regularly. It is important that tree management completed as part of this Strategy does not significantly increase bush fire risk to assets on the Central Coast. This will be achieved by the following practices in bush fire prone land:

- Installation of large shrubs and trees rather than ground layer vegetation in bush fire prone areas, where ground layer vegetation will be maintained through regular mowing and slashing;
- Installing canopy plantings that contain smooth, less flammable bark in bush fire prone areas;

- Ensuring a gap of at least two metres occurs between the roofline any building and likely edge of canopy plantings;
- Ensuring that planted trees reach a maximum intended canopy of less than 15% foliage cover, with spacing of at least five metres between stems.
- Priority will be given to planting non-sclerophyll species at the bushland interface with species with high moisture such as Lilly Pilly and Tuckeroo.
- Suburb specific planting plan or park successional planting plan, these will be compliance with relevant Codes of Practice such as the Rural Fire Service's Planning for Bush fire Protection.

The importance of appropriate tree selection

Historically during the planting of trees on road reserves, their future size was not always considered. This resulted in damage being caused to roads and footpaths and the requirement of regular pruning of trees

planted under power lines. At other times, species selection has not considered aspects such as provision of shade, benefits to wildlife or use of species that are best suited to the space.

To ensure appropriate tree species selection, the following questions must be addressed during place based planning including:

- Are there height restrictions for the site, such as overhead power lines or nearby buildings? If so, only plants with an estimated maximum height of less than five metres should be used.
- Are underground services present? If could sedges, grasses or small shrubs be used?
- Is the site highly developed such as within a main street and as such, is a deciduous species more suitable for use than an evergreen species such as allowing additional solar access in winter.
- How large is the space? Should a species that reaches a large maximum height and spread be used rather than smaller specimens from species that reach a smaller height and spread? What planting mix would best address any heat island issues?



- How can the specimen enhance the space? For example, would a large tree with a future spreading canopy enhance the space or would the space feel cramped?
- In parkland situations, which specimens will enhance the passive recreational opportunities of the area? In these situations, one or two larger species should be used instead of multiple smaller ones.
- Are there other historical plantings in the area which future plantings need to complement? If so, the same or similar species must be considered.
- Is the site on bushfire prone land? If so, bushfire considerations need to be met.
- Is the site adjacent to bushland? If so, only local native species should be used.

The selection of appropriate tree stock is also essential, with any trees planted as part of this Strategy being in accordance with any relevant Australian Standard regarding Tree Stock for Landscape Use. Prior to Council accepting any stock, inspections must occur to ensure root growth and growth form is consistent with the Australian Standard.





The importance of involving community groups in implementing this Strategy

Existing community groups are already actively involved in promoting the retention and expansion of the urban forest. It is considered that these types of groups offer the greatest benefit in incorporating their on-ground work in parks rather than along roads due to the inherent risks along roadsides from utilities and traffic.

Street tree planting events will occur through Council coordination rather than through coordination by community groups. These events will occur where 10 or more properties on a street contact Council requesting street tree planting in a single application by Council staff. Council will then contact a representative of the interested residents and arrange a date for

planting. Tubestock will also be provided to the residents as part of the Backyard Habitat program. It is then expected that the residents will undertake initial watering and monitoring of trees to determine if failure or damage occurs.

Development of the Backyard Habitat program

The majority of the Urban Forest occurs on private land and as such, the involvement of the community in protecting and expanding the urban forest is paramount. To maintain and expand the urban forest on private land, a three year trial of the Backyard Habitat program will be trialled where residents can join the program and receive free tubestock to be planted on their property along with advice and networking opportunities with other local residents.

What is Citizen Science and how does it relate to this Strategy?

Urban ecology is the scientific study of the relationship among plants and animals with each other and their surroundings in the context of an urban environment. In the Central Coast context, urban ecology may relate to the use of trees, shrubs and groundcovers in areas such as parks, road reserves and backyards by different species of wildlife. The urban forest is often used by a range of invertebrates, birds and mammals or may contribute foraging habitat for species such as the Gould's Wattled Bat while it forages for insects. This Strategy supports the use of Citizen Science programs to quantify the value of the Central Coast urban forest as providing habitat for fauna, including insects, mammals and birds.

Possible Citizen Science programs that will be investigated for development through the Backyard Habitat program include:



- The development of a smartphone application which allows the community to log sightings of different vertebrate and invertebrate wildlife, including the establishment on an online community that can assist with species identification.
- Annual urban ecology "BioBlitz" events to engage the community in Citizen Science activities, where the community participate in activities to survey invertebrates and vertebrate fauna in urban parks along with quantifying diversity of plants and fungi.

Processes for ensuring the replacement of removed public trees and maintenance of urban wildlife habitat

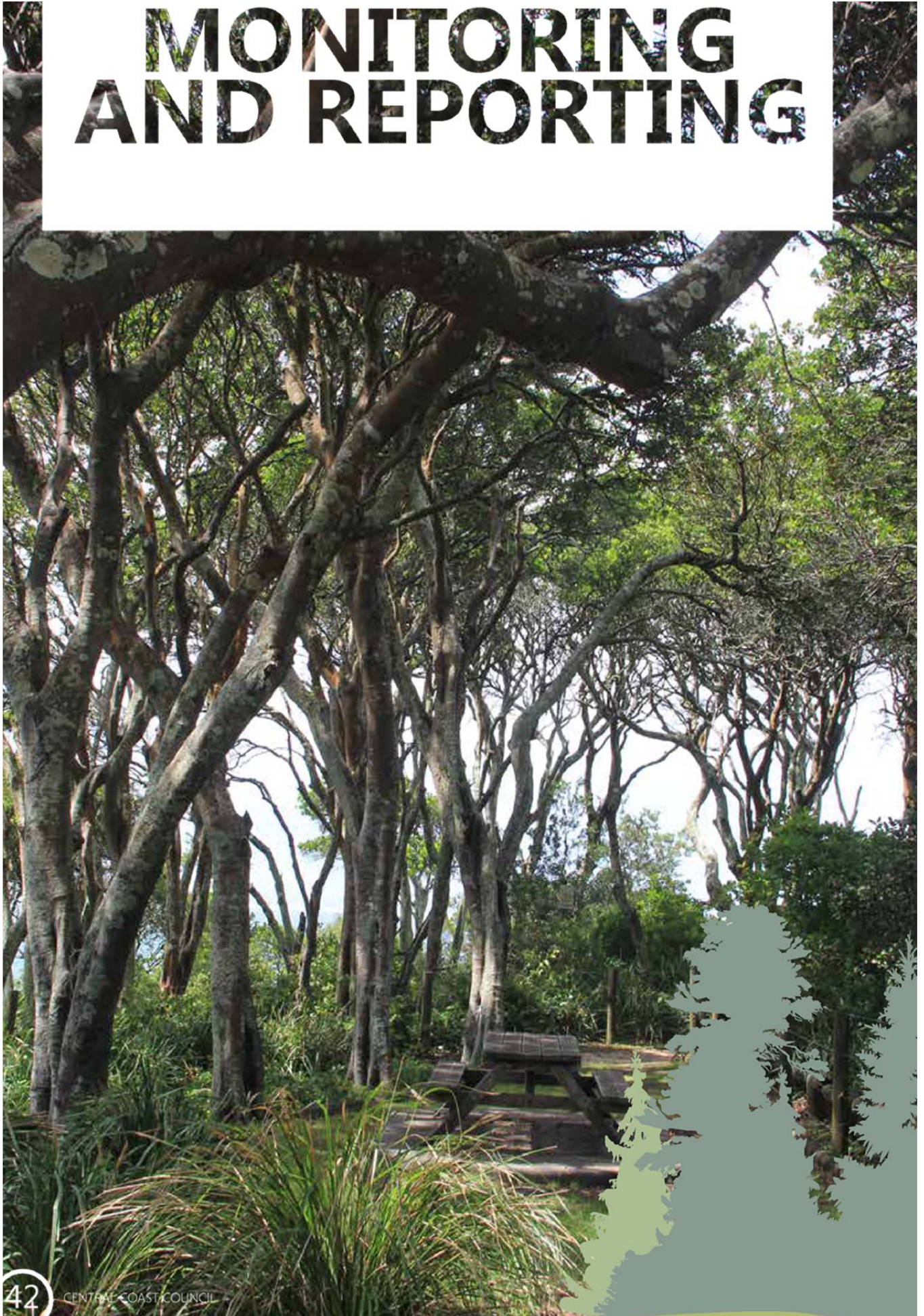
Each year Council removes over 1,500 public trees and in order to ensure that public tree canopy cover is maintained, this Strategy identifies a number of standards in which removed trees must be adequately replaced and maintained. These are:

- All removed trees must be replaced within 12 months of their removal by no less than two replacement trees.
- Where practicable, replacement trees should be planted within 50 metres of the site of the tree removal or alternatively within the same suburb.

- Replaced trees must be monitored for no less than two years and if they are substantially damaged or die during that time, they must be replaced.
- If removed public trees contain tree hollows, their loss must be compensated by the installation of at least two nesting boxes nearby for every hollow that is lost.

This process is captured within Council's internal systems and subject to regular internal reporting.

MONITORING AND REPORTING



Monitoring, evaluation, reporting and improvement strategies for the urban greening

A Monitoring, Evaluation, Reporting and Improvement (MERI) committee will be established to guide the implementation of this Strategy. It will consist of representatives from relevant sections of Council. The committee will meet twice annually and track the progress towards meeting the identified actions and benchmarks. Once every two years the committee will undertake a review of the identified actions and determine if the actions require amendment or modification, allowing for continuous improvement of the Strategy. A full review of the Strategy will occur in 2025 and 2030. The full review is to:

- Resurvey of tree canopy cover using the iTree application in each urban suburb.
- Resurvey of heat island mapping using Landsat 8 imagery to determine the level of change in heat mapping.
- Determine if the level of tree removal has changed over time and if so, if additional planting is required in suburbs not currently considered for broadscale planting.
- Determine if the levels of identified planting are being met and if not, what strategies can be put in place to meet the planting targets.



STRATEGIES AND ACTIONS

Strategic Goals

Strategic Goal 1: Sustain and enhance the existing urban forest including associated cover such as shrubs and gardens, on an intergenerational basis.

Strategic Goal 2: Ensure appropriate space is retained across all lands within the CCC LGA to allow for the direct or indirect replacement of removed trees and shrubs, and facilitate new plantings.

Strategic Goal 3: Engage and support the community during the implementation of the Greener Places Strategy

Strategic Goal 4: Ensure that a suitable tree species, in optimal densities with optimal maintenance are used for planting to ensure the urban forest reaches its full potential and reduce infrastructure interaction.

Strategic Goal 5: Establish integrated asset management between green and built assets to enable sustainable, whole of asset life outcomes for all asset classes, and reduce Council's corporate risk profile.

Strategic Goal 6: Undertake appropriate monitoring and data collection to ensure Council is informed of the status of the Urban Forest.

Strategic Goal 7: Maintain and increase habitat for urban wildlife.

Strategic Goal 8: Mitigate the Urban Heat Island Effect.

Action Categories

Policy and Planning (P&P): relates to improving policy and planning around urban greening management.

Tree Management (TM): relates to improving the management of trees on both public and private land.

Community Engagement and Education (CEE): relates to how this Strategy will engage the community.

Expanding Habitat for Urban Wildlife (EXP) which relates to how this Strategy will increase the amount of habitat available for urban wildlife, including insects, birds, reptiles and mammals.

Action number	Strategic goals	Action
Policy & Planning		
P&P 1	1,2,8	Prepare planning controls to improve tree planting and retention outcomes from development.
P&P 2	4 & 7	Develop relevant operational and technical specification manuals for urban greening & private and public tree removal / replacement in roads and open space.
P&P 3	4	Review and align relevant procedures/ processes to ensure tree management compliance with relevant Australian Standards for trees.
P&P 4	4 & 5	Develop a tree management system (tool/ database) to determine planting locations, record, analyse risk and inform ongoing tree planting (such as unmanaged land, successional planting) & replacement.
P&P 5	1, 7 & 8	Develop a Central Coast Green Grid Plan.
P&P 6	1, 7 & 8	Develop a Central Coast Green Grid Plan for the region by December 2020.
P&P 7	1	Develop methodology & process to review and update local heritage significance tree in the Comprehensive Local Environmental Plan on needs basis.
Tree Maintenance		
TM 1	1 & 2	Prepare an operational plan for strategic public tree replacement at a ratio of 2 replacement trees for every removed tree across the region.
Community Engagement & Education		
CEE1	3	Identify opportunities for community partnerships to fund and resource landscaping and streetscape improvement projects.
CEE2	3	Develop and promote community/School programs and events to improve regional biodiversity and tree management such as a Backyard Habitat program, Citizen Science program & support establishment of native gardens on private lands.
Increasing habitat urban wildlife and reducing urban heat Island effects		
EXP1	7	Review and update Water Sensitive Urban Design Manual and Civil Works Specification to increase areas of non-forested habitat.

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APPENDIX





Central Coast Council Heat and Tree Canopy Mapping Analysis

Project report

December 2018



Central Coast Council Heat and Tree Canopy Mapping Analysis

Prepared for Central Coast Council

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1 Introduction

1.1 Background

The liveability of cities and their resilience to climate change is influenced by a range of factors including the extent and quality of green infrastructure and the presence of urban heat islands. Tree canopy cover is a key part of green infrastructure in a city and is receiving increasing attention from urban land planners and managers nationally and internationally. This is due in large part to trees being recognised for providing multiple benefits including improved human health and wellbeing, improved amenity and air quality, and noise abatement, climate change mitigation through carbon sequestration in plants, economic benefits from enhanced commerce and property values, and climate change adaptation through reduction of the urban heat island effect by shading and transpiration.

Urban heat islands are areas that retain more heat than the surrounding landscape. The presence of urban heat islands is a key concern for local government given that extreme heat leads to greater mortality in our community than any other natural hazard. This is especially so for vulnerable members of the community. Green infrastructure, including grassed areas and trees on public and private property can help to moderate surface and air temperatures and thus reduce the impact of the urban heat island effect.

1.2 Objectives and structure

Mitigating urban heat islands and investing in green infrastructure are priorities under the Central Coast Council Community Strategic Plan. As part of its response to these priorities, Council is developing a Central Coast Urban Forestry Strategy. This Strategy will inform the management of the urban forest over the next 30 years.

Central Coast Council engaged Seed Consulting Services, working in partnership with EnDev Geographic, to undertake urban heat mapping and tree canopy analysis for the settled areas across the Council. The objectives of this project are to:

- provide exploratory insight into how landscape and development decisions have impacted heat distribution across Central Coast Council, and in turn, how heat affects liveability; and
- determine the level of tree canopy coverage across each suburb of Central Coast Council.

This work provides landscape-scale analysis of urban forest canopy cover and the thermal distribution across suburb and council scales, and over time, to provide robust decision-making support for how the Council considers its urban forest and heat effects in the planning process.

2 Urban Heat

2.1 Assessing urban heat

2.1.1 Approach and method

To provide a high-level assessment of the thermal performance of the Central Coast Council landscape, two satellite datasets were acquired from the Landsat 8 Operational Land Imager. The two datasets (captured on January 19, 2018 and March 27, 2013) were both collected on warm days with the BOM reporting a maximum temperature in the area of 30.6°C and 29.5 °C, respectively (BOM 2018). A timeseries of land surface temperatures and vegetation indices were created, urban heat island and change analyses were conducted, and summary statistics were calculated at the council and suburb scales.

Satellite thermal data provide an extensive, inclusive view of heat distribution across a large area, collected at a single moment in time. For this study, two Landsat 8 Satellite datasets, collected on January 19th, 2018 and March 27th, 2013 at approximately 11:05am local flyover time, were analysed to assess the thermal profile of the Central Coast Council. Landsat 8 provides the highest resolution thermal data (100m2 resampled to 30m2) freely available from satellite platforms. Each image was converted from raw digital data into land surface temperature using the standard processing protocol (Landsat 8 User's Manual 2016, Martin et. al., 2015). For each of the two Landsat datasets, land surface temperature was calculated using both bands 10 and 11 resulting in two thermal images that were then averaged to produce the composite Land Surface Temperature maps of the Council for 2018 and 2013.

In addition to general heat distribution, heat concentration was also assessed through the inclusion of a heat island assessment. Heat islands, specifically Urban Heat Islands, are any areas that exhibit a significant warming above what would naturally occur in area, driven by light coloured, low density, respirating, natural materials being replaced by high density, often dark, dry, man-made materials that absorb heat more readily, leading to artificial hot spots. To assess heat islands, the two datasets were normalized around the mean value, creating a map of "relative heat" presented in degrees Celsius above and below the mean value. Heat islands were identified as any areas warmer than 2 °C above the mean, and extreme heat islands were identified as any areas warmer than 4 °C above the mean.

Landsat 8 data contains nine datasets in addition to thermal information. For the same acquisition dates, the Normalized Difference Vegetation Index (NDVI) was also calculated (Al-doski et al. 2013). Plants undergoing photosynthesis give off a strong signal of near-infrared light, undetectable to the human eye. NDVI uses the difference between red and near-infrared signals to determine the amount of photosynthesis going on in a given area and is presented here as the NDVI map.

Temperatures, heat islands, and NDVI values were assessed for each of the 156 suburbs within Central Coast Council, with additional focus on the 11 target suburbs identified.

Temperature and NDVI values were calculated for both the 2018 and 2013 timepoints, and a timeseries analysis was applied to identify the trend and magnitude of changes that have occurred over the intervening period.

The key deliverables from this analysis are:

Data:

- 2018 Land Surface Temperature Dataset (.tif)
- 2018 Urban heat islands (.tif)
- 2018 NDVI (.tif)
- 2013 Land Surface Temperature Dataset (.tif)
- 2013 NDVI (.tif)
- Council results spreadsheet (.xls)
- Suburb results spreadsheet (.xls)

Maps:

- 2018 Heat Islands Map
- 2018 Land Surface Temperature Map
- 2018 NDVI Map
- 2013 Land Surface Temperature Map
- Heat Change Map 2013-2018
- 2013 NDVI Map
- NDVI Change Map 2013-2018

2.1.2 Understanding urban heat

The data collected describe the land surface temperature of the study area which directly influences air temperature. The varying influence of surface heat on air temperature is governed by local conditions known as micro-climates. In addition to surface heat, many local factors affect air temperature including building shadows, urban wind-tunnelling, and fountains which have a cooling effect, and air conditioners, traffic exhaust, and other sources of waste heat which have a warming effect. Understanding the balance between surface and air temperature requires a detailed micro-climate model.

Region wide surface temperature information provides an appropriate and sufficiently reliable indicator on which to base landscape scale recommendations about where to prioritise heat mitigation activities. This is because it reflects locations where air temperature and absorbance of solar radiation is high, which impacts directly on human thermal comfort (Matzarakis, et al., 2007 in Norton, et al., 2015).

2.2 Urban heat analysis results

Land surface temperatures and the presence of urban heat islands are discussed first based on 2018 satellite imagery followed by an assessment of the change in surface temperature between 2013 and 2018. NDVI is then assessed to provide an overall indication of greenness in 2018, and as a change since 2013, followed by discussion of the heat characteristics of 12 target suburbs nominated by Council.

2.2.1 2018 Land surface temperature

Analysis of the 2018 land surface temperature map shows a medium range of temperatures from 21 to 43 °C (Figure 1). Warmer areas appear to concentrate among urban areas not immediately adjacent to the coast, suggesting a pronounced cooling influence from the ocean, but not from internal water bodies (Table 1). Other concentrations of heat occur in most developed areas including agricultural corridors along Peats Ridge Rd., Wisemans Ferry Rd., and George Downs Dr. Overall, forested areas presented a strong cooling signal, with some variation driven by the aspect (direction of slope) of the hills and other drivers of vegetation health.

The hottest suburbs concentrated amongst the more developed areas, near but generally not immediately adjacent to the coast. The southern end of the council holds the hottest three suburbs, all measuring greater than 4 °C above average: Ettalong Beach, Umina Beach, and Booker Bay (*part of Woy Woy likely fits in this group as well. For further discussion see limitations*) (Table 1). The other hottest suburbs are spread across the central and northern regions, among near-coastal areas.

Open areas can have wide ranging heat signatures based on vegetation cover and condition. Dry barren earth can easily become some of the hottest areas in a landscape, but well-watered vegetation can be some of the coolest. Different parts of the agricultural season can have similarly divergent heat effects. As harvest season approaches, many crops are left to dry in the field, causing them to act more like barren earth than vegetation which may help explain the strong heat signal from the interior.

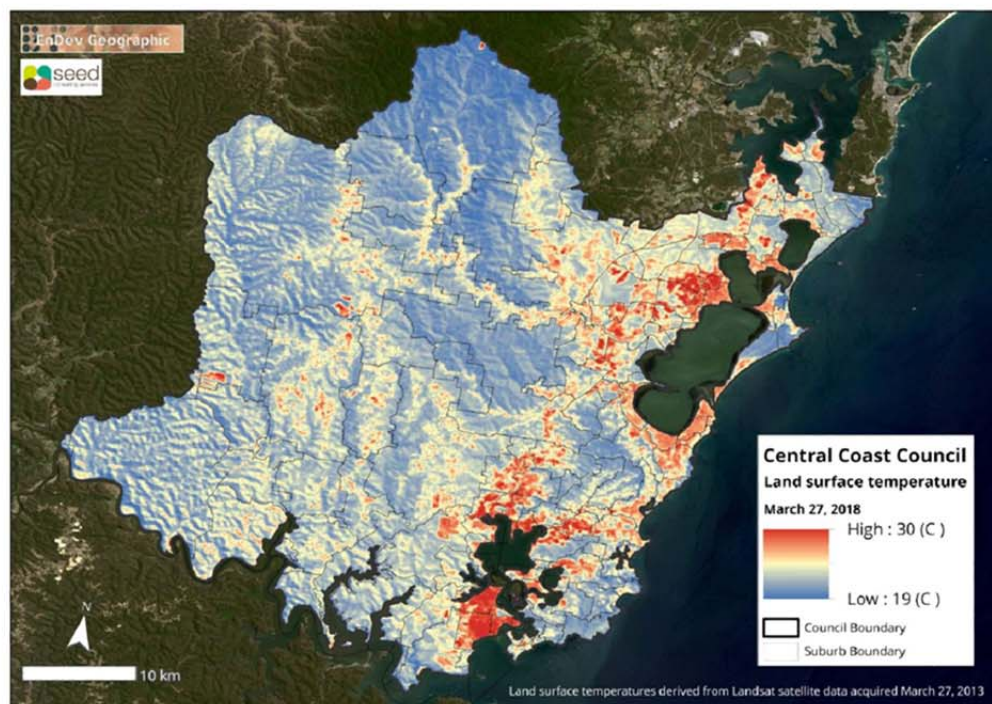


Figure 1. 2018 Land surface temperature map.

Table 1. 2018 Ten hottest suburbs.

Rank	Hottest Suburbs 2018	Temperature above baseline (°C)
1st	ETTALONG BEACH	5.73
2nd	UMINA BEACH	4.38
3rd	BOOKER BAY	4.37
4th	WOONGARRAH	4.07
5th	BLUE HAVEN	4.00
6th	POINT FREDERICK	3.97
7th	EAST GOSFORD	3.97
8th	LAKE HAVEN	3.88
9th	WATANOBBI	3.80
10th	LONG JETTY	3.41

2.2.2 2018 Heat islands

The distribution of urban heat islands largely follows the patterns presented in the temperature map (Figure 2), but this is not always the case. Mixed-use areas that break up heat absorbing landscapes with cooling features such as green infrastructure and lighter coloured surfaces, can present localised hotspots that do not accumulate to larger heat islands. In this study, the most dominant heat island signal comes from the suburb of Long Jetty with over 90% of its area falling within a heat island (Table 2). Although it is only the 10th hottest suburb, its more homogenous land cover means there is little relief from the heat, whereas hotter suburbs have more concentrated heat islands. Heat islands pose a serious challenge in this area as the ten suburbs with the highest proportion of heat islands all have 80% or more of their area classifying as a heat island.

Within heat islands there often exists areas of further heat concentration, called extreme heat islands. Of the ten suburbs with the highest percentage of extreme heat islands, seven are also in the top ten hottest suburbs overall, suggesting extreme heat islands warrant more attention in considering heat mitigation options.

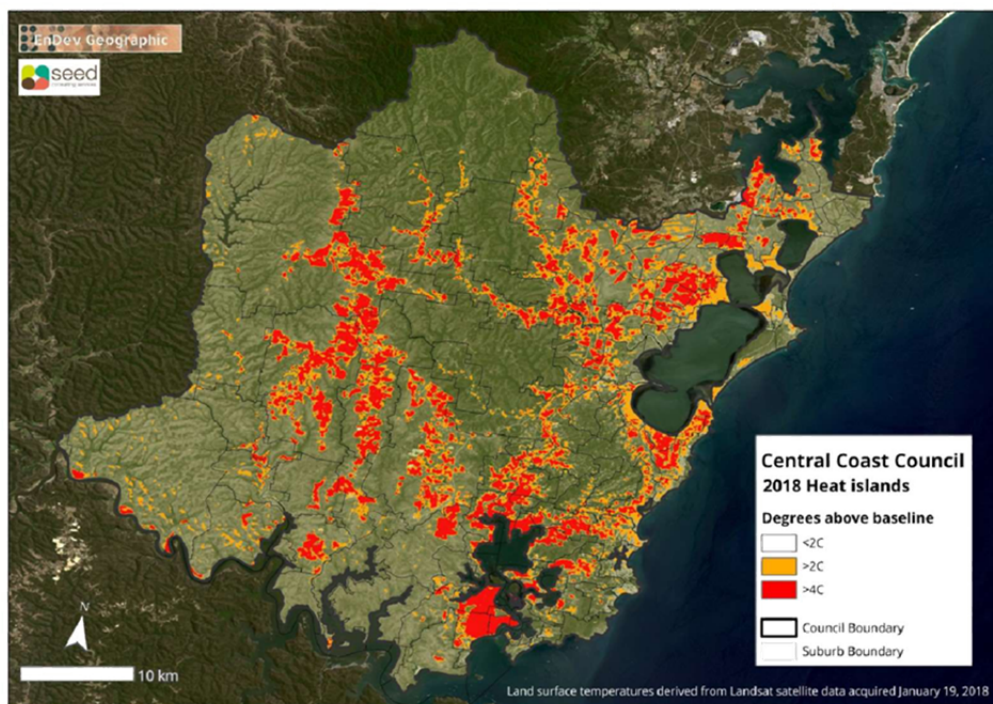


Figure 2. 2018 heat islands map.

Table 2. Suburb heat island ranking.

Rank	Suburbs with the highest proportion of heat islands 2018	Temperature above baseline (C)
1st	LONG JETTY	91.0%
2nd	LAKE HAVEN	88.9%
3rd	GOROKAN	87.0%
4th	WATANOBBI	86.8%
5th	WOONGARRAH	85.9%
6th	KILLARNEY VALE	83.5%
7th	UMINA BEACH	82.8%
8th	ETTALONG BEACH	81.1%
9th	BLUE HAVEN	79.9%
10th	KANWAL	79.7%

2.2.3 2013 Land surface temperature

Landscape temperatures in 2013 demonstrated a similar pattern of cool forests, warm cities, and mild coastal areas (Figure 3), but distinctly lacking the patterns of heat in the agricultural areas identified in 2018. As this data was collected in a different season—spring instead of march—it is likely that this signal is associated with a different phase of the crop cycle, more of a short-lived land cover change than a long-term land use change. Of the hottest suburbs in 2013, many are the same with 7 suburbs ranking in the top 10 both in 2013 and 2018 (Table 3). The relationship with vegetation is a driving influence, with all 10 of the 2013 hottest suburbs falling in the bottom quartile of NDVI values.

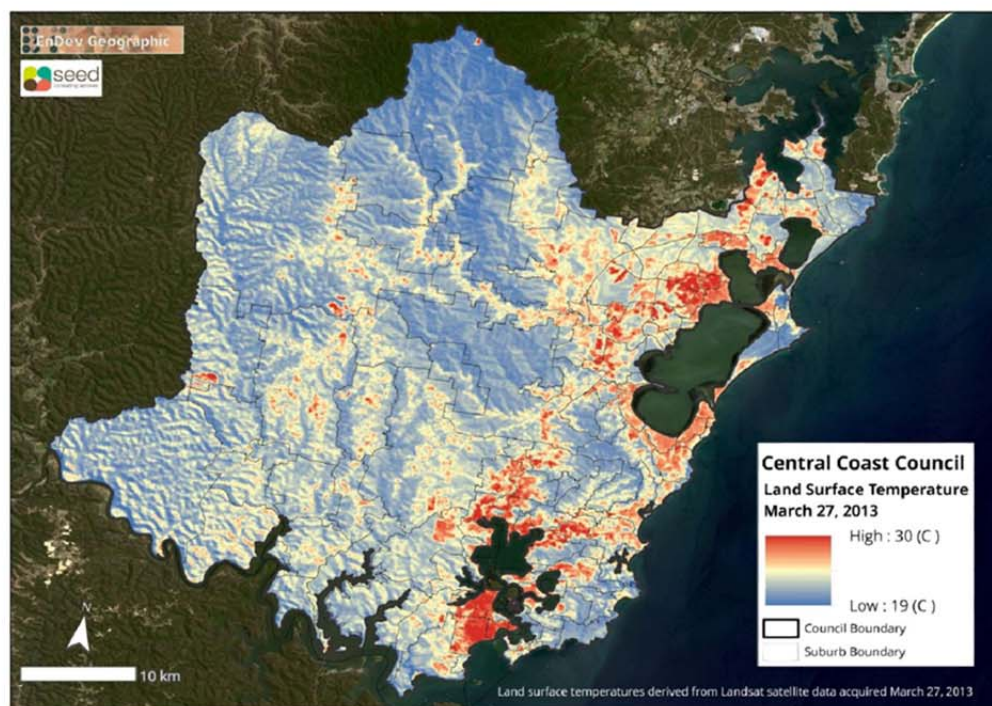


Figure 3. 2013 Land surface temperature map

Table 3. 2013 Ten hottest suburbs.

Rank	Hottest Suburbs 2013	Temperature above baseline (C)
1st	LAKE HAVEN	3.26
2nd	ETTALONG BEACH	3.16
3rd	UMINA BEACH	2.94
4th	BOOKER BAY	2.60
5th	GOROKAN	2.51
6th	KANWAL	2.28
7th	POINT FREDERICK	2.25
8th	LONG JETTY	2.23
9th	WATANOBBI	2.22
10th	WOONGARRAH	2.19

2.2.4 Change in thermal landscape 2013-2018

Assessing thermal landscapes over time reveals where changes have occurred and, knowing what actions have taken place in that area, allows a better understanding of the thermal impacts of land use decisions. Comparing the 2018 land surface data with the 2013 data reveals several patterns: major warming in the agricultural interior, warming in some urban areas, slight cooling along coastal areas, but with the majority of the area unchanged (Figure 4). The most dominant of these patterns, the warming of the agricultural interior is most likely a result of different phases in the crop cycle between January and March, as discussed previously.

While most suburbs fall in the middle, five suburbs were in the 10 hottest in 2013, 10 hottest in 2018, and were also in the 10 that warmed the most during that period: Ettalong Beach, Woongarah, Booker Bay, Point Frederick, and Watanobbi. These suburbs may warrant additional, more localised assessment (Table 4).

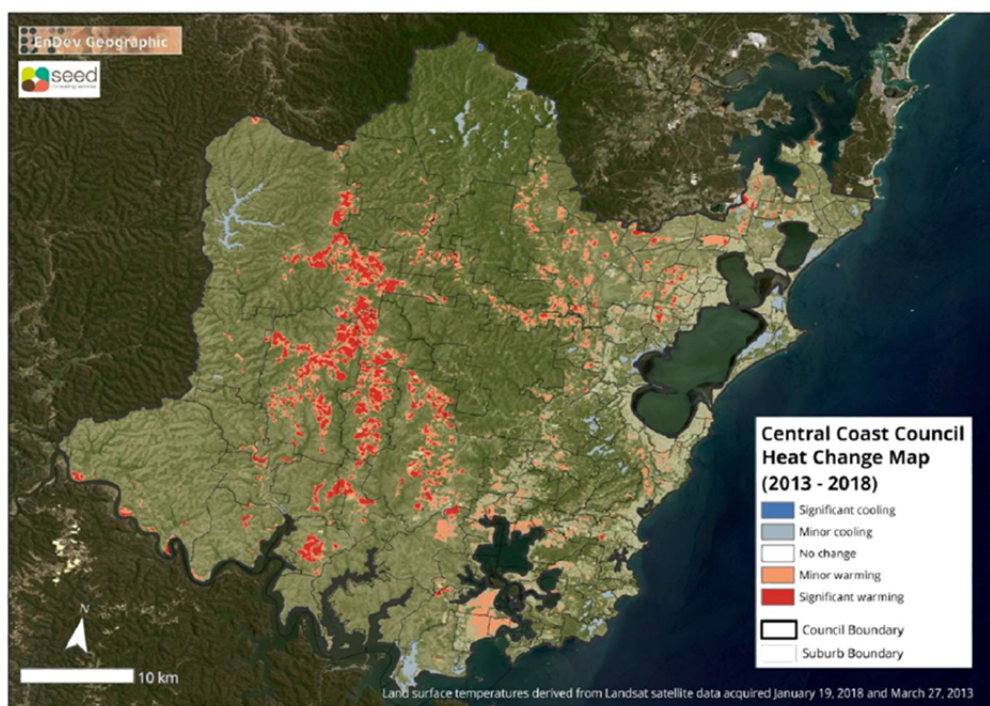


Figure 4. Heat change map 2013-2018.

Table 4. Suburbs experiencing the greatest warming between 2013 and 2018.

Rank	Suburbs experiencing the most warming between 2013 and 2018	Temperature increase (C)
1st	ETTALONG BEACH	2.57
2nd	ALISON	2.03
3rd	PEATS RIDGE	1.96
4th	BLUE HAVEN	1.88
5th	WOONGARRAH	1.88
6th	EAST GOSFORD	1.79
7th	BOOKER BAY	1.77
8th	KIAR	1.76
9th	POINT FREDERICK	1.72
10th	WATANOBBI	1.58

2.2.5 2018 NDVI

The Central Coast Council lies in a lush coastal region of New South Wales. On a scale of -1 (barren earth) to 1 (tropical rainforest), the mean NDVI value the Council registered at 0.34 verifies the heavy degree of vegetation. The 2018 NDVI map reveals a strong corridor of vegetation from Ravensdale, across western Jiliby, down through Ourimbah, and ending in Macham (Figure 5). The western region and other areas are heavily vegetated, but this NNW-SSE corridor appears particularly lush and holds all 10 of the suburbs with the highest NDVI values (Table 5).

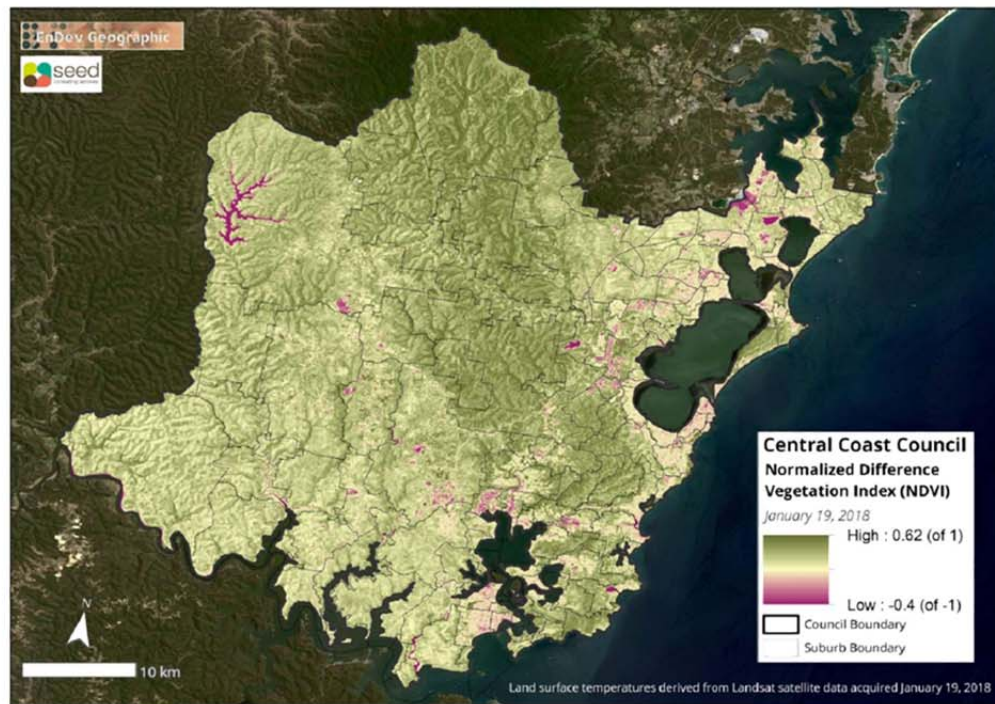


Figure 5. 2018 NDVI map.

Table 5. Suburb statistics of NDVI.

2018 Highest NDVI Suburbs			2013 Highest NDVI Suburbs		Greatest NDVI Change Suburbs (2013-2018)	
Rank	Suburb	2018 NDVI Mean Value (-1 to 1)	Suburb	2013 NDVI Mean Value (-1 to 1)	Suburb	NDVI Increase
1st	RAVENSDALE	0.43	LITTLE JILLIBY	0.40	WISEMANS FERRY	0.06
2nd	LEMON TREE	0.41	PALMDALE	0.39	RAVENSDALE	0.06
3rd	LITTLE JILLIBY	0.41	PICKETTS VALLEY	0.39	BOX HEAD	0.05
4th	PALM GROVE	0.41	WYONG CREEK	0.38	COGRA BAY	0.05
5th	HOLGATE	0.41	MATCHAM	0.38	LEMON TREE	0.04
6th	OURIMBAH	0.40	HOLGATE	0.38	TEN MILE HOLLOW	0.04
7th	CEDAR BRUSH CREEK	0.40	PALM GROVE	0.38	CEDAR BRUSH CREEK	0.04
8th	WYONG CREEK	0.40	GLENNING VALLEY	0.38	MARLOW	0.03
9th	MATCHAM	0.40	RAVENSDALE	0.37	PHEGANS BAY	0.03
10th	PALMDALE	0.39	MOUNT ELLIOT	0.37	PALM GROVE	0.03

2.2.6 Change in NDVI 2013-2018

To further understand the role of vegetation and green infrastructure in the changing thermal landscape, NDVI was also calculated from the 2013 data for comparison, resulting in an NDVI change map (Figure 6). Comparing NDVI from differing seasons presents challenges as the photosynthesis varies during different parts of the growing season. The biggest apparent change occurs in the “browning” of the agricultural region, again, most likely capturing different parts of the crop cycle, and the “vegetation corridor” appears to increase in lushness. However, the most useful aspect of the NDVI change map lies in the peri-urban area where purple areas identify locations that have shifted from *vegetated* to *built*. Land use change and build-out in suburbs such as Mount White, Terrigal, Hamlyn Terrace, Woongarah, and Gwandalan are easily identifiable in the NDVI change analysis.

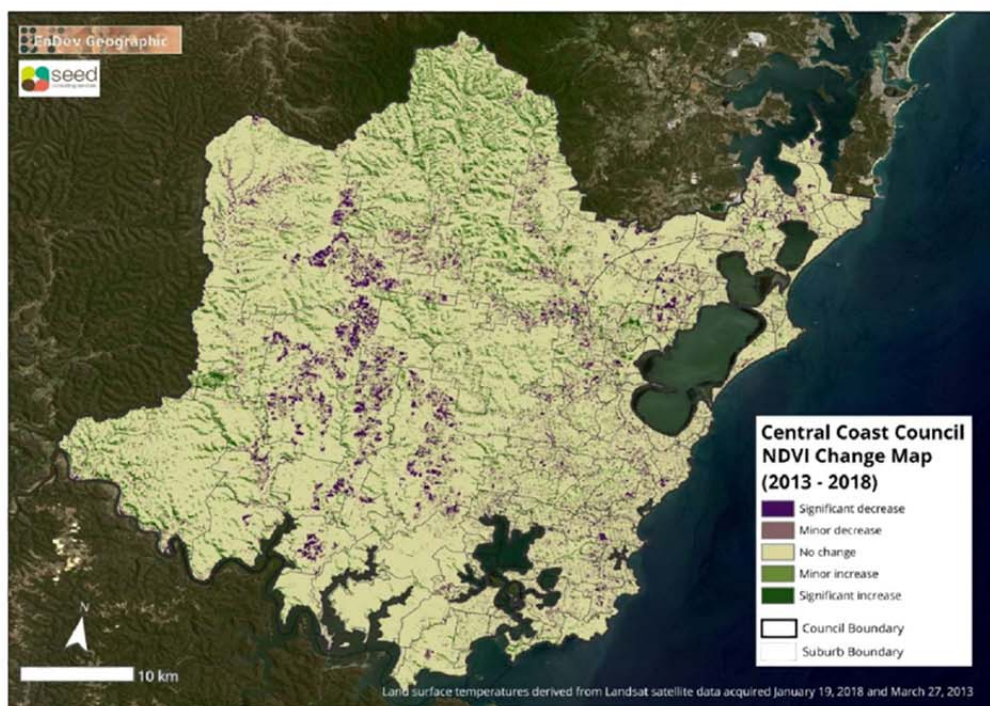


Figure 6. NDVI change map from 2013-2018.

2.2.7 Target suburbs

The 11 target suburbs identified for this analysis generally fall within the middle 50% of the range for all suburbs, across all included measures. Lake Haven does stand out as being the 8th warmest suburb, with Gosford, Erina, and The Entrance also falling in the top 25% of warmest suburbs (Table 6). These four suburbs also contain considerable heat islands with all of them having more than half of their areas registering more than 2 °C above average. All of the target suburbs have moderate-high NDVI scores that barely changed between 2013 and 2018. Overall, these 11 suburbs do not stand out from the broader area evaluated in this assessment.

Due to the limited resolution of the satellite-based data, maps of the target suburbs are presented in two groups corresponding to Southern (Figure 7 & Figure 8) and Northern Suburbs (Figure 10 & Figure 11).

Table 6. Suburb statistics of target suburbs

Suburb	2018 Warmest Suburb Rank	2018 Heat Islands (>2C) Coverage (%)	2018 Mean Temp deviation from baseline (°C)	2013 Mean Temp deviation from baseline (°C)	Temp Increase Rank	2018 NDVI Mean Value (-1 to 1)	Change in Mean NDVI between 2013 and 2018
ERINA	17th	66.6%	3.05	2.00	26th	0.27	0.00
GOSFORD	14th	63.8%	3.21	1.89	15th	0.25	0.00
KARIONG	71st	15.5%	0.74	0.33	55th	0.30	0.01
TERRIGAL	41st	48.9%	1.66	1.15	43rd	0.29	-0.01
WOY WOY	38th	30.7%	1.74	1.28	50th	0.28	0.01
LAKE HAVEN	8th	88.9%	3.88	3.26	37th	0.21	-0.01
THE ENTRANCE	24th	70.9%	2.50	1.90	38th	0.18	0.00
TUGGERAH	78th	33.7%	0.53	1.10	109th	0.30	0.01
TOUKLEY	116th	30.0%	-0.76	0.66	140th	0.27	0.02
WARNERVALE	66th	35.5%	0.87	0.84	77th	0.30	0.02
WYONG	39th	48.9%	1.70	1.36	64th	0.30	0.03

2.2.7.1 Southern suburbs

The southern target suburbs include Erina, Gosford, Kariong, Terrigal, and Woy Woy. A colour imagery map is presented (Figure 7) to provide the context for interpreting the 2018 urban heat map (Figure 8).

In Erina, a clear pattern of heat is demonstrated by the Erina Fair Shopping Centre. The large swath of impervious buildings and carparks produce a clear heat island signal (Figure 9). Although the shopping centre is mainly covered with white roofs which reflect some of the heat, the surrounding bitumen car parks and buildings themselves absorb heat with the dark parking lot to the north of the centre being the hottest location in Erina. By contrast, the extensive green spaces surrounding the shopping centre are some of the coolest in the suburb and provide a substantial break on the heat island. Erina on average measured 3 °C above baseline, with two thirds of its land classifying as a heat island with the shopping centre being the largest (Table 6). Figure 9 illustrates the effectiveness of satellite data in capturing landscape scale patterns of land uses and their general influences on heat, but also demonstrates the limitations imposed by the resolution of the satellite imagery whereby the influence of small and medium features are unresolvable.



Figure 7. Colour imagery map of the southern target suburbs.

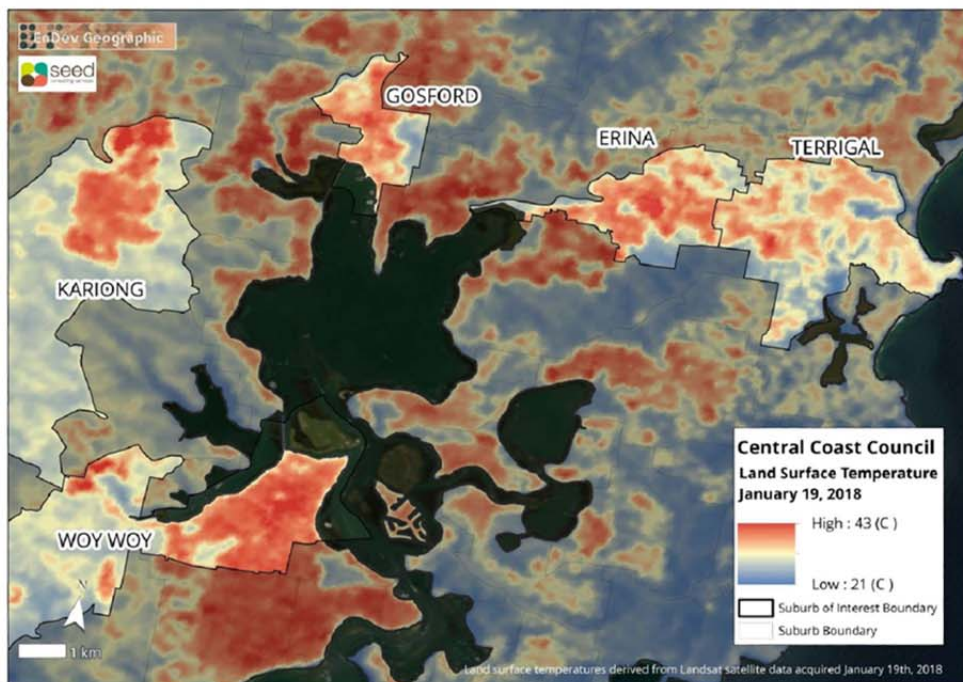


Figure 8. 2018 Land surface temperature map of the southern target suburbs.



Figure 9. Erina suburb satellite colour image (left) and land surface temperature (right).

Gosford is the hottest of the southern target suburbs measuring 3.2 °C above baseline temperature with over 60% of its land falling under a heat island (Table 6). Most notably, compared to 2013, the average surface temperature in Gosford has increased by 1.3 °C. This rate of warming is the 15th highest among suburbs in the Central Coast Council. The warmest location is the Gosford Hospital and the surrounding area which has exhibited some continued warming since 2013. Rumbalara Reserve, along the east side of the suburb, is the coolest areas followed by Gosford City Park along the waterfront.

Kariong, on average, generally falls within the surface temperature range of most councils (<1 °C above background) on account of its large vegetated areas to the west, though it has warmed by 0.5 °C over the last 5 years. The pattern of warming, however, is highly unequal, all of the warming occurring in the urban areas which exhibited >3 °C of surface warming during that same period.

Terrigal, though slightly warmer than Kariong, demonstrated a very similar pattern of ~0.5 °C of warming over the last 5 years. The primary driver of this heat is the new residential development in the south west quadrant of the suburb, south of Kings Avenue, where large areas have been transformed from natural to built environments which has now become the hottest area in the suburb. This pattern is also present in the NDVI change map. The rest of Terrigal is moderated by vegetated areas to the south and interspersed through-out, and the cooling effect of the ocean to the east.

Woy Woy also has two distinct lobes of heat, with warmer urban areas to the east and cooler vegetated areas to the west. The eastern lobe is primarily residential with some commercial areas to the north. The NDVI change map shows some loss of vegetation evenly distributed across this area. The temperature change map shows that many of these same areas have

warmed during that same time period, however areas closer to the water have experienced less warming.

2.2.7.2 Northern suburbs

The northern target suburbs include Lake Haven, The Entrance, Toukley, Tuggerah, Warnervale, and Wyong. Colour images of these areas are presented (Figure 10) to provide the context for interpreting the 2018 urban heat map (Figure 11).

Lake Haven is one of the hottest suburbs in the Central Coast Council measuring nearly 4°C above baseline (Table 6). Lake Haven has continued to warm over the last 5 years, with warming occurring evenly across the area causing nearly 90% of its area to classify as a heat island. The high surface temperature in Lake Haven corresponds to limited vegetation (as measured through NDVI, Table 6) and the warming corresponds to a slight decrease in vegetation over the last 5 years. However, some cooling areas are present along the waterfront areas.

Similarly, The Entrance has one of the lowest levels of cooling vegetation, while averaging 2.5°C above baseline temperature; a pattern that would likely be much worse if it weren't surrounded by water on three sides. A small cool area exists around the oval at the centre of town and immediately along the ocean shoreline, but otherwise heat builds up over the predominately dark rooved residential areas of The Entrance.

The commercial corridor of Tuggerah presents a steady signal of urban with as the large buildings and dark carparks trap absorb and re-radiate heat. The Tuggerah Super Centre sits at the centre of this urban heat island. Overall, Tuggerah has a substantial mix of green space which helps offset that heat and only one third of its land falling under a heat island, and exhibited a cooling between 2013 and 2018 driven by cooling in the forested area along the water front.

Toukley is the only one of the targeted suburbs that measured cooler than baseline on account of its large forested areas, proximity to the ocean, and extensive waterside (Figure 12). Toukley has a high fraction of vegetation, the health of which appears to have increased over the last 5 years. The golf course also provides a cooling benefit though not as strong as the closed canopy forest. The residential and commercial precinct, while warmer than baseline, averaged less than 1°C above baseline making it one of the cooler developed areas.

The two hottest areas in Warnervale are the airport and the industrial precinct (Figure 13). The airport averaged 6°C above baseline while the industrial areas averaged 5°C above baseline. While significant, this heat is isolated to small pockets that are removed from residential areas which restricts exposure mainly to employees of those areas and they interspersed with heavily vegetated areas which minimizes their contribution to larger heat islands. The heavily vegetated cool areas are broken by an area of open ground with little vegetation which further concentrates heat in the areas surrounding the built environment.



Figure 10. Colour imagery of the northern target suburbs.

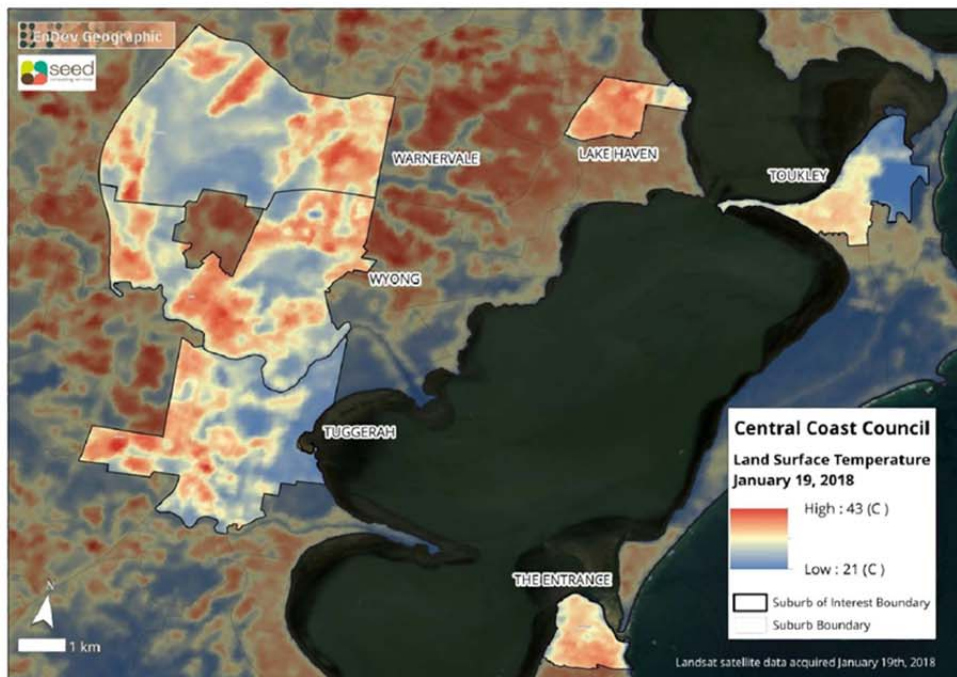


Figure 11. 2018 Land surface temperature map of the northern target suburbs.



Figure 12. Toukley colour image (left) and land surface temperature (right).

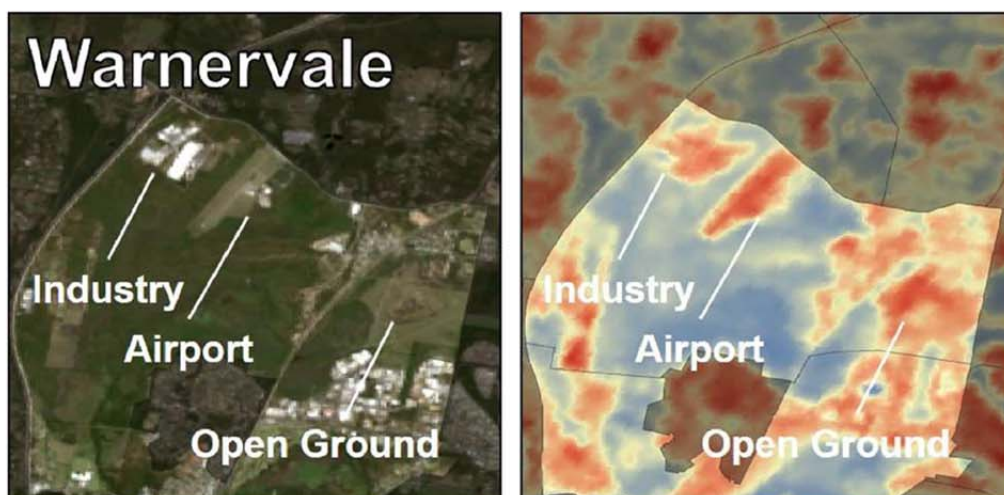


Figure 13. Warnervale colour image (left) and land surface temperature (right).

The broader Wyong suburb presents a mix of forest, farm, and urban space. On average, it measures 1.7 °C above baseline, but considering most of the vegetated lands are cooler than average, the heat is heavily concentrated in the urban areas. Specifically, heat is centred around Wyong Station and tracks to the northwest and southeast until it encounters vegetated lands.

2.2.8 Limitations

The two datasets were both collected on warm days as verified with Bureau of Meteorology data. While thermal conditions were similar on the two days, landscapes are also

conditioned by the temperature and precipitation of the preceding month. As such, a late March collection likely captures a different temperature and precipitation regime, and therefore thermal data and vegetation may present differently. Appropriate consideration should be applied in extrapolating patterns of change from two different seasonal timepoints. Additionally, satellite data measures land surface temperature which is a direct influence on air temperature, but other factors also bear influence. For example, different prevailing winds can be responsible for differences between air and land surface temperature, especially in coastal settings.

This analysis is conducted at the suburb and council scale which is ideal for assessing landscape scale patterns. However, summarizing data to this scale can overlook some patterns, especially when aerial units are of varying size. For example, the suburb of Woy Woy contains two lobes, one urban (eastern) and one vegetated (western). Considered individually, the urban lobe may be one of the hottest in the council but combined it does not register as abnormally hot.

Satellite data provide a broad vantage point, capturing large areas at a single time-point which allows for direct comparison of the heat impacts across the whole of the city. However, there are three primary limitations to using satellite data. The first limitation is the resolution of Landsat data which for thermal data is 100m², meaning that the heat signal from any feature smaller than this is merged with neighboring features. This resolution is suitable for identifying the temperature of large parking lots, but will not clearly identify the temperature of individual roads. As such, Landsat is ideal for large, landscape and city scales studies, but encounters difficulty in determining the heat contribution of smaller features.

The second limitation stems from the fixed orbit the Landsat satellite which results in an 11:05AM overpass. Late morning is ideal for clear sky captures of colour imagery, but is sub-optimal for thermal data capture which is best suited to late afternoon capture. The third limitation is date selection. Satellites pass overhead on set days, (every 16 days for Landsat) irrespective of weather. This study relied on Landsat overpasses that coincided with warm days. Originally, the study intended to compare a decade-long timeseries, but data coverage and quality of 2008 were not suitable for this analysis, leading to the 5-year timeseries.

These limitations are inherent products of satellite-based studies. Circumventing these limitations requires selecting a more adaptable platform for collecting thermal data, such as airborne or UAV-based sensing. Airborne data collection can cover similar areas at much higher resolution and can be tasked to fly at optimal times and dates, providing much greater detail and answering more specific questions.

3 Urban Canopy Cover

3.1 Approach and method

3.1.1 Focal suburbs

The primary focus of this project was to investigate urban land cover, particularly canopy cover, in order to facilitate urban planning and strategic decision making. Council identified 94 (61%) of their suburbs as falling within the urban footprint (Table 7, Figure 14), forming the basis of this project. The remaining suburbs were considered more rural than urban and were not included in the land cover analyses. Analyses were conducted at the suburb scale and these results combined to provide “urban wide” results for the Council area.

3.1.2 i-Tree Canopy

Land cover was analysed using the i-Tree Canopy software¹ which allows a user to readily, and statistically rigorously, classify land cover amounts within a user-defined area overlaid on Google Earth imagery. As each point is classified, i-Tree Canopy provides automated running statistical estimates for land cover categories of the estimate total area (km²) and percent cover (%) within the study area, as well as an uncertainty estimate (i.e. standard error, SE). Generally, the more points that are classified, the lower the standard error and the more precise the estimated result should be. However, the more land-cover categories defined, the more points that need to be classified in order to achieve statistical stabilisation of estimates (Jacobs, et al., 2014).

i-Tree Canopy suggests surveying 500-1000 points per sample area, though the difference in resources required to survey 500 points versus 1000 points can be substantial when multiple areas are involved, with potentially little gain in precision and varying levels of confidence in the outputs. The authors of Australia’s national canopy benchmarking report undertook further evaluations and found that between 600-1000 points would tend to provide a standard error of <3%⁷. However, this again would result in varying confidence levels in outputs given the varying sampling intensity among larger and smaller areas (i.e. likely lower confidence levels for larger areas, and higher for smaller areas).

For this project, a power analysis was conducted *a priori* to determine how the number of survey points per suburb would vary given differing confidence levels (CL) and confidence intervals (CI). The outputs indicate the number of points which would achieve statistically acceptable levels of error among suburbs of varying sizes whilst limiting the potential for surveying more points than necessary to produce fit-for-purpose outputs.

With a need to achieve a balance between limited resourcing and acceptable levels of statistical error, the Central Coast Council selected a 95% CL and 5% CI, which equated to 384 points per suburb. The way to relate these power analyses to the assessment outputs is, for example: based on the 384 points surveyed in each suburb, if the assessment outputs estimate a canopy cover of 25% then we are at least 95% confident that the actual canopy

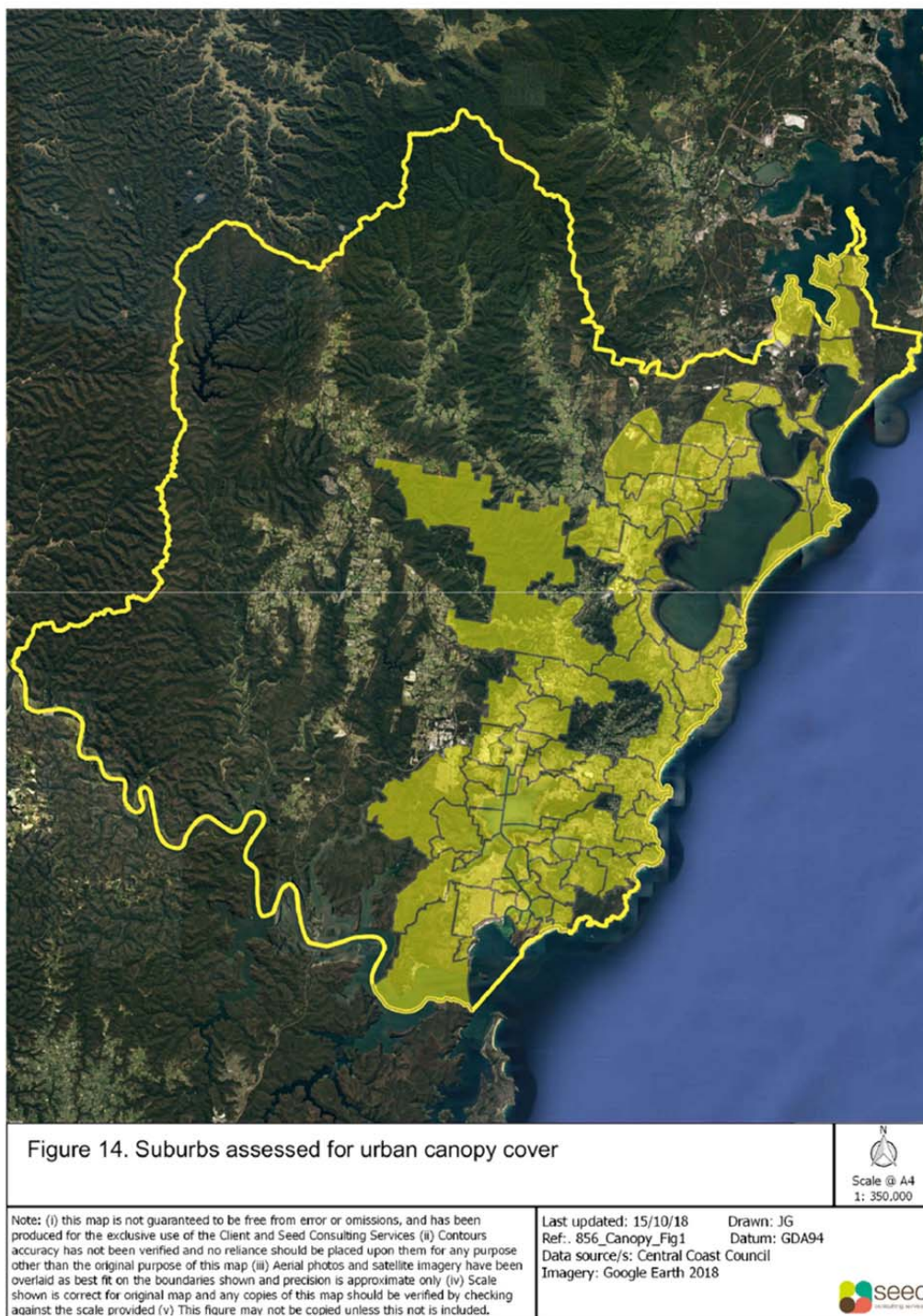
¹ <https://canopy.itreetools.org/>

cover across the city is between 20% and 30% (i.e. estimated output plus or minus the 5% confidence interval). To greatly improve on these confidence levels and intervals significantly more points would need to be surveyed. However, statistically and for the requirements of this project, this level of power is considered acceptable.

Note that the urban-wide assessments are based on the collation of the suburb-level assessments and therefore are based on a total of 36,096 points, which roughly equates to a 95% CL and a 0.5% CI.

Table 7. The 94 suburbs, and their areas, assessed for this project (see also Figure 14).

SUBURB	Area (km2)	SUBURB	Area (km2)	SUBURB	Area (km2)
Avoca Beach	5.20	Horsfield Bay	0.54	Saratoga	4.69
Bateau Bay	8.70	Kanwal	3.03	Shelly Beach	1.42
Bensville	6.67	Kariong	30.84	Springfield	5.48
Berkeley Vale	7.33	Kilarney Vale	3.64	St Huberts Island	3.26
Blackwall	1.92	Killcare	2.98	Summerland Point	3.78
Blue Bay	0.64	Killcare Heights	2.62	Tacoma	2.81
Blue Haven	3.06	Kincumber	12.33	Tacoma South	1.61
Booker Bay	1.23	Kincumber South	2.76	Tascott	4.37
Budgewoi	3.73	Koolewong	4.20	Terrigal	10.98
Buff Point	2.46	Lake Haven	2.07	The Entrance	1.96
Canton Beach	1.02	Lake Munmorah	6.65	The Entrance North	1.26
Chain Valley Bay	7.10	Lisarow	13.03	Toowoona Bay	0.72
Charmhaven	8.35	Long Jetty	3.05	Toukley	4.08
Chittaway Bay	1.31	MacMasters Beach	6.51	Tuggerah	11.58
Chittaway Point	1.88	Magenta	8.36	Tuggerawong	1.84
Copacabana	2.48	Manning Park	8.89	Tumbi Umbi	15.44
Daleys Point	2.25	Mardi	11.26	Umina Beach	8.38
Davistown	2.82	Narara	10.00	Wadalba	4.41
East Gosford	2.44	Niagara Park	4.52	Wagstaffe	0.93
Empire Bay	6.77	Norah Head	4.63	Wamberal	10.58
Erina	6.21	Noraville	2.36	Warnervale	15.43
Ettalong Beach	2.55	North Avoca	2.08	Wattandobbi	2.13
Forresters Beach	3.39	North Gosford	2.28	West Gosford	6.41
Glenning Valley	6.79	Ourimbah	104.89	Woongarah	6.33
Gorokan	3.63	Patonga	35.89	Woy Woy	22.90
Gosford	4.10	Pearl Beach	1.50	Woy Woy Bay	10.65
Green Point	18.27	Phegans Bay	0.78	Wyoming	8.60
Gwandaran	3.77	Point Clare	5.57	Wyong	13.52
Halekulani	1.75	Point Frederick	1.42	Wyongah	1.24
Halloran	3.49	Pretty Beach	1.13	Yattalunga	0.93
Hamlyn Terrace	6.27	Rocky Point	0.16		
Hardys Bay	0.71	San Remo	2.74		



3.1.3 Land cover categories

Thirteen land cover categories were used to assess each of the points. These categories were based on similar assessments conducted for other local Council areas in Queensland and South Australia (Table 8; Plate 1).

3.1.4 Assessment errors and considerations

The interpretation of satellite imagery and aerial photos is open to interpretation by the user, which may lead to an inherent level of error in the land cover classification, particularly if the quality of the imagery/photo is poor. Such error was minimized as much as possible by considering the surrounding land use context and comparing images in other time periods. Key interpretation issues that may be faced in such analyses include:

- Non-anthropogenic land-cover changes:
 - seasonal variations may result in a point's land-cover category changing between different assessment dates. For example, a point classified as "grass other" in one year/month may be classified as "bare ground" in another year/month due to changes only caused by seasonal influences. Other similar changes may occur due to fluctuations in water levels in waterways and water bodies;
- Inferred points:
 - user-rationale was used to interpret land cover under points where shadows impeded a clear view; where necessary, comparison with imagery from other time periods and Google street view were also assessed;
 - where a point fell over a temporary cover (e.g. cars, junkyard debris), the more permanent land cover is classified. For example, a point falling over a car parked on a grassy area, would be classified as "grass" not "impervious". Similarly, a point falling over a boat on the water would be classified as "water";
- Photo skew and quality:
 - the quality of aerial photos and satellite imagery (particularly older images) can vary substantially in quality and resolution and influence the ability to clearly identify land cover; and
 - aerial photos can appear displaced or skewed due to variation in the capture angles of the aircraft/satellite relative to the feature. This displacement increases as the look angle moves away from a vertical capture angle, and so features at the edge of an image will have more displacement than those directly below the sensor at the time of acquisition. When these photos are georeferenced, this skew can impact on where certain points appear to fall. User interpretation is required in these cases to infer how the photo would appear if not displaced/skewed.

Table 8. Land cover categories used for i-Tree Canopy analysis. Categories used in this analysis were consistently applied irrespective of tenure (i.e. public or private land). See also Plate 1.

CATEGORY	CODE	DESCRIPTION
IMPERVIOUS		
Impervious – building	IB	A permanent built structure (e.g. house, carport, shed). Residential, commercial, industrial, public or any other.
Impervious – other	IO	Impervious surfaces not included in building and road cover classes. Includes footpaths, driveways, sports courts, swimming pools, fences, water features and perceived temporary structures (e.g. shade sails).
Impervious – road	IR	A sealed road, highway, service lane, airport runways, railway lines, light rail, car park. Excludes unsealed roads/tracks/car parks.
TREE CANOPY COVER		
Tree – impervious	TI	Tree canopy over perceived impervious surface. All trees obviously located within impervious surface.
Tree – pervious	TP	Tree canopy over perceived pervious surface. Includes mangroves, native forest, plantation, park trees.
PLANTABLE SPACE		
Bare ground	PBG	Non-vegetated pervious surface with tree planting potential. Includes areas of erosion. Excludes bare ground between agricultural plantings.
Grass	PG	Grassed areas with tree planting potential. Includes public parks, private lawns and areas beside active portion of sporting fields, as well as non-tree plants (e.g. shrubs and short hedges), pasture, grasslands.
UNPLANTABLE SPACE		
Agriculture	UA	Active cropping or other agricultural activity. Includes tree crops, sugar cane, vegetables, tilled paddocks, and aquaculture ponds. Includes bare ground between agricultural plantings.
Bare ground	UBG	Non-vegetated, non-plantable pervious surfaces. Includes earthworks, cliffs, extractive industries (quarries), beach rock, sand traps in golf courses, unsealed tracks/roads/driveways, car parks, and horse running tracks. Excludes bare ground between agricultural plantings.
Grass	UG	Grassed areas that are not plantable. Includes sporting fields, school ovals, golf fairways, putting greens, grass airport runways, and grass cover associated with extractive industries.
Sand	US	Non-vegetated portion of coastal sandy beaches and mudflats, to low tide mark. Usually adjacent to wetlands, mudflats and coasts.
Aquatic vegetation	UV	Vegetation growing on coastal sand dunes or around wetlands and waterways. Areas where achieving canopy cover is not likely due to environmental constraints (e.g. saltwater intrusion). Includes fringing or aquatic vegetation (not trees) associated with waterbodies, sedge lands, saltmarsh.
Water	W	Aquatic & marine waterbodies. Includes rivers, creeks, estuaries, canals, lakes, dams, marina, quarry water pits. Does not include pools.

Plate 1. Aerial images showing examples of each land cover category under a randomly allocated point (yellow dot).



3.1.5 Case study - historical canopy change assessment

As a case study, historical land cover within Woy Woy was assessed using 2005 aerial imagery provided by Council. The points for this suburb were converted to a GIS shapefile and overlaid on the historical imagery. The current classified land cover categories were visually compared to land cover in the 2005 aerial imagery. Using the i-Tree Canopy "change survey" function, land cover classifications for each point were reclassified as required to match 2005 land cover. The revised classifications in i-Tree Canopy were saved as new project files to enable future comparisons.

Examination of percent land cover change over time was conducted using a GIS and Excel to conduct additional spatial and statistical analyses based on the i-Tree Canopy land cover assessments. Change in percent land cover over time was assessed by comparing in Excel the difference in percent land cover between 2005 and current.

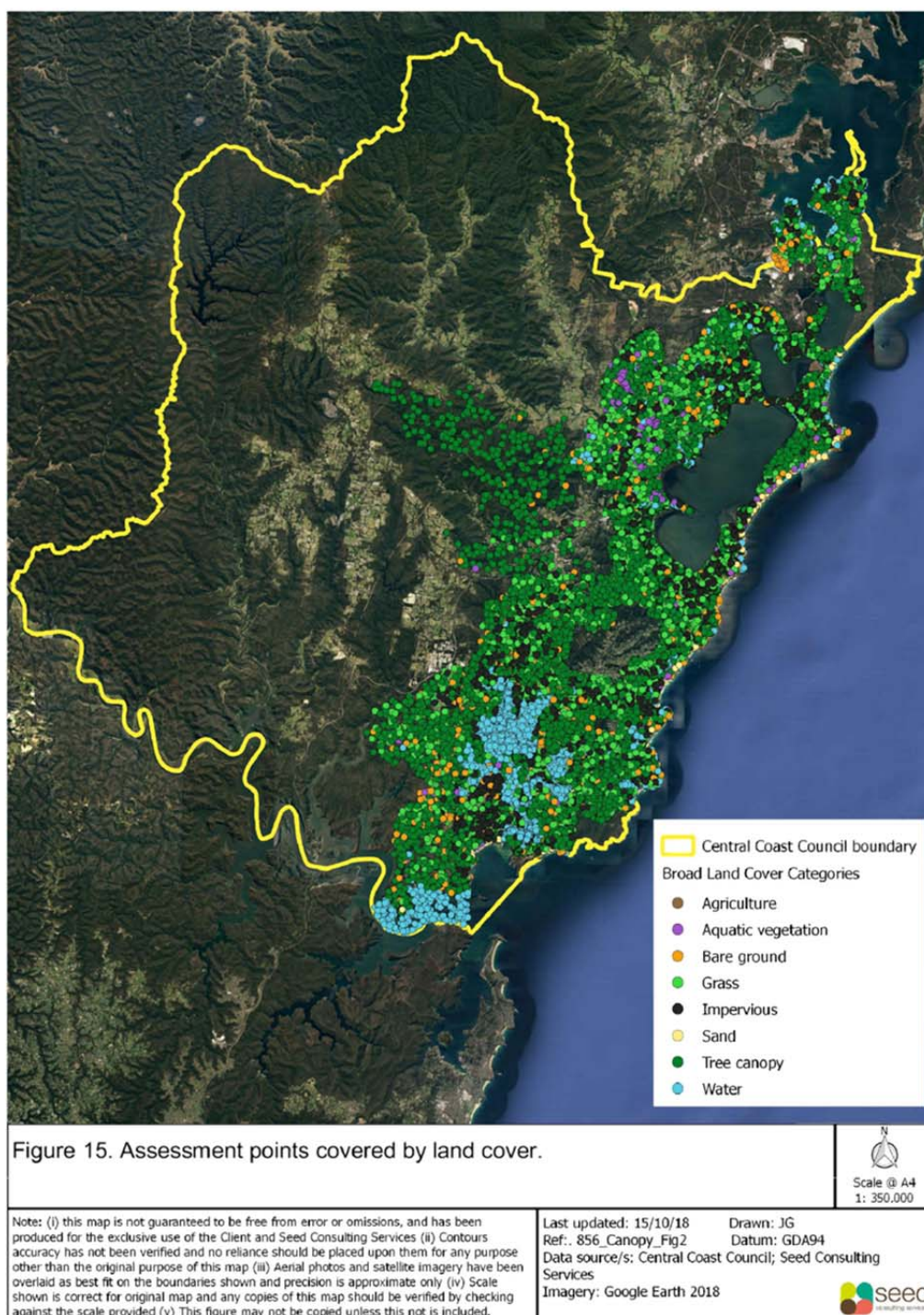
3.2 Urban canopy cover results

3.2.1 Across the urban area

The 94 suburbs assessed covered an area of 628.8km² (land and water area), representing approximately 30% of the total Central Coast Council area (land and water). Suburbs ranged in size from Rocky Point at 0.16km² to Ourimbah at 104.9km² (Table 1, Figure 15). A total of 36,096 points were assessed across all suburbs.

Across the 94 suburbs, hereafter referred to collectively as the "urban area", tree canopy was the dominant land cover type, covering nearly 42% (264km²) of the urban area (Figure 16). The percent cover of impervious surfaces was roughly equal to the percent cover of plantable space, with both at nearly 21% (131km²) (Figure 13). Unplantable surfaces comprised the remaining 16% of the urban area, equal to approximately 102km² (Figure 16).

Canopy cover predominantly occurred over pervious rather than impervious surfaces (38.54%, 242.4km² and 3.39%, 21.3km², respectively) (Figure 16). This is likely driven by the relatively large proportions of treed reserves and ranges which are either protected or unsuitable for development or agriculture. Approximately half of all impervious cover was attributed to buildings (60km²), with roads and other impervious surfaces (e.g. footpaths, driveways, car parks, pools) each comprising approximately a quarter of the total impervious cover (5%, 31.4km² and 6.42%, 40.4km², respectively) (Figure 16). Bare ground and grassed areas considered to be potentially plantable with trees represent a substantial opportunity for increasing canopy cover within the urban areas. Almost all of the plantable space are currently grassy areas rather than bare ground (18.62%, 117 km² and 2.25%, 14.1 km², respectively) (Figure 16). The proportion of plantable space on Council owned and managed land, however, may be significantly lower, if tenure patterns in Central Coast Council follow those seen in many urban councils, worldwide. Water and associated aquatic vegetation represented most of the areas considered to be unplantable (together, 12.11%, 76.1 km²) (Figure 16), with unplantable bare ground covering approximately 2% of the urban area, equivalent to 12.6km². This unplantable bare ground is of particular interest as at least part of it may be due to the urban development works, which may in the future become impervious surfaces.



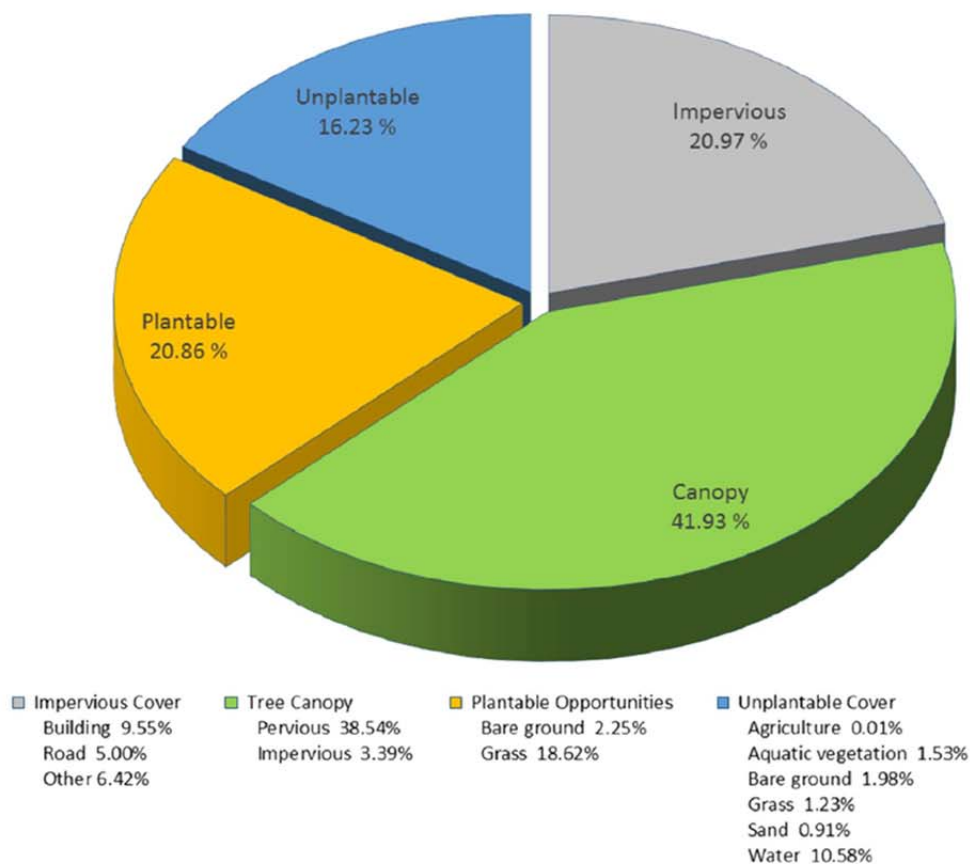


Figure 16. Estimated current land cover across the urban areas (94 suburbs) of Central Coast Council.

3.2.2 Suburb specific trends

Current land cover trends varied substantially among the 94 suburbs assessed (Figure 17 and Figure 18). Whilst all suburbs contained a mixture of impervious, canopy, plantable space, and unplantable cover, the proportions of land cover varied. Full details of land cover amounts for each suburb are provided in Appendix A.

Impervious cover ranged from 0.52% (0.19km²) in Patonga to more than 50% in both Long Jetty and Lake Haven (1.55 km² and 1.05 km²). However, given the range of size across suburbs, from a total area perspective, Woy Woy contained the greatest area of impervious cover at 3.94km² (17.19%) followed by Umina Beach at 3.54km² (42.19%) and Bateau Bay at 3.08km² (35.42%); and Rocky Point and Hardy's Bay contained the smallest area of cover at 0.06km² (equivalent to 35.68% and 8.85%, respectively).

Canopy cover ranged from 7.03% (0.09 km²) in Booker Bay to 89.58% in Ourimbah. Given the large proportion of forested areas and the large size of the suburb, Ourimbah also had the greatest area canopy cover at 93.96 km². The influence of this large forested area is highlighted when considering the next greatest area of canopy cover was 20 km² in Kariong, representing 64.84% of that suburb area, followed by 14.21km² in Patonga (39.58%). Comparatively, Rocky Point had the smallest area of cover at 0.04 km² (24.22%), followed by Blue Bay and Booker Bay at 0.06km² and 0.09km² (respectively 8.85% and 7.03%).

Plantable space ranged from 4.17% (0.18 km²) in Koolewong to 42.19% (2.67km²) in Woongarah. By way of physical area though, Ourimbah presents the greatest opportunity for increasing canopy cover, with 6.83 km² of plantable space (6.51%), followed by 6.51km² in Kariong (21.09%). The least opportunity for increasing canopy cover appears to be in Rocky Point, Wagstaffe, Horsfield Bay and Phegans Bay, all of which had less than 0.1km² of potential plantable area (30.73%, 7.29%, 14.84%, and 10.94%, respectively). These areas of potential plantable space are particularly important strategically increasing canopy cover. When combined with thermal heat mapping, areas of plantable space that overlap with thermal hotspots can indicate priority planting locations. However, further assessments should first consider the tenure of land cover within suburbs, as Ourimbah may not have the greatest amount of plantable space on public land, which is where Council can have the most immediate impact.

The level of planting opportunities on private versus public land will need to be carefully considered, as to how representative such plantable space opportunities are for Council action.

Unplantable cover ranged from 0.52% (0.01km²) in Wyongah to 67.45% (2.83km²) in Koolewong. Koolewong's high percent unplantable cover was due primarily to the large proportion of Brisbane Water surface comprising this suburb (66.41%). The influence of water on thermal mapping outputs may be of particular interest as a potential cooling mechanism to support tree canopy cooling effects. The greatest area of unplantable space was 18.5km² (51.56%) in Patonga, again primarily due to this suburb comprising a large proportion of water surface, namely Broken Bay and the mouth of the Hawkesbury River. The lowest amount of unplantable area was in Wyongah and Rocky Point which both has 0.01km² worth.



Figure 17. Percent current land cover for suburbs 1-47, ordered alphabetically. Refer to Appendix A for further details on percentages and equivalent land areas for each suburb.

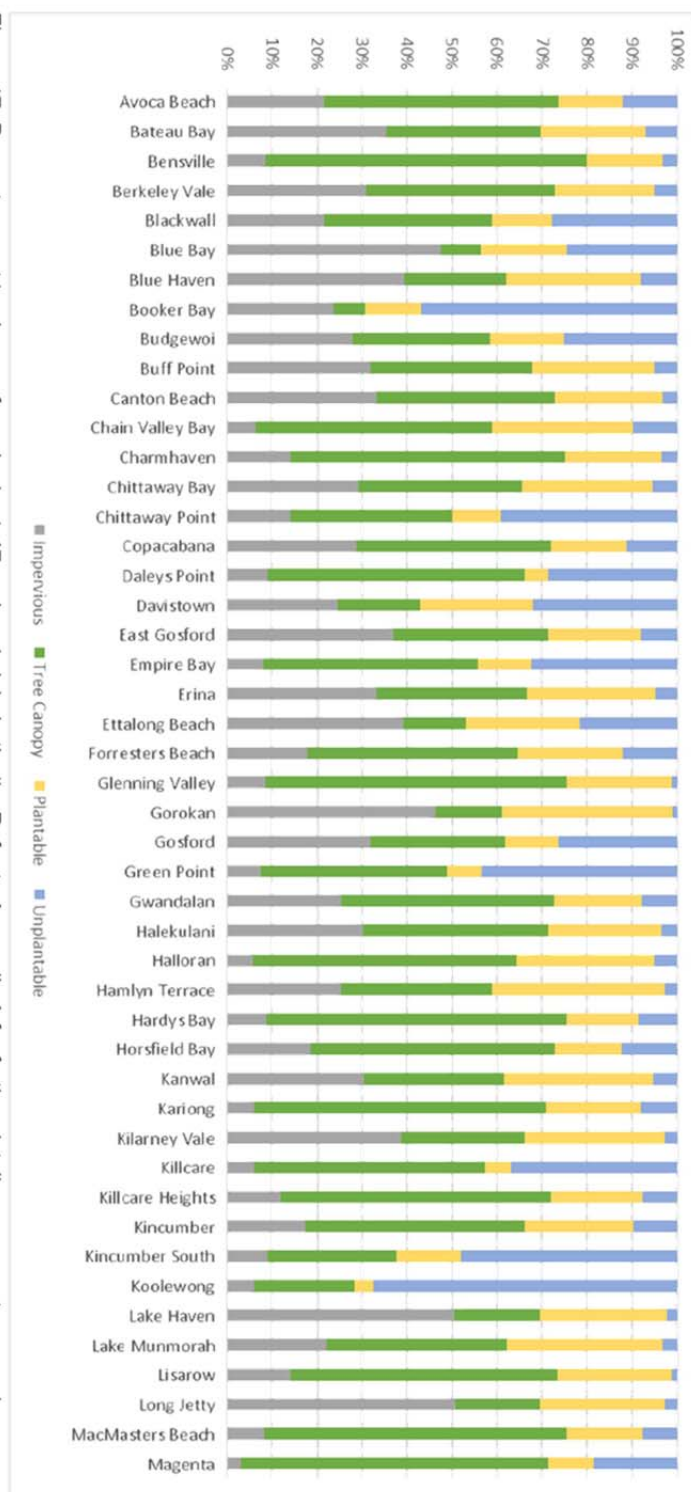
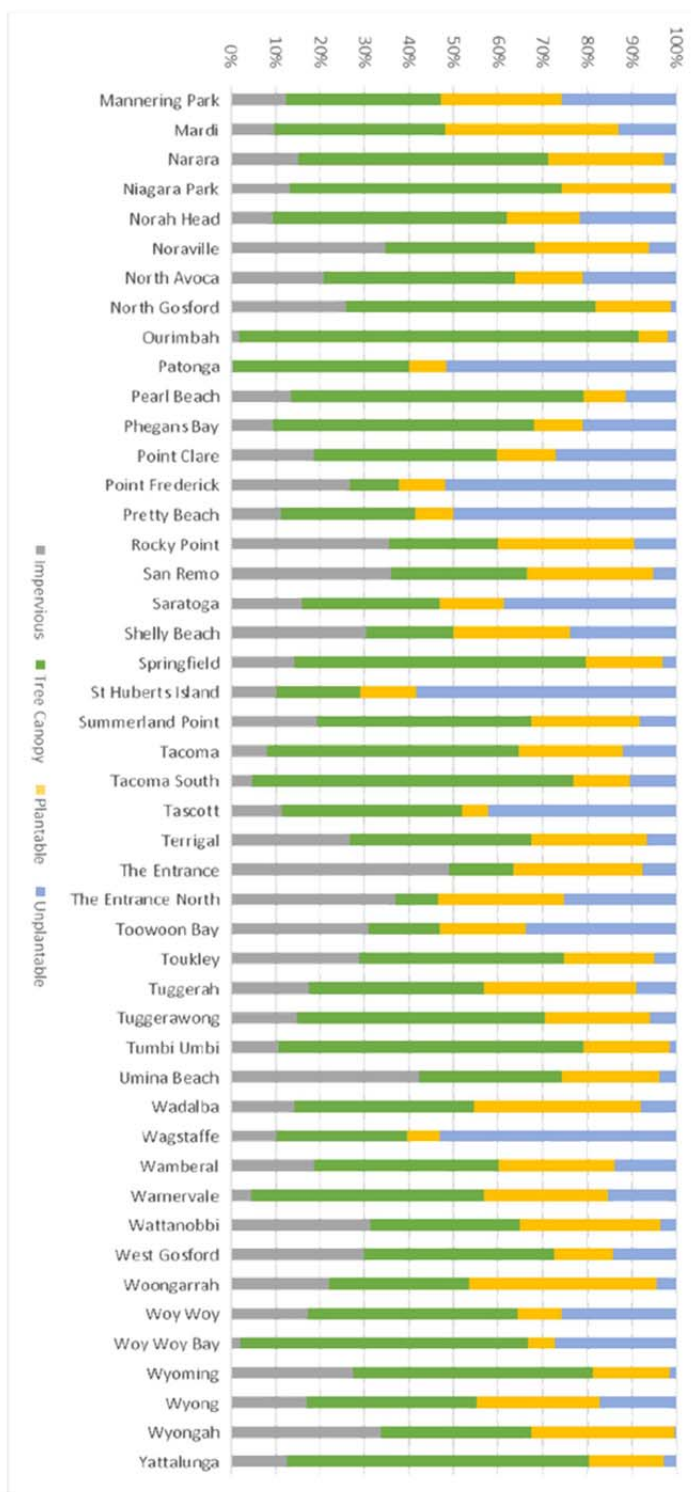




Figure 18: Percent current land cover for suburbs 48-94, ordered alphabetically. Refer to Appendix A for further details on percentages and equivalent land areas for each suburb.



3.3 Case study results – land cover change in Woy Woy

Over the nine years between 2005 and 2014, Woy Woy experienced changes in all land cover types, though the direction and statistical significance varied for each land cover type. Both impervious and unplantable space cover increased over time, though neither increase was statistically significant (Figure 19). Unplantable space cover increased by more than impervious cover (4.95%, 1.1 km² and 3.65%, 0.8 km² respectively), with an increase in unplantable bare ground being the primary driver (2.34%, 0.5 km²). For impervious cover, other impervious surfaces increased the most, followed by buildings and then roads (2.08%, 0.47 km², 1.04%, 0.24 km², and 0.52%, 0.12 km² respectively). Over the same time, plantable space and tree canopy cover both decreased, by 7.55% (1.72km²) and 1.04%, (0.24km²) respectively (Figure 19). The loss of tree canopy cover was the only significant change for the suburb (p = 0.037). The total area lost was 1.73km², which is equivalent to just over 254 rugby league fields worth.

Trends of decreasing tree canopy and plantable space, together with increasing impervious and unplantable space are indicative of urban in-fill (Plate 2); a trend commonly observed in cities worldwide. Investigate of land cover change trends on private versus public land will further inform strategic decision-making and action prioritization. The increase in predominantly impervious bare ground includes current earthworks and building sites, indicating that in the future the amount of unplantable bare ground may decrease and impervious may increase as development occurs and buildings are built (Plates 2 and 3). For example, a conversion of 75% or more of the current unplantable bare ground to impervious would make the change in impervious cover since 2005 statistically significant. The trend appears to have continued since 2014 based on cursory interrogation of 2017 imagery for Woy Woy (Plate 3). If permitted to proceed unchecked, this pattern of land cover change, particularly the significant tree canopy loss, has substantial implications for the future liveability of cities and the health and well-being of urban environments and communities.

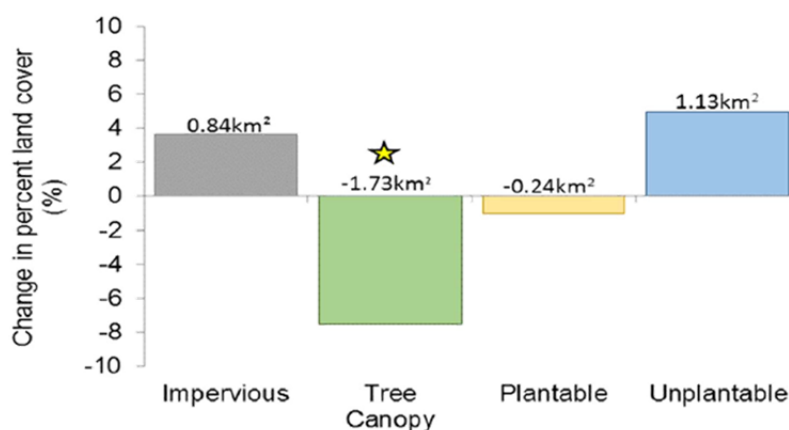


Figure 19. Change in impervious, tree canopy, plantable space and unplantable space cover in Woy Woy between 2005 and 2014. The equivalent amount land area is also shown for each land cover type, with a yellow star indicate a statistically significant change.

Plate 2. Aerial images showing examples of land cover change in Woy Woy between 2005 and 2017. The process of urban in-fill is clear, with trees and grassy areas replaced by impervious surfaces. Key changes between 2005 and 2014 are outlined in red on both images; additional urban in-fill and/or canopy loss between 2014 and 2017 are outlined in yellow on the 2014 image.

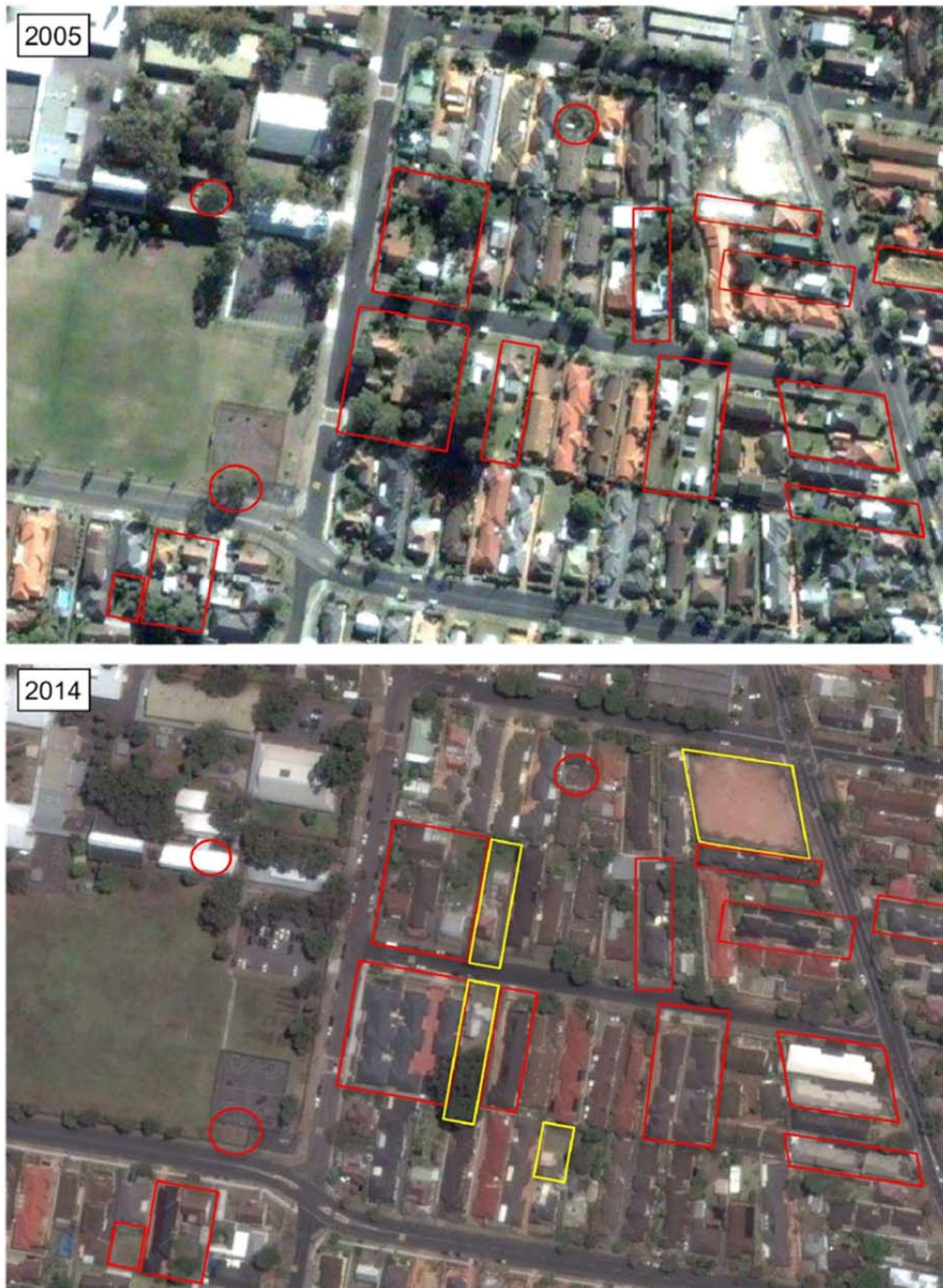


Plate 3. Aerial images showing example of urban in-fill in Woy Woy, and the conversion of tree canopy to unplanted bare ground to impervious. This highlights this importance of analysing land cover over time to fully appreciate trends in land cover change.



4 Key Findings

Thermal and urban tree canopy mapping of the Central Coast Council reveals substantial insights into the broad trends and relationships between land use, vegetation, and thermal performance. The suburb-level analysis allows for targeting of areas that exhibit the highest temperatures, highest and lowest vegetation, and the greatest chance for planting new trees. The time series assessment for thermal performance identifies which areas may increasingly become problems in the future. More detailed analysis of the data identifies specific areas where changes in land use have resulted in changes in thermal performance.

Key findings include the following:

- some suburbs were consistently hot in the time periods assessed, such as Long Jetty, Lake Haven, and Umina Beach. In contrast, others were hot initially and increased in heat over time including Ettalong Beach, Booker Bay, Point Frederick, Watanobbi, and Woongarah;
- suburbs such as East Gosford and Blue Haven are emerging future heat centers;
- the most dominant heat island signal comes from Long Jetty with over 90% of its area falling within a heat island;
- across the 94 urban suburbs tree canopy was the dominant land cover type, covering nearly 42% (264km²) of the urban area. Canopy cover within each suburb varied significantly, ranging from 7.03% (0.09km²) in Booker Bay to 89.58% (93.96km²) in Ourimbah;
- the percent cover of plantable space across all urban suburbs was about 21% (131km²). Almost all of the plantable space are currently grassy areas rather than bare ground (18.62%, 117 km² and 2.25%, 14.1 km², respectively). Plantable space ranged from 4.17% (0.18 km²) in Koolewong to 42.19% (2.67km²) in Woongarah. The greatest areas of plantable space however occur in Ourimbah (6.51%, 6.83km²) and Karingong (21.09%, 6.51km²);
- an understanding of land cover by tenure within each suburb will greatly enhance strategic decision-making, particularly the amount of plantable space on public versus private land;
- the Woy Woy case study shows the power of investigating land cover change over time to gain a greater understanding of specific drivers of change. This could further be refined by integrating tenure analyses, to understand drivers of change on public and private land;
- the target suburbs analysed as part of the heat island analysis indicated that development is leading to warmer suburbs and that cooling is associated with more green infrastructure.

Specific locations can be identified for heat mitigation activities by identifying areas with the largest numbers of people that may be exposed and/or are vulnerable to excessive urban heat. A priority neighbourhoods framework was developed by Norton, et al. (2015), which identifies areas of heat exposure, behavioural exposure and social vulnerability, and where they intersect, to determine the location of priority areas for mitigation actions (Figure 20).

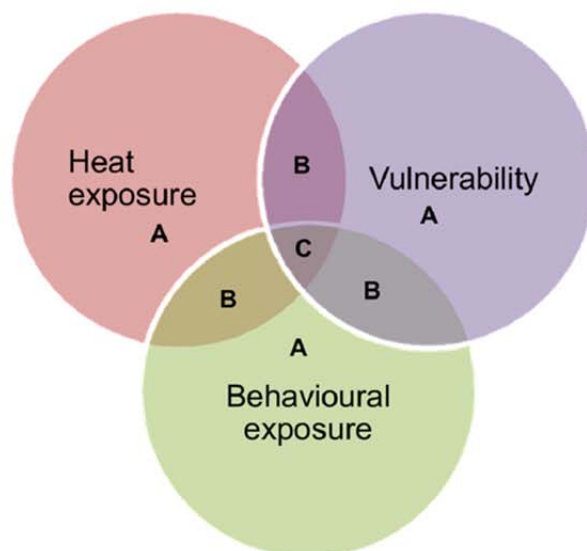


Figure 20. Framework to identify priority neighbourhoods for heat mitigation activities. Factors required to identify neighbourhoods of high (C), medium (B) and moderate (A) priority for urban green infrastructure (UGI) implementation for surface temperature heat mitigation. The key factors are high daytime surface temperatures (heat exposure) intersecting with areas with more vulnerable sections of society (vulnerability) and identifying the zones of high activity (behavioural exposure) in this area (Norton, et al., 2015).

Combining the suburb level thermal assessment with the i-Tree vegetation assessment reveals areas where high temperatures and plantable spaces align. These suburbs represent opportunities for capitalizing on the cooling benefits of green infrastructure.

To understand where high temperatures were close to plantable opportunities, suburbs were ranked from hottest to coolest, and from highest percent of plantable space to lowest (Table 9). These rankings were combined to provide a "hot and plantable" ranking showing which suburbs would benefit most from additional green infrastructure. The results of this analysis suggest that suburbs such as Woongarra, Hamlyn Terrace, Blue Haven, Gorokan and Wadalba are the highest priority for planting because of the higher than regional average surface temperatures and the availability of open space. Of the target suburbs identified by Council, three are in the top 12 ranked suburbs (Lake Haven, Erina, The Entrance).

Table 9. Ranking of suburbs in the Central Coast Council based on relative average surface temperature above that of the region, and the availability of open space for the planting. Suburbs in bold text are those identified as priorities by Central Coast Council.

Rank	Suburbs with combined heat and plantable space	Relative Temperature (°C)	Plantable Space (%)
1st	WOONGARRAH	+ 4.07	42.19
2nd	HAMLYN TERRACE	+ 3.37	38.28
3rd	BLUE HAVEN	+ 4.00	29.95
4th	GOROKAN	+ 2.93	37.76
5th	WADALBA	+ 2.84	37.24
6th	KANWAL	+ 3.05	33.33
7th	LAKE HAVEN	+ 3.88	28.13
8th	LONG JETTY	+ 3.41	27.60
9th	ETTALONG BEACH	+ 5.73	25.26
10th	SAN REMO	+ 3.13	28.39
11th	ERINA	+ 3.05	28.65
12th	THE ENTRANCE	+ 2.50	29.17
...
22nd	WYONG	+ 1.70	27.60
25th	TERRIGAL	+ 1.66	25.78
32nd	TUGGERAH	+ 0.53	34.38
33rd	WARNERVALE	+ 0.87	27.86
39th	GOSFORD	+ 3.21	11.98
55th	KARIONG	+ 0.74	21.09
58th	WOY WOY	+ 1.74	9.90
71st	TOUKLEY	-0.76	20.31

The determination of actual plantable space needs to be supplemented with an onground assessment of factors such as the width of verges, location of power lines and presence of underground services, all of which influence whether a tree can be planted, and grow to maturity, in a given location. Once the right tree is chosen for the right place, other factors will also influence the successful establishment of trees, such as water availability, soil type (e.g. sandy soils can lead to lower establishment rates) and seasonal conditions. An analysis of onground planting factors should complement any further prioritising of areas to plant trees to mitigate heat islands.

The planting priority analysis could be further added to by understanding the alignment of these areas with the distribution of vulnerable people and behavioural exposure (e.g. outdoors lawn bowls clubs, bikeways, footpaths and playgrounds). Further refinement to inform decision-making could come from analysis of land cover by tenure, which would

enable, for example, areas of plantable space opportunities on public land (where Council can most readily act) to be differentiated from areas of plantable space on private land (which would require community and private land holder contribution).

Other than the presence of trees, other land use management decisions can be made that influence the temperature in cities. For example, dark coloured, impervious surfaces such as bitumen roads and dark roofs can absorb large amounts of heat while artificial turf, rubber soft fall matting used in playgrounds, and bare ground can also be amongst the hottest land surface types in an urban landscape (e.g. City of West Torrens, 2017). Importantly for the urban heat island effect, bitumen roads retain this heat into the evening and re-radiate heat well into the night. In contrast, green space features like living turf are cooler than average during the day and night. For example, urban heat island analysis in Adelaide found that there was a 14°C different in the surface temperature of artificial compared with living turf on a warm summer day.

Actions to mitigate the urban heat island need to be well costed. As such, consideration should be given as to whether it is more cost effective to choose materials and make land use decisions at the development stage to create a cooler city, or whether retrofitting can achieve the same outcomes after development and building construction has occurred. In the case of the latter, smaller block sizes can mean that land use features that lead to cooling, such as open green space, are more challenging to install after development has occurred.

This analysis and the data created provide a high-level assessment of the current land cover baselines for each urban suburb and locations where heat change has occurred. Further investigation of this data, such as looking at large developments that have taken place between 2013-2018, tenure analyses, and land cover change over time will further reveal the impact that development and planting programs have on the thermal performance of the Central Coast Council landscape.

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Appendix A. Land Cover for Each Urban Suburb

The following Table shows, for each urban suburb assessed, the area (km²) of the suburb (includes water bodies) and the outputs for each land cover type. Land cover types are as follows:

- Impervious cover = impervious – building (IB), impervious – other (IO), and impervious – road (IR);
- Tree canopy cover = tree over pervious surface (TP), and tree over impervious surface (TI);
- Plantable space cover = bare ground (PBG), and grass (PGr);
- Unplantable space cover = agriculture (UAg), aquatic vegetation (UAV), bare ground (UBG), grass (UGr), sand (USa), and water (UWa).

Outputs presented for each land cover type are:

- Pts = Number of i-Tree Canopy points classified as that land cover type (out of 384);
- % Sub = equivalent percent cover across the suburb for that land cover type; and
- Area km² = equivalent area in square kilometres of that land cover type.

		IB			IO			IR			TP			TI			PBG			PGr			UAg			UAV			UBG			UGr			USa			UWa		
Suburb	Area km2	Pts	% Sub	Area km2	Pts	% Sub	Area km2	Pts	% Sub	Area km2	Pts	% Sub	Area km2	Pts	% Sub	Area km2	Pts	% Sub	Area km2	Pts	% Sub	Area km2	Pts	% Sub	Area km2	Pts	% Sub	Area km2	Pts	% Sub	Area km2	Pts	% Sub	Area km2	Pts	% Sub	Area km2			
MacMasters Beach	6.51	15	3.91	0.25	9	2.34	0.15	8	2.08	0.14	248	64.58	4.21	10	2.60	0.17	10	2.60	0.17	55	14.32	0.93	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00	1	0.26	0.02	0	0.00	0.00	28	7.29	0.47
Magenta	8.36	2	0.52	0.04	5	1.30	0.11	5	1.30	0.11	259	67.45	5.64	3	0.78	0.07	14	3.65	0.30	25	6.51	0.54	0	0.00	0.00	19	4.95	0.41	1	0.26	0.02	21	5.47	0.46	27	7.03	0.59	3	0.78	0.07
Manning Park	8.89	18	4.69	0.42	20	5.21	0.46	9	2.34	0.21	129	33.59	2.99	5	1.30	0.12	31	8.07	0.72	73	19.01	1.69	0	0.00	0.00	10	2.60	0.23	63	16.41	1.46	2	0.52	0.05	0	0.00	0.00	24	6.25	0.56
Mardi	11.26	12	3.13	0.35	15	3.91	0.44	10	2.60	0.29	145	37.76	4.25	3	0.78	0.09	11	2.86	0.32	138	35.94	4.05	0	0.00	0.00	9	2.34	0.26	8	2.08	0.23	1	0.26	0.03	0	0.00	0.00	32	8.33	0.94
Narara	10.00	26	6.77	0.68	21	5.47	0.55	11	2.86	0.29	205	53.39	5.34	10	2.60	0.26	11	2.86	0.29	89	23.18	2.32	0	0.00	0.00	0	0.00	0.00	6	1.56	0.16	3	0.78	0.08	0	0.00	0.00	2	0.52	0.05
Niagara Park	4.52	28	7.29	0.33	10	2.60	0.12	13	3.39	0.15	226	58.85	2.66	8	2.08	0.09	5	1.30	0.06	89	23.18	1.05	0	0.00	0.00	1	0.26	0.01	3	0.78	0.04	1	0.26	0.01	0	0.00	0.00	0	0.00	0.00
Norah Head	4.63	12	3.13	0.14	12	3.13	0.14	12	3.13	0.14	198	51.56	2.39	4	1.04	0.05	8	2.08	0.10	55	14.32	0.66	0	0.00	0.00	15	3.91	0.18	29	7.55	0.35	5	1.30	0.06	24	6.25	0.29	10	2.60	0.12
Noraville	2.36	63	16.41	0.39	36	9.38	0.22	34	8.85	0.21	116	30.21	0.71	13	3.39	0.08	7	1.82	0.04	91	23.70	0.56	0	0.00	0.00	3	0.78	0.02	6	1.56	0.04	8	2.08	0.05	7	1.82	0.04	0	0.00	0.00
North Avoca	2.08	39	10.16	0.21	21	5.47	0.11	20	5.21	0.11	147	38.28	0.80	18	4.69	0.10	13	3.39	0.07	45	11.72	0.24	0	0.00	0.00	11	2.86	0.06	10	2.60	0.05	1	0.26	0.01	13	3.39	0.07	46	11.98	0.25
North Gosford	2.28	40	10.42	0.24	39	10.16	0.23	20	5.21	0.12	198	51.56	1.18	17	4.43	0.10	9	2.34	0.05	56	14.58	0.33	0	0.00	0.00	0	0.00	0.00	5	1.30	0.03	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00
Ourimbah	104.89	2	0.52	0.55	3	0.78	0.82	2	0.52	0.55	342	89.06	93.42	2	0.52	0.55	4	1.04	1.09	21	5.47	5.74	0	0.00	0.00	1	0.26	0.27	6	1.56	1.64	1	0.26	0.27	0	0.00	0.00	0	0.00	0.00
Patonga	35.89	1	0.26	0.09	0	0.00	0.00	1	0.26	0.09	151	39.32	14.11	1	0.26	0.09	3	0.78	0.28	29	7.55	2.71	0	0.00	0.00	1	0.26	0.09	15	3.91	1.40	2	0.52	0.19	1	0.26	0.09	179	46.61	16.73
Pearl Beach	1.50	33	8.59	0.13	7	1.82	0.03	12	3.13	0.05	220	57.29	0.86	32	8.33	0.12	5	1.30	0.02	31	8.07	0.12	0	0.00	0.00	4	1.04	0.02	9	2.34	0.04	4	1.04	0.02	18	4.69	0.07	9	2.34	0.04
Phegans Bay	0.78	12	3.13	0.02	17	4.43	0.03	7	1.82	0.01	207	53.91	0.42	18	4.69	0.04	8	2.08	0.02	34	8.85	0.07	0	0.00	0.00	0	0.00	0.00	14	3.65	0.03	2	0.52	0.00	0	0.00	0.00	65	16.93	0.13
Point Clare	5.57	37	9.64	0.54	14	3.65	0.20	20	5.21	0.29	142	36.98	2.06	16	4.17	0.23	9	2.34	0.13	42	10.94	0.61	0	0.00	0.00	0	0.00	0.00	10	2.60	0.15	2	0.52	0.03	0	0.00	0.00	92	23.96	1.34
Point Frederick	1.42	46	11.98	0.17	40	10.42	0.15	16	4.17	0.06	28	7.29	0.10	15	3.91	0.06	5	1.30	0.02	35	9.11	0.13	0	0.00	0.00	1	0.26	0.00	2	0.52	0.01	0	0.00	0.00	0	0.00	0.00	196	51.04	0.73
Pretty Beach	1.13	17	4.43	0.05	12	3.13	0.04	14	3.65	0.04	101	26.30	0.30	15	3.91	0.04	3	0.78	0.01	30	7.81	0.09	0	0.00	0.00	0	0.00	0.00	9	2.34	0.03	4	1.04	0.01	0	0.00	0.00	179	46.61	0.53
Rocky Point	0.16	69	17.97	0.03	44	11.46	0.02	24	6.25	0.01	70	18.23	0.03	23	5.99	0.01	1	0.26	0.00	117	30.47	0.05	0	0.00	0.00	2	0.52	0.00	3	0.78	0.00	1	0.26	0.00	0	0.00	0.00	30	7.81	0.01
San Remo	2.74	67	17.45	0.48	33	8.59	0.24	38	9.90	0.27	98	25.52	0.70	19	4.95	0.14	6	1.56	0.04	103	26.82	0.74	0	0.00	0.00	0	0.00	0.00	6	1.56	0.04	7	1.82	0.05	0	0.00	0.00	7	1.82	0.05
Saratoga	4.69	29	7.55	0.35	20	5.21	0.24	12	3.13	0.15	105	27.34	1.28	14	3.65	0.17	9	2.34	0.11	46	11.98	0.56	0	0.00	0.00	0	0.00	0.00	1	0.26	0.01	2	0.52	0.02	0	0.00	0.00	146	38.02	1.78
Shelly Beach	1.42	58	15.10	0.21	31	8.07	0.11	28	7.29	0.10	68	17.71	0.25	7	1.82	0.03	5	1.30	0.02	95	24.74	0.35	0	0.00	0.00	17	4.43	0.06	4	1.04	0.01	45	11.72	0.17	26	6.77	0.10	0	0.00	0.00
Springfield	5.48	28	7.29	0.40	15	3.91	0.21	11	2.86	0.16	242	63.02	3.45	10	2.60	0.14	10	2.60	0.14	56	14.58	0.80	0	0.00	0.00	3	0.78	0.04	1	0.26	0.01	4	1.04	0.06	0	0.00	0.00	4	1.04	0.06
St Huberts Island	3.26	20	5.21	0.17	15	3.91	0.13	4	1.04	0.03	62	16.15	0.53	11	2.86	0.09	11	2.86	0.09	37	9.64	0.31	0	0.00	0.00	5	1.30	0.04	1	0.26	0.01	0	0.00	0.00	1	0.26	0.01	217	56.51	1.84
Summerland Point	3.78	37	9.64	0.36	20	5.21	0.20	17	4.43	0.17	176	45.83	1.73	9	2.34	0.09	24	6.25	0.24	69	17.97	0.68	0	0.00	0.00	0	0.00	0.00	4	1.04	0.04	0	0.00	0.00	0	0.00	0.00	28	7.29	0.28
Tacoma	2.81	15	3.91	0.11	6	1.56	0.04	10	2.60	0.07	213	55.47	1.56	4	1.04	0.03	4	1.04	0.03	86	22.40	0.63	0	0.00	0.00	12	3.13	0.09	0	0.00	0.00	5	1.30	0.04	0	0.00	0.00	29	7.55	0.21
Tacoma South	1.61	8	2.08	0.03	6	1.56	0.03	4	1.04	0.02	273	71.09	1.15	4	1.04	0.02	4	1.04	0.02	45	11.72	0.19	0	0.00	0.00	3	0.78	0.01	0	0.00	0.00	1	0.26	0.00	0	0.00	0.00	36	9.38	0.15
Tascott	4.37	20	5.21	0.23	15	3.91	0.17	9	2.34	0.10	153	39.84	1.74	2	0.52	0.02	4	1.04	0.05	19	4.95	0.22	0	0.00	0.00	0	0.00	0.00	11	2.86	0.13	2	0.52	0.02	0	0.00	0.00	149	38.80	1.70
Terrigal	10.98	32	8.33	0.92	41	10.68	1.17	29	7.55	0.83	151	39.32	4.32	6	1.56	0.17	6	1.56	0.17	93	24.22	2.66	0	0.00	0.00	1	0.26	0.03	4	1.04	0.11	1	0.26	0.03	1	0.26	0.03	19	4.95	0.54
The Entrance	1.96	86	22.40	0.44	54	14.06	0.28	48	12.50	0.24	47	12.24	0.24	8	2.08	0.04	7	1.82	0.04	105	27.34	0.54	0	0.00	0.00	2	0.52	0.01	9	2.34	0.05	5	1.30	0.03	9	2.34	0.05	4	1.04	0.02
The Entrance North	1.26	63	16.41	0.21	40	10.42	0.13	39	10.16	0.13	27	7.03	0.09	10	2.60	0.03	11	2.86	0.04	97	25.26	0.32	0	0.00	0.00	31	8.07	0.10	2	0.52	0.01	1	0.26	0.00	54	14.06	0.18	9	2.34	0.03
Toowoomba Bay	0.72	55	14.32	0.10	32	8.33	0.06	32	8.33	0.06	50	13.02	0.09	11	2.86	0.02	6	1.56	0.01	68	17.71	0.13	0	0.00																

		IB			IO			IR			TP			TI			PBG			PGr			UAg			UAV			UBG			UGr			USa			UWa		
Suburb	Area km2	Pts	% Sub	Area km2	Pts	% Sub	Area km2	Pts	% Sub	Area km2	Pts	% Sub	Area km2	Pts	% Sub	Area km2	Pts	% Sub	Area km2	Pts	% Sub	Area km2	Pts	% Sub	Area km2	Pts	% Sub	Area km2	Pts	% Sub	Area km2	Pts	% Sub	Area km2	Pts	% Sub	Area km2			
MacMasters Beach	6.51	15	3.91	0.25	9	2.34	0.15	8	2.08	0.14	248	64.58	4.21	10	2.60	0.17	10	2.60	0.17	55	14.32	0.93	0	0.00	0.00	0	0.00	0.00	1	0.26	0.02	0	0.00	0.00	28	7.29	0.47			
Magenta	8.36	2	0.52	0.04	5	1.30	0.11	5	1.30	0.11	259	67.45	5.64	3	0.78	0.07	14	3.65	0.30	25	6.51	0.54	0	0.00	0.00	19	4.95	0.41	1	0.26	0.02	21	5.47	0.46	27	7.03	0.59	3	0.78	0.07
Manning Park	8.89	18	4.69	0.42	20	5.21	0.46	9	2.34	0.21	129	33.59	2.99	5	1.30	0.12	31	8.07	0.72	73	19.01	1.69	0	0.00	0.00	10	2.60	0.23	63	16.41	1.46	2	0.52	0.05	0	0.00	0.00	24	6.25	0.56
Mardi	11.26	12	3.13	0.35	15	3.91	0.44	10	2.60	0.29	145	37.76	4.25	3	0.78	0.09	11	2.86	0.32	138	35.94	4.05	0	0.00	0.00	9	2.34	0.26	8	2.08	0.23	1	0.26	0.03	0	0.00	0.00	32	8.33	0.94
Narara	10.00	26	6.77	0.68	21	5.47	0.55	11	2.86	0.29	205	53.39	5.34	10	2.60	0.26	11	2.86	0.29	89	23.18	2.32	0	0.00	0.00	0	0.00	0.00	6	1.56	0.16	3	0.78	0.08	0	0.00	0.00	2	0.52	0.05
Niagara Park	4.52	28	7.29	0.33	10	2.60	0.12	13	3.39	0.15	226	58.85	2.66	8	2.08	0.09	5	1.30	0.06	89	23.18	1.05	0	0.00	0.00	1	0.26	0.01	3	0.78	0.04	1	0.26	0.01	0	0.00	0.00	0	0.00	0.00
Norah Head	4.63	12	3.13	0.14	12	3.13	0.14	12	3.13	0.14	198	51.56	2.39	4	1.04	0.05	8	2.08	0.10	55	14.32	0.66	0	0.00	0.00	15	3.91	0.18	29	7.55	0.35	5	1.30	0.06	24	6.25	0.29	10	2.60	0.12
Noraville	2.36	63	16.41	0.39	36	9.38	0.22	34	8.85	0.21	116	30.21	0.71	13	3.39	0.08	7	1.82	0.04	91	23.70	0.56	0	0.00	0.00	3	0.78	0.02	6	1.56	0.04	8	2.08	0.05	7	1.82	0.04	0	0.00	0.00
North Avoca	2.08	39	10.16	0.21	21	5.47	0.11	20	5.21	0.11	147	38.28	0.80	18	4.69	0.10	13	3.39	0.07	45	11.72	0.24	0	0.00	0.00	11	2.86	0.06	10	2.60	0.05	1	0.26	0.01	13	3.39	0.07	46	11.98	0.25
North Gosford	2.28	40	10.42	0.24	39	10.16	0.23	20	5.21	0.12	198	51.56	1.18	17	4.43	0.10	9	2.34	0.05	56	14.58	0.33	0	0.00	0.00	0	0.00	0.00	5	1.30	0.03	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00
Ourimbah	104.89	2	0.52	0.55	3	0.78	0.82	2	0.52	0.55	342	89.06	93.42	2	0.52	0.55	4	1.04	1.09	21	5.47	5.74	0	0.00	0.00	1	0.26	0.27	6	1.56	1.64	1	0.26	0.27	0	0.00	0.00	0	0.00	0.00
Patonga	35.89	1	0.26	0.09	0	0.00	0.00	1	0.26	0.09	151	39.32	14.11	1	0.26	0.09	3	0.78	0.28	29	7.55	2.71	0	0.00	0.00	1	0.26	0.09	15	3.91	1.40	2	0.52	0.19	1	0.26	0.09	179	46.61	16.73
Pearl Beach	1.50	33	8.59	0.13	7	1.82	0.03	12	3.13	0.05	220	57.29	0.86	32	8.33	0.12	5	1.30	0.02	31	8.07	0.12	0	0.00	0.00	4	1.04	0.02	9	2.34	0.04	4	1.04	0.02	18	4.69	0.07	9	2.34	0.04
Phegans Bay	0.78	12	3.13	0.02	17	4.43	0.03	7	1.82	0.01	207	53.91	0.42	18	4.69	0.04	8	2.08	0.02	34	8.85	0.07	0	0.00	0.00	0	0.00	0.00	14	3.65	0.03	2	0.52	0.00	0	0.00	0.00	65	16.93	0.13
Point Clare	5.57	37	9.64	0.54	14	3.65	0.20	20	5.21	0.29	142	36.98	2.06	16	4.17	0.23	9	2.34	0.13	42	10.94	0.61	0	0.00	0.00	0	0.00	0.00	10	2.60	0.15	2	0.52	0.03	0	0.00	0.00	92	23.96	1.34
Point Frederick	1.42	46	11.98	0.17	40	10.42	0.15	16	4.17	0.06	28	7.29	0.10	15	3.91	0.06	5	1.30	0.02	35	9.11	0.13	0	0.00	0.00	1	0.26	0.00	2	0.52	0.01	0	0.00	0.00	0	0.00	0.00	196	51.04	0.73
Pretty Beach	1.13	17	4.43	0.05	12	3.13	0.04	14	3.65	0.04	101	26.30	0.30	15	3.91	0.04	3	0.78	0.01	30	7.81	0.09	0	0.00	0.00	0	0.00	0.00	9	2.34	0.03	4	1.04	0.01	0	0.00	0.00	179	46.61	0.53
Rocky Point	0.16	69	17.97	0.03	44	11.46	0.02	24	6.25	0.01	70	18.23	0.03	23	5.99	0.01	1	0.26	0.00	117	30.47	0.05	0	0.00	0.00	2	0.52	0.00	3	0.78	0.00	1	0.26	0.00	0	0.00	0.00	30	7.81	0.01
San Remo	2.74	67	17.45	0.48	33	8.59	0.24	38	9.90	0.27	98	25.52	0.70	19	4.95	0.14	6	1.56	0.04	103	26.82	0.74	0	0.00	0.00	0	0.00	0.00	6	1.56	0.04	7	1.82	0.05	0	0.00	0.00	7	1.82	0.05
Saratoga	4.69	29	7.55	0.35	20	5.21	0.24	12	3.13	0.15	105	27.34	1.28	14	3.65	0.17	9	2.34	0.11	46	11.98	0.56	0	0.00	0.00	0	0.00	0.00	1	0.26	0.01	2	0.52	0.02	0	0.00	0.00	146	38.02	1.78
Shelly Beach	1.42	58	15.10	0.21	31	8.07	0.11	28	7.29	0.10	68	17.71	0.25	7	1.82	0.03	5	1.30	0.02	95	24.74	0.35	0	0.00	0.00	17	4.43	0.06	4	1.04	0.01	45	11.72	0.17	26	6.77	0.10	0	0.00	0.00
Springfield	5.48	28	7.29	0.40	15	3.91	0.21	11	2.86	0.16	242	63.02	3.45	10	2.60	0.14	10	2.60	0.14	56	14.58	0.80	0	0.00	0.00	3	0.78	0.04	1	0.26	0.01	4	1.04	0.06	0	0.00	0.00	4	1.04	0.06
St Huberts Island	3.26	20	5.21	0.17	15	3.91	0.13	4	1.04	0.03	62	16.15	0.53	11	2.86	0.09	11	2.86	0.09	37	9.64	0.31	0	0.00	0.00	5	1.30	0.04	1	0.26	0.01	0	0.00	0.00	1	0.26	0.01	217	56.51	1.84
Summerland Point	3.78	37	9.64	0.36	20	5.21	0.20	17	4.43	0.17	176	45.83	1.73	9	2.34	0.09	24	6.25	0.24	69	17.97	0.68	0	0.00	0.00	0	0.00	0.00	4	1.04	0.04	0	0.00	0.00	0	0.00	0.00	28	7.29	0.28
Tacoma	2.81	15	3.91	0.11	6	1.56	0.04	10	2.60	0.07	213	55.47	1.56	4	1.04	0.03	4	1.04	0.03	86	22.40	0.63	0	0.00	0.00	12	3.13	0.09	0	0.00	0.00	5	1.30	0.04	0	0.00	0.00	29	7.55	0.21
Tacoma South	1.61	8	2.08	0.03	6	1.56	0.03	4	1.04	0.02	273	71.09	1.15	4	1.04	0.02	4	1.04	0.02	45	11.72	0.19	0	0.00	0.00	3	0.78	0.01	0	0.00	0.00	1	0.26	0.00	0	0.00	0.00	36	9.38	0.15
Tascott	4.37	20	5.21	0.23	15	3.91	0.17	9	2.34	0.10	153	39.84	1.74	2	0.52	0.02	4	1.04	0.05	19	4.95	0.22	0	0.00	0.00	0	0.00	0.00	11	2.86	0.13	2	0.52	0.02	0	0.00	0.00	149	38.80	1.70
Terrigal	10.98	32	8.33	0.92	41	10.68	1.17	29	7.55	0.83	151	39.32	4.32	6	1.56	0.17	6	1.56	0.17	93	24.22	2.66	0	0.00	0.00	1	0.26	0.03	4	1.04	0.11	1	0.26	0.03	1	0.26	0.03	19	4.95	0.54
The Entrance	1.96	86	22.40	0.44	54	14.06	0.28	48	12.50	0.24	47	12.24	0.24	8	2.08	0.04	7	1.82	0.04	105	27.34	0.54	0	0.00	0.00	2	0.52	0.01	9	2.34	0.05	5	1.30	0.03	9	2.34	0.05	4	1.04	0.02
The Entrance North	1.26	63	16.41	0.21	40	10.42	0.13	39	10.16	0.13	27	7.03	0.09	10	2.60	0.03	11	2.86	0.04	97	25.26	0.32	0	0.00	0.00	31	8.07	0.10	2	0.52	0.01	1	0.26	0.00	54	14.06	0.18	9	2.34	0.03
Toowoona Bay	0.72	55	14.32	0.10	32	8.33	0.06	32	8.33	0.																														



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