Sunshine Coast COUNCIL

Sunshine Coast
Street Tree Master Plan 2018
Part A: Street Tree Master Plan Report

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Acknowledgements

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Disclaimer

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Foreword

Here on our healthy, smart, creative Sunshine Coast we are blessed with a wonderful environment.

It is central to our way of life and a major reason why our 320,000 residents choose to live here – and why we are joined by millions of visitors each year.

Although our region is experiencing significant population growth, we are dedicated to not only keeping but enhancing the outstanding characteristics that make this such a special place in the world.

Our trees are the lungs of the Sunshine Coast and I am delighted that council has endorsed this master plan to increase the number of street trees across our region to balance our built environment.

In developing this master plan, council undertook a comprehensive analysis of the Sunshine Coast's urban forest and existing street tree network to identify where the trees were most needed and which species should be planted.

I'm pleased to report that the Sunshine Coast is already one of the greenest local government areas in Queensland, with 57% of all land covered with some trees, and through this master plan, we aim to increase that percentage.

Some of our most densely populated areas require additional street trees and this plan provides recommendations for placement and species to help ensure each area benefits from the positive environmental, visual, social and economic impacts trees provide.

As well as providing shade and cooling, street trees improve the look and feel of our places and help make the Sunshine Coast a healthy and vibrant place to live.

Thank-you to everyone in our community who took part in the consultation phase in late 2017.

Your input has helped council to set a clear direction for future street tree planting and we look forward to your continuing engagement as we raise the importance of trees as a community asset and resource.

Cr Jenny McKay
Community and Environment Portfolio

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"... one of the most desirable places to live, work, invest, play and visit (*Sunshine Coast Council Corporate Plan 2018-2022)*."

Introduction

Executive summary

Trees shade, cool and balance the built environment and contribute to the health, character and prosperity of our communities.

The Sunshine Coast is best characterised by its natural assets. From the unique rock formations of the world heritage listed Glass House Mountains to the 130 kilometre stretch of coastline and pristine beaches, the region's distinct and often dramatic land form, and all of the trees plants and water associated with it, are fundamental to the region's liveability. The stunning natural surroundings don't just contribute to the enviable Sunshine Coast lifestyle, they're central to it.

Along with the region's warm subtropical climate, this natural capital is also a major drawcard for holiday makers, with the diversity of landscapes and experiences on offer attracting millions of local and international visitors to the coast every year, significantly contributing to the local economy.

The network of green spaces that frame, shade, link and cover the region are responsible for the lush subtropical setting that the Sunshine Coast is known for. Street trees are integral to these green spaces, performing a critical environmental role as well as providing many visual, social and economic benefits.

They sequester carbon, produce oxygen, filter pollutants, reduce run off and prevent erosion. When strategically positioned they can significantly reduce energy requirements through the provision of shade and cooling. Trees feed and shelter wildlife. They are instrumental in the conservation of biodiversity. Trees make our streets more attractive. They buffer the built environment and provide a sense of vertical scale. Trees act as landmarks and meeting points. They make our towns vibrant living places by providing quality spaces for day to day life. Shady streets bring urban life outdoors and encourage people to meet and socialise, improving the health and wellbeing of our communities and helping to drive the local economy.

The Sunshine Coast is presently in a major phase of development. New and upgraded infrastructure is constantly required to support greenfield

development and densification of existing residential areas. In a landscape that continues to grow and change, council must manage trees in a way that not only sustains the existing level of benefits provided, but maximises these benefits in the future. If we are realistic and smart about where and how we establish new street trees, we can safeguard the Sunshine Coast's urban amenity and outstanding liveability while embracing the growth necessary for the region's future prosperity.

This will not only require cooperation and commitment from all involved, but a proper understanding and appreciation of the role street trees play on the Sunshine Coast; what the physical barriers to successful tree establishment are, and how these can be overcome.

The *Trees in the Urban Landscape* section within the plan's *Background* details exactly why trees are so important to our everyday lives and how they will become even more important in the future. The *Challenges and Opportunities* section considers the juxtaposition of street trees and a rapidly growing, ever-changing region, and considers ways that the Sunshine Coast's existing and future street trees can better integrate with the changing landscape.

The *Analysis* section takes a much closer look at the existing street tree canopy and shade cover network across the region and helps identify trends and priority planting areas.

The *Strategic Directions* of the plan presents the plan's vision and guiding principles for street tree planting, provides region wide species lists, identifies street tree planting priorities and presents a staged plan of action.

With a vision to *Protect, sustain and enhance the region's existing and future street tree network through better selection, placement and care of street trees*, the end goal of the plan is the provision of a street tree network that is attractive, functional and resilient. A street tree network that is compatible with the wishes and expectations of the local community, as well as visitors to the Sunshine Coast.

The plan seeks to achieve this goal through priority based implementation of the following key strategies, detailed in the *Guiding Principles* of the plan. These are to:

- prioritise the planting of new street trees in locations where they will provide the most visual, environmental, economic and social value
- shade and cool high-use pathways
- build canopy in vacant 'plantable' spaces
- lessen the impacts of development on the Sunshine Coast by filling existing and creating new spaces that can accommodate large canopy trees
- reduce the costs of early tree losses, tree and infrastructure conflicts and recurring maintenance by selecting and planting quality trees suited to the specific conditions of the planting site
- increase resilience within the Sunshine Coast street tree population through species diversification and ongoing renewal or replacement of street trees
- improve street tree establishment rates through extension of young tree maintenance programs and establishment of partnerships between council, developers, local businesses and residents to help care for new trees.

Council aspires to the provision of a street tree network that is not only sustainable, but one that celebrates the rich diversity and uniqueness of the region. Local street tree planting strategies and species palettes suited to the diversity of areas within the region are provided in a separate section of the plan.

"A city-region that prides itself on its attributes, competitive advantage and outstanding natural assets. A place where its community is passionate about the lifestyle that we are fortunate to enjoy and the values that we hold (*Sunshine Coast Council Corporate Plan 2018-2022*)."

"... An environment that is central to the Sunshine Coast way of life, and critical to supporting our economy and community (*Sunshine Coast Council Corporate Plan 2018-2022*)."

Purpose of the plan

The *Sunshine Coast Street Tree Master Plan* sets the direction for future street tree planting in the Sunshine Coast Council region.

It details why trees are so important, communicates the region's street tree planting strategies and priorities and provides guidance for locations, layouts and species to use.

The plan also provides a staged action plan to guide implementation of the street tree planting strategies presented.

In essence, the plan serves to identify where and how street trees can provide the greatest benefits to the Sunshine Coast. In setting the direction for street tree planting, the plan also seeks to facilitate a more co-ordinated approach to the maintenance and delivery of new infrastructure and street trees in the future, and as such, better balancing natural and built capital as the region continues to grow.

Key objectives

The *Sunshine Coast Street Tree Master Plan* seeks to:

Sustain

- Existing **regional and local character** by planting the right trees in the right locations and more of them.
- The current **extent of tree cover** through ongoing replacement and succession street tree planting programs and improved tracking and monitoring of new trees.
- Our **future street tree population** by building diversity and resilience in the existing street tree network.

Enhance

- The **local and visitor experience** by planting more trees in more places.
- The **liveability** of the region through shading, cooling and greening our network of streets.
- The **distinct character of the region's various localities** by infilling existing avenues on major thoroughfares, and planting feature trees in key locations.
- The **region's visual amenity** by planting new trees in locations where potential conflicts are low and potential benefits are high.
- The **amenity of a growing and changing region** by ensuring adequate space is reserved or constructed for street trees.
- The **existing level of street tree benefits provided** through better selection, monitoring and maintenance of future street trees.

Reduce

- **Conflicts and** long term **maintenance requirements** through appropriate selection and placement of new trees, and ongoing stakeholder consultation.
- **Solar glare and ambient temperature** by planting trees to shade and cool major pedestrian routes and 'hot spots' in built-up urban areas.
- **Energy consumption** and the financial burden of cooling 'hot spots' by planting trees in strategic locations.
- **Our carbon footprint** with new tree plantings that will both absorb carbon emissions and store carbon to lessen the impacts of climate change, and locally mitigate heat as temperatures rise.
- **Poor plant establishment rates and high young tree maintenance costs** through improved tracking and maintenance of new trees and the establishment of community and corporate partnerships to help care for young trees.

Engage and partner

- With the **Sunshine Coast community** to help council decide what types of trees are planted where.
- With the **Sunshine Coast community and business sector** to help care for new trees while they are establishing.
- With the **Sunshine Coast community** to encourage more private tree planting and raise awareness of trees as a community resource.

Plan structure / How to use the plan

This plan is presented in two parts:

Part A:

Part A of the plan—the *Street Tree Master Plan Report*—is divided into *Background* which provides the necessary context and *Strategic Directions* which present council's vision, strategies and plan of action for sustaining and enhancing the Sunshine Coast's existing and future street tree network.

Part B:

In recognition of the diversity of Sunshine Coast landscapes, and the vital importance of retaining character in our 'community of communities', council's specific approach to delivering local street tree planting initiatives are detailed in individual *Street tree strategies.*

The *Street tree strategies* identify future street tree planting opportunities in each of the region's 27 *Local Plan Areas* (LPAs) and present palettes of suitable street tree species for each.

These local strategies have been tailor made to the subject local area considering land use, function, community values, priorities, existing opportunities and constraints for street tree planting.

These strategies are accompanied by *Priority planting plans* (maps) highlighting priority locations for street tree establishment in the short term (over the next five years).

The plan has been designed to be used in conjunction with the *Sunshine Coast Open Space Landscape Infrastructure Manual* which contains the associated technical content including guidelines for the selection of street tree stock and specifications for the planting and maintenance of new trees.

Plan scope

The plan applies to 'street trees' defined as trees that grow within road reserve spaces (land not associated with a title deed reserved for the transport of vehicles). Street trees are generally found as individual specimens or groups, along formed footpath and median spaces within the urban footprint of the Sunshine Coast. However, the plan also applies to road reserve trees in rural townships and rural residential areas.

The plan addresses street trees associated with all levels of the road hierarchy (see *Sunshine Coast Planning Scheme 2014, Schedule 6: Planning scheme policies, SC6.17 Planning scheme policy for the transport and parking code*). This includes those under the control of both state and local government.

Planning horizon

The *Street tree master plan report* (Part A) is intended to have a twenty year span of influence but will be reviewed as required to respond to changes in legislation, and the wishes and needs of the community.

The *Street tree strategies* (Part B) will require review after five years to determine whether priorities have changed as an outcome of strategy implementation, and ongoing monitoring of the street tree network. Species lists contained within both Parts A and B of the plan will be reviewed periodically and may be subject to change over time due to community preference, taxonomic reclassification (changes in plant names), release of new and/or improved species varieties or cultivars, pest or disease outbreaks; or as an outcome of current or future street tree trials.

The *Priority planting plans* have been prepared with a five year time frame for delivery in mind. This implementation period may be shorter or longer depending on council's wider program priorities and available budgets. These plans will be updated in the future to reflect not yet mapped sites in consultation with the Sunshine Coast community and local businesses.

Who will use the plan

Council

The plan will support a range of council officers involved in the planning, design and delivery of open space and infrastructure, as well as officers responsible for maintaining existing networks. The plan provides a platform for cross-council collaboration – an opportunity for street tree network objectives and priorities to be realised through capital projects and operational programs.

Community

The plan and associated educational resources provide a reference tool for the community and council's *Treemendous Tree Care Partnerships* provide opportunity for direct involvement in its implementation. The live nature of Part B of the plan, the local *Street tree strategies*, also allows for ongoing engagement with local communities in the development of specific planting strategies and species palettes, with updates possible over time.

Parts A and B of the plan and the *Plan Overview* summarising the key features of the plan, are available on council's web site for all to use. Additional resource materials are also available to encourage landowners to enhance and strengthen the region's 'urban forest' by planting more trees on private land.

Developers/landowners

The plan aims to guide street tree selection and placement in new residential developments by identifying desired landscape character and street tree network structure, as well as advocating species for use. The plan aspires to encourage land developers to incorporate appropriate spaces for large growing trees in all urban residential developments. With specific reference to dual occupancy and smaller assessable development, the plan aims to encourage retention and the proper protection of existing street trees (especially the protection of spaces that will help support their future growth and stability in accordance with *AS 4970-2009 Protection of trees on development sites*). See also the *Sunshine Coast Open Space Landscape Infrastructure Manual – Preliminaries – Vegetation Management*.

External bodies/service providers

Collaboration with external bodies and service providers will allow for the formulation of strategies to address potential conflicts, while ensuring the Sunshine Coast's street tree network continues to thrive and grow.

Policy and planning context

Planning framework

The *South-East Queensland Regional Plan 2017* and *Sunshine Coast Planning Scheme 2014* are the principal planning documents for the region, stating planning intent and guiding development into the future.

These documents have been used to help build local strategies for street tree planting by defining local character and provide planning context around existing and future land use.

South East Queensland Regional Plan 2017

The *South-East Queensland Regional Plan 2017* is the over-arching document governing planning in the region and takes precedence over all other planning instruments. The purpose of the plan is to sustainably manage growth and change in South East Queensland to protect and enhance quality of life for residents of the region.

The plan's vision for South East Queensland is for "...a future that is sustainable, affordable, prosperous, liveable and resilient to climate change."

Sunshine Coast Planning Scheme 2014

The *Sunshine Coast Planning Scheme 2014* is the local planning instrument for the Sunshine Coast guiding development in the *Planning Scheme Area* until 2031. The strategic intent of the *Sunshine Coast Planning Scheme 2014* is Green space for Generations "...in 2031 the Sunshine Coast is one of the most biologically diverse areas in Australia and is renowned for its natural environmental values and leafy, subtropical urban environments."

Strategic context

The *Sunshine Coast Street Tree Master Plan* seeks to both reflect and align with various Sunshine Coast Council strategic documents. These include but are not limited to the:

Sunshine Coast Council Corporate Plan 2018-2022

The *Sunshine Coast Council Corporate Plan* is council's principal strategic document and sets the strategic direction for council for the next five years according to five identified goals.

- A smart economy
- A strong community
- A healthy environment
- Service excellence
- An outstanding organisation

Sunshine Coast Environment and Liveability Strategy 2017

The plan highlights the region's "unprecedented growth and the rapidly evolving digital age" as significant drivers of council's strategic direction as well as the major regional projects which will make the region "an even better place to live, work and play for present and future generations." The plan acknowledges the link between the Sunshine Coast landscape and the Sunshine Coast way of life, the critical role the region's environment continues to play in supporting our economy and community and the importance of "maintaining and enhancing the region's natural assets, liveability and environmental credentials" into the future.

The purpose of the *Sunshine Coast Environment and Liveability Strategy* is to provide long term strategic direction to guide growth and shape the Sunshine Coast for future generations to 2041. It focuses on the natural environment and how it can be preserved and enhanced, as well as the liveability of the region – enabling a good quality of life for all residents in an accessible and well-connected built environment.

The Sunshine Coast Environment and Liveability Strategy provides the key policy positions for this plan. These include:

Landscape and character policy positions:

1.1 The distinctive and diverse landscape is preserved to maintain the beauty of the area.

1.2 The landscape, character and heritage values retain the unique identity of the area.

Open space policy positions:

5.1 An integrated and connected open space network is provided that is responsive to a changing environment and respects community needs.

5.2 The open space network ensures equitable access to a range of experiences to encourage active and healthy lifestyles and supports community well-being.

5.3 Open space provides the green frame around and within our built form to connect us to the environment and create a strong sense of identity within a community of communities.

Stormwater and flooding policy position:

6.3 Flooding and stormwater management protects the natural and built environment.

Neighbourhoods and housing policy position:

7.1 Good urban design and urban form supports compact and self-contained neighbourhoods to improve the use of existing infrastructure and minimise the use of resources.

Sustainable design policy positions:

9.1 The built environment is designed to be low carbon, resilient, well connected, have minimal environmental impact and enhance liveability and local character.

9.2 Living infrastructure is integrated with the built form to create liveable neighbourhoods, support urban biodiversity and create great urban places.

Adaptation and resilience policy position:

12.1 Adaptation enables the whole community to build climate and disaster resilience.

The *Sunshine Coast Street Tree Master Plan* serves to address Transformational Action 17 of the strategy - Greening our neighbourhoods: Delivering cool and shady streets and places to connect and enhance our neighbourhoods and promote biodiversity, resilience and community wellbeing.

Sunshine Coast Regional Economic Development Strategy 2013–2033

This strategy provides a 20 year vision and blueprint for sustainable economic growth. It will help to ensure the region actively participates in the global economy and deliver the lifestyle and opportunities for local residents and businesses alike.

Sunshine Coast Major Events Strategy 2013–2017

The *Sunshine Coast Major and Regional Events Strategy* is the long term planning document for major and regional events in the region.

Sunshine Coast Positive Aging Strategy 2011–2016

Council has developed the *Sunshine Coast Positive Ageing Strategy* to address the changing needs of older people on the Sunshine Coast.

Sunshine Coast Sustainable Transport Strategy 2011–2031

The *Sunshine Coast Sustainable Transport Strategy* identifies what is required to provide a sustainable, integrated and safe transport system.

Sunshine Coast Waste Strategy 2015–2025

The *Sunshine Coast Waste Strategy* has been developed to shape council's future waste management infrastructure needs and develop strong resource recovery markets. This strategy aims to also ensure that this essential community service remains both cost effective and customer focused whilst protecting the health of the public and the natural environment.

Additional plans of relevance include the:

- Sunshine Coast Active Transport Plan 2011–2031
- Sunshine Coast Energy Transition Plan 2010–2020
- Sunshine Coast Heritage Plan 2015–2020
- Sunshine Coast Local Government Area Biosecurity Plan 2017
- Sunshine Coast Reconciliation Action Plan
- Sunshine Coast Road Safety Plan 2016–2020
- Sunshine Coast Sport and Active Recreation Plan 2011–2026
- Sunshine Coast Council Unsealed Roads Upgrade Plan 2015–2035.

Sunshine Coast Open Space Landscape Infrastructure Manual

The plan has been designed to be used in conjunction with the *Sunshine Coast Open Space Landscape Infrastructure Manual.* The manual provides technical reference materials directly relating to street tree planting including guidelines for the selection of street tree stock, and specifications for tree planting and young tree maintenance. The manual also provides the background detail (how trees function and what they require for good growth) to support many of the discussions and recommendations of the plan.

The manual details council's specific requirements for the protection of trees on development sites. The manual also describes a range of tree sensitive and/or alternative design treatments to enhance growing conditions or extend the space available for tree root growth.

Legislation and standards

There are many different legislation and standards also considered relevant to the development of this plan. These include, but are not limited to:

National legislation

- Aboriginal and Torres Strait Islander Heritage Protection Act 1984
- Disability Discrimination Act (DDA) 1992
- Environmental Protection and Biodiversity Conservation Act 1999
- Native Title Act 1993.

Queensland Legislation – acts and subordinate Legislation

- Aboriginal Cultural Heritage Act 2003
- Anti-Discrimination Act 1991
- Biosecurity Act 2015
- Electricity Act 1994
- Electrical Safety Act 2002
- Environment Protection Act 1994 and regulations
- Local Government Act 2009
- Native Title (Queensland) Act 1993
- Nature Conservation Act 1992 and regulations
- Queensland Heritage Act 1992
- Soil Conservation Act 1986
- Sustainable Planning Act 2009 and regulations
- Torres Strait Islander Cultural Heritage Act 2003
- Vegetation Management Act 1999 and regulations
- Work Place Health and Safety Act 2011 and regulations (such as Work Health and Safety Regulation 2011)
- Water Act 2000 and regulations.

Australian Standards

- AS 2303–2018 *Tree stock for landscape use*
- AS 4970–2009 *Protection of trees on development sites*
- AS 4373–2007 *Pruning of amenity trees.*

Local laws

This document is to be used in conjunction with *Local Law and Subordinate Local Law No. 4* (*Local Government Controlled Areas, Facilities, Infrastructure and Roads*) *2011* which provides the framework to determine how local government controlled land, facilities, infrastructure and roads may be used for the benefit of everyone.

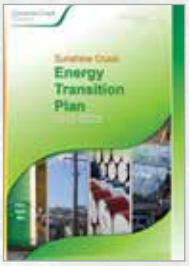
It is an offence to plant, clear or damage vegetation in a local government controlled area unless prior written approval has been granted by council. Council regulates planting in road reserves to ensure unobstructed and safe pedestrian movement and adequate sight-lines for vehicular traffic. Inappropriate streetscape plantings can reduce visibility and pose a risk to both pedestrians and motorists. Inappropriate streetscape plantings can also damage underground services such as water, sewerage, power and telecommunication cables (see Sunshine Coast Council Fact sheet – *Planting, clearing or damaging vegetation in a local government controlled area*).

Regional Economic Development Strategy 2013-2033

SC Corporate Plan 2018-2022

SC Environment and Liveability Strategy 2017

SC Active Transport Plan 2011-2031



SC Energy Transition Plan 2010-2020

SCC Local Government Area Biosecurity Plan 2017

SC Sustainable Transport Strategy 2011-2031

Figure 1: Diagram showing key Sunshine Coast Council strategies and plans closely consulted in the development of the Sunshine Coast Street Tree Master Plan.

Background

Trees in the urban landscape

Sunshine Coast landscapes

The Sunshine Coast encompasses an area of 2,291 square kilometres containing a diverse range of geological and geographic features. The Sunshine Coast Council Local Government Area (LGA) extends from Emu Mountain in the north to the Pumicestone Passage in the south, and as far west as the Conondale Ranges. The LGA is blessed with significant natural capital comprising a stunning 60 kilometre stretch of coastline and 78,000 hectares of open space in the form of foreshores, amenity reserves, bushland and road reserve. It is one of the largest LGAs in Australia. It is also one of the most biodiverse.

Natural landscape

The region's rich biodiversity is attributed to its complex geological origins and a range of resulting rock types, topography and soils (Wilmot 2007). The natural landscape reflects this diversity. Seventy-five regional ecosystems are present which can be divided into six broad vegetation communities; foredune, mangrove and saltmarsh, heath and wallum, eucalypt and rainforest.

While this plan is focused on street trees, the types of trees and where they are planted can have an influence on our natural plant communities and such issues have been considered and addressed within the plan.

Street trees provide a buffer and protection to natural areas and provide corridors and connections between bushland reserves or areas of conservation. Street trees can contribute to the biodiversity values of natural areas and the region as a whole, but can also have a negative impact on these values if not properly planned for. When the wrong species is used for example, it may self perpetuate and outcompete natural plant communities. Species attractive to wildlife that may be especially vulnerable to attack by predators or road deaths planted inappropriate locations can also put wildlife at risk.

Rural landscape

The distinct character of many of the region's hinterland towns and landscapes reflects the rich history of the region. Agriculture, rural and rural residential living comprise the major land uses in the Sunshine Coast hinterland.

The Blackall Range does however also offer a hinterland tourist experience with twelve percent of the coast's visitors staying in the popular hinterland locations of Mapleton, Flaxton and Montville in 2016.

Nambour and Beerwah are the major economic hubs of the hinterland both earmarked for further growth and expansion (*South East Queensland Regional Plan 2017*).

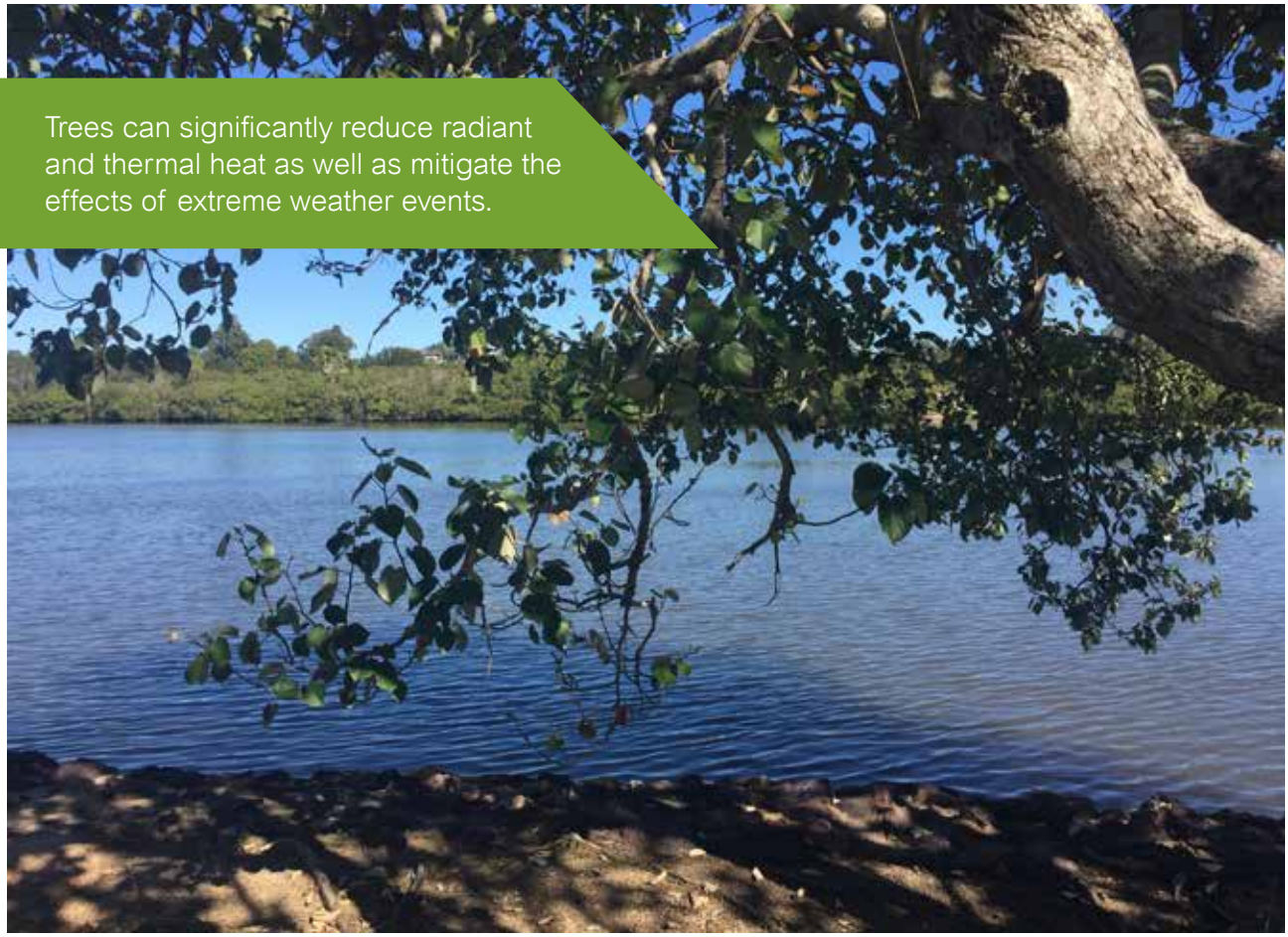
Again with the focus of this plan being on 'street trees' many of our rural streets with no standard verge spaces or even kerb and channel seem to not fit the criteria. The most populated areas of the Sunshine Coast hinterland however, officially occur within the region's urban footprint, and street trees contribute significantly to rural town character as well as the amenity of residential and rural residential streets. Street trees also provide the same social, economic, environmental and aesthetic benefits in rural areas as they do in urban landscapes.

Urban landscape

Seventy percent of the Sunshine Coast's residents live along the region's urban coastal belt. The region's largest urban centre and principal activity centre of the Sunshine Coast is Maroochydore. Other major coastal centres include Caloundra and Mooloolaba.

The Sunshine Coast coastal character blends casual urban environments and tourist precincts with a strong focus on foreshores and beaches. Urban intensity is highest between Caloundra and Maroochydore, an area also known as the region's *Sunshine Coast Enterprise Corridor* where future growth and development will be concentrated. This densification or move towards a medium density built form will significantly change the appearance of the built landscape, and the coastal strip of the Sunshine Coast as a whole.

Street trees offer the potential to not just soften, frame and provide vertical scale to buildings, they also make urban environments more comfortable and liveable through the provision of shade and cooling.



Trees can significantly reduce radiant and thermal heat as well as mitigate the effects of extreme weather events.

The benefits of trees

Trees provide many environmental, visual, social and economic benefits. They have the potential to locally reduce the severity of climate change and in a warming climate, will help to mitigate and manage increased heat with their shading and cooling canopies.

Environmental benefits

Trees perform critical 'ecosystem services' and help to maintain biodiversity. They regulate sunlight to our houses and streets and reduce ambient temperature through the provision of shade and cooling.

Brisbane City Council reported that in 2011/12 its 575,000 trees sequestered 7300 tonnes of carbon to the value of $168,000, air pollution removal to the tune of 87,200 tonnes annually (valued at $44,200) and 653,733m^3 of rainfall interception valued at $1,444,533 (estimated using i-Tree ECO V5 National Urban Forest Alliance 2014).

The many environmental benefits of trees are summarised in *Table 1: The environmental benefits of trees.*

Trees absorb and store carbon, release oxygen, shade and cool their surroundings, reduce and filter storm water run off and bind soils preventing erosion.

Table 1: The environmental benefits of trees

Environmental benefits
Provision of shade (reflection and absorption of solar radiation). Strategically positioned trees can significantly reduce energy consumption for cooling of buildings (air conditioning) (McPherson et al. 2016). Shaded pathways can help increase 'walkability' (Sarker et al. 2015) reducing motor vehicle dependency and as such, greenhouse gas emissions.
Cooling the surrounding air as an outcome of evapo-transpiration. Temperature differentials of between 4.1 °C and 18.7 °C can be experienced beneath clusters of shady trees (Thom et al. 2016).
Sequestration and storage of carbon (carbon dioxide is the main greenhouse gas contributing to enhanced greenhouse effect and climate change).
Production of oxygen (trees convert carbon dioxide to oxygen which is released) and carbon (which is stored in wood as an outcome of respiration).
Absorption and biofiltration of storm water (reducing peak flows, nutrient content and level of pollutants in storm water runoff, helping to mitigate flooding, reducing erosion and drainage infrastructure requirements). In low intensity rain events, street trees can capture and reduce rainfall run off by up to twenty percent (Livesley 2013).
Tree roots bind soils and restrain bank edges, reducing the rate and severity of erosion.
Air quality improvement through pollutant filtration (ozone reduction, dust and chemical particulate removal).
The provision of food and shelter for wildlife (including insects).
Improving soils through decomposition of matter and nutrient recycling and the forming of symbiotic relationships with soil microorganisms.
Wind reduction.

Trees make our streets more attractive and provide a visual edge to the roadway, delineating the road corridor.

Visual benefits

Street trees are well recognised as essential elements of high quality and inviting urban spaces.

Healthy, attractive trees add identity and visual interest to the appearance of our local streets and neighbourhoods. Conversely, neighbourhoods with less tree cover, small or poor quality street trees can undermine an area's image and sense of community pride.

Larger trees can act as landmarks and provide critical 'first impressions' when planted as entry statements. They create attractive, inviting landscapes leading us into our major centres and local towns through gateway and avenue plantings.

Trees can complement or provide relief from the built form. They lend interest to the sides of buildings and can mask the negative effects of development as our region grows.

'Liveable' street treatments, including trees planted between the footpath and roadway, have been found to increase road safety, including fewer vehicle collisions and pedestrian or cyclist injuries (Dumbaugh 2006).

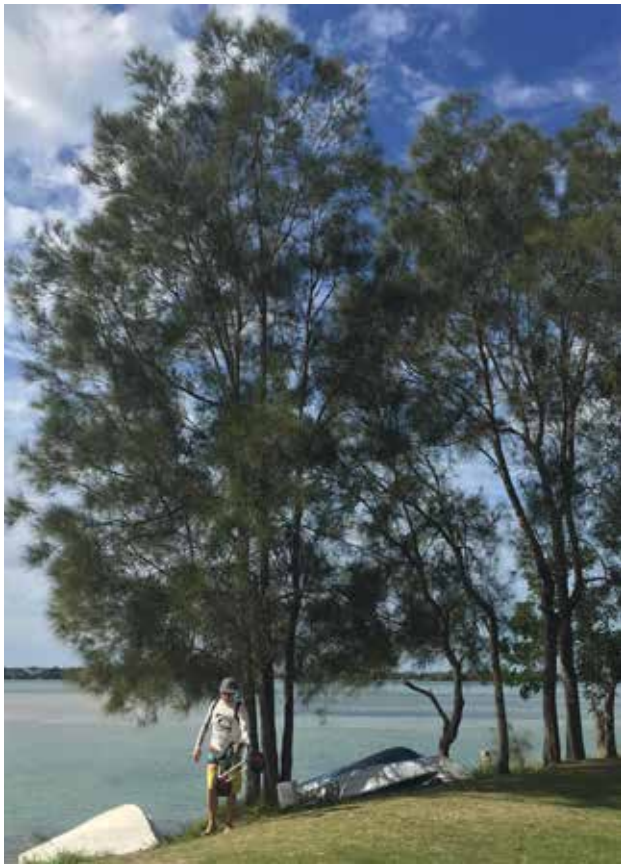
Tree lined roadways improve driver concentration and provide a real and perceived physical barrier between cars and pedestrians (Ely and Pitman 2014).

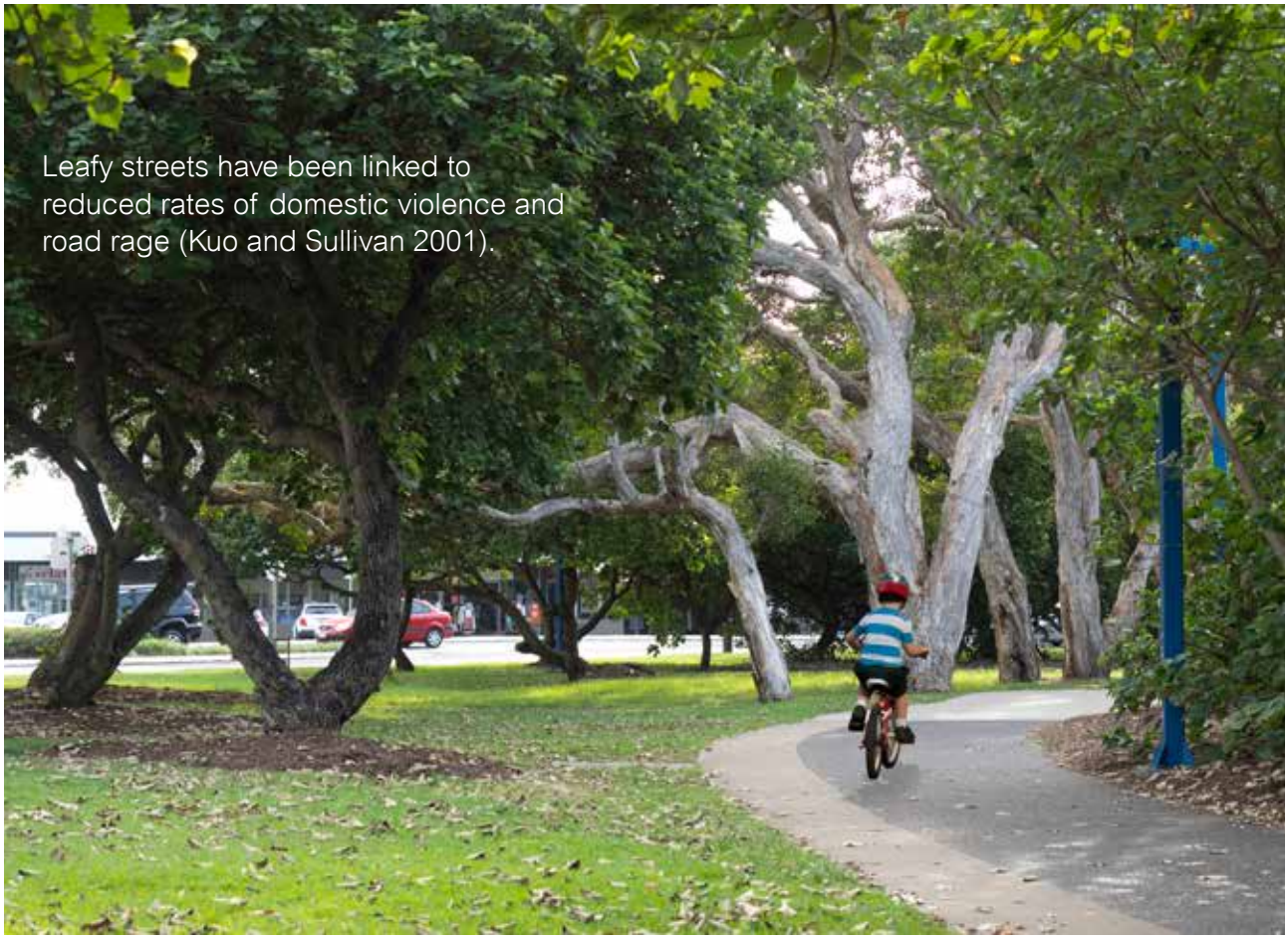
Some of the visual benefits of trees are summarised in *Table 2*: *The visual benefits of trees.*

Table 2: The visual benefits of trees

Visual benefits
Provide visual amenity.
Contribute to placemaking and local character.
Create privacy through screening.
Buffer and soften the built environment.
Mask or moderate the impacts of development.
Frame views.
Provide vertical scale and spatial definition to our streets and high rise localities.
Define paths of travel delineating curves and changes in the road (legibility of routes).
Act as landmarks and legacies from the past.
Provide subtropical ambience.
Contribute to community identity.
Provide seasonal change and interest.
Enhance cultural events.
Bring nature into our urban environments.

Trees make the places we live, visit and travel through more attractive.





Leafy streets have been linked to reduced rates of domestic violence and road rage (Kuo and Sullivan 2001).

Social benefits

Trees significantly contribute to the health and wellbeing of our communities. They connect us to nature and to each other.

Street trees contribute to healthier urban lifestyles (Astell-Burt et al. 2014). The shade they provide makes it easier for us to exercise and walk, encouraging outdoor lifestyles and physical activity. People living in greener areas are forty percent less likely to be overweight or obese (Planet Ark 2016). Leafy settings have been shown to reduce stress, foster recovery and enhance concentration. Participation in tree planting and stewardship activities has also been shown to strengthen local communities (Svendson 2009).

Both the quality and quantity of greenery in streetscapes has been linked to self reported reductions in stress and positive feelings of belonging in adults (de Vries et al. 2013). Office workers may need as little as five minutes of walking through nearby leafy streetscapes to deliver a 'dose of nature' that improves productivity back at work (Largo-Wight et al. 2011). Even more importantly, safe, inexpensive and accessible doses of nature for children can improve learning and reduce symptoms of attention deficit disorder (Kuo and Faber Taylor 2004).

The social benefits of trees are summarised in *Table 3*: *The social benefits of trees*.

Table 3: The social benefits of trees

Social benefits
Psychological wellbeing (trees can provide a sense of peace and calm and reduce stress).
Enhanced walkability of pedestrian networks through shade and cooling (treelined streets surrounding parks, recreation and community facilities for example encourage people to walk rather than drive to these places).
Provide legacies and links to the past and help create community identity.
Encourage feelings of connectedness to nature.
Decrease blood pressure (studies have found traffic calming, reduced domestic violence and crime in general are linked to environments where there is good tree cover).
Encourage outdoor lifestyles, activity and participation in community life (health and well being for the older members of the community and play for young children).
Encourage productivity in workers and the study habits of female students (see information box below).
Minimise noise pollution and extreme heat which have been linked to aggression.
Treed outlooks have been linked to faster rates of recovery for hospital patients and improved mental heath.
Street trees provide a buffer between vehicles and pedestrians and can increase safety, or the perception of safety for pedestrians.

Trees make places. Their presence can encourage activity, connectedness and calm.

Increasing tree canopy cover is one of the most cost effective strategies for cooling buildings and local neighbourhoods (Norton et al. 2013).

Economic benefits

Trees make places. They improve the appearance, economic value and liveability of our towns. Trees create atmosphere and encourage activity. They offer increased vibrancy and comfort to commercial areas. Businesses on tree lined streets have been shown to be more profitable than non-tree lined streets (Wolf 2005) with shoppers in warm climates likely to spend more time and money in cool and leafy locations.

Houses in leafy streets also attract higher sale prices. When separated from other house, property and location features, Brisbane residential home-buyers preference for houses in leafy streets attracted property prices up to 3.73% higher than comparable non-leafy streets (Plant et al. 2017).

Yet the strongest case for leafy streets may come from the energy saving benefits of cooler, tree-shaded streets and neighbourhoods in our warming climate. Reducing peak summer temperature by one degree is estimated to reduce energy usage (through reduced cooling load) by 5% (Norton et al. 2013).

30,500 urban trees located along a 19 kilometre stretch of the Pacific Highway in Northern Sydney store an estimated $1.65 million of carbon (based on a carbon value of $23 per tonne) and have been shown to deliver annual benefits worth $97,770 relating to carbon sequestration, air pollution removal, building energy savings and avoided carbon emissions (Amati 2013).

See Table 4: *The economic benefits of trees* for a summary of cost savings associated with trees.

Table 4: The economic benefits of trees

Economic benefits
Reduced energy consumption for cooling through the provision of shade to buildings and lowered ambient air temperature via evaporative cooling.
Enhanced economic activity or commercial centres shaded by trees are more attractive and comfortable to shoppers (more frequent and longer trips have been recorded in tree lined streets).
Increased streetscape amenity and higher property values.
Extended life of hard surfaces (i.e. asphalt) as an outcome of tree shade.
Reduced loading on storm water infrastructure and associated cost savings.
Enhanced community wellbeing and reduced reliance on health services.

Summary of street tree benefits

Street trees are critical to the future sustainability of the Sunshine Coast. They are directly linked to social wellbeing and positively contribute to the look, feel and prosperity of our region.

Trees and temperature

A well established body of evidence supports the role of trees in temperature modification. This section of the plan details the science behind the cooling benefits of trees and documents some of the research findings and applications to urban policy and practice in warming Australian cities.

The temperature under the shade of a medium to large sized tree can be several degrees cooler than ambient temperature. Trees reduce land surface temperatures by absorbing radiant heat from the sun and shading the spaces beneath or adjacent (depending on the time of day and angle of the sun). Trees reduce ambient temperature through evaporative cooling.

By mitigating excess urban heat, tree canopy cover and its shade can play a critical role in reducing both heat related health costs and summer home cooling costs in the subtropics.

Shade

A direct relationship exists between areas shaded by trees and cooler land surface temperatures (Ali-Toudert & Mayer 2007; Kurn et al. 1994, Shashua-Ba et al. 2010). Street trees can help manage the impacts of heat, especially in densely populated communities and along popular pedestrian routes. Studies have confirmed that older and younger members of our communities are the most vulnerable to extreme heat. UV exposure during a person's first eighteen years of life is also the most critical for cancer causing skin damage (Norton et al. 2013; Kimlin and Guo 2012).

Shading homes and buildings also reduces heat gain during hotter days. In South East Queensland trees provide the greatest shade benefit when planted on the east and west sides of homes and alongside east-west orientated streets (Norton et al. 2015). In the summer months high angled sun on the south side of buildings is also a priority for shading (Doick and Hutchings 2013).

Cooling

Trees not only provide shade but also cooling. The process causing trees to cool the surrounding air is termed evapo-transpiration and occurs while a plant is photosynthesising (converting sunlight to usable energy). The by-product is cooling of the leaf surface (evaporative cooling) which effects a reduction in the temperature of the surrounding air. The denser the tree canopy, the greater the surface area from which evaporative cooling can occur.

Rainforest species provide more cooling benefits on account of their leaf size, leaf arrangement and higher water use than low water users such as eucalypts (gum trees) which have adapted strategies to slow or halt evapo-transpiration (and as such conserve water use) as a response to drought.

Large single specimens of broadleaved species have the potential to provide greater cooling benefits than a group of smaller trees with sparser canopies and less total leaf surface area (City of Melbourne, 2012).

Brisbane City Council targeted 'shade hungry' footpaths along popular pedestrian routes in their 'Neighbourhood Shade-ways' program developed in 2006/07. On a summer day, surface temperatures of tree shaded pathways were found to be up to seven degrees cooler than unshaded pathways (National Urban Forest Alliance 2014). Temperature differentials of between 14.1 °C and 18.7 °C have been forecast beneath clusters of shady trees in heat wave conditions in Adelaide (Thom et al. 2016). While McPherson et al. (2009) reported that the interior of cars in tree shaded car parks can be between twenty-two and twenty-eight degrees cooler than car parks without trees.

Trees can significantly improve thermal comfort and relief from summer heat stress at the street and local neighbourhood scale (Norton et al. 2013).

The urban heat island effect

Temperatures in urban areas are significantly higher than in undeveloped or rural areas due to the 'heat island effect' where hard surfaces high in thermal conductivity and heat storage capacity and low in reflectivity not only increase ambient temperature but also retain heat (Norton et al. 2013).

Urban areas are hotter than rural areas as an outcome of vegetation removal and a higher volume of impervious surfaces and buildings to permeable spaces. Highly urbanised areas tend to get hotter because of the lack of breeze. The heat is exacerbated by hard surfaces reducing water availability for trees and lowering rates of evaporative cooling. Structured drainage systems also deplete soil moisture levels (Norton et al. 2015). Heat production from cars and air conditioners, and air pollutions also contribute to the 'urban heat island effect'. Built up areas are generally two degrees hotter than rural areas. International research indicates that localised temperature increases associated with the urban heat island effect already exceed those predicted by climate change models over coming decades (Grimm et al. 2008; McCarthy et al. 2010).

A key driver of the 'urban heat island effect' (especially with reference to private land) is new or replacement tree planting not keeping pace with the amount of vegetation removed as a part of the urban consolidation process. The problem is exacerbated by replacement of permeable surfaces with non-permeable surfaces, which in turn require even more trees for natural shade and cooling.

The City of Melbourne has estimated that one of the many benefits of a plan to increase tree canopy cover from twenty-two to forty percent by 2031 (predominantly on public land) is a forecast reduction of up to two degrees in average daytime summer temperature (NGIA 2012).

Trees and ecosystem services

Modelling tools are now being used to equate the 'ecosystem services' provided by trees with the cost savings they provide.

Trees absorb the first thirty percent of precipitation reducing run off rates and filtering storm water. Brisbane City Council reported that in 2010 the city's 575,000 street tree population was providing an estimated $1.65 million in annual benefits from air pollutant removal, carbon sequestration and rainfall interception (National Urban Forest Alliance, 2014). More recently, in locations where their 'Neighbourhood Shade-ways' projects and storm water treatment priorities coincided, modelling was used to estimate the value of trees in storm water treatment. The modelling forecast annual reductions of 3,240 tonnes for suspended solids, six tonnes for total phosphorous, 20 tonnes for total nitrogen and 1,070 tonnes for gross pollutants across around 22,000 tree planting sites (State of Australian Cities 2013).

Urban forests

Our future tree planting priorities, like those of other leading Australian cities, need to emerge from a 'whole of forest' or 'urban forest' planning approach.

'Urban forest' is a term describing the sum total of green spaces in an urban environment both within public and private land including trees, shrubs, grass, climbing plants on the walls and roofs of buildings (and the soil and water in and around them). Parklands and streetscapes have the greatest influence over the extent and quality of urban forests.

The City of Melbourne has taken the lead in evidence based urban forest planning in Australia and the *City of Melbourne Urban Forest Strategy 2012-2032* is recognised as a blue print for how to grow an urban forest (202020 Vision 2013).

Along with Brisbane City Council and Sydney City Council, the City of Melbourne has shared valuable and compelling data on the state of their urban forests, developing urban forest strategies and setting targets for planting programs that will increase not just the amount of future tree cover but the diversity and resilience of their tree populations for other LGAs to follow. Many of the same principles of growing a sustainable urban forest are applicable to the Sunshine Coast Council region.

The premise is that for an urban forest to be sustainable it must be resilient. To be resilient it must be diverse (in the types, shapes, ages and locations of plantings). To be resilient an urban forest must be 'climate change ready'.

Trees and climate change

The expected consequences of climate change in Queensland include increased drought, storm and cyclone intensity, biodiversity and ecosystem impacts on tropical rainforests, wetlands, terrestrial vertebrates and marine life; and damage to coastal infrastructure (as a result of storm surge related flooding). South East Queensland has been identified as a 'hot spot' increasingly vulnerable to climate change due to its ever-growing population and coastal location (Choy et al. 2010).

The cause and effects of climate change are reciprocal. Carbon emissions are linked to rising temperatures. Rising temperatures cause us to burn more fossil fuels to help to cool the built environment.

Trees help reduce the impact of greenhouse gas emissions. They sequester (capture) and store carbon in their wood and provide oxygen in return. The quantifiable direct benefits of trees on a population level in carbon capture and storage at a regional scale are significant. Yet indirect benefits of tree shaded footpaths and cycleways which support the uptake of active and public transport, reducing single vehicle travel also reduce greenhouse gas emissions.

Tree shade can also reduce peak summer energy demands in our warming climate. The Sunshine Coast's mean surface air temperature increased by about 1 °C between 1910 and 2013 (Dowdy et al. 2015). Locally relevant climate projections indicate further increases in mean surface temperature of between 0.7 °C to 1.3 °C by 2030, with mean surface temperature expected to increase by 2.7 °C to 4.7 °C by 2090.

Increasing tree canopy coverage is one of the most cost effective strategies for cooling buildings and local neighbourhoods (Norton et al. 2013). Carefully positioned shade trees can reduce household energy demand in Sydney's climate change scenarios by 2 to 5% (Lin 2016). The City of Melbourne's work suggests that increasing urban canopy cover by 10% could reduce daytime surface temperature by more than 1 °C (Norton et al. 2015).

The capacity for trees to play their part in mitigating urban warming will depend on their own resilience to changing climate. Not all trees currently adapted to local conditions will necessarily tolerate a warmer climate. Many of the Sunshine Coast's naturally occurring rainforest (closed forest) species have a low tolerance to extreme heat and may not effectively grow here the future. In a worst case scenario we are likely to see a significant change in the composition of plants in our natural environments with species adapted to warmer conditions moving in, and species preferring cooler conditions moving out. The southern migration of species for example is already occurring, impacting the natural habitable range of some species traditionally confined to the warmest parts of the continent.

A recently released study (Kendal et al. 2017) determines the heat vulnerability risk of the most commonly represented tree species in a number of LGAs across Australia, including Brisbane City Council. The study which considers the known temperature limits of various species and extreme scenarios in the latest temperature increase projections, suggests that a number of species currently well represented on the Sunshine Coast may not be able to tolerate local temperature increases projected for South East Queensland in the future. The list of the most at risk includes species from the genus *Flindersia* (Queensland maple for example), species from the genus *Syzygium* (syn. *Acmena*) (lilly pillys); *Lophostemon confertus* (Qld brush box); *Brachychiton acerifolia* (Illawarra Flame tree), *Callistemon salicina* (syn. *salignus*) (white bottle brush) as well as Brisbane City Council's most commonly planted species of eucalypts (*Eucalyptus* sp). While the authors are careful not to advocate wholesale selection against these species (which would be an extreme reaction on the basis of this early research), they do suggest that where important species have been identified as heat vulnerable, that strategies of resistance based on greater intervention should be employed. These include improving general growing conditions, increasing pest management programs, irrigating trees more frequently and for longer durations and species diversification.

Conversely, some of the best represented exotic trees and species hailing from Northern Australia were identified as low heat vulnerability risk in worst case climate change scenarios. These include *Delonix regia* (poinciana), *Peltophrum pterocarpum* (yellow poinciana), *Caesalpinia ferrea* (Leopard tree), *Tabebuia* sp (trumpet trees) and *Corymbia ptychocarpa* (swamp bloodwood).

Adaptable and resilient landscapes

Lack of diversity within a tree population makes an urban forest vulnerable in the event of mass pest or disease breakout, or changes to the growing environment. The more diverse a tree population, the more resilient it is. Ensuring an assortment of species within a street tree population increases adaptability potential and resilience.

Species diversity

The Sunshine Coast landscape is characterised by its natural plant palette. Council ensures a high proportion of locally native (naturally occurring) species to non-indigenous natives or non-native plants are cultivated in the landscape and will continue to advocate the use of the Sunshine Coasts' indigenous suite of plants in the first instance (especially in relation to supporting our naturally occurring birds, insects and arboreal mammals). Biotic homogenisation (reduced diversity in composition of plant populations) however threatens resilience. Exotic and native (non-indigenous) trees which have proven adaptability to locations outside their natural origin may be the most successful tree types in the future if weather extremes start to impact on natural plant communities. Including some exotic and non-local native trees in the street tree mix therefore helps build resilience.

Urban forests with limited species diversity are vulnerable to changing climates and pest and disease outbreaks. As a 'rule of thumb' Santamour (1990) suggested that no more than 10% of urban tree populations should be of one species (the specific tree, for example Melaleuca quinquinervia – broad leaved paperbark), no more than 20% of any one genus (related species are grouped into genera for example the genus Melaleuca represents all paperbark types) and no more than 30% of any one plant family (related genera are grouped into families for example the Myrtaceae family includes genera Melaleuca, Eucalyptus, Callistemon and Leptospermum). Kendal et al. (2014) suggests a move away from the 10:20:30 rule of thumb towards homegrown species diversity targets based on the level of existing diversity and vulnerability.

Given the likelihood of a southern migration of non-native species (Williams et al. 2012) Sunshine Coast landscapes are likely to benefit from greater use of species from Northern Queensland and the Northern Territory in the future. There are also benefits to the ongoing use of some exotic trees as accent plantings or as a part of landscapes with a heritage character. Deciduous exotic trees in some locations also offer seasonal change and light filtration in the winter when the sun's arc is lower.

Within-species diversity (genetic diversity) can also be enhanced through the utilisation of a range of species 'ecotypes'. Some tree species have a very wide natural range and relative tolerances can vary according to the ecotype, (i.e. geographic origin) of the propagating source. Ensuring that a range of sources of seed or mother stock (where propagation is from cuttings) are used in production can increase resilience within a species.

This is especially applicable where the relative tolerances of the species (to drought or periodic inundation for example) come under strong genetic control.

A diversity of broad-leaved species in a street tree population is ideal for heat mitigation because of increased shade and cooling function as an outcome of greater leaf surface areas. Rainforest type trees and those that come from moist environments have higher rates of evapo-transpiration and greater output in terms of cooling because they are physiologically adapted to wetter environments. The higher rates of evapo-transpiration and cooling are a result of higher water use.

This means that for rainforest trees to provide maximum rates of cooling, aside from temperatures needing to be within their natural range of adaptation and tolerance, soil water must not be a limiting factor.

Where soil water is a particularly limiting factor, irrigating trees will increase evapo-transpiration rates and cooling (and shade and reduce temperature in our urban environments) however the cooling benefits must be weighed against the cost of supplying additional water to the site.

While some rainforest species originate from drier rainforest sites (*Brachychiton acerifolius* – Illawarra flame for example), rainforest trees are not suitable for cultivation in many Sunshine Coast locations, even where additional water can be provided.

Conifers (pines and related plants with needle like foliage) and eucalypts are not as efficient as broad-leaved rainforest tree types when cooling their surroundings. The ecological value of eucalypts (gum tree types including all species within the genera *Eucalyptus, Corymbia* and *Angophora*), Australian conifers (*Araucaria bidwillii* – bunya pine, *Araucaria cunninghamii* – hoop pine and *Agathis robusta* – kauri pine) and sheoaks (*Casuarina* and *Allocasuarina*) however is significant. These species are synonymous with the landscape character of the Sunshine Coast. They are also likely to be more tolerant to future changes in temperature, especially in significantly reduced precipitation scenarios.

Diversity of form

Formal avenues of the same species are often more typical of temperate climate cities. In the subtropics, mixtures of species reflect our milder climate and more diverse landscapes. Cooling potential is also greatest where a diversity of tree form exists. While a closed canopy or arched canopies over a street provide unbroken shade, they also prevent escape of trapped heat overnight when cooling generally occurs. There is potential for greater air flow for cooling through a more diverse tree structure and spacing. Consideration therefore needs to be given to the design of streetscapes among higher density built form and in centres supporting both daytime and night time activity.

Age diversity

A mixed aged street tree population not only supports a succession of maturing trees for future generations, it also provides more ecosystem services.

The potential a street tree population has for making a significant impact on climate change through carbon capture and storage is dependent on the age balance within the population. Young actively growing trees for example, absorb more greenhouse gases than over-mature or declining trees.

In the development of their Urban Forest Strategy (2012- 2032), the City of Melbourne mapped the useful life expectancies of their street and park tree population with startling results. The study found that 30% of their highly valued trees were either in decline or nearing decline. It concluded that if significant steps weren't taken to remedy the situation, not only would the current look feel and of the city change significantly over time, it would also become increasingly hotter.

The City of Melbourne has since developed a program of street tree planting to enhance canopy coverage and sustain all of the environmental visual, economic and social benefits so integral to the LGA.

Future directions

Transitioning towards a broad range of tree species, and as such, a more diverse street tree palette may not only 'future proof' our street tree network from the potential impacts of climate change but also respond better to the diverse range of growing conditions in our 'Community of Communities'. A greater emphasis on the use of mixed planting themes and a higher ratio of trees from warmer climates or local species with greater adaptation potential (local dry rainforest species for example) is recommended.

Growing sites for potentially heat vulnerable street tree species (species currently near their limit of heat tolerance) need to be selected carefully. Resilience of locally important yet potentially heat vulnerable species should be promoted through greater cultural intervention to ensure the best possible conditions for growth are provided (irrigation, soil nutrification and active programs of pest control for example).

The average age and estimated useful life expectancies of the existing Sunshine Coast street tree population is currently unknown. Further analysis would allow council to determine how many new trees will be required, and to set canopy cover targets to optimise future benefits of our street tree population. In the meantime, council needs to be aware of potential species overuse; to ensure that every tree removed is replaced with at least one new tree; and to plan for the future by planting succession trees where stands of even aged mature trees grow.

Species selection must balance the desired character and function of the vegetation with the specific growing conditions of the site. Good species selection matches the species to the site, rather than attempting to alter the site to suit the requirements of a desired species.

Summary of the role of street trees in temperature modification and the need for increased population adaptability and resilience.

Trees have a critical role to play in shading and cooling our region. Solar glare, ambient temperature and energy use can be reduced in urban 'hot spots' through strategically placed trees that shade and cool their immediate surroundings.

Council needs to plant more trees in more spaces in general, plan for succession trees, and increase population diversity to grow the street tree population resilience required for the future. Wider use of exotic (tropical climates) and non-indigenous native trees (naturally occurring in Northern Queensland and the Northern Territory) is encouraged, as is the greater use of local dry rainforest species to combat the increased periods of drought and warmer temperatures predicted for the future.

Council needs to be 'climate change ready' in order to mitigate the impacts of projected temperature increases including careful site selection for potentially heat vulnerable species and the integration of strategies of resistance (increased intensity and frequency of maintenance) for all new street tree plantings.

Challenges and opportunities

Regional growth and development

Tourism

Tourism is one of the Sunshine Coast's largest industry sectors in terms of profile, employment and output. While our natural and cultural landscapes attract visitors to the Sunshine Coast (and are integral to ongoing visitation), the seasonal influx of tourists places a heavy load on our existing infrastructure and green assets. Renewal of assets in tourist precincts in response to expectations and use can also affect the existing street tree network.

The flow-on effects of the ever-growing population of permanent residents on the Sunshine Coast also impacts street trees.

In 2015/16 there were 2.9 million visitors to the Sunshine Coast Council region up 2% on 2014/2015 figures. 10.9 million visitor nights were recorded for the same period with $1.8 billion in expenditure.

Population growth

The Sunshine Coast is one of the fastest growing regions in Australia. With 60 km of open coastline, the coast attracts many sea changers as well as tourists. Over 57,000 new residents have moved to the Sunshine Coast in the last ten years – a population growth of 25% (ABS 2016).

The current population of the Sunshine Coast LGA is 303,400 residents. With a population density of 1.26 persons per hectare on average, and an annual growth rate sitting at 1.6% in 2016 (expected to increase to 2.82% by 2026), the population is expected to reach 380,649 by 2026 (Sunshine Coast Council 2016). Recently released projections suggest the population will swell to over 500,000 people by 2041.

The S*outh East Queensland Regional Plan 2017* forecasts that a further 87,000 new dwellings will be needed to accommodate the coast's population in the year 2041. Infill development will account for around 53,700 of these with the remainder (33,000 approximately) to be established in greenfield developments of Palmview and Caloundra South, Beerwah East, Sippy Downs and Kawana and other urban-zoned land developments (Sunshine Coast Council 2017).

Demographics and human heat vulnerability

The region's stunning environment and subtropical climate is linked to a skew in population demographics, with a higher percentage than the national average of retirees residing on the Sunshine Coast (ABS 2016). Older and younger members of our community (those greater than sixty-five and younger than five years of age) are the most vulnerable to heat (Norton et al. 2013).

Older and younger members of our community are also more likely to walk to community facilities and local shopping centres or to spend time walking for passive recreation. 'Hot spots' which generally have low vegetation cover and a high proportion of impermeable surfaces within vulnerable communities are priority areas for the provision of shade. These include pedestrian spaces around schools and child care centres, aged care facilities and community centres.

"The region is renowned for its natural assets, distinct communities, location, unprecedented investment opportunities, strong community and unrivalled environmental credentials (*Sunshine Coast Council Corporate Plan 2018-2022*)."

14,292 development related applications were received by council in 2016 and with $1.44 billion worth of construction approved, building approvals reached an eight year high.

Development impacts

The Sunshine Coast Council region is currently in a phase of major growth and development. Despite ongoing efforts to protect existing trees, vegetation losses on private land are expected as the urban footprint of the region continues to increase. Offsetting vegetation losses by optimising tree cover on public land and a greater emphasis on 'tree sensitive' design as a part of development assessment will help to minimise the negative impacts of development on existing and future street tree networks.

The following key development 'hot spots' have been identified in council's Building Approvals: Heat Map and Activity Heat Map and Hot Spots (Sunshine Coast Council 2017) for the period between 2012 and 2017:

- Maroochydore including Sunshine Cove
- Buddina, Mooloolaba and Mountain Creek including the Brightwater development and University precinct of Sippy Downs
- Kawana and surrounds including Birtinya (home of the new health precinct) Meridan Plains and the new Creekwood residential development
- The Caloundra area including Pelican Waters Caloundra West, Bells Reach and the new suburb of Baringa as a part of the Aura development.
- Peregian Springs, Peregian Breeze and Bli Bli as a result of the Parklakes developments.

Between 2013 and 2016 there were high levels of activity within the *Sunshine Coast Enterprise Corridor* which stretches from Maroochydore to Caloundra South. This corridor has also been designated the key zone for commercial and residential growth over the next 20 years. It is likely to accommodate approximately 70% of the region's projected population growth and a substantial level of new business investment in the region's high-value industries (Invest Sunshine Coast 2012).

The loss of large trees from urban areas

The Sunshine Coast's urban forest includes all of the trees growing on private land as well as land under the care and control of council (either as landowner or trustee for the state). The removal of large shade trees from private land significantly impacts the overall volume of trees providing ecosystem benefits to the region.

A study of the urban forest of the greater Melbourne area (Block, Livesley & Williams 2012) reported that although most local government bodies are planting more trees on public land than they are removing, the quality and extent of urban tree cover is still declining due to the clearing of trees from private land. Infill development and densification in Melbourne's long established inner suburbs has specifically resulted in the loss of large mature trees from the landscape. The trend is for these large trees to be replaced with smaller scale plantings, which provide reduced environmental benefits and alter landscape character.

Smaller lot sizes also limit the planting of large growing trees on private land. A typical outcome of urban intensification is reduced permeable spaces and lowered volumes of soil available to support large growing trees. A minimum of 30 m^3 of available soil volume (Leake and Haege 2014) is necessary to sustain a large growing tree yet very few new housing blocks reserve this amount of unsurfaced outdoor space.

Infill development and street trees

While 'greenfield' development threatens the extent and connectivity of tree cover across all land types, 'infill' development specifically threatens street trees. Subdivision and development, and redevelopment for dual occupancy/urban intensification can significantly impact the presence and quality of the region's streetscape plantings. Over 45% of the forecast development required to house the 2041 population of the Sunshine Coast will occur as infill development within the existing urban footprint. The medium density housing (2 to 6 stories) which is the likely result of this densification is expected to change the face of the existing urban landscape, especially in the regions targeted growth area, the *Sunshine Coast Enterprise Corridor*, which stretches from Caloundra South to Maroochydore.

While the outcome of the forecast multi-story infill development on existing street trees will be far reaching if mechanisms to protect specimens are not secured before the wave of construction commences, smaller developments (for dual occupancy for example) cause the unnecessary loss of more than acceptable level of street trees already. Realignment of existing driveways or the creation of new (additional) accesses is one of the most significant causes of premature removal of street trees in the region. Self assessable applications for many of the more minor property improvements (new driveways for example) compound the problem. Trees that are retained are frequently constrained as an outcome of the resulting reduction in growing space. In worst case scenarios they are irreparably damaged during construction. Where existing street trees are in direct conflict with the construction envelope, and cannot be replaced in situ, removal of the tree results in the permanent loss of a street tree location.

Increasingly, new infrastructure conditioned for installation in road reserve spaces as an outcome of private land development is causing the loss of, or damage to, existing street trees or future tree planting sites.

This includes footpaths, above or below ground electrical infrastructure and improved road treatments (kerb and channel for example).

Indirect impacts to planting sites, specifically changes to soil conditions, presents another set of challenges to street tree establishment. Disturbance of road reserve land adjacent to development sites (for access, site storage and other construction related activities) can have long term impacts on soils in urban areas. Significant disturbances to soil structure, fertility and moisture regimes (including structured drainage systems removing additional water from the soil) impact the potential establishment of new trees, as well as the health of existing specimens.

Soil compaction, which most commonly occurs as a result of heavy equipment moving through a site, is the most common form of construction related soil damage. Compacted soils have significantly reduced pore spaces (necessary for air flow and water infiltration as well as root extension). Removal of the top soil horizon (the most fertile, friable and biologically active layer of soil where tree roots naturally proliferate) during 'soil stripping' results in direct loss of microorganisms (that work in symbiosis with tree roots) loss of soil nutrients and reduced water holding capacity of soils. Inversion of soil profiles which often occurs when excavations are backfilled has the same, if not more of an impact. Inverted soils are notorious along the coastal plain of the Sunshine Coast.

Moreover, the incorporation of foreign materials in soil profiles (building rubble or dried concrete slurries for example) also affects soil structure, pH and nutrient availability. Many plants are sensitive to soil pH changes and only function properly within normal ranges. Poor nutrient availability has numerous effects with slow, stunted growth and yellowing foliage common indicators of nutrient deficiencies in plants. Liming of soils can occur as an outcome of concrete leachates (run off) raising soil pH (making soils more alkaline) and affecting tree growth. Conversely, acid wash down of exposed aggregate pathways can lower soil pH (acidifying soil). Disturbance and dispersal of marine clay/acid sulphate soils during excavation work is another risk that must be controlled in many Sunshine Coast landscapes.

With enforced exclusion and general protection of street trees growing adjacent to development sites (see the *Sunshine Coast Open Space Landscape Infrastructure Manual - Preliminaries - Vegetation Management*), unnecessary damage to street trees and street tree soils as an outcome of infill development can be prevented. Other mechanisms to help reduce the impact of infill development on street trees are listed in Table 5: *Options for better outcomes for street trees growing adjacent to infill development sites.*

Table 5: Options for better outcomes for street trees growing adjacent to infill development sites

Options for improved street tree outcomes
Review documentation and check lists to include triggers for privately certified development assessments to seek referral advice from council officers where street trees are located within a nominal setback/zone of impact.
Where the installation of new road reserve infrastructure is to be conditioned as a part of a development approval (for example a new footpath), explore the potential for a referral to be made to a suitably qualified council officer to determine potential street tree impacts. Potential conflicts may then be mitigated through tree sensitive design or realignment of the infrastructure before construction.
Explore the potential for existing tree and/or ground protection to be conditioned in development approvals (with no commencement authorised until a council officer signs off on satisfactory exclusion of tree protection/ground protection zones). Investigate the potential for a nominal fee for tree protection services to be included in development assessment fees and charges to help council resource monitoring of tree protection sites (for more information regarding council's standard tree protection requirements see the Sunshine Coast Open Space Landscape Infrastructure Manual - Preliminaries - Vegetation Management).
Investigate the potential for conditioning of soil remediation at the completion of works as a part of a development approval (in instances where ground protection cannot occur during construction due to site access requirements or other limitations).
Investigate options for all privately certified or council assessed infill development approvals to include street tree planting conditions, or charges for council to plant new trees on the adjacent nature strip on works completion. Such a program could serve to counteract the visual impacts of development on the region and value-add to the upgraded property. Explore potential for council to charge property developers a nominal 'tree offset' fee where an approval results in permanent loss of a tree growing site in the adjacent road reserve.

Greenfield development and street trees

While street tree planting is an important element of large scale residential developments, early losses are particularly high and costly to both council and land developers. Prudent maintenance of street trees planted early to enhance land sales is often counteracted by inadequate protection and death of trees during construction. Many young trees in new residential developments are illegally removed or irreparably damaged during the building process. Some of the younger residential estates in the Sunshine Coast Local Government Area have a high proportion of stunted, damaged or missing street trees in general when they should be the thriving urban forests of the future.

This unnecessary waste of plant material could be overcome if developers were to delay soft streetscaping works until the built landscape is complete. A mutually beneficial arrangement whereby council plants and establishes street tree plantings on behalf of developers would allow council to control the quality of planting stock, preparation of the planting site and the specific planting technique and amount of maintenance received in order to achieve desired standards and lower long term maintenance needs.

Soil quality and adequate planting site preparation are also major factors in street tree establishment. Cut and fill soils are typical of major residential developments and while avoiding loss of the natural soil horizon is in many cases not possible, ensuring an adequate planting site is created through amelioration of existing soils (something that is presently not addressed very well) may also be possible under council run planting programs.

Such an arrangement would benefit developers by transferring the responsibility for stock quality and establishment maintenance to council, as well as removing the need for on/off maintenance inspections and the requirement for developers to replace street trees that have failed or are not worthy of retaining. This has often occurred several times before street trees are considered adequately established or acceptable for handover.

The ever-shrinking spaces for street trees in new housing developments is a more complex problem. The majority of new developments maximise lot yield and provide minimal space for street tree amenity. Small lots of adjoining narrow streets is the typical streetscape formation. These narrower roads have narrower road verges. Coupled with increasing footpath widths, the amount of space available for street trees in modern residential developments has drastically decreased.

Within these retracting spaces there is competition below the road verge with an ever increasing network of pipes and cables including electricity, sewage, water and telecommunications cables. A higher proportion of driveways as an outcome of smaller lot sizes, indented parking to compensate for loss of traditional on street parking options and even bin set down points are emerging infrastructure elements competing for space in the road verge in additional to the traditional competing infrastructure elements including underground services, footpaths and electrical infrastructure.

In many recently developed housing estates, space that could have been used to establish feature trees has been used instead for the creation of biopods/water sensitive urban design treatments (WSUDs) not integrated with street tree installations. Biofiltration systems that do not feature street trees bypass significant opportunities to manage increasing rates of storm water run off while providing passive irrigation to trees.

While planning codes may intend for street trees to promote amenity in new residential streetscapes and to be given priority over other infrastructure elements (see *Sunshine Coast Planning Scheme 2014, Part 9: Development codes, 9.4.2 Landscape Code* for example), less space and greater competition in today's multiuse road verges means that many residential developments will simply not have the capacity to support the growth of healthy, large or long-lived street trees.

It is suspected that an adequate tree canopy may fail to establish in many of the local streets of currently under construction and future residential developments if the situation doesn't change. Accidental or wilful damage to young street trees during construction, or as an outcome of the lack of on-road parking opportunities in these newly emerging estates will account for some establishment failures.

It is more likely however that the majority of trees failing to reach a size where they can provide any measurable benefit to the local community will be directly related to inadequate soil volumes and the basic needs of street trees not being met (especially where the natural soils no longer exist). For a full description of tree growth requirements see the *Sunshine Coast Open Space Landscape Infrastructure Manual - Trees - Overview*).

Trees are often extremely resilient because by nature they are opportunistic. In the absence of opportunity however trees will simply adapt to their growing environment. Root systems in confined spaces without opportunity for natural egress (especially where root barrier is used) will have less biomass and therefore less capacity for water (which drives the processes attributed to growth) and nutrient (also essential to plant growth and development) uptake.

Heavy shading (sunlight is another basic tree growth requirement) as an outcome of higher density living, can further restrict the ability for street trees to thrive.

While little can be done to change the maximum lot yield philosophy in the short term, ongoing monitoring of street tree development in these newer residential estates is likely to prove the case for more space for street trees over time.

In the meantime, significant opportunity still exists for new residential estates to make space for some strategically positioned larger growing street trees and some consideration for integrating roadside bioretention with street trees (such as 'Water Smart Street Trees' being trialled in Brisbane). Taking small steps to compensate for the limitations of today's standard residential streetscape layout (with minimal impact to lot yield) will have a significant impact on the extent and quality of tree cover in residential estates in the future.

Purpose-built tree planting sites for larger canopy trees can include nodes at slightly increased intersection setbacks (see *Figure 2*: *Sketch showing a large canopy tree planted on a truncated corner* below) or mid-block blisters/ buildouts or centre medians, reserving smaller trees for smaller verge spaces.

With appropriate site preparation (soil ripping and amelioration) and design elements (flush kerbs, swale grading and subsoil drainage) customised centre road medians can also support feature and avenue trees of a scale and quality that will compensate for the limited potential of street trees in standard locations.

Table 6: *Options to improve street tree establishment outcomes in new residential developments* lists potential mechanisms for improved rates of street tree establishment in greenfield sites for exploration.

Where larger areas of garden bed/deep soils simply cannot be preserved or created due to competing demands for the space, permeable surface treatments (that better provide for root growth beneath) or alternative methods of extending spaces for root growth should be employed (see the *Sunshine Coast Open Space Landscape Infrastructure Manual - Vegetation management* for further information).

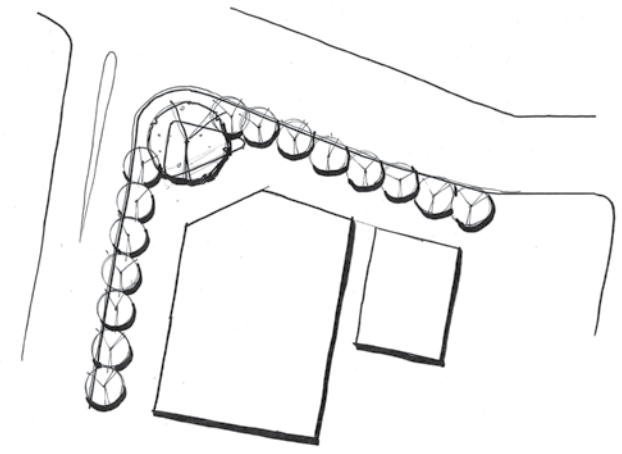


Figure 2: Sketch showing a large canopy tree planted on a truncated corner.

Table 6: Options to improve street tree establishment outcomes in new residential developments

Options to improve street tree establishment outcomes
Investigate the potential for council to deliver street tree planting in new housing estates on behalf of the developer (via developer contributions) at construction completion to avoid tree removal or damage during construction. Provide opportunity under such a system for developers to plant fast growing temporary trees if desired (for example pioneer species such as *Macaranga tanarius* or a nitrogen fixing species such as those belonging to the genus *Acacia*) to assist with land sales.
Encourage the incorporation of customised planting spaces or large canopy tree nodes to accommodate feature or boulevard trees in all new residential streetscapes. These include creating enlarged spaces on the corners of intersections (truncated intersections), mid block cluster or buildout style planting sites, and creating deep soil zones in roundabouts and median strips. Best horticultural practice should be used to create optimum conditions for tree growth within these purpose built planting sites (including appropriate soils, drainage and passive watering).
Embed tree sensitive design practices into new development, including soil preparation methods and treatments that extend zones of potential root growth (for example the creation of root trenches within the road verge) (see *Sunshine Coast Open Space Landscape Infrastructure Manual - Vegetation management* for further information).
Integrate water sensitive urban design treatments (WSUDs) with streetscape planting to deliver both storm water management and spaces for healthy tree growth, rather than single purpose large scale retention basins.
Monitor and document street tree development in standard verge spaces of new residential developments.

Careful consideration should be given to the use of artificial soil environments (root cells for example) that may become sterile/devoid of nutrients over time. Engineered spaces beneath pavements, such as structural cells or tree vaults, allow for root extension, however offer no potential for replenishment of soil media. Organic content of the filler soil in engineered spaces needs to be low to avoid shrinkage of soils following break down of organic content. If filler soils are too sandy and the required cation exchange capacity (clay content) cannot be achieved, the trees may become nutrient deficient over time requiring ongoing manual applications of liquid fertiliser. Additional watering of engineered spaces may also be necessary during prolonged drought. Council is committed to ongoing trials of such systems, especially in conjunction with development in urban business centres.

Careful consideration should also be given to the routine installation of root barrier as a part of bulk street tree planting works (see *Sunshine Coast Open Space Landscape Infrastructure Manual - Embellishments - Planting*). Root barrier should never completely encircle a planting site unless it is especially large. Root deflector which directs tree root growth lower into the soil profile is preferred by council should a root growth restricting treatment be deemed necessary.

Future directions

A coordinated approach to canopy building on public land to offset the unavoidable loss of trees in urban areas is critical if the existing level of benefits is to be sustained into the future.

Increased tree planting will also help screen and soften the impacts of the ever-expanding built environment on the region.

Appropriate sites for large canopy trees should continue to be secured. Existing road reserve sites where ample soil volume still exists and no apparent conflicts or competition for use of the space, are considered high priority locations for the planting of new street trees.

Wherever possible biofiltration treatments (biopods/WSUDs) should be systems that integrate street trees with storm water management.

This will be particularly beneficial in infill areas and small lot development areas where increased surface impermeability will require the shade and cooling of street trees as well as additional mechanisms for the management of increased run off.

Making space for large canopy trees in all future housing estates and redeveloped streetscapes is also critical — including at intersections, within roundabouts and centre medians.

Compact trees should provide visual relief where existing spaces simply don't afford establishment of larger specimens with large canopy trees to be planted in nearby parks, community facilities, medians, and at intersections.

The planting of large canopy trees in local park locations where they can contribute to the amenity of residential streetscapes is one such example of this.

Short, medium and long term analysis of street tree development in maximum lot yield residential developments should be commenced.

Mechanisms to ensure no unnecessary loss of existing trees or damage to soils and tree planting sites occurs as an outcome of development should be explored including surveys and tree protection plans for worthy existing trees, enforceable TPZs (tree protection zones) and the requirement for road reserve protection bonds.

Recommendations

Identify opportunities for the planting of new street trees and prioritise protection of existing street trees in the high growth *Sunshine Coast Enterprise Corridor* where development is to result in increased densities in the future.

Secure sites where large growing trees will provide the greatest benefits in the future, and potential for future conflict is low, for the planting of new street trees. Priority sites for investigation include the interface of streetscapes and local parks and council managed community facilities.

Encourage 'Tree sensitive design' including:

- the use of tree planting nodes to accommodate large canopy trees in high density residential areas where larger trees would make a significant landscape contribution and standard verge spaces are insufficient
- mechanisms to improve tree retention rates and protection of existing street trees adjacent to development sites by embedding tree protection planning into the development approval process
- alternative street design treatments to reverse the proliferation of narrowing verge widths, relaxation of building setbacks and competing interests for above and below ground road reserve space.
- Integrated storm water management–street tree installations

Analyse street tree development in local streets of new residential estates to develop an evidence base for the case for more spaces for street trees.

Encourage Sunshine Coast residents to plant large growing trees on private land to help sustain the region's urban forest.

Investigate mechanisms for ensuring sufficient road verge spaces that can support tree development are provided in all new residential developments.

Develop shade or canopy cover percentage targets for the entire region as well as specific localities (especially new residential and commercial precincts).

"There's a growing body of evidence suggesting that the inclusion of trees and other streetscape features in the roadside environment may actually reduce crashes and injuries on urban roadways" (Nadeiri 2003). The author examined the safety impacts of aesthetic streetscape enhancements placed along the roadside and medians of five arterial roadways in downtown Toronto. Using a quasi-experimental design, the author found that the inclusion of features such as trees and concrete planters along the roadside resulted in statistically significant reductions in the number of mid-block crashes along all five roadways, with the number of crashes decreasing from between 5 and 20 percent as a result of the streetscape improvements. The author concluded that the presence of a well-defined roadside edge may lead drivers to exercise greater caution.

Major infrastructure

Existing transport networks

There are 3,343 kilometres of sealed and unsealed roads with the Sunshine Coast LGA. A total of 372 kilometres (12%) are state controlled (declared under Section 24 of the *Transport Infrastructure Act 1994*) and managed by the Department of Transport and Main Roads (DTMR). The Sunshine Coast Council manages a balance of 2,971 kilometres (88%) of roads, 601 kilometres of which are currently unsealed.

Constraints to the establishment of street trees in designated road reserves largely depend on who controls the road (state or council), and are primarily based on road safety.

Clear zones and frangibility

Provision for adequate line of sight, sight distance to signs and CPTED (Crime Prevention Through Environmental Design) principles for passive surveillance and street lighting, are some of the factors that affect the presence and positioning of street trees on major road corridors.

Where roads are high speed, clear zones (the distance from the edge of the road carriage that must remain clear of fixed infrastructure in the event of a vehicle coming off the road) or frangible vegetation (vegetation that does not impede the impact of a vehicle) requirements also apply. Most tree species cannot be classified as frangible.

While it has been suggested that the presence of trees may encourage safer driver behaviour, where clear zone requirements apply, planting trees behind safety barriers (guard rail) is the only option available to establishing trees (as opposed to shrubs) on high speed major transport corridors.

The median strip in a lengthy section of Caloundra Road, the southern gateway to the Sunshine Coast, for example, is surrounded by guard rail. A significant opportunity for establishment of a gateway planting in this location therefore may exist. This, as well as other potential opportunities to increase landscape amenity in locations where strict clear zone limits apply, should be examined further.

State Controlled Roads and new tree planting

While only 12% of the potential space available to grow street trees within road reserve in the Sunshine Coast Local Government Area is under state control, the extent and quality of plantings in these high profile locations has a significant impact on Sunshine Coast amenity.

Survey work undertaken as a part of the development of this plan suggests that a good proportion of currently vacant, priority planting locations (high visibility, deep planting zones — see *Strategic directions* for further detail) occur on the region's major thoroughfares, most of which are managed by the state (DTMR). Some of these low tree occupancy rates can be attributed to road safety requirements. A number of these vacant sites however may simply reflect the difficulties council faces when attempting to plant or protect trees located in areas under formal state control. Or in the case of previously existing trees, limited budgets for tree replacement in state managed programs.

While the safety of road users is the top priority for council, considerable loss of amenity will continue to occur along our major thoroughfares if street trees are not renewed in extensive sections of vacant road reserve on state managed roads.

Future transport networks

New transport infrastructure priorities for the region are centred around interlinking and connecting new population growth areas. The *South East Queensland Regional Plan 2017* identifies three priorities for the provision of new public transport (rail) networks:

- Beerwah and the region's coastal activity centres
- Caloundra and Maroochydore
- Palmview and the Sunshine Coast University and Kawana Hospital precincts.

The *Sunshine Coast Planning Scheme 2014 Strategic Framework Map 1 Land Use Elements* presents these priority transit corridor as the *Maroochydore to Caloundra Priority Transport Corridor* (light rail) and the *Dedicated Public Transport Corridor* (CAMCOS) as well as identifying future transit hubs.

The Beerwah–Coastal connection including Kawana and Sippy Downs is planned to be addressed through a new heavy rail line offshoot at Beerwah (linking Beerwah, Caloundra South, Caloundra and Kawana). New sections of rail line will have minimal impact on existing street tree networks as the transport corridor exists mostly outside of the street tree network. Locations where the rail line is to be duplicated however will impact existing street trees and the potential for planting new trees in the meantime. Proposed transit hubs may also impact the potential for street tree establishment in some of these areas.

Priority links between Caloundra and Maroochydore are planned to be addressed through a light rail network. Route options for this network are currently under investigation with the preferred route encompassing Nicklin Way, Brisbane Road and Aerodrome Road. Street tree plantings in areas of potential conflict with the preferred light rail alignment should be postponed in the short term and integrated into the project once plans have been finalised.

Future directions

Council should strengthen relations with the Department of Transport and Main Roads (DTMR) the body governing control of state managed roads to discuss:

- opportunities for street trees plantings in currently vacant, high profile locations
- potential for new maintenance agreements for council to plant and maintain desired street tree plantings in key locations on DTMR controlled roads
- opportunities for the establishment of trees behind key sections of existing guard rail on distributor and collector roads.

Recommendations

Ensure tree planting programs are compatible with the requirements of future transport networks and major projects.

Continue to work with internal and external partners to better balance road safety needs with town and streetscape amenity.

Ensure new street trees are integrated in place making and urban renewal projects, infrastructure upgrades and expansion of networks.

Develop and strengthen partnerships to ensure street tree planting, major projects and/or infrastructure upgrades occur simultaneously.

Identify potential tree planting nodes on major arterial roads and connections and negotiate council managed maintenance agreements for the establishment of new vegetation in high profile areas.

Explore options for the placement of trees behind existing guard rail and the installation of new lengths of guard rail to facilitate safe tree establishment in high speed environments where tree benefits may be required.

Competing infrastructure

Trees must share what is typically very limited space within the road reserve with many other infrastructure elements. Power poles, overhead wires, street lights and signs present some of the above ground challenges to new tree establishment. Water, sewerage, underground power and telecommunication conduits present below ground challenges.

Added to these challenges are new infrastructure projects and ongoing programs of renewal. Expansion of the existing footpath network, road widening, kerb and channel with other drainage works, new cycle lanes, crossings, pram ramps, intersection works, indented parking, upgraded infrastructure for access and inclusion (for example bus stop upgrades) are just some of the activities that can both threaten existing road reserve trees and impact on the potential establishment of new trees. Where road reserve interfaces with coastal infrastructure, street trees may also be impacted (either directly or indirectly) by the construction or renewal of revetment walls, seawalls, groyne erosion control and beach access structures.

Amongst these many challenges surrounding competition and constraints for space, there are opportunities to integrate new street tree planting with infrastructure installation and renewal.

Footpaths

New footpath installation programs present excellent opportunities for streetscape renewal and infill or extension of existing street tree plantings in local streets. Strengthening general comfort and sun protection along the region's major pedestrian routes with shade tree plantings is in-line with council's vision to "get people out of cars and into more sustainable modes of transport (*Sunshine Coast Active Transport Plan 2011-2031*)." Shading pathway networks along routes to local parks or between recreation facilities may also encourage local residents to use active transport to visit these places (i.e. people may chose to walk to a park rather than drive if the route is shaded). The *Sunshine Coast Planning Scheme* 2014 (see *Sunshine Coast Planning Scheme 2014, Part 9: Development codes, 9.4.2 Landscape Code*) directs developers to provide unbroken shade to footpaths (where a development is assessable under the code) by planting trees at 6m intervals.

Pedestrians have been reported to perceive themselves to be safer when trees form a protective barrier between the pathway and road corridor. Motorists have also been shown to exercise more caution where trees delineate the road carriageway from adjacent pedestrian zones (Naderi 2003).

Opportunities for planting future street trees can be lost when footpath widening or installation works fail to retain sufficient space for future tree establishment between the back of kerb and footpath edge. Street trees generally require less maintenance over their lifetime when planted in the section of road verge between the back of kerb and footpath edge. Where set backs are narrow, street trees positioned between the footpath and property boundary are likely to require future property overhang pruning works. There's also a greater potential for conflict with underground services (often located nearer to the property boundary) or private property. In many cases minor pathway realignment or incorporation of designated planting sites through local narrowing/ scalloping of pathways can make a world of difference to the potential for a tree to establish and shade the pathway in the future.

One of the key challenges with respect to planting trees in conjunction with footpath works is safeguarding the infrastructure from future tree root damage. While ensuring adequate provision of space for both trees and essential infrastructure is the easiest way to reduce future conflicts, increasingly this is becoming impractical.

Trees are living biological systems that require light, oxygen and water as well as sufficient above and below ground space for growth and development. When space for root growth is limited, and conditions conducive to root growth are created below or in close proximity to infrastructure, damage often occurs. Tree roots travel the path of least resistance and gravitate toward moisture gradients. Moist areas created as a result of condensation at the interface of the soil layer and traditional footpath slab for example, provide an ideal environment for tree root growth.

The likelihood of new trees causing damage to adjacent infrastructure is an outcome of factors such as the:

- existing conditions of the site
- available soil volume for tree growth
- distance between the footpath and new tree
- species of tree for planting and inherent characteristics
- size of trees on maturity (large growing trees are generally more likely to cause pathway damage and fast growing trees will generally cause more damage in a shorter period of time)
- watering methods and cycles (frequent shallow watering will encourage root growth nearer to the surface while deep irrigation will encourage roots to stay deeper in the soil profile).
- Soil type (clay soils with a shallow top soil profile and hard pan beneath for example) will encourage root growth nearer to the surface.

Selecting trees that will remain small and compact through their lifetime is one option to address infrastructure damage potential. 'Tree sensitive design' is another. The *Sunshine Coast Open Space Landscape Infrastructure Manual* details some of the factors that lead tree root growth in the direction of hard surfaces, and provides guidance for designing treatments and spaces compatible with trees. The manual also details how to appropriately protect existing trees from construction damage. This is naturally the most sustainable approach to delivering new infrastructure in locations where trees already exist.

Table 7: *Treatments to minimise tree damage to footpaths* lists some of the treatments available to support tree root growth while minimising the risk of damage occurring in the future.

Table 7: Treatments to minimise tree damage to footpaths

Design and construction treatments
Provide sufficient setbacks between existing trees. Realign or scallop (locally reduce the width of) pathways where possible to accommodate future street trees.
Construct pathways with thicker concrete and extra reinforcing to combat the force of root heave and prevent lifting of the pathway surface. Include specialised trip prevention treatments/dowel joints.
Undertake tree root trenching parallel to the footpath to create a preferred path of travel for tree roots thereby encouraging root extension parallel to the footpath rather than underneath it.
Create structured tree root pathways below footpaths to areas of greater soil volume beyond (for example within the sub base 100mm wide by 300mm deep).
Irrigate where roots are wanted, compact soils where they are not wanted.
Use elevated (boardwalk, decking for example) or suspended treatments to retro-fit footpaths around existing large trees. Use permeable surface treatments (that do not create a condensation layer beneath) and deeper drainage/aggregate bedding layers below non-permeable treatments to encourage roots to stay deeper in the soil profile.
Install root cells within or adjacent to the planting site (where appropriate) and incorporate root deflectors (where appropriate).

Electrical infrastructure

The electrical infrastructure network presents many challenges to tree establishment. Services located both above and below ground severely limit the space available for growing street trees. Management of the required clearances between lines and vegetation reduces the level of environmental and visual benefits trees are able to provide in these locations, if trees are present at all.

While power is installed underground in new developments, a significant above ground network remains elsewhere which detracts from the overall amenity of our streets and towns. Establishing new trees beneath overhead wires is complex, as the necessary maintenance of required clearances (to avoid outages and service disruption) is the responsibility of the energy provider and a significant financial burden. Power companies not wishing to perpetuate a network of sizeable trees under overhead wires is an understandable position, but with limited funds available for the high cost of undergrounding power in established urban areas (where greening is needed the most) council must often forgo the opportunity establish new trees where overhead wires are present. This is a poor outcome for council and our community, as power poles and naked wires are infrastructure elements that could benefit from visual screening or softening.

Vegetation clearance pruning programs also present a significant threat to the long term viability and useful life expectancies of existing trees. The structural integrity of specimens is often compromised by lopping or pruning works designed to provide adequate and lasting below wire clearance. Trees that have been lopped to meet wire clearances are also often unsightly.

A memorandum of understanding (MOU) between Energex and the Sunshine Coast Council has been established to document the needs and obligations of each party with regard to vegetation management. A commitment to resolving areas of conflict by both parties is expressed within the MOU. Strategies for reducing conflict between street trees and electrical infrastructure including cost sharing for reconfiguration of the network where high value trees grow are described.

There are several options available to council where required tree benefits cannot be fully realised as an outcome of existing electrical infrastructure in place:

- undergrounding power is the most expensive option. The appropriateness as well as availability of funding for this purpose is a key consideration. Trenching for underground power may also impact on existing trees and the potential for this needs to be considered when exploring options for minimising conflicts between vegetation and the electrical services network
- the replacement of traditional overhead spanned structures with aerial bundled cables (ABC) reduces the clearance requirement significantly. Young trees can be formatively pruned so that clearance pruning does not destroy future form or function
- re-routing or relocating spans of the network to move away from planting sites where there is a need for trees to provide benefits (for example shading of a major pedestrian route in an area identified as vulnerable) is another option
- raising power poles or tensioning slack wires may be possible in some circumstances, allowing more room for a tree of a standard size to growth beneath
- the establishment of council managed clearance or formative pruning programs for selected new plantings, where council has established a need for vegetation (of an appropriate scale) in areas where overhead power lines exist.

The MOU states that the tree selection options as listed in Table 8: *Tree selection options to avoid tree–electrical infrastructure conflicts* should be explored to avoid future conflicts. Increasing planting densities may also effectively compensate for the lack of vertical scale provided by vegetation beneath wires. Reducing planting centres from 6 to 8m to 3 to 5m for example may be appropriate in some situations where green relief is critical to balancing the built environment.

Table 8: Tree selection options to avoid tree–electrical infrastructure conflicts

Tree selection options to avoid conflict
Select trees that are small sized on maturity (in some situations large shrubs may be suitable) or normally crown below the height of the low voltage wires, tree species with weeping habits for example (species that may be easily climbed should be avoided).
Select trees that are slow growing so that mature dimensions are not reached for many years and/or the specimen reaches its useful life expectancy prior to conflict with overhead wires.
Select trees that have a decurrent (without a clear leading stem) or multibranched structure which are more tolerant of directional pruning or can be effectively shaped, in early growth stages, through formative programs to minimise future conflict with overhead services. For example the genus *Callistemon* (bottle brush).
Select trees that exhibit a framework of fine branching and are therefore tolerant of hedge type pruning undertaken at a higher frequency, such as genus *Syzygium* (lilly pilly).

Service compounds

Pump stations and similar land parcels or compounds annexed for the purpose of service provision offer some potential for the establishment of trees to both build tree canopy, and screen unsightly structures. Potential locations for the establishment of low conflict plantings in such spaces warrants further investigation.

Solar collectors

With battery technology improving all the time, a much higher proportion of energy is likely to be generated by solar collectors in the future. Street tree planting placement is already respectful of the presence of solar panels within adjacent properties with council electing to be a good neighbour and not position trees in a manner that may reduce the efficacy of solar collectors as a tree matures. Trees however are also solar collectors, and their role in carbon sequestration and mitigating heat in urban areas is critical and will become even more so as time goes on. It should be noted therefore that the placement of future solar panels, especially large scale urban installations, will need to appropriately consider potential impacts to existing or future street tree infrastructure.

Future directions

Council's Parks and Gardens Branch will continue to work closely with internal and external partners to ensure new and existing trees are integrated into all future footpath programs.

Tree–infrastructure conflicts are reduced over time with larger trees reserved for larger planting sites (purpose built if necessary) and compact street tree species used for standard verge spaces within the local street network.

Sensitive footpath design treatments including upscaled reinforcement and specialised dowel joints are used wherever possible to allow for larger growing trees to be planted alongside footpaths in priority sites (such as high use pedestrian routes and bikeways as well as significant links between town centres, parks and community facilities to take the pressure off roads).

Council will continue to work with Energex to ensure compatibility of electrical infrastructure and trees. Such initiatives for better outcomes to be explored include identification of sections of the network for undergrounding of power or conversion to ABC wires and partnerships between council and Energex to establish shade tree plantings in alternative locations to compensate for the limitations of other sites.

Opportunities to plant large growing trees in suitable locations within service compounds (pump stations and mobile phone towers on council land leased to service providers for example) to both build canopy and mask what is often unattractive infrastructure are explored.

The foreseeable impacts of future large scale solar panel installation on existing and future street trees are properly considered and strategies to reduce impacts devised.

The case for street trees (in urban environments especially) continues to be strongly communicated.

Recommendations

Proactively plant trees to provide shade to all key pedestrian networks. Plant trees in conjunction with new footpath works wherever possible to create shade and increase pathway comfort on hot days.

Select trees with a compact form for planting near existing or new infrastructure and where verge space is limited.

Ensure sufficient verge width remains between the road and footpath edge to accommodate existing or future trees.

Utilise specialised treatments and pathway alignments to accommodate existing or future street trees.

Continue to work in partnership with Energex to ensure that risks to the network remain low, while striving to achieve a better balance between streetscape amenity and electrical infrastructure networks.

Select appropriate trees for planting beneath wires and incorporate five year formative pruning programs into operational programs where appropriate.

Collect data on sites and service easements where canopy building can occur without conflict.

Consider how new street trees can continue to be provided when exponential increases in solar collector installations occur and how conditions for street tree protection may be built into the development assessment process.

Existing views

The region's scenic amenity helps make the Sunshine Coast an outstanding place to 'live, work, invest and play'. Coastal and hinterland views however present considerable challenges to creating and sustaining street tree cover.

The value of the Sunshine Coast's scenic amenity is detailed in the *Sunshine Coast Planning Scheme 2014* and 'significant views' for preservation as an outcome of development are presented in the *Local plan codes* associated *Local Plan Elements* maps (see Part 7: *Local plans, 7.2 Local plan codes*).

The vast majority of the region's views and vistas (from both public and private locations) are not documented. Patterns of change in the extent of vegetation framing view lines are also largely unknown.

Sustaining vegetation cover in our esplanade locations is extremely difficult. While council has resolved not to position trees in a manner that may restrict scenic amenity, many of our streets that interface with foreshores suffer from lack of reinvigoration, with decline of many even aged tree stands. New or even replacement tree planting in many of these locations has simply not occurred on account of the expectations of existing and/or pre-existing views.

These environments comprise some of the highest visitation and use in the region, and the amenity offered by mature trees at the street level is also a key factor for consideration. Moreover, vegetation often plays a critical role in erosion or sand blow protection in coastal environments.

Our foreshore streetscapes are some of the most difficult environments to establish new trees, with exposure and vandalism compounding viewline challenges. Lack of natural recruitment solidifies the unsustainable nature of the situation at present.

The dune vegetation from Alexandra Headland through to Cotton Tree for example, is in a clear state of decline.

While council is committed to taking a cautious and site responsive approach to the planting and management of street trees in locations where scenic amenity (both coastal and hinterland) may be threatened, further work is required to establish a hierarchy of values considering view importance, quality, setting, accessibility and visitation for example and community priorities with regard to both public and private scenic amenity.

Future directions

Every effort should be made to ensure that new trees are positioned with respect to the preservation of existing public and private views. In relation to distant views, a wider program of consultation should be undertaken before new street trees are planted.

Replacement trees should be returned to the exact location of the previously existing tree in areas where new trees may impede existing open views as they develop. In the case of the installation of critical coastal infrastructure, this may not always be possible. In these situations replacement trees should be planted as near to the previous location as possible, with respect to the preservation of existing views. Replacement trees should be planted as soon as practically possible to avoid the development of personal attachment to the creation of temporary views.

Opportunities to proactively plant succession trees inside existing informal clumps and stands of trees in streets that intersect with foreshores (and do not currently afford views to the water) should be explored further.

The potential for mapping existing tree canopy extents in and around the region's major public view points to allow the development of vegetation management plans in consultation with the community should also be investigated.

Recommendations

Ensure new tree plantings are located in a manner that is respectful of the preservation of existing views.

Consult with all relevant parties when creating shade and amenity in foreshores or locations where coastal or hinterland views may exist.

Explore the potential to map existing vegetation/tree canopy extents in and around public view points and view sheds and develop vegetation management plans in consultation with the community. Plan for succession tree plantings outside of agreed view sheds.

Tree supply, monitoring and maintenance

The availability and quality of nursery stock

To achieve the vision of the *Sunshine Coast Street Tree Master Plan* to 'protect, sustain and enhance the region's street tree network' and 'plant more of the right trees in the right locations', the supply of quality advanced tree stock that can keep pace with demand is required.

Growing trees with properly developed root systems capable of providing sufficient structural support and nourishment requires technical precision. Seedlings develop quickly in our subtropical climate and if not potted-on at the right time, will often not recover the required root system health and structure to either survive initial planting shock, be self-supporting or achieve the required vigour for a long and healthy life.

An Australian Standard (*AS 2303-2018 Tree stock for landscape use*) guides selection of tree stock of an acceptable quality for landscape plantings. Species substitutions are increasingly being made as an outcome of stock of the chosen species, selected for the characteristics of a specific site, not meeting the standard. The outcome is often unsuccessful, especially where substitute species do not match the growing conditions of the subject site.

While it is recognised that the standard works better for some species than it does for others, root to shoot ratios, trunk stability, root occupancy and formation of roots within the pot are key indicators of stock quality and will have a heavy influence on the success of the planting. It is also recognised that some stock quality issues can be overcome with root pruning, however more resources (council officers generally) are required to guide and supervise planting works where delicate root pruning is required, or a more skilled contractor workforce is necessary. Additionally not all tree root deformities are evident at the time of planting, or able to be corrected if they are. Energy reserves (carbohydrate) are also taken from the plant at a time when a young tree, undergoing transplant shock, needs its energy reserves the most. Council's wish is to minimise poor establishment risks by advocating use of stock that does not require rectification works at the time of planting — stock that meets the industry standard.

It is also acknowledged that soil type and general site conditions as well as preparation of the tree planting hole are additional factors strongly linked to the success of new street trees. Council has formulated detailed specifications to guide planting site preparation including soil amelioration, planting procedures and young tree maintenance, as well as selecting quality tree stock in-line with the standard, (see *Sunshine Coast Open Space Landscape Infrastructure Manual - Embellishments - Planting*) to once again reduce the risk of poor tree establishment.

There has also long been a supply and demand short-fall with regard to less commonly used tree species. Many of the region's indigenous species that may be selected based on their suitability for a site are simply unavailable through external tree supply networks. With tight delivery time frames for most capital work projects, there are usually insufficient lead times for purpose or custom grown tree stock of the preferred species to be developed. Again, species substitution is frequently the outcome which sees plants that are not suited to the specific conditions of the planting site utilised, or opportunities to strengthen landscape character and support local biodiversity, lost.

Reactivation of council's nursery

Council has recently identified significant opportunity to grow quality stock of desired species via re-activation of its internal operational nursery. Programs aim to produce high quality specimens of Sunshine Coast signature local native and desirable yet elusive native and exotic tree species available for trial and if successful, wider use in the future. It is hoped that reactivation of council's nursery will also promote the use of high quality nursery trees in all Sunshine Coast landscapes, raising awareness of the fundamental influence of stock quality on the appearance, resilience, longevity and short, medium and long term maintenance requirements of street and park trees.

Young street tree maintenance

Newly planted trees require care and an intensive schedule of maintenance for initial survival and ongoing growth and development. Advanced trees of the standard 45 litre size generally take one to two years to establish post planting. Without proper early care, many young trees fail to establish. Insufficient maintenance during the establishment phase of a tree is one of the leading causes of early tree loss.

The quality of the tree at the outset, planting technique used, and general care and attention provided in the first year of development is strongly linked to the health, vigour and form of the tree in the future. A tree that struggles through establishment either as an outcome of a poorly developed root system at the time of planting, or lack of care during establishment, may die before it is able to support itself, or have a high maintenance requirement throughout its lifetime.

The currently limited operational programs of young tree maintenance, as well as insufficient duration of contractor 'on maintenance' periods for street trees planted as a part of capital programs and in new residential developments are evident across the Sunshine Coast.

The cost of ensuring young trees receive frequent watering and mulching (and the application of soil stimulants or fertiliser where necessary) during the critical first year of life is significant, and well above the purchasing and planting costs. Council has found that where residents specifically request the planting of a tree adjacent to their property and agree to help care for it in the early stages of its life, the tree has a far greater chance of successful establishment. Such programs of stewardship also significantly reduce maintenance costs allowing redirection of funds to plant more trees in more places.

Council has also found that where trees are planted as a part of a contractual arrangement, establishment success rates are much higher where there is at least a 12 month maintenance period associated with the plantings. Success is also greater where contract documents specifically detail the frequency of maintenance visits required.

It has long been established that the smaller the stock at the time of planting, the quicker it is to establish. Council is also trialling the use of smaller stock in appropriate streetscape plantings. This may also assist in overcoming stock quality and poor tree establishment issues in the future.

Tracking 'no net loss'

The environmental, aesthetic, social and economic benefits provided by an individual street tree (either open–grown or forming a part of a group or avenue planting) are lost when removed without replacement.

Street trees removed from locations where they play a critical role as a part of an intricate urban ecosystem can have a significant impact on the functioning of the ecosystem and the plants, animals, insects and microorganisms relying on complex symbiotic relationships and natural balance for their very survival.

Council strives to ensure all trees removed as an outcome of natural attrition, damage, construction or maintenance of critical infrastructure; are replaced at a minimum ratio of 'one for one'. Vegetation of high retention value is presently offset according to council's '*no net canopy loss'* formula which requires replacement trees to number that which would replace the canopy area of the high value tree(s) within a specified period (three or five years generally).

Despite systems of tracking replacement trees or tree offset requirements as a part of operational and capital programs, collating an inventory of all required tree replacements to achieve a 'no net loss' is difficult. Historically there has been little success tracking council's performance with regard to replacement tree planting. New systems of capturing data relating to all new street tree plantings delivered operationally however are now in place, with plans to add new plantings delivered as an outcome of capital works programs to the dataset at the end of the contractor maintenance period.

Succession/recruitment planting programs

The currently limited operational program of proactive tree planting is also evident in the existing street tree network of the Sunshine Coast, specifically the planting of succession trees to key open space–streetscape interfaces.

Foreshore landscapes of principally an amenity rather than conservation function, are high priorities for recruitment planting so that much needed shade and visual amenity can be sustained in these areas for future generations.

Future directions

Poor plant establishment rates and high young tree maintenance costs can be reduced with improved stock quality, greater availability of species suited to the specific conditions of the subject planting site, using improved systems of recording and monitoring new tree plantings (in capital and operational programs as well as new residential developments), scheduled maintenance of young trees for longer periods and the use of smaller stock in appropriate locations.

The establishment of community and corporate partnerships to help care for young trees under council's *Adopt A Street Tree Program* will not only reduce rate payer funded maintenance requirements for the subject trees but the early nurturing is likely to guarantee good health, vigour and resilience in the long term.

Activation of council's internal nursery is a positive step towards ensuring quality locally significant species that have been difficult to obtain, but offer great potential for the region, become more widely available over time.

Improved systems of tracking of all newly planted trees will allow council to better track its total 'no net loss' target and also allow analysis of condition and survival rates across a variety of site conditions, planting types and priority planting locations. Proactive maintenance programs for revisiting young street trees will be investigated to help ensure that the Sunshine Coast's street tree population is stronger and healthier in the future.

A proactive planting program for declining streetscape–foreshore interfaces (scoped in conjunction with public view–shed analysis and community consultation) will serve to deliver much needed succession trees and commence investigation of view–line management issues.

Recommendations

Produce a higher volume of street trees through council's nursery. Grow alternative species identified for wider use or trial plantings and desired species that are generally unavailable through standard tree supply networks.

Encourage production of quality trees through external supply networks. Promote council's preferred street tree species lists to encourage local suppliers to grow a wider range of street tree species.

Ensure young tree maintenance programs of a sufficient duration and frequency are contractually secured, monitored and audited. Explore the potential for council to deliver street tree planting and maintenance in development sites via a developer contribution system.

Form partnerships with the community and corporate sector to care for or provide support for new tree plantings in the development of *Adopt A Street Tree Programs.* Prioritise programs for local streets with low canopy cover and a high capacity for planting where local residents indicate they will assist.

Monitor existing tree cover over time to track council's performance in sustaining the existing street tree network. Expand council's centralised system of data capture to incorporate all new tree plantings in the region. Continue to ensure that every tree removed is replaced at 'no net loss' and 'no net canopy area loss' for high retention value trees.

Commence a program of succession planting in declining foreshore streetscapes in conjunction with view shed investigations.

Analysis

This section of the *Sunshine Coast Street Tree Master Plan* details analysis of the Sunshine Coast's vegetation cover, with a particular focus on the existing street tree network, to help identify street tree planting priorities for the region and establish benchmarks for future canopy cover targets.

Vegetation mapping

Assessment of the extent of vegetation cover across the urban footprint and rural townships of the Sunshine Coast Council LGA (as at 2014) was undertaken using the Sunshine Coast Council's existing *LiDAR* derived dataset for analysis.

Multi-spectral imagery was used to evaluate patterns of change in vegetation cover in the region over the past ten years (see the plan's *Appendix* for detailed methodology and results).

Study area

The entire Sunshine Coast Council LGA (Local Government Area) encompassing 2,291 square kilometres of land (see *Figure 3: LiDAR generated map of Sunshine Coast Council LGA*) formed the study area.

Local study areas were defined according to the *Local plan area* (LPA) urban land area divisions established in the *Sunshine Coast Planning Scheme 2014* (see *Part 7*: *Local plans, 7.2 Local plan codes*). These LPAs include urban landscapes and rural town centres of the Sunshine Coast Council region and are shown in *Figure 4: Map of Sunshine Coast Council region Local Plan Areas* (LPAs).

Areas of the region that fall outside of these LPA divisions are generally located within the rural landscape and are not immediately applicable to this plan. These areas are however addressed within the local *Street tree strategies* developed for each area (Part B of the plan).

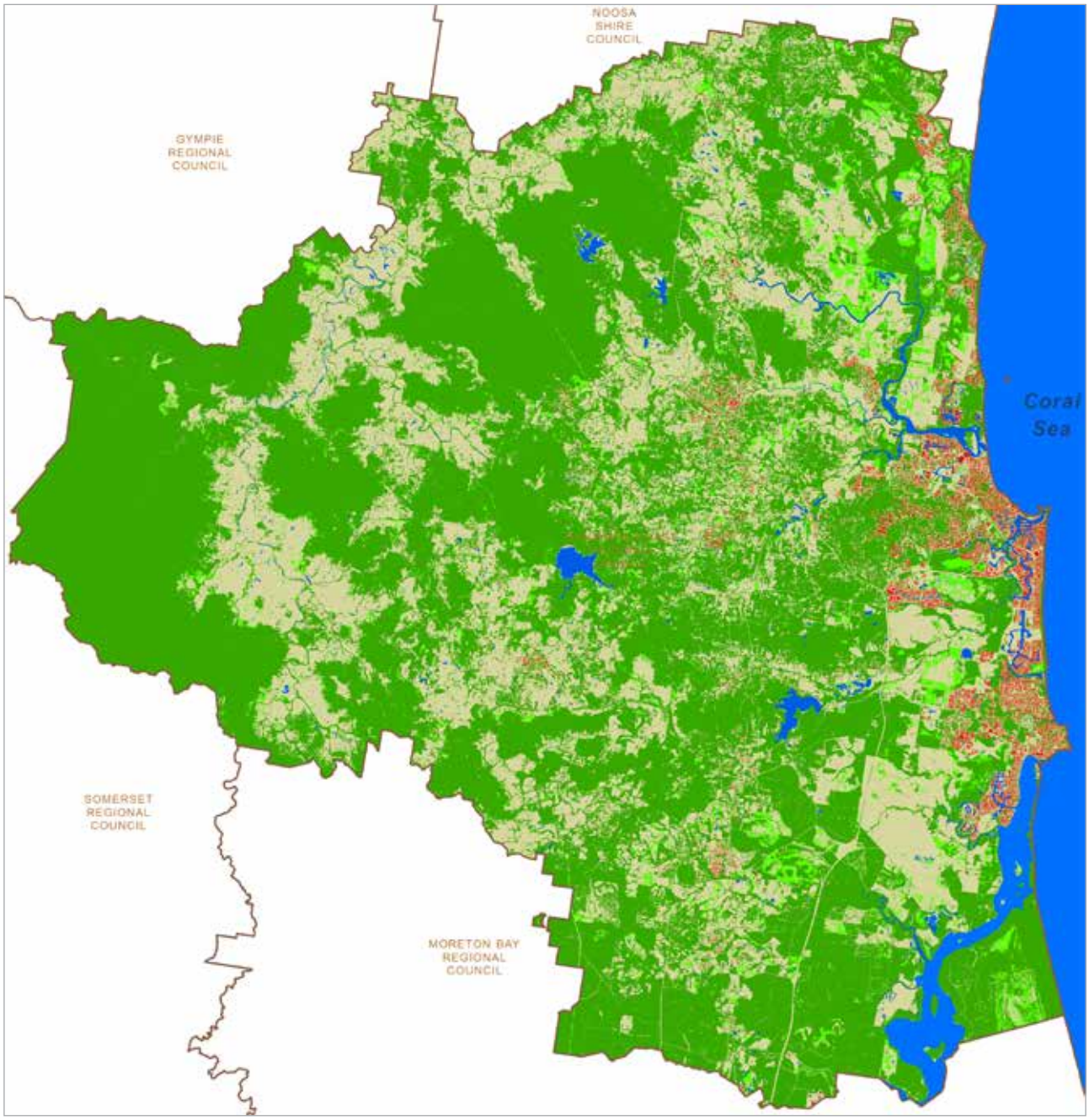


Figure 3: *LiDAR* generated map of Sunshine Coast Council LGA.
Vegetation is shown in green, buildings in red and water in blue.

Summary of statistical methods

LiDAR mapping data captured in 2014 was used to generate statistics surrounding the coverage and structure of vegetation across the whole Sunshine Coast Council region, allowing for comparison with available data from other LGAs across Australia.

More detailed assessment within the Sunshine Coast Council LGA, allowed comparison between the extent, quality and shade value of existing vegetation in each LPA.

Measures of canopy cover, height, shade projections in mid–summer, and foliage density, were calculated per square metre of land for each of the twenty seven LPAs of the Sunshine Coast Council region.

These are defined as:

- canopy cover: the percentage of land covered by vegetation greater than 2m in height (how much vegetation is present?)
- foliage density: the percentage of sunlight being blocked by leaves, branches and fruit (how effective is this vegetation at shading and cooling the environment?)
- canopy height: the average height of vegetation across defined land areas, including all vegetation greater than 30cm in height (what is the average height of the vegetation?)
- canopy shade: the total area of land directly covered by vegetation greater than 2m in height plus the extent of land shaded by this vegetation in mid-summer at both 9am and 3pm (what is the shading value of the vegetation?).
- Data generated was averaged for each area and used to create a 'foliage score' which allowed for ranking the value of the vegetation within each LPA beyond simply comparing percentage cover in plan view (the higher the 'foliage score' number, the greater the value of the vegetation).

Two datasets were generated and analysed:

- the first includes all vegetation greater than 2m in height within the subject LPA regardless of ownership or tenure
- the second includes only vegetation within areas of road reserve (all land that is not associated with a title deed and is formally reserved for the transport of vehicles) to allow for closer evaluation of street tree extents.

Figure 5: LPA comparisons of vegetation value between all lands and road reserve lands only, plots the foliage scores created for each LPA. Results are also presented as colour–coded tables of statistics in the Appendix of this report.

Summary of key findings

In June 2014, the Sunshine Coast Council LGA (Local Government Area) as shown in Figure 3: *LiDAR generated map of Sunshine Coast Council Local Government Area* (LGA) was made up of 57% vegetation (above 30 cm), 28% ground, 7% low vegetation (below 30 cm), 2% buildings and 6% water.

The map shows that the Sunshine Coast is a very 'green' LGA and that the most urbanised areas of the region are from the Pumicestone Passage to the Maroochy River (also known as the *Sunshine Coast Enterprise Corridor*).

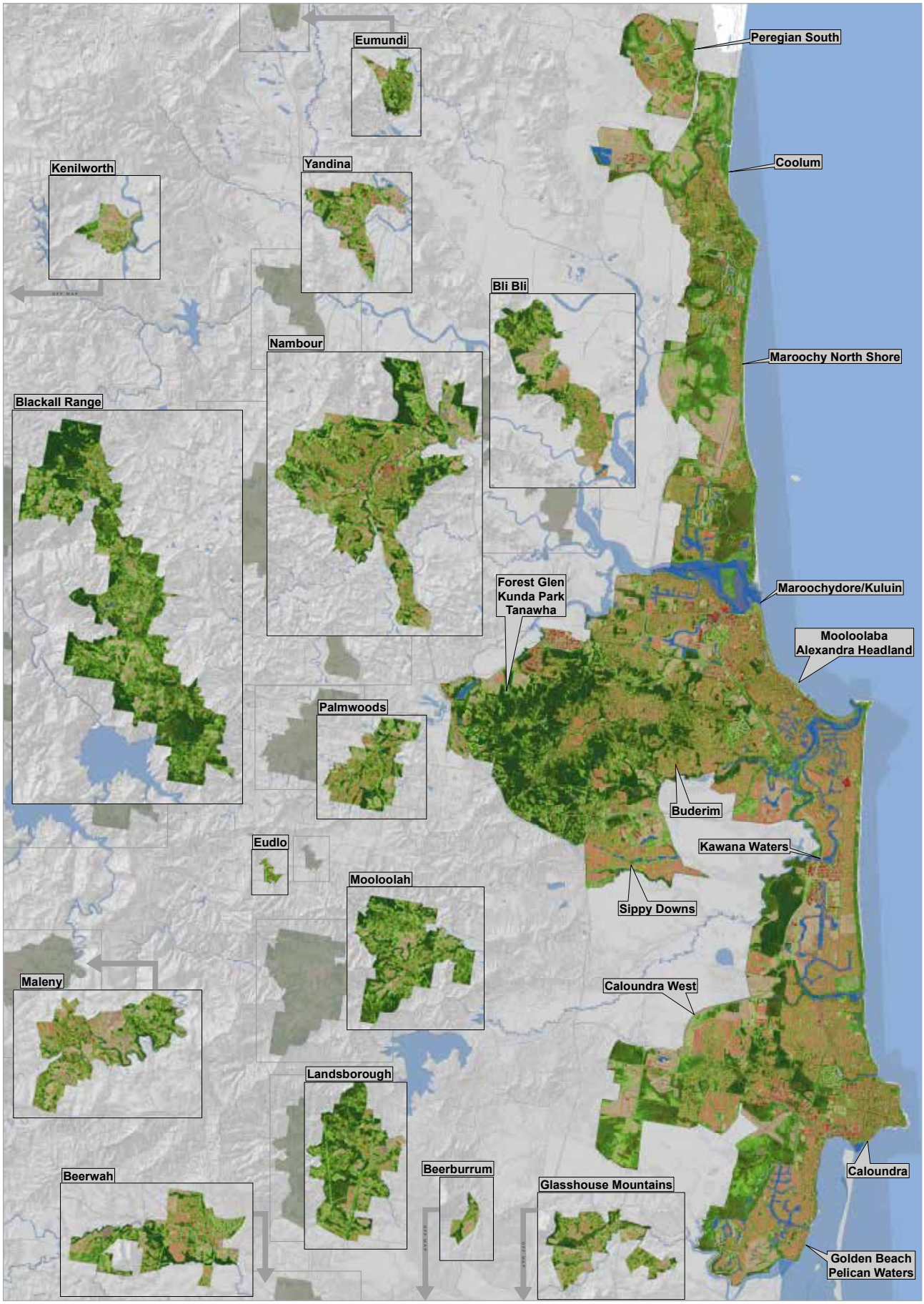


Figure 4: Map of Sunshine Coast Council region Local Plan Areas (LPAs).

These results are consistent with those presented in a nation-wide canopy modelling study undertaken in 2012 (Jacobs et al. 2014). In this study, the Sunshine Coast LGA was found to be one of the greenest in Queensland with 57% of all lands containing vegetation more than 2 metres tall (the percentage cover reported for the Brisbane City Council LGA at the time was 49% and the national average 39%).

These comparisons show that in 2014, the Sunshine Coast was performing very well in terms of tree canopy cover. Vast tracts of vegetation growing in state forest, council managed bushland or national park helped account for the good result.

Statistics generated for the Sunshine Coast's more densely populated areas however provide greater insight into the Sunshine Coast's 'urban forest '.

The graph in *Figure 5: LPA comparisons of vegetation value between all lands and road reserve only*, plots foliage scores for each LPA with all lands shown in blue and road reserve lands only in red.

The Sunshine Coast LPAs with highest foliage scores across all land types at the time of data capture, where vegetation could be said to provide greatest value are:

- Blackall Range
- Forest Glen / Kunda Park / Tanawha
- Mooloolah
- Landsborough
- Buderim
- Eumundi
- Nambour
- Eudlo
- Palmwoods.

With the exception of the Forest Glen / Tanawha / Kunda Park and Buderim LPAs, all of these localities officially occur within the Sunshine Coast's hinterland. Not surprisingly, the Blackall Range with its rich and fertile soils, cooler climate and large expanses of forest, tops the list. At the time of data capture, this area contained vegetation cover over 62% of all lands and 48% of road reserve.

The Forest Glen / Tanawha / Kunda Park LPA was also shown to be performing very well despite the large industrial area within (and the newer residential estates of Forest Glen showing substantially less vegetation volumes than parts of Mons and Tanawha).

Significant differences between vegetative cover and foliage score across all land types and statistics generated for road reserve areas only were found for:

- Beerburrum
- Maroochy North Shore
- Buderim
- Nambour.

Statistics reported for all land types for Buderim and Nambour showed above–average values, yet slightly below–average values were reported for road reserve spaces in each area. Conversely, figures generated for the Beerburrum and Maroochy North Shore LPAs showed above–average foliage scores for road reserve spaces (in the case of Beerburrum this was very high), but average to below-average values for all land types.

Local Plan Areas within the *Sunshine Coast Enterprise Corridor* scored the lowest for all of the vegetation parameters analysed (with the exceptions of Kenilworth which also shows comparatively low foliage scores). Twenty percent or less of road reserve spaces were reported to contain vegetation of significance in the areas of:

- Maroochydore / Kuluin
- Kawana Waters
- Golden Beach / Pelican Waters
- Sippy Downs
- Mooloolaba / Alexandra Headlands
- Kenilworth.

Bli Bli, Caloundra and Caloundra West reported only marginally better statistics for road reserve canopy cover.

Statistics generated for all land types also showed that the coastal strip from Golden Beach to the Maroochy River (Maroochydore) (the *Sunshine Coast Enterprise Corridor)* scored the lowest for the combined measures of percentage, shade value, and density of tree canopy as well as the average heights of trees, for the entire region (with the addition of Kenilworth, Sippy Downs and Peregian South).

Average vegetation heights in these localities ranged from 2.2 to 3.6 metres. In contrast, vegetation growing in the Forest Glen / Tanawha / Kunda Park, Blackall Range, Mooloolah, Landsborough and Buderim LPAs averaged between 8.5 and 12.7 metres tall. Comparisons of percentage canopy cover for each LPA are shown in *Figure 6: Info-graphic showing Sunshine Coast Council region Local Plan Areas* (LPAs) *and canopy cover percentages* (*all lands*).

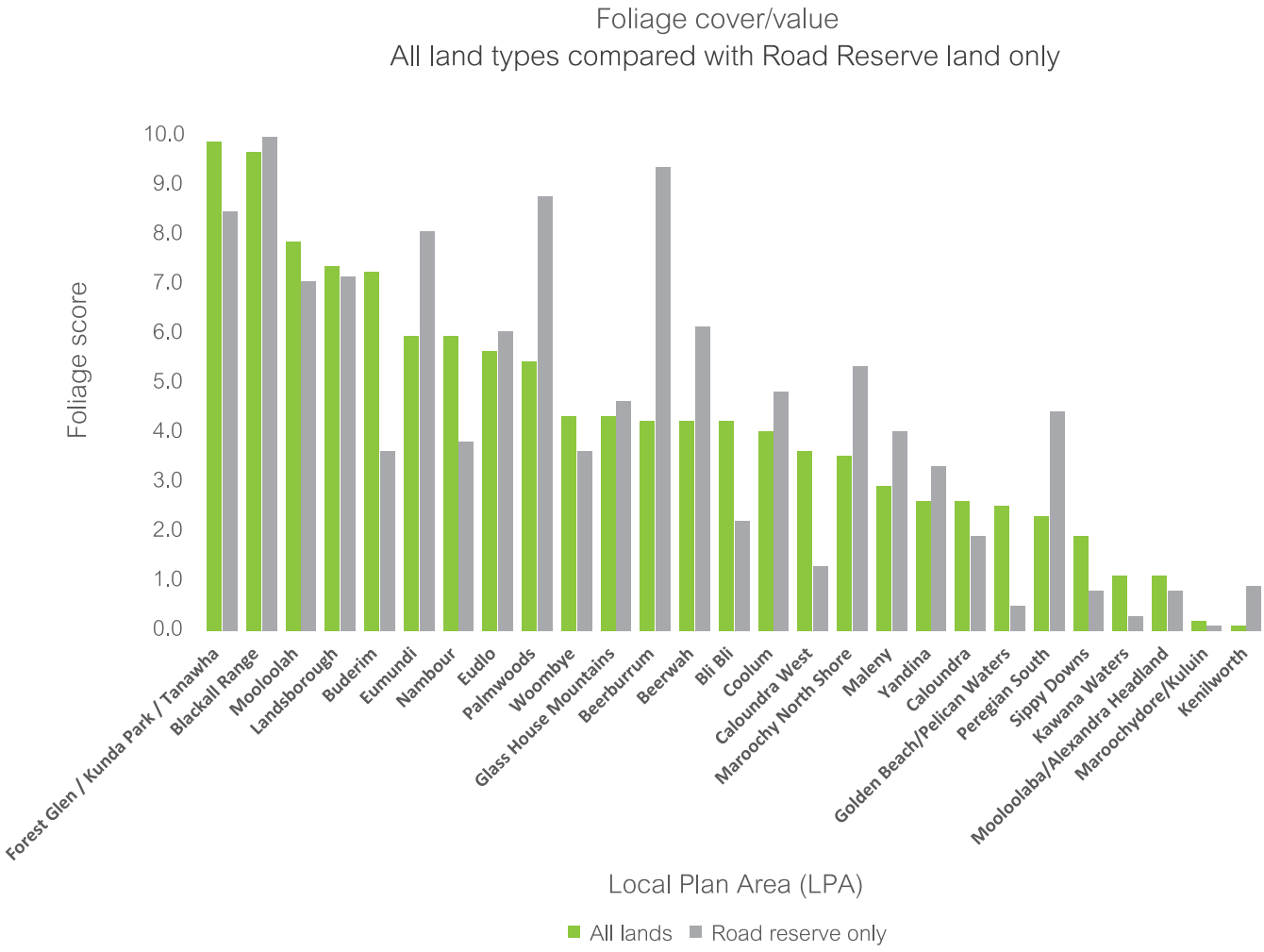


Figure 5: LPA comparisons of vegetation value between all lands and road reserve only

Discussion and conclusions

These results confirm that street trees growing within our most densely populated areas (and the focus of future development densification) currently provide the least amount of benefits.

Good opportunities exist to provide greener, cooler streetscapes by prioritising shade tree planting programs in the areas of Golden Beach / Pelican Waters, Caloundra, Mooloolaba / Alexandra Headland and Maroochydore.

Results also show the harsher and more modified the environment, the lesser the extent of tree canopy. Tree establishment is notoriously difficult within the coastal plain of the Sunshine Coast due to infertile and/or modified or inverted soils. These results may also indicate that more work is required to ensure the right conditions are provided for young establishing trees in these areas, that greater intervention is needed with regard to soil health and nutrition, and that cyclic maintenance needs to occur at greater frequencies.

In most situations, land use and context can explain canopy extents and foliage scores that may seem at odds with landscape character. Kenilworth for example contains a very high proportion of grazing pastures and many areas where there is no formal road verge to accommodate street trees. The figures for the Maleny LPA tell the same story.

With regard to the Maroochy North Shore LPA, statistics reported for all land types generated far lower rankings than those reported for road reserve areas only. The Sunshine Coast Airport and vast stretch of lowland vegetation within the Mt Coolum National Park occurring north of the plan are likely to impact the overall volume of vegetation reported for the LPA.

Young, still establishing trees that have been planted in newer residential developments also need to be considered. Stocking rates are generally high in such areas but trees are still too small to have a meaningful impact on vegetation cover statistics. Peregian Springs and a good proportion of Kawana Waters, Sippy Downs and Bli Bli are comprised of younger residential estates where field investigations confirm that street tree occupancy is generally very good.

The newer residential estates of the Beerburrum plan area are also believed to be responsible for the low figures reported for canopy cover across all land types in the locality, despite its large trees and forest feel.

LPAs where the low scores for road reserve cover are not as easy to explain and should be seen as a cause for concern include Buderim and Nambour. These areas are less likely to have significant patches of young still developing street trees affecting statistics as the bulk of residential living is long established. Vegetation cover statistics in the older established areas of the region therefore, perhaps provide the most meaning and reference for where we need new trees the most.

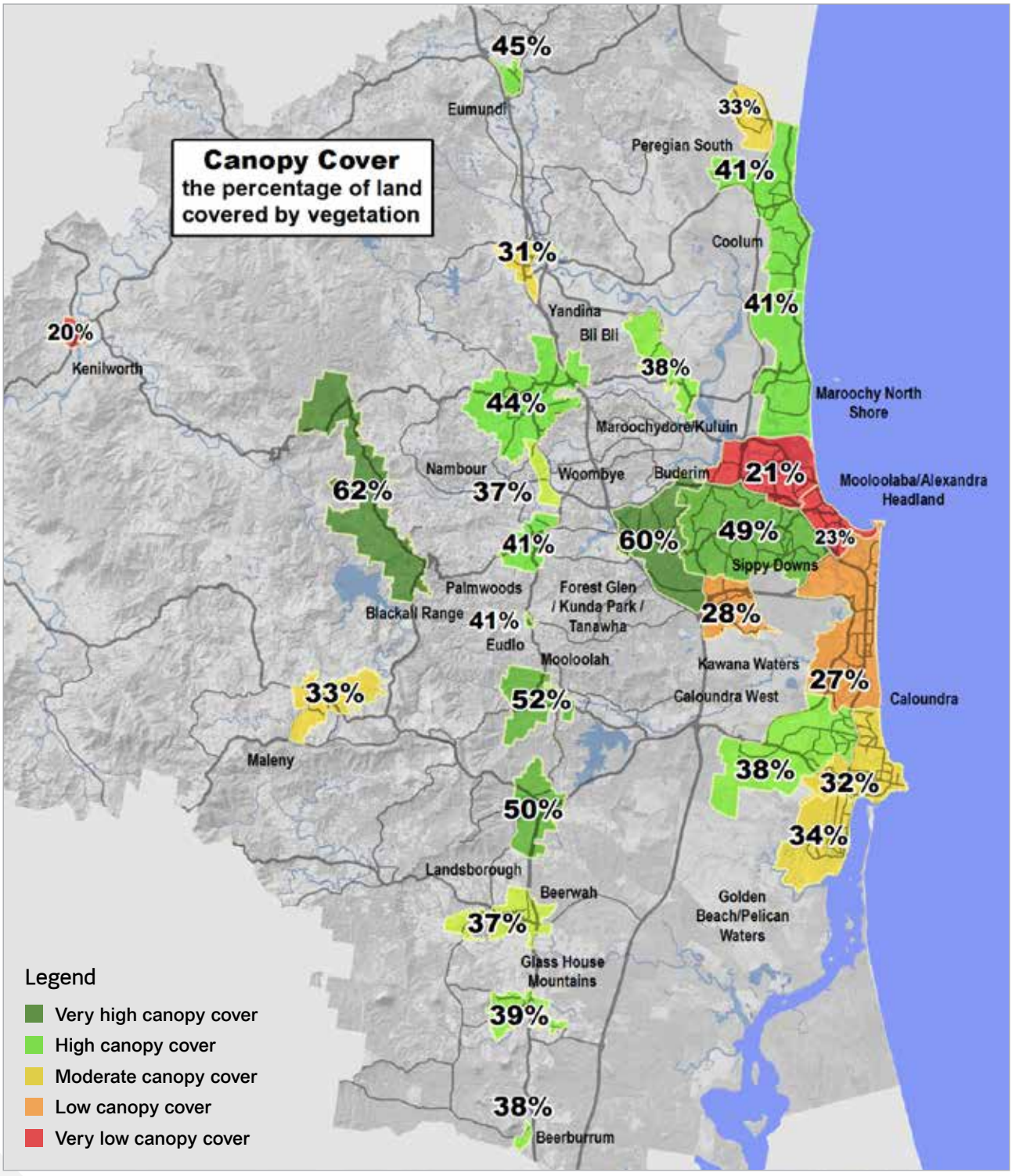


Figure 6: Info-graphic showing Sunshine Coast Council region Local Plan Areas (LPAs) and percentage canopy cover (all lands).

Change in canopy extents over time

Changes in percentage canopy cover between 2005 and 2015 were examined for each of the LPA's local plan areas (LPAs) using multi-spectral imagery as detailed in the *Appendix* to this report.

Trends showed most areas had lower vegetation indexes (on average 2% less tree cover) in 2015 than in 2005. These results reflect the ever-growing nature of the region but also suggest that increased rates of street planting may be required to compensate for the volume of vegetation clearing.

Despite highest cover overall, measurable losses of road reserve cover between 2005 and 2015 were found for the Forest Glen and Blackall Range LPAs. The greatest reductions in vegetation cover within road reserve lands over the 10 year period were reported for Eudlo (down by 5.5% on the 2005 figures) and Glass House Mountains (down by 5.2% on the 2005 figures).

Eumundi showed the greatest decline in overall tree cover (all land types) for the 10 year period, a decrease of 6.83%. A significant decrease was also shown for Woombye with statistics reporting a decrease of 5.39% in tree cover over all lands over the ten year period. In contrast, Peregian South showed an increase of 3.98% and Kawana Waters a very positive increase in vegetation cover of 7.8% across all lands types over the reporting period.

Future directions

Despite validation required of areas that actually need new street tree plantings as opposed to where trees are perhaps still young and small, the early analysis would suggest that council should prioritise funding for street tree planting in:

- The *Sunshine Coast Enterprise Corridor* specifically the localities of Caloundra, Maroochydore / Kuluin, and Mooloolaba / Alexandra Headland which are long established areas with few new housing estates showing significant vegetation losses over time as well as low levels of existing cover and relative value across all land types and road reserve spaces only. With development focused on this area increased street tree numbers will be required to soften and provide vertical scale to the built landscape and provide shade and cooling.
- Kenilworth where low canopy cover is coupled with the greatest number of extreme heat days projected for the future for the entire region. The creation or modification of street tree planting sites may be necessary to provide suitable spaces for street tree in this locality.
- Buderim and Nambour where canopy cover within road reserve spaces is significantly less than all land types and ongoing infill development will place additional pressures on the street tree population in the future.
- Glass House Mountains and Eudlo where there was significantly less road reserve vegetation in 20015 than 2005.

Results suggest that more detailed investigation into the structure and age of street tree populations should be carried out in the areas of Sippy Downs, Caloundra West and Bli Bli to determine if canopy statistics are skewed by a higher proportion of land subdivision and urban residential development.

Vegetation statistics for all land areas indicate that council should also target the *Sunshine Coast Enterprise Corridor,* Beerburrum, Kenilworth, Eumundi and Woombye for the promotion of planting of trees on private land. Free tree programs may assist. If determined there are few opportunities for the planting of trees in private land in these areas (for example in the case of Maroochy North Shore) council should perhaps turn attention to growing the urban forest in these areas by increasing tree planting on public land.

Detailed *Foliage and Shade Cover* plans have been generated for each local plan area. These maps have been used to further detail tree planting opportunities at a local level and are presented within the *Street tree strategies* that comprise Part B the *Sunshine Coast Street Tree Master Plan*.

Potential for using council's existing and future *LiDAR* dataset to drill down further to identify 'hot spots' within localities and to the street level to help engage local communities and prioritise future planting programs for local residential streets now exists, and should be utilised in the future.

The preliminary statistics provide all-important benchmarks to measure ongoing progress against. These results should be examined against successive *LiDAR* data capture (fresh *LiDAR* data is to be captured in 2018) and ongoing annual assessment of Multispectral Seasonal Fractional Cover to allow for tracking and monitoring of extents of cover over time. Using these figures to measure increases or decreases against forecasts from tree planting activities will also help council to develop local canopy cover/foliage score targets. This will help council to achieve the key street tree planting objective of not just sustaining existing canopy extents over time, but enhancing local shade tree cover to provide cooler, greener communities in the future.

Recommendations

Conduct investigations within well-established local plan areas with poor tree canopy cover as opposed to new estates where young trees exist, to identify barriers or opportunities for enhancing street tree coverage.

Prioritise street tree planting in suitable locations (purpose built if necessary) within the *Sunshine Coast Enterprise Corridor* and, Kenilworth, Nambour, and Buderim.

Intensify programs of young tree maintenance in the *Sunshine Coast Enterprise Corridor* and areas of the region where low canopy cover and smaller trees are coupled with poorer soils.

Focus on the *Sunshine Coast Enterprise Corridor* and Eumundi, Woombye, Kenilworth, Maroochy North Shore and Beerburum for the promotion of planting new trees on private land. Explore mechanisms for stricter control over tree clearing in areas where canopy has significantly retracted as a part of the Development Assessment Process.

Explore methodologies and funding opportunities to build upon tree canopy mapping including using the technology to map view sheds, to prioritise heat-vulnerable community areas, identify visibly declining tree populations or to develop future shade targets.

Continue to monitor annual change in canopy extents with Multi-spectral imagery and re-evaluate road reserve extents with fresh *LiDAR* capture in 2017.

Develop local tree planting targets to sustain existing canopy extents. These need to be realistic and deliverable and can be used to help forecast budget increases if necessary.

The existing street tree network

Field observations were carried out to both ground-truth statistical analysis of vegetation cover and to provide greater insight into the types of trees used for street tree planting in the region and their current performance.

Further detail is contained within the individual precinct plans developed for each LPA (Part B - *Street tree strategies*), some commentary is provided below to help form future directions and the *Species selection guidelines* of the plan.

Street tree species suitability and performance

Dominant species

Considering the wide range of species that naturally occur within the region (especially the vast suite of under-utilised rainforest plants), a relatively narrow street tree palette predominates.

The best represented street tree species in the region, used in a range of applications, is *Cupaniopsis anacardiodes* (tuckeroo) which naturally occurs in foreshore plant communities of the Sunshine Coast. The species performs very well as an urban street tree with a rounded crown, dense canopy and wide range of tolerances. *Syzygium hemilamprum* (syn. *Acmena hemilampra* - blue satinash) is also fast becoming another of the most commonly planted species in urban streets of the Sunshine Coast. Again, this tree (the broad-leaf form offers a good alternative to the more widely represented crinkle leaf form) is both attractive and reliable.

Other street tree species that also currently dominate streetscapes include *Buckinghamia celcissima* (ivory curl), *Xanthostemon chrysanthus* (golden penda), *Backhousia citriodora* (lemon myrtle), *Tristaniopsis laurina* 'Luscious' (water gum), *Harpulia pendula* (tulipwood) and *Elaeocarpus obovatus* (hard quandong). These species are also consistent in appearance and remain relatively compact when mature.

While there is good justification for the selection of reliable street tree species— and in many cases, specifically with regard to the coastal plain where poor soils dictate the available species palette— over–reliance on a narrow set of species increases risk of losses across the region in the event of significant changes to climate and specific growing environments, or pest and disease outbreaks.

A fine line also exists between selecting species with proven success and the risk of creating repetitive streetscapes. This narrow street tree base palette has the potential to result in uninspiring landscapes rather than those of a lush, vibrant, subtropical character that the Sunshine Coast Council aspires to. Field research has also showed that these common compact species have been planted in many locations where larger trees may have been grown.

More problematic is over–representation of species that are unreliable or in the case of *Grevillea baileyana* (white oak) or *Flindersia brayleana* (Queensland maple), species that are too successful and have now come under question due to their potential for self establishment (see *Weed species*).

Lophostemon confertus (Queensland brush box), has been markedly over–used as a street tree in recent years, especially in newer urban residential developments. As an urban street tree on the Sunshine Coast, the species has proved unreliable. Young trees are especially vulnerable if not hardened-off before planting into open situations. Juvenile specimens have also been found to require a higher frequency of maintenance compared to other species, and are slower to establish. The tree can be sizeable on maturity if it does establish well, but is often inappropriately selected for new housing developments where space is limited and compact trees are more appropriate for the longer term. A close relative of the species, *Lophostemon suaveolens* (swamp box) is generally under-utilised despite its widespread natural occurrence on the Sunshine Coast (especially in low-land areas) and more compact form.

Backhousia citriodora (lemon myrtle) and *Tristaniopsis laurina* (water gum) local rainforest species are compact with dense, luxuriant canopies. These species thrive when water is not a limiting factor but are frequently selected for use in sites where the existing soils simply cannot accommodate their water requirements, especially in large-scale residential developments.

Araucaria heterophylla (Norfolk island pine) has cemented its place along Sunshine Coast foreshores (along with its close relative *Araucaria cookii* - Captain Cook's pine which is narrower and often with a crooked stem) despite not being a native tree (the species is endemic to Norfolk Island but is generally accepted to be naturalised in Australia).

The species is synonymous with coastal landscapes across the eastern seaboard of Australia and provides a distinct and valued character to many of the Sunshine Coast's front-line coastal sites. While the tree is a consistent performer in exposed coastal landscapes, the species is also widely used inland, when other local natural character species (hoop pine for example) could have been used.

Species with undesirable traits

Species once planted widely on the coast that are now notorious for their especially vigorous root growth or surface rooting characteristics (as evidenced in the existing Sunshine Coast street tree network), include *Melaleuca leucadendra* (weeping paperbark) and *Syzygium tierneyanum* (river cherry). These attractive trees are inappropriate for standard street tree use and are best reserved for planting in parks, sufficiently set back from areas of potential conflict.

Other species noted to have inherent problems or performance issues include the range of grafted flowering gums *Eucalyptus* 'Summer red' and 'Summer beauty' purpose made hybrids (crosses) of *Corymbia ficifolia* (flowering gum) of assured colour, grafted onto reliable *Corymbia ptychocarpa* (swamp bloodwood) root stock. Since development of these hybrid species, they have frequently been used in place of the pure swamp bloodwood species (an attractive compact tree native to the Northern Territory) selected for their promise as even smaller trees with guaranteed flower colour. These hybrids however, are more often than not, shrub-like in habit, have proven to be extremely slow to establish and may be brittle.

Elaeocarpus reticulatus (blueberry ash) once widely planted in the region (in Beerwah especially) more closely resembles the habit of a shrub than a tree (and is therefore difficult to maintain due to a spreading rather than upright habit). This species should be reserved for use in garden bed or natural character grouped plantings.

Melaleuca (syn. *Callistemon*) *viminalis* (bottle brush) is widely represented due to extensive planting of the species from the 1970s onward. Despite its attractiveness to nectar feeding birds, the species often has an untidy appearance, retaining dead twigs and seed capsules. Its crown also tends to open up over time which can detract from landscapes rather than enhance them. A range of successful bottle brush cultivars with a more compact form are now available and recommended for use in streetscape plantings instead.

Species for special planting treatments

Other attractive or local character species poorly suited to standard road verges as evidenced in streets of the Sunshine Coast Council region include *Callitris columellaris* (Bribie Island pine). This locally important species can create a dusty environment beneath as an outcome of needle drop. This species requires good set backs from areas of high public use.

Delonix regia (poinciana) and a range of other species listed in the *Species selection guidelines* of the plan also provide a strong character element to many Sunshine Coast streetscapes. With structural traits better suited to large open sites however, these are not recommended for introduction into new streets due to their high maintenance requirement.

Some of the larger, more prolific fruiting lilly pillys (*Syzygium oleosum, Syzygium forte* and *Syzygium moorei*) are proving to be better suited to parks or large mulched areas than adjacent to footpaths.

All species of the genus *Ficus* (fig) (the naturally occurring varieties making a stunning contribution to the landscape, are ecologically important and provide a high level of ecosystem benefits) require ample room to remain trouble free as they mature.

Other species that also require ample room and are better suited to garden bed style plantings include:

- *Araucaria bidwillii* (bunya)
- *Caesalpinia ferrea* (leopard tree)
- *Castanospermum australe* (black bean)
- *Commersonia bartramia* (brown kurrajong)
- *Grevillea robusta* (silky oak)
- *Mangifera indica* (mango)
- *Melicope elleryana* (pink euodia)
- *Pandanus tectorius* (screw pine)
- *Peltophorum pterocarpum* (yellow flame tree)
- *Terminalia catappa* (Indian almond)

Species for performance monitoring

Elaeocarpus eumundii (Eumundi quandong) appears to have strong mycorrhizal (beneficial soil fungi) associations and performs better when grouped with other rainforest plants. This species is widely used as a street tree however it's variable performance (particularly in the coastal plain) is also evidenced in the existing Sunshine Coast street tree network and further monitoring of the species is required. It is recommended that this species is reserved for hinterland areas or where its use is necessary to perpetuate the existing landscape character of an area.

Weed species

Plants classified as weeds will either have, or threaten to have, an impact on the existing biodiversity values of the region or local area as well as the potential to spread. These plants can out–compete native species and can alter the composition of vegetation communities. A number of these species have been planted in the past for amenity, cultural or commercial purposes. As circumstances have changed and knowledge has increased regarding the adaptability that these plants have within their new environments, a number of these trees are now formally listed as invasive plants.

The *Sunshine Coast Council Local Government Area Biosecurity Plan 2017* lists 79 *Priority invasive plants* requiring an active management response in accordance with the Biosecurity Act 2014. Listed trees consist of *Cinnamomum camphora* (camphor laurel), *Celtis sinensis* (Chinese elm), *Cecropia pachystachya*, *Cecropia palmata* and *Cecropia peltata* (Mexican bean trees), *Handroanthus chrysotrichus* syn. *Tabebuia chrysotricha* (golden trumpet tree), *Gleditsia triacanthos* (honey locust) and *Ailanthus altissima* (tree of heaven).

A further 11 trees are listed as *Restricted invasive plants which under the plan* should be reduced, controlled or contained. These include *Spathodea campanulata* (African tulip tree), *Ligustrum lucidum* (privets – broad-leaf privet, tree privet) and all *Salix* species other than *Salix x babylonica, Salix x calodendron* and *Salix x reichardtii* (willows). Trees classified as *Priority invasive or Restricted invasive plants* should not be planted in any streets or parks within the Sunshine Coast LGA.

183 *Locally Significant invasive plants* that are considered undesirable, with continued propagation, planting and potential impacts needing to be carefully considered before use include *Syagrus romanzoffiana* (cocos palm), *Koelreutaria elegans* (golden rain tree), coral tree or Indian coral tree (*Erythrina x sykesii*), dwarf umbrella tree (*Schefflera arboricola*), exotic pines (*Pinus* sp.), Indian hawthorn (*Rhaphiolepis indica*), loquat (*Eriobotrya japonica*), olive (*Olea europaea*), Queensland umbrella *tree* (Schefflera actinophylla) and rosewood tipuana (*Tipuana tipu*). This plan recommends that use of these species are also avoided in all Sunshine Coast streetscapes.

Other listed *Locally Significant invasive trees* comprise of native yet not naturally occurring (not locally native) species that are proving too successful out of their natural range.

These species that have long been used successfully in cultivation in subtropical Queensland are now spreading from cultivated to natural environments. These include *Corymbia torelliana* (cadaghi), Queensland maple (*Flindersia brayleyana*), weeping fig (*Ficus benjamina*) and *Grevillea baileyana* (white oak).

These species have been shown to not only compete with natural populations as an outcome of their ability to self-propagate but also threaten to pollute gene pools by interbreeding with locally native species (Navie 2014). *Corymbia torelliana* (cadaghi) and *Ficus benjamina* (weeping fig) have not been planted in public open space areas of the Sunshine Coast for some time and this plan recommends that their disuse continues. *Grevillea baileyana* (white oak) and *Flindersia brayleana* (Queensland maple) however are identifiable character species in several localities (including Bli Bli) and are not considered a significant threat in areas where soils are poor (for example the coastal plain as opposed to hinterland areas) and landscapes are highly contrived. These species are not recommended for use in the Sunshine Coast hinterland environments nor near bushland areas however this plan recommends the species are monitored in lower risk environments (urbanised, poorer soils) rather than removed from planting palettes all together.

A further species listed as a *Locally significant invasive plant, Jacaranda mimosifolia* (commonly known as blue jacaranda), while no longer planted as a standard street tree in the region, is a signature species of a number of Sunshine Coast localities (Beerwah, Buderim and Landsborough for example) and a celebrated tree due to its seasonal show of colour. This plan recommends that future use of this species is restricted to infill character plantings only (to replace avenue plantings in Beerwah for example) and ongoing monitoring.

Current pest and disease issues

Pests and diseases are natural components of a functioning ecosystem. The impact they have on trees can vary depending on the extent of the infestation and the role that the specific organism plays. Impacts can be minimal and therefore not noticeable within large and densely vegetated natural areas, but within developed areas, where there is generally less diversity and a cultured growing environment, the impacts can be substantial.

In environments that have undergone minimal disturbance, pests and diseases are generally held in balance. Within changing or constructed environments however, natural processes that help maintain the balance may be lost, or pests and diseases that were never part of the local environment may out-compete the local populations of plants and animals. There are several pests and diseases of trees occurring within the region with the potential to have a devastating impact if not properly managed.

Phellinus noxius

Phellinus noxius is a soil-borne fungal pathogen that causes the disease 'brown rot' in trees. When there's an ecological imbalance it begins to feed on living as well as dead tree tissue, can cause significant die-back and may eventually lead to the death of a tree. The fungus targets certain species, and generally specimens in a reduced state of health although this is not always the case.

Susceptible hosts include species of the genus *Ficus* (figs), *Araucaria* (South–Pacific conifers especially Norfolk Island pine), species of the *Eucalyptus* genus (gum trees), the coast's signature *Pandanus tectorius* (pandan or screw palm) and as recent evidence would suggest a number of additional local coastal species. Its presence is generally indicated by a white mycelium (fungal strands) stocking at the base of an infected tree however this stocking is only present seasonally and may not be or become evident at all.

Tell–tale rust/brown streaks may also be found on the trunk of an infected tree but in many situations visual indicators of its presence do not appear until the tree is in an advanced state of decline. *Phellinus noxius* can, in many cases, be tolerated by a tree if the specimen is cared for properly (generally with a seasonal reduction in health followed by a period of recovery). A tree can however be completely overcome by the fungal pathogen when its defences are low and may ultimately die as a result. Prevention of infection is presently the only method of control. Council is currently managing known infected trees with natural plant health care treatments and controlling spread of the infection through hygienic work practices. Further containment of infection is possible via baiting with another fungal agent, *Trichoderma* sp, which has been found to consume the fungal pathogen in laboratory trials and in field trials, has been found to contain the spread (J.J. Fletcher 2017 Personal Communication July 30 2015). Council is currently developing an integrated pest management program including trialling a program of soil inoculation in locations where the pathogen is known to be persistent and impacts are increasing.

Myrtle rust

Myrtle Rust (*Puccinia psidii sensu lato*) is a relatively recently described fungus that is closely related to the eucalypt or guava rusts. These rusts are serious pathogens which affect plants belonging to the plant family Myrtaceae which includes well-known Australian natives belonging to the *Melaleuca* or *Callistemon* (paperbark and bottle brush), *Syzygium* (lilly pilly) and *Eucalyptus* (eucalypts/gum trees) genera.

Myrtle rust is distinctive in appearance producing masses of powdery bright yellow or orange/yellow spore–filled lesions on young actively growing leaves.

The pathogen requires warm, moist conditions for production of fungal spores and thrives in the wet season. Repeated infection of highly susceptible plants may result in plant death. Early evidence

from the Sunshine Coast's amenity landscapes is showing most species temporarily recover, however long term impacts are not yet known.

Several species have been shown to be particularly susceptible. These include the non-native lilly pilly *Syzygium jambo*s, *Rhodomyrtus psidiodies* (native guava) and *Gossia bidwillii* (python tree). While the species *Rhodosphoera rhodanthema* (deep yellow wood) is not in the Myrtle family and therefore not a host for Myrtle rust, another rust is having a devastating affect on the species with almost identical symptoms.

The rust is very difficult to control as the fungal spores are carried by wind from one plant to another. Ensuring that highly susceptible species are not used, Myrtaceous (belonging to the *Myrtaceae* family) species are not planted as monocultures and that infected stock is not brought into new landscapes (especially those that interface with natural areas) are some of the methods council is using to keep the problem under control to prevent future mass infection.

Leaf hopper and Cane weevil

The Sunshine Coast's signature palm species *Pandanus tectorius* (pandan/screw palm) is presently susceptible to two significant pests. The first, a leaf hopper (*Jamella australia*e) that is believed to have been inadvertently introduced to the region numerous years ago, causes die back of the crown of the plant. Severe infestation can lead to death if left untreated.

A natural wasp predator was introduced to the region in the late 1990s and has kept the pest in-check for some time. In cases of severe infestation however, an integrated pest management program is necessary to eradicate the insect from the plants.

A second boring pest yet to be formally identified is also causing similar symptoms of crown die back, but is not restricted to sheltered parts of the canopy as is usually the case with the leaf hopper. With infestations more severe in sugar cane growing areas, it is believed that the responsible pest may be the sugar cane weevil borer (*Rhabdoscelus obscurus*) which is major pest of the sugar cane industry. Early trials to treat heavy infestations have been conducted with soil injection. Populations will continue to be monitored in conjunction with a suitable integrated pest management program where required.

Flying foxes

Flying foxes are attracted to trees that produce soft fruits or flowers containing a high concentration of nectar. Trees that develop white or yellow flowers on the ends of branches and can be readily seen at night are specifically selected for foraging. The palette of preferred species includes figs, palms, lilly pillys, paperbarks, bottle brushes, grevilleas, most eucalypts and coastal banksias.

Flying foxes are nocturnal and travel significant distances to forage therefore avoiding the planting of desirable foraging trees is neither practical nor effective in keeping flying foxes out of certain areas (despite council's aspiration to reduce their presence and impact in urban residential areas).

Flying foxes do however cause significant concern for a number of local communities directly affected by their presence. Urban roosts of concern in the Sunshine Coast Council region are located in Coolum, Maroochydore, Mooloolaba, Moffat Beach, Landsborough and Palmwoods. Council is committed to minimising direct impacts of flying fox communities on local residents and risks of additional foraging time or spill–over of roosts into surrounding streets can be reduced through thoughtful street tree species selection in these areas.

Future directions

Opportunities to diversify the existing palette of Sunshine Coast street trees should be taken wherever possible expanding use of uncommon Sunshine Coast native species (for example rainforest trees) and native (not naturally occurring within the local area but native to other parts of Queensland or Australia) trees. The ratio of exotic trees used for accent and highlight plantings in local and regional activity centres should also be increased.

Mixed species planting themes are encouraged for use wherever appropriate. Diversity within formal avenues of trees should be increased to minimise the threat of substantial impact of pest, disease or warming in the future.

A more distinct and identifiable street tree character should be established for the Sunshine Coast Council area through reinforcement and greater use of signature plants as feature and gateway trees. The hoop pine (*Araucaria cunninghamii*) naturally occurring in many Sunshine Coast landscapes for example is a key character species that should be targeted for wider use.

The use of *Lophostemon confertus* as a street tree should be minimised. *Syncarpia glomulifera* (turpentine) and many species of the *Diploglottis* (tamarinds), *Diospyros* (persimmons), *Cryptocarya* (laurels), *Angophora* (apple or rose gums), *Syzygium* (lilly pillys) and *Flindersia* (Bennett's ash for example) genera growing successfully on the Sunshine Coast are some of the possible alternatives to commonly used yet unreliable species (*Lophostemon confertus* – brush box for example) or species identified as having with undesirable traits for street tree use. These species also show great potential for providing greater cooling benefits to the region (in sites that can either naturally support the specific requirements of rainforest trees or be readily irrigated).

All trees listed as *Priority invasive plants* and *Restricted invasive plants* within the *Sunshine Coast Local Government Area Biosecurity Plan* (2017) should not be planted into any public open space areas of the Sunshine Coast Council region. Additional species that should not be used as street trees due to their weed potential, extreme pest or disease susceptibility or undesirable developmental traits include *Corymbia torelliana* (cadaghi), *Ficus benjamina* (weeping fig), *Melaleuca leucadendra* (weeping paperbark), *Syzygium tierneyanum* (river cherry), *Elaeocarpus reticulatus* (blueberry ash), *Syzygium jambo*s (rose apple), *Rhodomyrtus psidiodies* (native guava) and *Rhodosphoera rhodanthema* (yellow wood).

The performance of *Elaeocarpus eumundii* (Eumundi quandong) should continue to be monitored. While an important local species of the Sunshine Coast, the tree is not recommended for use in parts of the region's coastal plain where its performance has been noted to be particularly inconsistent.

*Jacaranda mimosifoli*a (blue jacaranda) should not be introduced into any localities or streetscapes where they are not already considered a signature tree. Similarly *Grevillea baileyana* (white oak) and *Flindersia brayleana* (Queensland maple) should be carefully considered before use with planting in low risk areas only, where the species are prominent and an important element of local character. Bottle brush species for use should be selected from one of the many cultivars (with improved visual and functional characteristics) available through the local nursery industry (see *Species selection guidelines* for more information).

Phellinus noxius susceptible species should not be used in locations with a known history of infection, or where the risk of infection is high. Monocultures of Myrtaceous trees should be avoided wherever possible to reduce the spread and potential impact of the Myrtle Rust disease, and despite the iconic status of *Pandanus tectorious* (pandanus palms) on the Sunshine Coast, numbers should be reduced to combat the species' maintenance intensity and on-going pest and disease threats.

Street tree selection strategies to avoid expanding existing flying fox roosts into surrounding urban residential streetscapes should be detailed in local *Street tree strategies* for each of the localities with significant flying fox roosts. A list of street tree species that are not preferred foraging food for flying foxes (including conifers with inconspicuous or low nectar producing flowers or no flowers or fruits at all) should be developed for use in high risk locations. The planting of avenues using species that form closed canopies should also be avoided in these areas.

Recommendations

Ensure ongoing site responsive street tree plant selection (select the right tree for the right location) and widen street tree palettes to reduce dominance of potentially over-used species.

Sustain Sunshine Coast regional and local character via the development of pre-defined signature and character palettes for the whole region and each local area.

Undertake performance based assessment of the existing Sunshine Coast street tree population composition to build an evidence base for species over-use and to determine appropriate compositions for the future.

Reduce the potential impact, spread and severity of pest and disease on street tree populations through selection against susceptible species where possible, quality control of tree stock, the use of natural predators and organic soil tonics and stimulants to enhance the health of susceptible species, and avoidance of monoculture street tree plantings wherever possible.

Develop local street tree planting strategies for flying fox affected localities including lists of non-preferred foraging species for high risk areas (near existing roosts).

Formulate an integrated pest management plan to control the spread of *Phellinus noxius* from infected sites and plant succession trees in adjacent areas that are not currently infected or in conjunction with biological soil inoculates to ensure currently impacted plant communities can be sustained.

Encourage the use of organic soil stimulants and soil enriching products as a part of integrated pest management programs and in all establishment maintenance programs for young trees. Extend young tree maintenance programs and provide ongoing irrigation wherever appropriate.

Strategic directions

Street tree planting guidelines

Region–wide responses to key issues and challenges for street trees on the Sunshine Coast and evidence of the need to improve the planning, design, planting and care of future street trees across the region were formulated in the *Background* section of this report (summarised under the headings *Future Directions* and presented in the *Recommendations* provided).

These responses were used to develop an overarching vision and guiding principles for street tree planting on the Sunshine Coast which are in line with the following policy positions provided in the *Sunshine Coast Environment and Liveability Strategy 2017*.

1.1 The distinctive and diverse landscape is preserved to maintain the beauty of the area.

1.2 The landscape, character and heritage values retain the unique identity of the area.

5.1 An integrated and connected open space network is provided that is responsive to a changing environment and respects community needs.

5.2 The open space network ensures equitable access to a range of experiences to encourage active and healthy lifestyles and supports community wellbeing.

5.3 Open space provides the green frame around and within our built form to connect us to the environment and create a strong sense of identity within a community of communities.

6.3 Flooding and stormwater management protects the natural and built environment.

7.1 Good urban design and urban form supports compact and self-contained neighbourhoods to improve the use of existing infrastructure and minimise the use of resources.

9.2 Living infrastructure is integrated with the built form to create liveable neighbourhoods, support urban biodiversity and create great urban places.

12.1 Adaptation enables the whole community to build climate and disaster resilience.

Our vision

The overarching vision for street tree planting on the Sunshine Coast is *to protect, enhance and sustain the Sunshine Coast Council region's existing and future street tree network through better selection, placement and care of street trees.*

Guiding principles

The eight principles developed to guide street tree planting on the Sunshine Coast are to:

Ensure locally responsive species selection and placement that reflects or complements existing character and design intent.

Plant large canopy trees and groups of trees to build canopy wherever space permits and conflict potential is low for provision of ecosystem services.

Ensure adequate space is reserved and created for future street trees (specifically engineered for tree planting if necessary).

Shade and cool major pedestrian routes and urban hot spots with higher street tree densities.

Create attractive and coherent streetscapes. Plant large canopy feature/anchor trees in strategic locations. Infill and extend avenues along major thoroughfares and town lead–ins to enhance the subtropical look and feel of the region.

Reduce conflict potential through better tree selection and placement of street trees and ongoing partnerships with the community and stakeholders.

Sustain the existing extent of canopy cover across the region through continued planting of offset trees, and building population resilience through diversification of species and succession plantings. Increase health and longevity of street trees through appropriate selection, planting and care of new trees.

Partner with the local community and corporate sector to help establish and care for new trees.

Ensure locally responsive species selection and placement that reflects or complements existing character and design intent.

Strategic outcomes

Character

- Regional character is enhanced through use of key signature species in high profile locations.
- Local character is respected through the use of precinct based street tree planting strategies reflecting the individuality of local places in the Sunshine Coast's 'community of communities'. See Part B: *Street Tree Strategies.*
- Avenue plantings are considerate of established local streetscape character and contribute to streetscape continuity (unless existing trees are performing poorly).
- Where no planting theme exists, streets may be suitable for the introduction of mixed native, subtropical planting arrangements or the introduction of exotic feature trees to reduce the dominance of over-used species, enhance population resilience and increase visual amenity.
- Feature tree selection and placement complements and reflects the natural and/or cultural landscape, existing views and natural land form.
- Natural character of bushland blends into surrounding streetscapes where appropriate.
- Where natural character planting themes are used the original regional ecosystem forms the base for plant selection where practicable.
- Planting nodes with a natural character design intent aim to enhance the ecological function of the site where appropriate.

Design intent and landscape function

- Street tree selection and placement reflects the purpose of the planting (shade provision, cooling, place making), and the conditions of the planting site.
- Street tree plantings integrate with the built form and the natural character of the area and reflect the design intent of structured landscapes.
- In urban areas, plantings are consistent with building styles and considerate of solar and pedestrian access requirements.
- Street tree layout is respectful of community safety, ongoing visibility of signs and commercial entities, existing views and vistas.
- New lighting and solar panel installations are considerate of existing and future street tree locations.
- For further guidance on street tree layout see Part B: *Technical and positioning guidelines.*

Scale and buffers

- Scale of plantings reflects use, design intent, and function of trees (shade and cooling for example).
- Landscape buffers are used to provide distinction and separation between incompatible land use areas. Plantings are of an appropriate scale where used as buffers. Plantings are of appropriate widths when framing or complementing views.
- Where trees are to provide landscape screening, tree selection ensures a minimum of 30% of the building elevation is screened when the planting reaches mature dimensions.
- Where planting spaces are not sufficient to support the establishment of large-growing trees, palm species (*Livistona, Archontophoenix* for example) are used to provide vertical scale to soften built up areas.

For further guidance on species selection see *Species selection guidelines.*

Plant large trees or groups of trees to build canopy wherever space permits and conflict potential is low.

Strategic outcomes

Large trees for large spaces

- Large maturing trees are planted in spaces where existing conflict potential is low and impact potential is high (see *Figures 7 and 8* for examples).
- In new residential land developments, deep planting environments that can accommodate large growing trees are preserved wherever possible and used as feature tree locations.
- Trees are planted to build canopy in public open space areas that intersect with streetscapes (see *Figure 8*). Positioning of new plantings should not compromise the potential for passive surveillance of play areas.
- Large canopy trees are planted in council controlled lease areas as appropriate (i.e. service compounds) or in appropriate locations along state controlled sections of the road network under special maintenance agreements.
- Foreshore landscapes (at street interfaces) are enhanced through the addition of large trees to existing stands (where there is no potential for loss of water views).
- Existing guard railed sites are used to establish large growing trees in centre medians and adjacent to high speed roads where 'frangible' trees are otherwise required.
- For large growing species lists see *Signature* and *Natural Character* palettes in Part B: *Street Tree Strategies*. See also the S*unshine Coast Open Space Landscape Infrastructure Manual* (*Embellishments - Planting - Landscape - Index*).

Figures 7 (above), 8 (top right) and 9 (bottom right): Artists impressions of sites where large trees or groups of trees can be planted to build canopy where conflict potential is low.

Ensure adequate space is reserved and created for future street trees.

Strategic outcomes

Entry statements

- Embed 'tree sensitive' design into all developments, including spaces for feature trees in new residential developments.
- Engineered tree planting sites are constructed to accommodate new trees in streetscape upgrades and new urban residential developments where insufficient space for large trees exists.
- Pathway alignment protects existing trees and/or retains adequate space for the establishment of future trees. Specialised dowel joints and other sensitive design treatments are incorporated where appropriate to allow for large trees to be planted.
- Storm water management/biofiltration systems integrate street trees wherever possible.
- Design of new infrastructure accommodates existing or future trees.
- Major boulevard verges and medians are constructed according to best horticultural practice to support large canopy trees.
- Guard rail is incorporated into locations where set-backs and clearances cannot be achieved otherwise and a critical need for tree benefits has been identified.
- Alternative sites are made available to accommodate trees where trees cannot be incorporated into standard verge spaces. Similarly, where tree retention or planting options have been exhausted in favour of infrastructure, alternative sites (across the road, in the median or nearby nodes) are secured for the ongoing provision of street tree benefits.

For more information see *Species selection guidelines.*

Figure 10: Artists impression of enhancing and extending existing avenues of street trees along major thoroughfares.

Shade and cool major pedestrian routes and urban 'hot spots' with higher planting densities to provide unbroken shade cover.

Strategic outcomes

Shade and cooling

- Prioritise trees to deliver shade and cooling to key pedestrian networks (see *Figure 11*).
- Species are selected and positioned so as to achieve maximum shade and cooling benefits in urban hot spots.
- Plantings are placed at 6m centres to maximise the potential for uninterrupted shade.
- New street tree plantings to the south side of footpaths on east-west orientated streets, and west side of footpaths on north-south orientated streets are given planting priority.
- Plantings aim to shade walls and outdoor areas from the western sun, reduce shading potential on the north side of properties; and aim to provide maximum solar radiation to existing solar collectors for the middle 6 hours of the day.
- Reduced overnight cooling in built-up areas is taken into consideration before creating streets with continuous canopy.
- Street trees along major pedestrian travel paths leading to amenity and bushland reserves, community and sports facilities, schools, aged care facilities and shopping precincts are planted at 6m centres to provide unbroken shade.

Figure 11: Artists impression of trees providing shade and cooling to key pedestrian networks.

Create landmark and gateway plantings and attractive and coherent streetscapes. Infill and extend avenues of street trees along major thoroughfares.

Strategic outcomes

Avenues

- All regional and local gateways are signified by multi-layered/subtropical landscape treatments (with large crowned/broad-leaved/dense canopy species as key features, see *Species selection guidelines: Local rainforest trees* for further information).
- Key cultural and commercial sites are highlighted with character or signature plantings. Existing feature and significant street trees are surveyed and added to protection overlays.
- Community facilities are enhanced with the planting of large growing trees in appropriate spaces.
- Council's nursery purpose grows feature trees according to signature palettes devised for local street tree planting strategies.
- Existing avenue plantings on major thoroughfares are enhanced and extended.
- Existing themes are respected (see *Figure 10*).
- Avenues plantings reflect formal species composition and layouts.
- Species diversity is enhanced with a change in species where natural or intuitive section breaks occur (see *Figure 12*).
- Where infrastructure inhibits planting of large trees on both sides of the road, compact species are planted to one side of the road, larger growing trees to the other.
- Blister plantings are used where infrastructure inhibits planting of continuous avenues.
- Layouts and selection of trees that will ultimately develop overarching canopies considers the requirement for night time cooling in areas of high urban intensity.

See *Sunshine Coast Planning Scheme 2014, Part 9: Development codes, 9.4.2 Landscape Code* for further guidance.

Figure 12: Artists impressions of increasing street tree diversity through changes in species where natural or intuitive section beaks occur.

Principle 6

Reduce conflict potential through better tree selection and placement of trees as well as ongoing partnerships with the local community, local businesses and external service providers.

Strategic outcomes

Street tree and infrastructure compatibility

- Compact street trees are used to shade and provide amenity to local residential streets and constrained spaces (see *Species selection guidelines*).
- The placement of street tree plantings considers existing infrastructure networks, future transport corridors and priority development areas, existing street and commercial signs and existing solar collectors.
- Partnerships between council and service providers are maintained and enhanced to ensure integrity of landscape design intent and the provision of essential services.
- Unless a formal, site specific arrangement is entered into, trees incompatible with formative or hedge type pruning are not planted below existing overhead electrical infrastructure. Underground or overhead bundled electricity cable is favoured.
- Identified existing public view points and vistas are retained with respect to the placement of new trees.

For further species selection guidance see *Species selection guidelines.* See also *Sunshine Coast Planning Scheme 2014, Part 9: Development codes, 9.4.2 Landscape Code.* For further information on council's standard tree protection requirements see the *Sunshine Coast Council Open Space Landscape Infrastructure Manual*.

Principle 7

Sustain the existing extent of canopy cover across the region. Build resilience and enhance diversity in the region's street tree network through species diversification and ongoing succession planting. Enhance street tree vigour and longevity through extension and intensification of maintenance programs.

Strategic outcomes

Sustainability

- The protection and retention of existing trees takes precedence over tree removal and replacement in programs of streetscape renewal. Tree retention rates are increased.
- The quality and quantity of the region's urban forest is enhanced with a diversity of species used and diversity of ages of trees as an outcome of proactive tree planting.
- Every tree removed is replaced at a minimum ratio of one for one to achieve a 'no net loss'.
- All new and replacement street tree planting is recorded to enhance maintenance scheduling, monitoring and recognition in council's asset register.
- Detailed succession planning is undertaken for aging roadside foreshore trees.
- Under-utilised locally native and native tree species and non-invasive exotic species are used as feature trees in appropriate urban settings to both increase population diversity and provide contrast to existing standard palettes. Trial sites are set up to explore the potential of under-utilised rainforest species as street trees.
- Quality tree stock and increased maintenance frequencies ensure longer lived and more sustainable street tree populations.
- Tree population health studies are undertaken to establish population life expectancy and prioritise succession trees.
- Landscape buffers are created with street tree plantings to protect the existing edge of bushland and recreational parkland.

Principle 8

Engage and partner with the community and corporate sector to determine future tree locations and help establish new trees.

Strategic outcomes

Treemendous Tree Care Partnerships

- Tree planting in residential areas is undertaken in close consultation with local residents.
- Local street and feature tree planting plans for high priority locations are developed with local communities and businesses.
- Street tree planting programs are prioritised in local streets where residents elect to help care for trees as they establish.
- Planting programs where local businesses elect to support and partner with council in the delivery of tree planting initiatives in commercial precincts are given priority.
- Community values and priorities influence tree species selection and placement in local streets.
- Street tree placement in local streets is consistent with an affected property owner's desire for natural light (see *Figure 13*).
- A higher proportion of trees significantly contributing to the Sunshine Coast urban forest grow on private land.

Figure 13: Artists impressions of street tree planting in residential streets.

Species selection guidelines

Tree species selection

This section of the plan provides guidance around the selection of species for use as street trees in the Sunshine Coast Council area and includes region-wide street tree palettes for specific functions and settings. More specific guidance on signature and natural character palettes and lists of trees suitable for use in residential streets for each of the region's 27 Local plan areas are contained within Part B – *Street tree strategies* of the plan.

Street tree palettes will be periodically reviewed as an outcome of street tree trials, the development of new species varieties and cultivars, or the advent of new pest or disease threats that may alter the performance and reliability of currently listed species.

The plan is to be used in association with the *Sunshine Coast Council Open Space Landscape Infrastructure Manual* where guidance for tree stock selection (in line with *AS 2303–2018 Tree stock for landscape use*) and tree planting and maintenance specifications can be found.

For standard advanced tree planting detail, maintenance specifications and guidelines for the selection of tree stock see also the *Sunshine Coast Open Space Landscape Infrastructure Manual – Embellishments – Planting Landscape*). The manual's *Plant Index* contains a comprehensive list of all plant species deemed suitable for cultivation in Sunshine Coast amenity landscapes. For specific species information including expected dimensions and preferred growing conditions see *Palettes – Planting – Planting index*).

Tree nomenclature

The names of trees in this document follow the *International code of botanical nomenclature* (2012) with genus and species given, followed by the plant's common name. While species is the principle taxonomic unit used, sub-species, varieties and cultivars that are recognised taxonomically may also be provided where distinction is required (for example a more superior cultivar such as *Tristaniopsis laurina* 'Luscious'). Where more than one plant name is in existence, the names given are in accordance with the *Census of Queensland flora* (Jessup 2015) and current as at January 2017.

Lilly pillys previously belonging to the genus *Acmena,* are now recognised as a part of the *Syzygium* genus. *Callistemon* (bottle brush) trees have mostly been incorporated into the *Melaleuca* (paperbark) genus.

To avoid confusion, the plan lists the synonym adjacent to the most widely accepted species name (abbreviated to syn.) as well as providing a common name for the species.

The term 'eucalypt' is used throughout the plan as a generic term or common name for all eucalypt-type (gum) trees that were once included in the *Eucalyptus* genus but have since been split into three separate genera – *Eucalyptus, Corymbia* and *Angophora.*

Guiding principles

- Select the right species for the location (match the species to the site, not the site to the species)
- Use a diverse palette of species with local native species forming the basis of planting plans with native or exotic trees used for accents
- Plant quality tree stock with well–formed root systems and appropriate root to shoot (root ball volume to height) ratios in all public open space areas.

Strategic outcomes

- Trees are selected by suitably qualified and experienced practitioners
- Tree selection is locally responsive and considerate of local conditions and individual site characteristics including soils, drainage, services and biological factors
- Trees are selected and situated so as to reduce the risk of conflict and lower maintenance requirements over the life of the tree
- Local native trees are predominately used for landscape plantings
- A greater proportion of rainforest origin trees and species reflecting the region's subtropical design intent are used in streetscapes and as feature plantings (where they can be supported by the existing site soils)
- Exotic and non-native species have a greater presence in activity centres and provide colour and contrast in strategic locations
- In constrained sites and many residential areas where smaller trees are desired, trees are selected from a base palette of compact trees
- Tree selection ensures no species or plant families are over-used where feasible alternatives exist
- Under-represented and unavailable species are propagated and grown in council's nursery and available for use in street tree trial programs
- Care is taken not to use species that have a short life span (less than 15 years) or for the most part have an untidy appearance
- Complementary species are selected for street trees plantings adjacent to council bushland reserves where appropriate (in consideration of any associated risk to wildlife as an outcome of movement need roadways).

Street tree palettes

Signature species for feature plantings

Signature trees of the Sunshine Coast are encouraged for planting at gateways and in high profile locations to help reinforce the local landscape character of the Sunshine Coast.

The hoop pine (*Araucaria cunninghamii*) for example is a prominent feature tree in the region and synonymous with the Sunshine Coast landscape. The visually appealing tree provides a distinct vertical element to streetscapes and with a wide natural distribution, performs consistently across a range of soil types. This plan recommends the use of this species wherever possible to create a common thread between the Sunshine Coast's community of communities' as well as a recognisable regional landscape character.

The culturally significant bunya pine (*Araucaria bidwillii*) is also a key Sunshine Coast character tree species. The large fruits that were an important food source for traditional owners of the land (and the subject of large gatherings and celebrations) however are potentially hazardous. Use of this species therefore is limited to large garden bed-type spaces where falling fruits can cause no harm (see Table 24: *Species for use as feature trees in garden beds only*).

Other stand-out signature trees include the suite of local fig tree species (best represented by the Moreton Bay fig – *Ficus macrophylla*), local eucalypts including the adaptable blue or forest red gum (*Eucalyptus tereticornis*) the ever-present broad-leaved paperbark (*Melaleuca quinquenervia*) as well as key rainforest species represented by genera *Flindersia*, *Syzygium* and *Elaeocarpus*. Key signature species for reinforcement either as specimen tree or group plantings in high profile Sunshine Coast locations are listed in Table 9: *Signature Sunshine Coast local tree species*.

Pandanus or screw palms (*Pandanus tectorius*) feature strongly in coastal landscapes as do coastal banksias (*Banksia integrifolia*) and naturally occurring sheoaks (*Casuarina equisetifolia* and *Casuarina glauca*). Introduced, yet naturalised, Norfolk Island and Captain Cook's pines (*Aracucaria heterophylla, Araucaria cookii*) are also significant landscape elements of the coastline. Continued use of these and other non-local yet established character species of the Sunshine Coast for future proofing as well as a character preserving, is also encouraged.

Table 10: *Exotic or non-indigenous native signature trees* lists the most prominent of these.

Table 9: Signature Sunshine Coast local tree species

Signature Sunshine Coast local tree species
Araucaria bidwillii (bunya)
Agathis robusta (kauri pine)
Angophora leiocarpa (rust barked apple)
Araucaria cunninghamii (hoop pine)
Banksia integrifolia (coast banksia)
Brachychiton acerifolia (Illawarra flame)
Callitris columellaris (Bribie Island pine)
Casuarina equisetifolia (horse-tail sheoak)
Casuarina glauca (swamp sheoak)
Corymbia citriodora subsp. *variegata* (spotted gum)
Corymbia intermedia (pink bloodwood)
Corymbia tesellaris (Moreton Bay ash)
Elaeocarpus eumundii (Eumundi quandong)
Elaeocarpus grandis (blue quandong)
Elaeocarpus obovatus (hard quandong)
Eucalyptus bancroftii (tumbledown gum)
Eucalyptus propinqua (mountain grey gum)
Eucalyptus racemosa (scribbly gum)
Eucalyptus siderophloia (northern grey iron bark)
Eucalyptus tereticornis (blue gum/forest red gum)
Ficus macrophylla (Moreton Bay fig)
Ficus obliqua (small-leaved fig)
Ficus virens (White's fig)
Flindersia bennettiana (Bennett's ash)
Flindersia schottiana (cudgerie)
Gmelina leichhardtii (white beech)
Grevillea robusta (silky oak)
Lophostemon confertus (Queensland box)
Lophostemon suaveolens (swamp box)
Melaleuca quinquenervia (broad leaf paperbark)
Pandanus tectorius (pandanus palm)
Podocarpus elatus (brown pine)
Syncarpia glomulifera (turpentine)
Syzygium francissii (giant water gum)
Syzygium (syn. *Waterhousia*) *floribunda* (weeping lilly pilly)
Toona cilita (red cedar)

Table 10: Exotic or non-indigenous native signature tree species

Exotic or non-indigenous native signature tree species
Albizia (syn.*Samanea*) *saman* (silk tree)
Alloxylon flammeum (tree waratah)
Araucaria cookii (Captain Cook's pine)
Araucaria heterophylla (Norfolk Island pine)
Caesalpinia ferrea (leopard tree)
Corymbia ptychocarpa (swamp bloodwood)
Delonix regia (poinciana)
Magnolia grandiflora (bull magnolia)
Peltophrum pterocarpum (yellow poinciana)

Local rainforest trees for wider use

The Sunshine Coast's suite of local rainforest trees are an untapped or under-utilised cooling and shade tree resource. Local rainforest trees have the potential to significantly increase the diversity of the region's street tree population while remaining in-keeping with the general preference for selection of naturally occurring species in the first instance.

Gallery/notophyll rainforest species

Gallery or notophyll rainforest trees (riverine/riparian) with their large leaf surface areas and dense canopies have the greatest capacity for cooling (see *Trees and temperature*). These types of trees are recommended for increased use in hot spots where shading and cooling is critical (in locations where good soil moisture exists or in scenarios where irrigation can be supplied).

Compact specimens encouraged for trial and/or wider use in local residential streets are listed in Table 11: *Compact rainforest (sub-tropical, littoral, swamp or gallery rainforest) tree species for trial or wider use in residential streetscapes*.

Rainforest trees hailing from Northern Australia have the added benefit of being more tolerant of, or adaptable to, warmer climates. With significantly higher temperatures predicted for the future in worst case climate change scenarios (see *Trees and temperature*), these types of species are recommended for incorporation in street tree planting palettes to help build population resilience. Larger specimens may buttress and are recommended for use in places with ample room. These include truncated corner or intersection nodes, extra-wide road reserve spaces, centre medians of appropriate width, irrigated roundabouts and other engineered planting sites. Some of the taller growing species proposed for use in larger spaces are listed in Table 12: *Shade trees (sub-tropical, littoral, swamp or gallery rainforest) tree species for trial or wider use in large planting sites*.

Table 11: Compact rainforest (sub-tropical, littoral, swamp or gallery rainforest) tree species for trial or wider use in residential streetscapes

Compact rainforest tree species for trial or wider use in residential streetscapes
Acronychia oblongifolia (white aspen)
Acronychia wilcoxiana (silver aspen)
Akania bidwillii (turnipwood)
Allosyncarpia ternata (an-yinik)
Backhousia anisata (aniseed myrtle tree)
Barklya syringifolia (leather jacket)
Castanospora alphandii (brown tamarind)
Choricarpia leptopetala (brown myrtle)
Commersonia bartramia (brown kurrajong)
Cryptocarya bidwillii (yellow laurel)
Cryptocarya rigida (rose maple)
Darlingia darlingiana (brown silky oak)
Davidsonia johnsonii (Davidson's plum)
Diospyros geminata (scaly ebony)
Diospyros pentamera (ebony)
Diploglottis campbelli (small leaved tamarind)
Drypetes deplanchei (yellow tulipwood)
Endiandra globosa (black walnut)
Endiandra pubens (hairy walnut)
Ganophyllum falcatum (scaly ash)
Jagera pseudorhurs (foam bark)
Litsea leefeana (brown bolly gum)
Mallotus discolour (yellow kamala)
Mischarytera lautereriana (corduroy tamarind)
Planchonella pohlmaniana (yellow boxwood)
Sarcopteryx stipita (steel wood)
Schizomeria ovata (crab apple)
Syzygium crebrinerve (purple cherry tree)
Syzygium paniculatum (magenta lilly pilly)

Table 12: Shade trees (sub-tropical, littoral, swamp or gallery rainforest) tree species for trial or wider use in large planting sites

Shade trees tree species for trial or wider use in large planting sites
Alectryon tomentosa (hairy birds eye)
Argyrodendron trifoliatum (white booyong)
Argyrodendron actinophyllum (black booyong)
Athertonia diversifolia (Atherton oak)
Backhousia subargentea (syn. *Choriocarpa subargentea*) (giant ironwood)
Cinnamomum oliverii (Oliver's sassafras)
Cryptocarya hypospodia (northern laurel)
Cryptocarya microneura (murrogun)
Cryptocarya obovata (pepperberry)
Dysoxylum fraserianum (rose mahogany)
Ficus fraserii (sand paper fig)
Ficus rubiginosa (rock fig)
Maranthes coryombosum (panari)
Gossia fragrantissima (sweet myrtle)
Musgravea heterophylla (briar oak)
Nauclea orientalis (leichhardt tree)
Santalum acuminatum (quandong / native peach)
Sloanea woolsii (yellow carrabeen)
Syncarpia glomulifera (turpentine)
Syncarpia hillii (Fraser Island turpentine)
Syzgium corynanthum (sour cherry)

Littoral rainforest species

Littoral rainforests occur on nutrient-enriched sands in protected areas close to the sea. Trees that naturally grow within these environments are generally tolerant of salt laden winds. Local littoral rainforest species therefore may be useful in protected coastal streets where soils are fertile (or fertiliser can be continually supplied) and free draining, but salt spray remains an issue and limits the range of species that can be planted. Suitable species are recommended for trial in an effort to expand the currently narrow palette of species used in coastal streetscapes (see Table 21: *Trial species for coastal environments* for all recommendations).

Swamp rainforest species

Swamp rainforests generally have a *Melaleuca* (paperbark) upper story and bangalow or fan palm *Archtonophoenix cunninghamiana* (piccabeen palm) or *Livistona sp* (fan palm) understory. These rainforests may however also include the specie *Mellicope elleryana* (euodia), *Glochidion ferdinandii* (cheese tree), *Elaeocarpus obovatus* (hard quandong), *Syzygium paniculatum* (brush cherry) and *Cupaniopsis anacardiodes* (tuckeroo) in the upper strata. Tree species originating from this type of rainforest offer potential for use in locations where soils may be poorly drained, seasonally inundated or significantly disturbed (compacted/ filled/inverted). This suite of species may be appropriate for trial in WSUD (water sensitive urban design) treatments as an alternative or in addition to *Melaleuca quinquenervia* (broad-leaved/swamp paperbark).

Dry rainforest trees species

Dry rainforests are generally located away from the coast in areas of lower rainfall or where rainfall is effectively low due to topography. Drier rainforest trees, and those naturally occurring on forest margins where they are more exposed and need to be more adaptable, have a wider range of environmental tolerances (specifically a greater tolerance to drier soils) than wet rainforest plants. Dry rainforest tree species for example are more likely to have deeper rooting characteristics.

Trees hailing from dry rainforest environments generally have smaller, tougher leaves and/or the ability to shed some of their leaves during dry periods to conserve water use. In the driest rainforests trees are often stunted and may only reach 5-6 m on maturity.

Species that naturally occur in dry rainforest environments or a combination of dry and other rainforest types (some species cross over a range of rainforest types) as well as those known to occur on the margins of rainforest (for example *Harpulia pendula* - tulipwood) offer good potential for future proofing. Little known species offer good potential for population diversification.

Many of the more compact local dry rainforest species are likely to be appropriate for use in local residential streets as they may be smaller and easier to manage as street trees. Table 13: *Compact dry rainforest trees for trial or wider use - residential streets* lists species recommended for trial in these spaces. Larger growing dry rainforest trees recommended for selection for larger sites are listed in Table 14: *Dry rainforest trees for larger sites*.

While diversification of street tree palettes is a key strategy for building resilience in local street tree populations in our warming climate, some dry rainforest species may still be vulnerable to the impacts of rising temperatures (especially in extreme climate change scenarios). Strategies for resilience (longer maintenance periods for example) may require integration in addition to site responsive species selection.

Table 13: Compact dry rainforest or rainforest edge trees for trial or wider use - residential streets

Compact dry rainforest or rainforest edge trees for trial or wider use - residential streets
Acronychia laevis (hard aspen)
Alectryon subcinereus (native quince)
Alectryon subdentatus (hard alectryon)
Alphitonia petriei (white ash)
Backhousia myrtifolia (lemon myrtle)
Baloghia inophylla (brush bloodwood)
Barklya syringifolia (leather jacket)
Cupaniopsis parvifolia (small-leaved tuckeroo)
Diospyros australis (yellow persimmon)
Ellatostachys xylocarpa (white tamarind)
Flindersia collina (leopard ash)
Geijera parvifolia (wilga)
Gossia bidwillii (python tree)
Guioa semi-glauca (wild quince)
Litsea australis (bolly gum)
Petalostigma triloculare (long-leaved bitter bark)
Petalostigma pubescens (quinine bush)
Sterculia quadrifila (peanut tree)
Syzygium oleosum (blue lilly pilly)

Table 14: Dry rainforest or rainforest edge trees for larger sites

Dry rainforest or rainforest edge trees
Alphitona excelsia (soap tree)
Aphananthe philippinensis (rough-leaved elm)
Beilschmiedia obtusifolia (blush walnut)
Brachychiton discolour (lacebark)
Brachychiton populneus (kurrajong)
Brachychiton rupestris (bottle tree)
Callistemon salignus (willow bottlebrush)
Choricarpia subargentea (giant ironwood)
Commersonia bartramia (brown kurrajong)
Cryptocarya glaucescens (jackwood)
Cryptocarya rigida (rose maple)
Cryptocarya triplinervis (three-veined laurel)
Diospyros pentamera (ebony)
Diploglottis australis (native tamarind)
Elaeocarpus obovatus (hard quandong)
Endiandra sieberii (cork wood)
Eremophila mitchellii (false sandalwood)
Eurochinus falcata (ribbonwood)
Ficus coronata (creek sand paper fig)
Ficus fraserii (sand paper fig)
Ficus macrophylla (Moreton Bay fig)
Flindersia australis (Crow's ash)
Flindersia bennettiana (Bennett's ash)
Flindersia collina (leopard ash)
Flindersia xanthoxyla (yellow wood)
Geijera salicifolia (brush wilga)
Glochidion sumantrum (cheese tree)
Mallotus phillippensis (red kamala)
Melaleuca stypheliiodes (prickly paperbark, large sites)
Olea paniculata (native olive)
Planchonella australis (black apple)
Podocarpus elatus (brown pine)
Polyscias elegens (celery wood)
Streblus brunonianus (whalebone tree)
Syzygium australe (brush cherry)
Syzygium smithii (magenta lilly pilly)

Species for accents and highlights

Accent trees include species that can be planted as understory to larger growing trees, species that can be grouped with other plants in layered subtropical garden beds, as well as species that can be planted as stand-alone features. In areas where a higher level of embellishment is appropriate (commercial precincts for example), the incorporation of accent plants not only promotes species diversity but also vibrancy.

Native accent species

Accent trees can also be incorporated in traditional streetscapes, in blister plantings or intersections for example. Illawarra flame trees (*Brachychiton acerifolius*), and fire wheel trees (*Stenocarpus sinuatus*) are key local species frequently used to provide accents in confined spaces.

Corymbia ptychocarpa (swamp bloodwood) a signature tree of many of the coast's localities (although not native to the local area, naturally occurring in the northern most regions of Australia) also offers significant visual amenity when selected for use in the right location. *Alloxylon flameumm* (tree waratah) is another relatively compact accent tree, adapted to warmer climates and useful for future-proofing (See Table 16: *Native species for accents and highlights*).

Exotic accent tree species

Many exotic trees especially species of South American and Asian origin perform well on the Sunshine Coast. Strategic plantings of these species are also encouraged as contrast or feature trees in town centres or precinct areas. Smaller growing species also encouraged for use in urban residential areas (for example on street corners as entry statements) include trumpet trees (*Tabebuia argentea, Tabebuia pallida*), frangipani (*Plumeria* sp), dwarf magnolias (*Magnolia 'Little gem'*) and crepe myrtles or pride of India trees (*Lagerstroemia* sp).

Palm trees for accents and highlights

Locally native piccabeen palms (*Archontophoenix cunninghamiana*) and a range of local and Northern Australian fan palms (*Livistona* sp) can be used in place of trees where vertical scale is needed but space is limited. Part B of the plan *Street tree strategies* nominates additional palm species suitable for specific localities, Cuban royal (*Roystonea regia*) for Eumundi for example.

Table 15: Native species for accents and highlights

Native species for accents and highlights
Alloxylon flameumm (tree waratah)
Alloxylon pinnatum (Dorrigo waratah)
Banksia robur (wallum banksia)
Brachychiton acerifolius (Illawarra flame tree)
Brachychiton bidwillii (little kurrajong – Maroochydore form)
Brachychiton discolour (lace bark)
Brachychiton populneus (kurrajong)
Brachychiton rupestris (bottle tree)
Corymbia ptychocarpa (swamp bloodwood)
Hymenosporum flavum (native frangipanni)
Melicope elleryana (euodia) (garden beds only)
Pandanus tectorius (screw palm) (garden beds only)
Stenocarpus sinuatus (fire wheel)

Table 16: Exotic species for accents and highlights

Exotic species for accents and highlights
Erythrina caffra (African coral tree)
Lagerstroemia indica (crepe myrtle)
Lagerstroemia speciosa (pride of India)
Magnolia 'Little gem' (little bull magnolia)
Morus nigra (mulberry)
Polythalia longifolia (Indian mast tree)
Plumeria sp (frangipani)
Pterocarpus indicus var pendula (rosewood)
Tabebuia argentea (silver trumpet tree)
Tabebuia pallida (trumpet tree)
Tabebuia palmeri (pink trumpet tree)
Tabebuia rosea (pink poui/pink trumpet tree)

Species for local streets

Tried and tested compact trees should form the base palette of street tree species for local residential streets. Species over-use should be controlled by reserving standard species for standard locations and using signature and accent tree palettes for higher impact plantings including entry statements, anchors and accents; and/or sites that can accommodate larger growing trees (i.e. wide verges, deep soils, truncated corners, park–street interfaces). Table 17: *Base street palette for local/residential streets* lists standard street tree species for use in residential streetscapes.

Street tree trial species

Where no planting themes exist, trial species may be appropriate for introduction to help enhance visual interest as well as expanding genetic diversity over time. Suites of local rainforest species exhibiting a compact mature form (either in the wild or in cultivation) are recommended for trial in appropriate locations (see Table 11: *Compact rainforest (sub-tropical, littoral, swamp or gallery rainforest) tree species for trial or wider use in residential streetscapes* and Table 13: *Compact dry rainforest or rainforest edge trees for trial or wider use - residential streets*).

Especially compact trees have been identified as useful for planting beneath over-head power lines. Table 18: *Street trees for trial beneath power lines* lists some of the species for investigation.

Local or alternative species varieties

Local forms

The *Street Tree Strategies* (Part B) of this plan provide local or recommended alternatives to more commonly used species in an effort to diversify the coast's street tree population. A red foliaged variety (*Hibiscus tiliaceous var. rubra*) of the common cotton tree (*Hibiscus tiliaceous*) for example, provides a more colourful alternative for use in Maroochydore where the common cotton tree is an ever-present feature of foreshore streetscapes. The Whitsunday form of the hoop pine (*Araucaria cunninghamii*) may prove to be the most successful ecotype for use near coastal locations.

Local seed of the tumbledown gum (*Eucalyptus bancroftii*) produces a better-formed street tree than non-locally procured stock and is preferred for use on the Sunshine Coast. The 'Little Kurrajong' (*Brachychiton bidwillii*) could potentially be used in place of the standard Kurrajong (*Brachychiton populneus*) or Illawarra flame tree (*Brachychiton acerifolius*). A local 'Maroochydore' form of this species warrants further investigation. See Part B: *Street tree strategies* for suggested variations or alternatives for specific localities.

Hinterland species

The hinterland of the Sunshine Coast provides a canvass for the cultivation of many tree species that cannot be grown elsewhere on the Sunshine Coast. The cooler climate, especially in localities at higher elevation, allows for use of an exotic deciduous as well as local tree palette and good opportunity for diversification. Specific hinterland species alternatives include *Cupaniopsis parvifolia* (small-leaved tuckeroo) as opposed to the standard species of tuckeroo (*Cupaniopsis anacardiodes*) and a hinterland alternative to *Grevillea baileyana* (white oak) – *Grevillea hilliana* (white silky oak). *Harpulia pendula* (tulip tree) may also be substituted with *Harpulia hillii* (blunt-leaved tulip) in appropriate hinterland locations.

Table 17: Base street palette for local/residential streets

Base street palette for local/residential streets
Backhousia citriodora (lemon myrtle)
Banksia integrifolia (coastal banksia)
Buckinghamia celcissima (ivory curl)
Cupaniopsis anacardiodies (tuckeroo)
Elaeocarpus obovatus (hard quandong)
Elaeocarpus eumundii (Eumundi quandong) (where existing only)
Eucalyptus bancroftii (tumbledown gum)
Grevillea baileyana (white oak) (coastal and coastal plain low-risk infill sites only)
Harpullia pendula (tulipwood)
Melaleuca (syn. *Callistemon*) *viridiflora* (broad leaved bottle brush)
Melaleuca (syn. *Caliistemon*) 'Wildfire' (weeping bottlebrush)
Syzygium hemilamprum (syn. *Acmena*)
hemilampra (blush satinash) (broad leaf or crinkle leaf form)
Tristaniopsis laurina 'Luscious' (water gum)
Xanthostemon chrysanthus (golden penda)

Table 18: Street trees for use/trial beneath powerlines

Street trees for use/trial beneath powerlines
Acronychia imperforata (Fraser Island apple)
Acronychia laevis (hard aspen)
Acronychia oblongifolia (white aspen)
Acronychia wilcoxiana (silver aspen)
Alectryon coriaceous (beach birds-eye)
Alectryon subcinereus (wild quince)
Archirhodomyrtus beckleri (small-leaved myrtle)
Banksia serrata (saw-toothed banksia)
Brachychiton bidwillii (little kurrajong)
Cercis canadensis (forest pansy)
Decaspermum humile (silky myrtle)
Denhamia bilocularis (orange bark)
Eucalyptus curtsii (plunkett mallee)
Eucalyptus kabiana (Mount Beerwah mallee)
Eucalyptus leucoxylon 'Euky Dwarf' (dwarf yellow gum)
Lagerstroemia indica (crepe myrtle)
Leptospermum brachyandrum (weeping tea tree)
Leptospermum petersonii (lemon-scented tea tree)
Magnolia 'Little Gem' (little gem magnolia)
Melaleuca (syn. *Callistemon*) *viminalis* 'Dawson River Weeper' (weeping bottlebrush)
Melaleuca (syn. *Callistemon*) *viminalis* 'Wildfire' (weeping bottlebrush)
Melaleuca (syn. *Callistemon*) *viridiflora* (broad-leaved paperbark)
Myrsine variabilis (muttonwood)
Petalostigma pubescens (quinine berry)
Petalostigma triloculare (long-leaved bitter bush)
Psydrax odorata (box-leaved canthium) *Syzygium australe* 'Aussie Southern' (lilly pilly)
Syzygium australe 'Resilience' (lilly pilly)
Syzygium hemilamprum (syn. *Acmena*) (broad-leaved lilly pilly) (crinkle-leaved form)
Syzygium (syn. *Acmena*) *smithii* var. *minor* (dwarf lilly pilly)
Syzygium (syn. *Waterhousia*) *unipunctata* (roly poly satinash)
Tabebuia sp (trumpet trees)
Telopea sp (waratah)

Cultivars and substitute species

More superior cultivars of a number of commonly planted street tree species exist and should always be selected over standard species. The species cultivar *Tristaniopsis laurina* 'Luscious' (water gum) should be given preference over the standard species (*Tristaniopsis laurina*) unless the planting site is particularly wet, responding better to drier soils. Similarly, *Syzygium paniculatum* 'Southern Form' (magenta lilly pilly) and *Syzygium australe* 'Resilience' have also proven to be superior street tree to the standard species.

Well established substitute species for the common bottle brush *Melaleuca* (syn. compact bottle brushes *Melaleuca* (syn. *Callistemon*) 'Wild fire' and *Melaleuca* (syn. *Callistemon*) *viridiflora*. *Melaleuca viridiflora* is also known to have a very wide tolerance range including coastal exposed sites as well as its smaller stature as demonstrated in its listing in Table 19: *Street trees for use/trial beneath power lines*. *Syncarpia glomulifera* (turpentine), and many species of the *Diploglottis* (tamarinds), *Cryptocarya* (laurels), *Diospyros* (ebonys) and *Angophora* (apple or rose gums) are suggested substitutes for over-planted sclerophyllous trees, namely the Queensland brush box (*Lophostemon confertus*). *Lophostemon suaveloens* (swamp box) is also considered a good substitute for this species in appropriate sites due to a narrower crown and shorter stature.

Species for coastal (exposed) sites

Streetscapes that interface with foreshore areas of the Sunshine Coast have been identified as key areas for rejuvenation within this plan. These areas are difficult to future-proof via diversification of species due to the nutrient poor, free draining soils; and salt-laden and often strong winds limiting the number of species that successfully grow in these areas (see Table 19: *Base coastal front line/exposed street tree palette*). Current trials may however find species of non-local origin suitable for use (where natural values will not be significantly impacted). The native but not indigenous *Calophyllum inophyllum* (beauty leaf) is one such example currently being trialled. Sunshine Coast local littoral rainforest species also offer potential to increase species diversity in protected coastal locations where salt tolerance is still required. Table 20: *Trial species for coastal landscapes* includes species council is currently trialling or recommending for future trials in coastal streetscapes.

Table 19: Base coastal front line/exposed street tree palette

Base coastal front line/exposed street tree palette
Araucaria heterophylla (Norfolk Island pine)
Araucaria cookii (Captain Cook's pine)
Banksia integrifolia (coastal banksia)
Casuarina equisetifolia (horse tail sheoak)
Casuarina glauca (swamp sheoak)
Hibiscus tiliaceous (cotton tree)
Pandanus tectorius (pandan/screw palm)
Terminalia catappa (beach almond) (where space permits, garden bed locations preferred)

Table 20: Trial species for coastal landscapes

Trial species for coastal landscapes
Araucaria heterophylla 'Hawaiian' (Norfolk Island pine, Hawaiian form)
Calophyllum inophyllum (beauty leaf)
Cocos nucifera (coconut) (dwarf form)
Cryptocarya microneura (murrogun) (protected sites)
Cryptocaraya triplinervis (three-veined laurel) (protected sites)
Cyclophyllum longipetallum (coast canthium)
Endiandra sieberi (corkwood) (protected sites)
Glochidion ferdinandii (cheese tree) (protected sites)
Leptospermum laevigatum (coast tea tree)
Leptospermum madidum (weeping tea tree) (protected sites)

Table 21: Species not to be planted as street trees on the Sunshine Coast

Species not to be planted as street trees on the Sunshine Coast
Eucalyptus 'Summer red' and 'Summer beauty'
Lagunaria patersonia (cow itch)
Elaeocarpus reticulatus (blueberry ash)
Melaleuca leucadendra (weeping paperbark)
Rhodosphaera rhodanthema (tulip satinwood)
Rhodomyrtus psidiodies (native guava)
Syzygium jambos (Malabar plum)
Syzygium tierneyanum (river cherry)

Species to consider carefully before use

In addition to locally invasive tree species listed in the Sunshine Coast Local Government Area Biosecurity Plan (2017) (See *Analysis: Weed species*), this master plan identifies several street tree species as undesirable and/or inappropriate for use as street trees in the region. These species may have a propensity for the development of large surface roots, poisonous fruits or irritating seed pods, a shrub-like form that is not suited to restricted road verge spaces, or extreme susceptibility to the Myrtle Rust disease (*Puccinia psidii sensu lato*). These are tabled in Table 21: *Species not to be planted as street trees on the Sunshine Coast*.

In the course of this plan's development, other species have been identified for performance monitoring. These includes species that have been recently identified as having weed potential in highly favourable locations, or species that are inconsistent in form or performance. These species should be used sparingly, and generally only to carry forward existing streetscape themes. Table 22: *Species to use sparingly or only where existing only* lists the most prominent of these.

Additional tree species that should be located carefully consist mostly of desirable feature trees that have some undesirable characteristics, such as large fleshy fruits, needles or branches that drop. Some may have a branching structure that is brittle or not conducive to pruning. While others, figs for example, simply need a great deal of space for their extensive root systems. These species are flagged in Table 23: *Species for use as feature trees in garden beds only*.

Flying foxes and street tree species

It is well understood that flying foxes are nocturnal and travel some distance to forage. Avoiding the planting of species they prefer as street trees (which is a considerable palette) therefore is not a viable nuisance reduction strategy. In streets immediately adjacent to identified urban roosts however, low fruiting or low nectar producing species may be used to avoid the occurrence of foraging as well as roosting where flying fox roosts are causing concern for local residents. Species that are non-preferred foraging food for flying foxes include conifers which have no or inconspicuous fruits and flowers, or flowering plants that produce very low levels of nectar.

Species suited to the Sunshine Coast are listed in Table 24: *Low fruiting or low nectar producing species for streets surrounding permanent flying fox roosts*.

Table 22: Species to use sparingly or only where existing only

Species to use sparingly
Elaeocarpus eumundii (Eumundi quandong)
Flindersia brayleana (Queensland maple)
Grevillea baileyana (white oak)
Jacaranda mimosifolia (blue jacaranda)
Lophostemon confertus (Queensland brush box)

Table 23: Species for use as feature trees in garden beds only

Species for use as feature trees in garden beds only
Araucaria bidwillii (bunya)
Castanospermum australe (black bean)
Caesalpinia ferrea (leopard tree)
Callitris columellaris (Bribie Island pine)
Grevillea robusta (silky oak)
Ficus sp (fig trees – all species)
Pandanus tectorius (pandanus palm/pandan)
Mangifera indica (mango)
Melicope elleryana (pink euodia)
Pandanus tectorius (screw pine)
Samanea (syn. *Albizia*) *saman* (rain tree)
Syzygium forte (white apple/flaky barked satinash)
Syzygium moorei (coolamon)
Tamarindus indica (tamarind)
Terminalia catappa (Indian almond)

Table 24: Low fruiting or low nectar producing species for streets surrounding permanent flying fox roosts

Low fruiting or low nectar producing species for streets surrounding permanent flying fox roosts
Allocasuarina littoralis (swamp sheoak)
Agathis robusta (kauri pine)
Araucaria heterophylla (Norfolk Island pine)
Brachychiton acerifolius (Illawarra flame tree)
Brachychiton discolour (lace bark)
Brachychiton populneus (kurrajong)
Brachychiton rupestris (bottle tree)
Backhousia citriodora (lemon myrtle)
Callitris columellaris (Bribie Island pine)
Casuarina equisetifolia (horse tail sheoak)
Casuarina glauca (swamp sheoak)
Delonix regia (poinciana)
Hymenosporum flavum (native frangipanni)
Leptospermum petersonii (lemon-scented tea tree)
Leptospermum polygalifolium (yellow tea tree)
Notolaea longifolia (mock olive)
Petalostigma triloculare (long leaf bitter bark)

Implementation

Street tree planting priorities

The plan identifies the numerous advantages to the presence of trees in our streets. It also establishes that in order to sustain and increase the benefits trees provide, new trees must be continually planted.

The plan outlines the many challenges to the establishment of new trees (and protection of existing trees) as an outcome of an ever-growing population, greater urban densities and the increasing extent of the urban landscape. Street trees are not only contending with less available permeable space as an outcome of these factors, they must also compete with essential services (water and sewer, power and telecommunications) within these shrinking spaces as demand continues to grow.

Despite this, many spaces in road reserve corridors that could potentially accommodate large growing trees without conflict are empty. Planting trees into as many of these spaces as possible is considered the primary street tree planting priority for the region. Potential planting locations (nodes) for investigation include intersections, roundabouts, centre medians, wide road verges, public open space areas that intersect with streets and unused areas of land around community facilities, car parks and service compounds (see *Figure 20*).

Providing shade to pathways and popular pedestrian routes is the second street tree planting priority for the region. Shading pathways around schools and community facilities and pedestrian links between shopping precincts, recreational areas and residential zones are the greatest priorities (see *Figure 21*).

The third priority for street tree planting in the short term is to enhance the general amenity and function of major avenue plantings. By infilling (planting gaps) and extending street tree avenues, regional and local gateways can be reinforced and strengthened (see *Figure 22*).

Once new trees have been planted into existing vacant spaces and priority locations, council can turn its attention to more complex issues such as; how to ensure adequate provision of space for trees in new residential developments, how to ensure consideration is given to all essential infrastructure including street trees, and what possible alternative treatments can be used to ensure the Sunshine Coast's built and natural landscapes are better balanced in the future.

Priority localities for proactive planting of street trees include the *Sunshine Coast Enterprise Corridor,* Nambour, Buderim, Eumundi, Kenilworth and Woombye.

Adopt A Street Tree Program

Council is committed to partnering with local residents to establish and care for new street trees in locations where they are wanted the most. It is well understood that young street trees that are desired and nurtured by adjacent residents have the best chance of surviving and thriving in urban landscapes.

Council is able to prioritise requests for street trees where residents elect to be the custodians of young trees. As a part of council's *Adopt A Street Tree Program*, local residents will be given opportunity to nominate their nature strip (or street where a number of residents come together to request street trees) to be included in the program. Local businesses are also encouraged to express a desire for new tree establishment in adjacent areas, as well as indicate whether they are able to partner with council in their early care and maintenance.

Council will work with local communities to identify where residents would like to see new street trees established. Streets where residents wish to join council's *Adopt A Street Tree Program* will be prioritised.

Opportunities for the establishment of fruit trees in appropriate sites (local parks for example), to be cared for as a part of a formal partnership between council and community will also be explored as a part of council's programs of tree adoption.

Figure 20: Example of tree planting priority 1: Plant trees where space permits and conflict potential is low.

Figure 21: Example of tree planting priority 2: Shade major pedestrian routes.

Figure 22: Example of tree planting priority 3: Infill and extend tree avenues on major thoroughfares.

Funding

Reactive street tree planting and maintenance is currently funded through the operational street tree maintenance budget which allows for replacement of trees removed, new trees plantings on request (where local residents are asked to help care for trees) and an annual program of 'whole street' plantings which focuses on residential areas where tree cover is especially low. A new operational proactive street tree planting program budget was provided in 2017/18 in order to implement the street tree planting priorities identified in this plan.

Monitoring and review

Programs of data capture for all newly planted trees currently in place will facilitate tracking and monitoring of council's 'no net loss' approach to street tree management as well as assist in the management of young tree maintenance programs.

New tree data capture, as well as data collected during both reactive (as a response to customer requests for maintenance) and proactive tree inspection, will allow council to develop species composition and performance profiles to further develop tree selection requirements for the future.

Council intends to monitor patterns of change in vegetative cover in the region through on-going analysis of spatial data. Fresh *LiDAR* data capture is scheduled for 2019. Generation of new vegetation statistics and comparison with existing data will allow tracking of council's performance. Ongoing collection and assessment of multi-spectral seasonal fractional statistics as well as *LiDAR* derived data will allow council to continue to monitor patterns of change in vegetative cover in the region over time and develop canopy cover/ shade targets and future street tree planting key performance indicators (KPIs).

The *Master plan report* and series of *Precinct planting strategies* (Parts A & B) have a 20 year planning horizon but will be reviewed as required to respond to changes in legislation and the wishes and needs of the community.

The *Priority planting plans* have been prepared with a five year time frame for delivery in mind. This implementation period may be shorter or longer depending on community support and interest in council's *Adopt A Street Tree Program*, council's wider priorities and available program budgets.

Once implementation is completed a review of planting priorities for each of the Sunshine Coast's distinct local areas will be undertaken.

Measurement of success

Some of the ways to measure success of the plan overtime include:

- annual increases in the numbers of street trees purchased or propagated, planted and maintained in the LGA
- a net increase in regional and local canopy cover over time (assessed via comparison of successive council LiDAR captures and multi–spectral seasonal fractional statistics for the region)
- a reduction in young street tree losses/required replacements
- ongoing registration and interest in council's *Adopt A Street Tree Program* and community engagement in additional *Treemendous Tree Care Partnership* programs as they are developed.

Action plan

A three–staged action plan has been developed for short, medium and longer term implementation of the plan. Stage one actions are intended for implementation within the short term. Stage two actions are intended for implementation within two years and Stage three action items have been developed according to a five year implementation time frame.

Stage one

Action	Timing
Prepare master plan report and develop key street tree planting priorities.	Complete
Develop local street tree planting strategies for the region's 27 Local Plan Areas.	Complete
Prepare a 'plantable spaces' inventory to address short term street tree planting priorities.	Complete
Consult with key external stakeholders and local residents. Finalise master plan report and street tree planting strategies.	Complete
Enhance and extend young tree maintenance programs including the *Sunshine Coast Enterprise Corridor* and coastal plain streetscapes where soils are poor.	Ongoing
Capture and track all new street tree plantings.	Ongoing
Secure program funding for implementation of precinct based street tree planting priorities, including community engagement.	Complete
Commence implementation of street tree priority planting program focusing on sites with high impact and low conflict potential.	Ongoing
Grow species specified in planting palettes that cannot be sourced from external suppliers at council's nursery.	Ongoing
Review Energex–SCC MOU with a view to securing better street tree outcomes to counteract requirements for protection of the electrical network.	2018-2019
Incorporate street tree planting priorities and 'Tree sensitive design' into capital works program.	Ongoing
Prepare fact sheets describing the traits, required care and general performance of the best represented species in the region.	2018-2019
Commence street tree planting trials of new or under-utilised species.	Ongoing
Develop agreements for council delivery of new trees in residential estate developments.	2018-2019
Develop landscape designs (including street trees) for all intersections mapped in the *Sunshine Coast Planning Scheme 2014* as Regional and Local Gateways	2018-2019

Stage two

Action	Timing
Develop priorities for residential street tree planting programs through community engagement. Prioritise planting in streets where residents will act as 'tree stewards'.	ongoing
Commence implementation of the *Adopt A Street Tree Program*.	ongoing
Undertake localised heat/vulnerability studies to further refine priority streets for tree planting. Incorporate further analysis of council's existing *LiDAR* derived dataset to map 'hot spots' as a part of the development of an Urban Forest Strategy. Prioritise street tree planting programs in identified 'hot spots' that coincide with areas where heat vulnerable community members live and congregate. Prioritise street tree planting in 'hot spots' within the *Sunshine Coast Enterprise Corridor.*	2019-2020
Enter into partnerships with external service providers to create streetscape feature plantings away from infrastructure.	Ongoing
Identify declining or vulnerable vegetation in streets that interface with foreshore areas. Undertake succession tree planting in conjunction with view shed mapping in close consultation with the community.	2019-2020
Analyse fresh *LiDAR* capture and correlate against existing canopy coverage data to identify patterns and track progress.	2018-2019
Develop shade targets for heat exposed activity areas such as near schools, shops, bus stops, hospitals, child care and aged facilities) across LPAs.	2018-2019
Commence a program of street tree data collection in new residential estates specifically targeting local streets with narrow road and verge widths to determine whether the establishment and growth potential of street trees are significantly compromised.	2018-2019
Identify opportunities for research partnerships with Sunshine Coast University and citizen science schemes to assist with monitoring UHI effects and developing urban biodiversity enhancement. Develop an award scheme for 'Tree sensitive design'.	2018-2020

Stage three

Action	Timing
Determine street tree planting priorities for connecting habitat or biodiversity corridors and providing buffer plantings to natural area reserves.	2019-2022
Undertake street tree population health (useful life expectancy) studies and develop strategies for succession planning and tree planting sustainability targets.	2019-2022
Report on relationships between tree canopy cover and socio economics, health, crime and weather data to further develop tree planting priorities for the region.	2019-2022
Create structured spaces for trees in key locations in conjunction with council partners.	2019-2022
Undertake analysis of tree survival, maintenance and customer request data to determine whether species patterns exist that can be remedied through tree selection.	2019-2022
Develop street by street species recommendations for the region.	2020-2022
Review the impact of projects on street trees in the region over the last 5 years.	2019-2022

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Glossary

Ambient temperature	The temperature of the surrounding air in a particular setting - i.e. inside a house or room, outside a particular public space.
Amenity tree	Trees with a primary purpose of providing social, economic, visual or environmental benefits to humans (in contrast with trees with primary production purposes such as timber or fruit). Street trees are predominately amenity trees.
Biodiversity	The variety of plant and animal life on a global or local scale.
Canopy cover / tree cover	The area occupied by tree foliage when seen in plan view (i.e. 'Birds eye view') either estimated in square metres for individual trees from field measures of the tree canopy spread or measured from aerial, satellite or *LiDAR* imagery analysis and expressed as square metres or percentage of land cover within a defined area such as road reserves, suburbs or local areas.
Carbon emissions	Every time fossil fuels such as gas, coal or oil are burnt, carbon dioxide is released into the atmosphere. These emissions, which are the predominant source of greenhouse gas emissions if not reabsorbed by plants and trees, trap and hold solar radiation (heat) in the atmosphere (plants and trees directly absorb carbon dioxide and can indirectly reduce carbon emissions by reducing air-conditioner use from shading and cooling effects or vehicle use through greater uptake of walking, cycling and public transport).
Carbon sequestration	A natural or artificial process by which carbon dioxide is removed from the atmosphere and held in solid or liquid form. In the case of trees, carbon removed from the air is stored in wood.
Clear zone	The distance from the edge of the road carriageway that must remain free of any elements including vegetation that a vehicle could collide with in a high speed situation that could otherwise have potentially recovered control of the vehicle and returned to the road. Actual clearance distances are set in accordance with the speed limit, traffic volume and road geometry.
Climate Change	A long term change in climate (weather and temperature) patterns on a global or local level, directly or indirectly linked to human activity, and over and above natural climatic variability recorded for similar time periods.
CPTED	Crime prevention through environmental design.
Deciduous	Refers to types of trees or shrubs that lose their leaves at one time during the year.
Ecosystem	A natural unit consisting of all plants, animals and micro-organisms in an area, functioning together with abiotic (non-living) features (soil, water, minerals etc.).
Ecosystem services	Ecosystem services (ES) are the direct and indirect goods and services provided by ecosystems for human well-being. They range from clean air and water, carbon storage and sequestration, production of food, recycling of soil nutrients, biodiversity, control of pests, to liveable climates, cultural and educational values. Those that impact negatively on human well-being are termed disservices. The urban forest is one of the main suppliers of Urban ES.
Ecotype	Geographic origin. Tolerance to drought, soil types or temperature can vary when a single species of vegetation grows naturally across a broad range of ecotypes.
Greenhouse gas emissions	Any gaseous compound that is capable of trapping and holding infrared radiation (heat) in the atmosphere. Generally carbon dioxide (CO^2).

Foliage score	Foliage score is a rating from 0 to 10, used in the analysis of Sunshine Coast vegetation, derived from a combination of measures of canopy cover, vegetation height, projected shade cover in midsummer, and foliage density, across defined areas, which provides a representation of the value of the vegetation.
Frangible vegetation	Vegetation that breaks on impact.
Evaporative cooling	Reduction in temperature resulting from the evaporation of a liquid. In reference to trees, evaporation of leaf water from pores in the surface of leaves (transpiration) effecting a temperature reduction.
Exotic	Refers to a non-native plant originating or naturally occurring in another country.
Genetic diversity	The total number of genetic characteristics in the genetic makeup of a species. Genetic diversity serves as a way for populations to adapt to changing environments.
Greenhouse gas emissions	Any gaseous compound that is capable of trapping and holding infrared radiation (heat) in the atmosphere.
Heat island effect	An urban environmental phenomenon whereby hard surfaces high in thermal conductivity and heat storage capacity, and low in reflectivity, increase ambient temperature and retain heat compared to surrounding areas less dominated by built form.
LAI (Leaf area index)	A measure of canopy density determined by the ratio of total leaf area to area of the canopy extent. Dense canopied trees have high LAI.
LGA	Local government area.
LiDAR	Light Detection And Ranging. Technology that uses millions of laser pulses to analyse the earth's surface in three dimensions at very fine scales. Laser light pulses penetrate through vegetation canopies and therefore provide a way to accurately measure the location, height and density of vegetation as well as the form and location of surrounding ground surfaces, buildings and infrastructure.
Native	Belonging to a country. In Australia, native plants naturally occur in Australian landscapes.

Photosynthesis	The process whereby a plant turns water and carbon dioxide into usable energy when the plant is exposed to sunlight. Oxygen is generally released as a by-product.
Radiant heat	Heat created by invisible electromagnetic infrared waves. Each element to the urban environment absorbs and reflects heat from sunlight to varying extent during a 24 hour period. There are consequent effects which are measurable in both ambient air temperature changes and radiant heat changes. Radiant heat changes are captured using thermal infrared cameras and other micro-climate equipment.
Regional Ecosystem	Regional ecosystems were originally described by Sattler and Williams defining vegetation communities within bioregions with a particular and consistent combination of associations including geology, land type and soil.
Respiration	A series of chemical reactions occurring in all living organisms to produce usable energy out of sugar. Oxygen is generally consumed and carbon dioxide released.
Street trees	Trees that grow along streetside footpaths (or verges).
Sunshine Coast Native	A species that naturally occurs (originates) on the Sunshine Coast. A locally native tree.
Thermal conductivity	Capability to transfer heat. Materials such as bricks, bitumen and concrete have high thermal conductivity, absorbing large quantities of solar radiation, and consequent heat, during the day, and then release it at night to contribute to urban heat island effects.
Tree	A woody perennial plant generally over five metres in height and more or less with branches radiating outwards from a single trunk.
Urban forest	All vegetation, planted or naturally grown, on public and private land within towns and cities including backyards, parks, natural area reserves, waterways, plazas, etc. Urban forest management most commonly refers to the tree component.
Urban canopy layer (UCL)	The layer of air between the ground and the top of roofs/trees. The micro climate around buildings and vegetation, within the UCL is the zone which directly effects humans experience of urban climate.

Appendix

Assessment of mapped existing vegetation cover

Method

The detailed vegetation mapping and statistics reported for Local plan areas (LPAs) are created using GIS mapping software, by performing calculations on advanced imagery captured from planes and satellites. Two light based imaging sensors were utilised in this study. The first is called *LiDAR* (Light Detection And Ranging) and uses lasers and precise 'time-of-flight' measurements. The second is called multispectral imaging, and uses cameras that are sensitive to light in non-visible wavelengths, i.e. beyond the red, green, and blue that a human eyes sees. These special light sensors have been proven as a dependable source of information for measuring the biophysical environment. Recent lowering of costs have provided opportunity for government and industry to increase their use of these technologies for consistent measurement, and for long-term monitoring of vegetation.

LiDAR Mapping

Aerial Laser Survey is a mapping technique that uses laser pulses to map objects in three dimensions (see Figure 1: Profile view of *LiDAR* mapping technique). The technology can create 3D maps of vegetation, buildings, and the ground. The Sunshine Coast Council captured its most recent Aerial Laser Survey in 2014 using a combination of light aircraft, high precision GPS satellite receivers, lasers and intelligent software.

More than 27 billion laser survey strikes captured over the entire region were converted into mapping outputs at 20 cm accuracy, and at one metre resolution. This aspect of the technology provides a way to accurately measure the location, height and structural properties of urban, horticultural and natural forest vegetation including topographic contours, building heights, and vegetation densities.

LiDAR Vegetation Statistical Methods

LiDAR pulses in Aerial Laser Mapping penetrate through the tree canopy and often reach the ground. This aspect of the technology provides a way to accurately measure the location, height and structural properties of urban, horticultural and natural forest vegetation in both two (plan) and three dimensions (height and density). Using GIS software, the 2014 *LiDAR* mapping data has been used to generate statistics surrounding the coverage and structure of vegetation across the chosen reporting area.

Canopy cover, height and density, shade projection in mid-summer, were measured per square metre of land, averaged for each of the localities of study and used to calculate a Foliage Score.

Canopy Cover is the percentage of land covered by vegetation (greater than 2m in height).

Canopy Height is the height of vegetation (including all vegetation greater than 30 cm in height).

Canopy Shade is the total area of land directly covered by vegetation as well as land shaded by vegetation in mid-summer at 9 am and 3 pm. Shade is calculated using vegetation height and time of day within mapping software.

Foliage Density is the percent of sky view being blocked by leaves, branches and fruit determined by the *LiDAR* pulse penetration analysis.

Foliage score is a rating from 0 to 10, derived from a combination of measures of canopy cover, vegetation height, projected shade cover in midsummer, and foliage density, which provides a representation of the value of the vegetation.

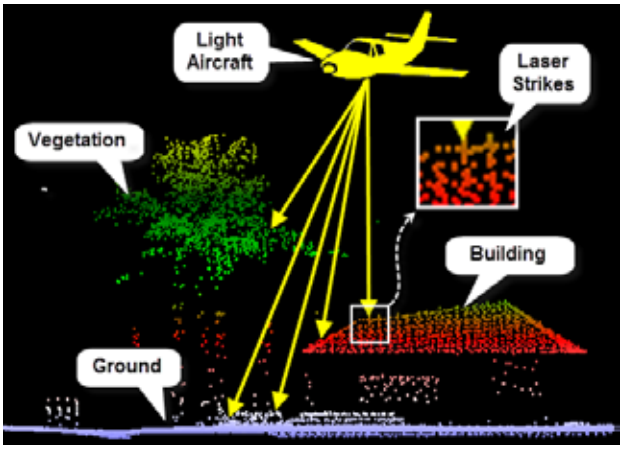

Figure 1: Profile view of *LiDAR* mapping technique

Figure 2: A comparison of standard aerial photography and *LiDAR* mapping. In the *LiDAR* mapping, buildings are represented by reds and pinks, vegetation in light and dark greens, and the ground in light browns and greys. The inset box (right side) shows the difference in mapping resolution when the view is zoomed in to a finer mapping scale. Whilst the *LiDAR* mapping has a lower one metre resolution, the vertical survey data can be exploited to automatically map many things, including topographic contours, building heights, and vegetation densities.

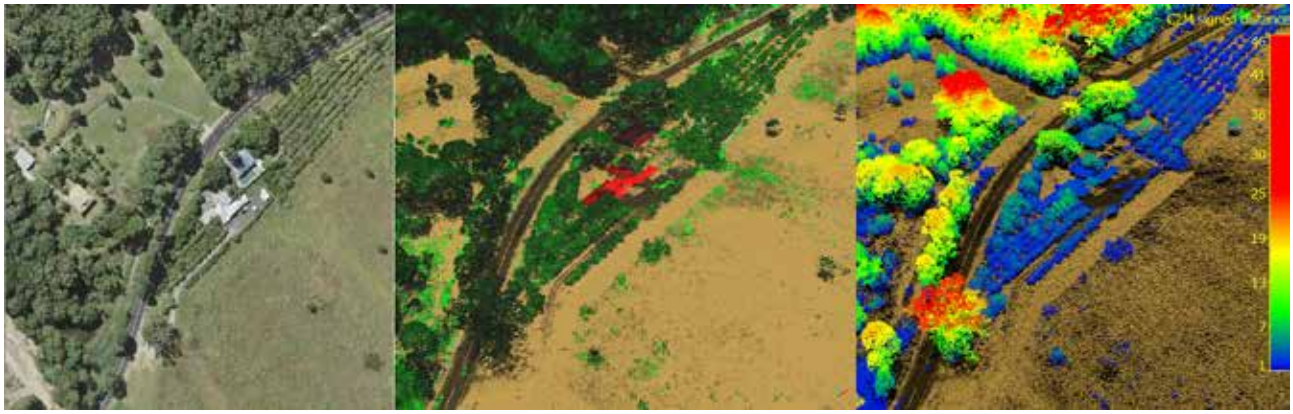

Figure 3: pictured from left to right: Aerial Orthophoto of a semi-rural area containing open grassed areas, regularly spaced fruit trees, a rural road and some natural vegetation; (MIDDLE) an oblique view of a colourised *LiDAR* data point cloud showing tree vegetation in green, buildings in red, and the ground in brown and black; and (RIGHT) the same *LiDAR* point cloud coloured according to height above ground in a range of colours from blue (shortest) through green, yellow and red (tallest).

Figure 5: Shade is calculated using tree height and time of day within mapping software. The left image shows standard aerial photography, the right image, a *LiDAR* derived vegetation map with trees (non-ground vegetation) in dark green, and the 9am/3pm summer shadows in light green.

Figure 5: Depiction of shade statistics generated.

Figure 6: (above) Four sites (A, B, C and D) chosen from *LiDAR* mapping to cross check modelled canopy shade projection data. Google street views at each site were used to superimpose and estimate actual canopy shade extent.

Results - *LiDAR* derived statistics

The following table of statistics for each LPA is an average percentage foliage cover calculated from *LiDAR* data collected in 2014. The higher the number, the more vegetation, trees or foliage an area has. There are two primary statistics provided for each LPA – road reserve, and all areas. The 'Road Reserve' numbers are calculated by including only the public road reserve areas, whilst the 'All Areas' number is calculated by assessing foliage cover for all land within the LPA regardless of tenure (i.e. it includes private tenure areas).

LiDAR Foliage Score - Local Plan Areas (LPA)							
	Local Plan Area	Foliage Score	Canopy Cover	Foliage Density	Canopy Volume	Canopy Shade+	Area sqkm
1	Forest Glen / Kunda Park / Tanawha	9.8	60%	49%	12.7	82.9%	16
2	Blackall Range	9.6	62%	49%	11.0	82.8%	25
3	Mooloolah	7.8	52%	39%	9.0	82.3%	8
4	Landsborough	7.3	50%	35%	8.5	81.7%	9
5	Buderim	7.2	49%	38%	8.5	79.3%	28
6	Eumundi	5.9	45%	32%	6.6	77.1%	2
7	Nambour	5.9	44%	33%	7.2	73.6%	20
8	Eudlo	5.6	41%	33%	5.2	79.5%	0
9	Palmwoods	5.4	41%	32%	6.4	72.7%	5
10	Woombye	4.3	37%	29%	5.1	68.5%	2
11	Glass House Mountains	4.3	39%	28%	5.3	66.4%	5
12	Beerburrum	4.2	38%	26%	5.5	67.2%	1
13	Beerwah	4.2	37%	27%	5.9	65.6%	8
14	Bli Bli	4.2	38%	26%	5.6	66.0%	7
15	Coolum	4.0	41%	26%	4.2	65.5%	19
16	Caloundra West	3.6	38%	25%	4.5	62.2%	23
17	Maroochy North Shore	3.5	41%	25%	4.2	59.7%	18
18	Maleny	2.9	33%	26%	4.1	58.0%	9
19	Yandina	2.6	31%	22%	4.2	58.3%	4
20	Caloundra	2.6	32%	22%	3.3	59.4%	13
21	Golden Beach/Pelican Waters	2.5	34%	21%	3.6	57.2%	13
22	Peregian South	2.3	33%	20%	3.6	56.3%	6
23	Sippy Downs	1.9	28%	20%	3.5	54.5%	8
24	Kawana Waters	1.1	27%	18%	3.2	46.9%	25
25	Mooloolaba/Alexandra Headland	1.1	23%	15%	2.2	56.3%	5
26	Maroochydore/Kuluin	0.2	21%	14%	2.2	45.8%	14
27	Kenilworth	0.1	20%	13%	2.8	45.3%	2
	Averages		38%	28%	5.5	66%	11

Table 1: Foliage score statistics for each LPA (all lands) (2014 *LiDAR* derived statistics).

LiDAR Foliage Score - (within Road Reserve)							
	Local Plan Area	Foliage Score	Canopy Cover	Foliage Density	Canopy Height	Canopy Shade+	Area Ha
1	Blackall Range	9.9	46%	38%	7.5	85%	136
2	Beerburrum	9.3	46%	33%	7.8	82%	14
3	Palmwoods	8.7	41%	34%	7.0	82%	76
4	Forest Glen / Kunda Park / Tanawha	8.4	40%	32%	7.7	77%	166
5	Eumundi	8.0	41%	29%	6.5	81%	25
6	Landsborough	7.1	37%	27%	5.9	79%	120
7	Mooloolah	7.0	35%	28%	5.3	81%	75
8	Beerwah	6.1	33%	25%	6.4	68%	118
9	Eudlo	6.0	32%	27%	4.5	77%	5
10	Maroochy North Shore	5.3	39%	25%	3.0	69%	256
11	Coolum	4.8	34%	23%	3.0	69%	284
12	Glass House Mountains	4.6	30%	22%	4.6	65%	72
13	Peregian South	4.4	33%	21%	3.5	65%	78
14	Maleny	4.0	27%	23%	3.1	67%	64
15	Nambour	3.8	26%	21%	3.5	67%	259
16	Woombye	3.6	25%	21%	3.2	66%	34
17	Buderim	3.6	24%	20%	2.8	70%	362
18	Yandina	3.3	25%	18%	3.1	64%	62
19	Bli Bli	2.2	20%	16%	2.1	64%	77
20	Caloundra	1.9	22%	17%	2.1	56%	254
21	Caloundra West	1.3	20%	13%	1.9	55%	319
22	Kenilworth	0.9	17%	14%	1.9	53%	18
23	Mooloolaba/Alexandra Headland	0.8	17%	12%	1.4	56%	125
24	Sippy Downs	0.8	18%	12%	1.5	54%	118
25	Golden Beach/Pelican Waters	0.5	18%	13%	1.3	51%	159
26	Kawana Waters	0.3	17%	12%	1.5	48%	397
27	Maroochydore/Kuluin	0.1	15%	11%	1.3	50%	221
	Averages		29%	22%	3.8	67%	144

Table 2: Foliage score statistics for each LPA (road reserve areas only) (2014 *LiDAR* derived statistics).

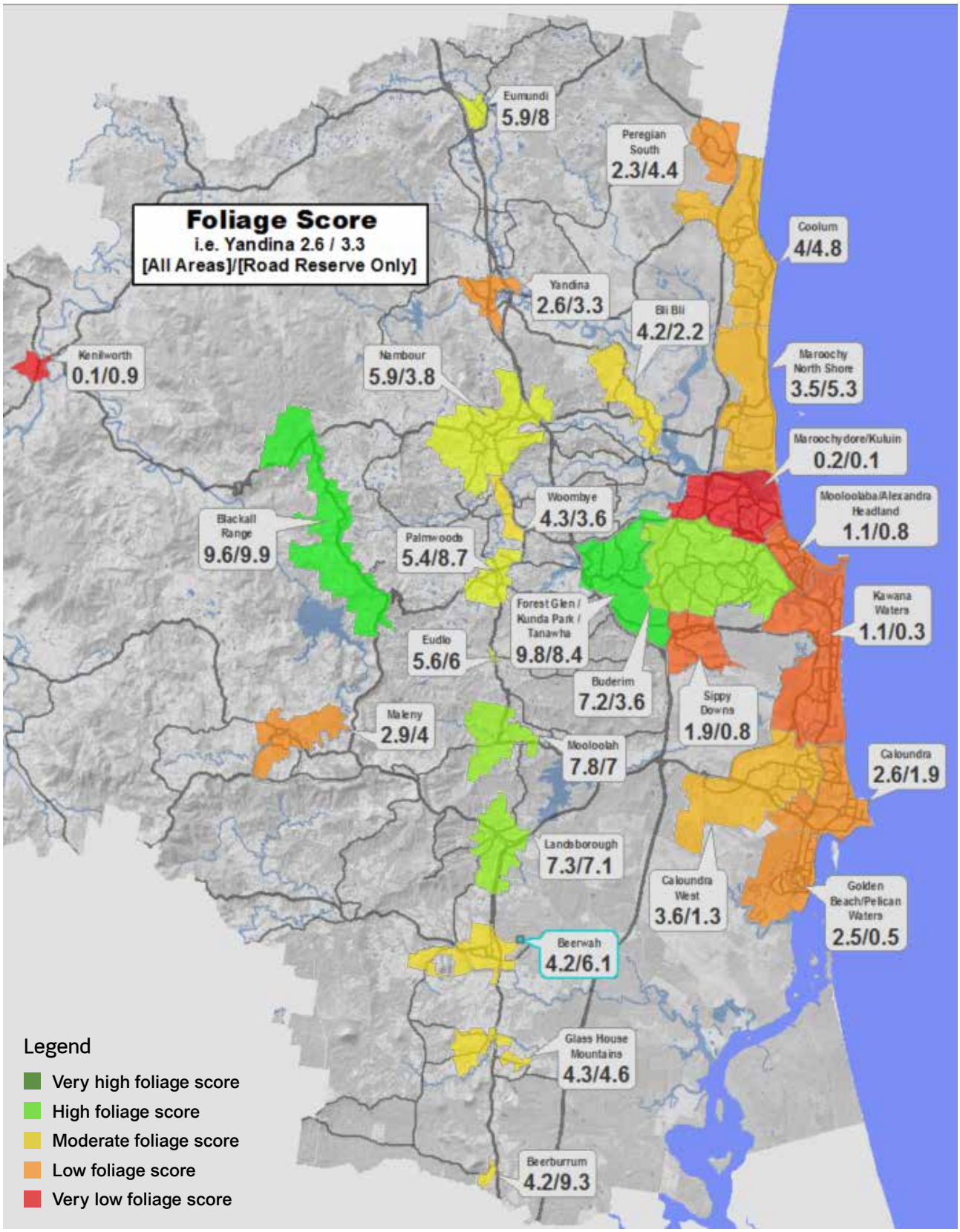

Figure 7: Info-graphic showing foliage scores for All Lands and Road Reserve spaces for each LPA.

Multi-spectral imagery analysis

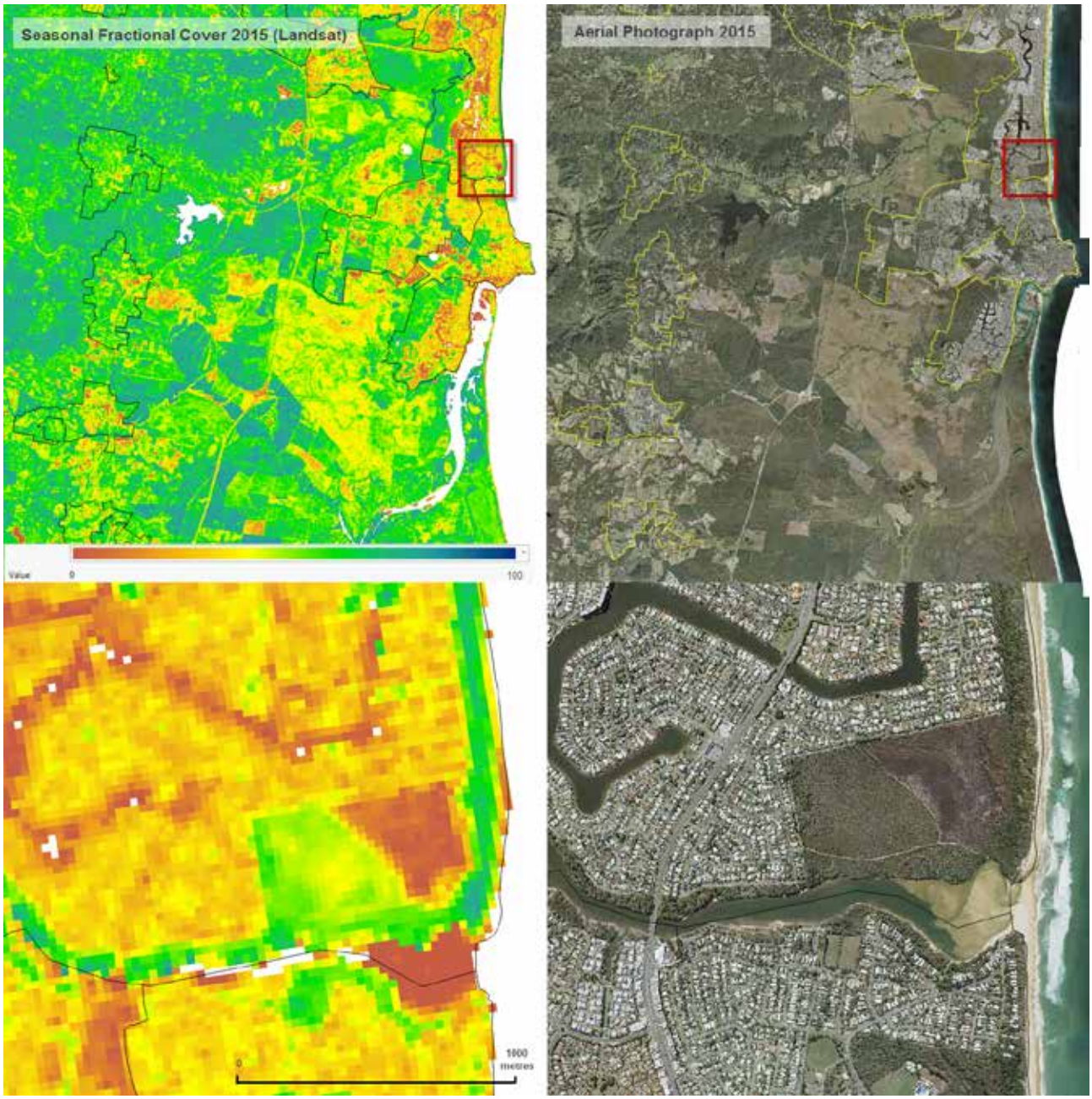

Figure 8: Mapping with multi-spectral imagery is a technique that uses both visible and non-visible light wavelengths. For example, calculations for each pixel within an image compare the spectral response (or intensity of light) from objects like vegetation, dirt, water, etc. Each type of object has a particular 'signature'. The response observed across a number of different wavelengths, including Red-Green-Blue and others such as Infrared, provide opportunity to determine what the object is most likely to be. Using this technique, scientists from the Queensland Government Remote Sensing Centre (DSITIA) have created a series of products that provide an indication of vegetation land cover in an area. The product used in this study is referred to as 'Seasonal Fractional Cover' and is derived from the 30 metre resolution Landsat-5 TM and Landsat-7 ETM+ sensors, through the automated prediction of over-storey foliage projective cover (FPC) from a large volume of Landsat imagery. The algorithm uses a comparison of parametric (Multiple Linear Regression, Generalized Linear Models) and machine learning (Random Forests, Support Vector Machines) regression models.

Results - Multi-spectral seasonal fractional cover statistics

Statistics generated using multispectral imagery provide an indication of woody vegetation land cover (vegetation index cover), and the following tables are a summary of average values for the Apr-May-June period of each year, for each Local Plan Area (LPA). Two tables are provided, firstly for all areas within the LPA (Table 3 below), and Table 4 opposite showing vegetation index cover statistics generated for the areas within road reserve only for each LPA.

All Public Areas Vegetion Index Cover												
Local Plan Area	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Avg
Forest Glen / Kunda Park / Tanawha	69.32	68.16	66.14	62.32	66.13	67.06	67.39	69.87	70.77	69.03	69.05	68
Blackall Range	65.17	63.89	63.14	63.67	64.84	66.57	64.71	65.57	68.14	65.05	65.97	65
Mooloolah	64.63	61.6	58.65	60.76	59.61	64.6	60.71	63.07	65.36	62.79	63.31	62
Eudlo	60.02	58.62	56.53	59.49	57.78	62.5	57.82	59.38	61.09	58.07	59.55	59
Maleny	60.26	60.05	54.97	61.4	57.59	61.91	57.04	57.42	61.51	57.04	59.25	59
Landsborough	58.23	56.73	55.53	56	57	59.88	56.17	58.95	61.2	58.77	59.34	58
Eumundi	63.83	58.03	49.53	54.29	55.38	58.53	55.35	58.86	59.42	57.46	55.9	57
Glass House Mountains	56.29	53.55	52.27	54.11	53.84	56.49	55.15	57.78	59.06	55.59	56.8	56
Beerburrum	53.38	50.79	50.1	52.46	52.46	56.95	55.48	53.33	55.59	52.52	54.27	53
Nambour	55.35	53.56	51	51.05	52.43	54.81	53.27	54.78	55.03	52.67	52.63	53
Yandina	55.01	50.65	49	52.23	51.78	55.04	49.93	53.83	55.91	53.41	52.6	53
Kenilworth	51.79	44.62	47.27	55.82	51.78	60.04	51.81	52.65	58.59	49.69	51.29	52
Palmwoods	51.92	50.99	48.19	49.89	50.53	54.96	52.61	54.43	54.64	52.1	53.44	52
Bli Bli	53.12	50.14	49.17	49.44	50.35	52.14	51.16	52.63	52.78	51.07	50.45	51
Woombye	56.39	51.4	48.79	49.49	47.44	52.6	49.2	52.01	52.46	49.73	50.82	51
Beerwah	51.53	52.58	47.58	46.78	47.01	52.13	49.52	51.9	52.86	48.9	51.43	50
Buderim	50.81	49.49	48.79	47.89	49.98	50.56	50.41	52.06	51.52	50.13	50.09	50
Coolum	51.64	50.4	48	47.13	49.5	49.92	49.72	51.13	50.53	49.8	48.16	50
Caloundra West	43.7	39.92	37.51	39.16	39.36	43.89	40.48	42.82	42.97	42.01	42.62	41
Maroochy North Shore	40.5	39.85	39.2	39.54	40	43.28	42.35	42.76	42.5	41.29	40.4	41
Caloundra	42.28	40.55	39.42	40.01	39.71	42.66	40.98	42.31	40.25	40	40.44	41
Maroochydore/Kuluin	42.94	40.57	39.12	39.76	39.94	41.79	40.54	41.86	41.41	39.13	39	41
Sippy Downs	38.73	35.06	34.98	37.42	35.27	42.08	37.53	40	41.27	40.46	41.41	39
Mooloolaba/Alexandra Headland	38.4	36.72	35.42	35.66	36.75	38	37.24	37.82	36.29	34.35	34.75	36
Golden Beach/Pelican Waters	35.92	32.75	31.63	32.89	33.42	37.34	34.74	35.25	34.8	34.04	34.87	34
Peregian South	29.02	30.91	32.21	30.63	31.86	35.33	32.59	34.97	35.53	35.28	35.6	33
Kawana Waters	35.58	32.59	32.67	32.1	32.28	34.55	33.01	33.62	32.25	30.93	32.63	33
Grand Total	47	45	44	44	45	47	45	47	47	45	46	50

Table 3: Annual vegetation index for each LPA (all lands) 2005-2015

Road Reserve Areas Vegetion Index Cover												
Local Plan Area	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Avg
Forest Glen / Kunda Park / Tanawha	67.4	66.03	63.9	58.9	65.3	64.9	66.3	69.8	70.2	68.5	68.8	66
Blackall Range	61.8	58.88	56.4	58.6	57.3	63.3	59.2	61.8	64	61.5	62	60
Mooloolah	61.4	60.52	60.2	59.6	61.9	62.6	61.9	63.1	64.7	61.8	62.8	62
Eudlo	59.5	55.81	45.2	51.2	52.4	55.8	52.7	57.3	56.2	55.3	53.8	54
Landsborough	57.5	57.1	53.9	54.9	55.3	59	55.4	57.3	59.5	57	57.8	57
Maleny	57.1	56.7	52	58.5	53.9	59.2	54.3	54.6	59	54.6	56.3	56
Beerburrum	56.5	54.49	53.6	53.4	55	57.7	54.8	57.9	60.1	57.7	58.3	56
Eumundi	56	53.49	51	51.6	52.4	60.3	55.2	55.6	56.5	53.2	53.9	54
Glass House Mountains	54.2	48.09	44.9	46.5	45.4	50.7	47.7	51.2	51.4	48.5	50	49
Palmwoods	52.4	50.18	47.3	49.8	50.4	53.5	50.4	53.7	55.1	53.9	52.8	52
Yandina	52.1	49.39	48.9	50.4	50.3	53	52.4	55.5	56.9	52.9	54.3	52
Kenilworth	51.8	50.48	48.1	49	50.6	54.4	52.8	55.1	55.6	52.7	54.5	52
Nambour	50.6	48.88	46.2	46.9	47.8	50.5	49.3	51.1	51	48.6	48.6	49
Woombye	49.6	46.51	46.3	46.4	47.8	49.4	48.6	49.9	50.2	48.1	47.4	48
Beerwah	49.6	48.28	45.6	45.2	47.6	48.6	48.6	50.1	49.4	48.8	47.4	48
Bli Bli	48.9	40.24	44.3	54.4	48.1	57.1	48.2	50.6	55.9	46.2	48.7	49
Coolum	48.8	50.96	46.6	44.4	45	50	47.9	51	52	47.5	50	49
Buderim	48.4	46.91	45.9	45.3	47.4	48.1	48.4	50.4	49.5	48	48.1	48
Maroochy North Shore	43.5	39.41	36.1	38.4	39.1	43.6	41	43.8	44.4	43.3	44	42
Caloundra West	42.4	41.57	40.8	40.2	41.8	44.4	44.5	45.4	45.3	44.3	43.7	43
Caloundra	42.1	40.31	39.3	39.4	40	42.5	41.3	43.6	41.2	40.9	41.5	41
Maroochydore/Kuluin	42	39.28	37.5	38.3	38.8	40.8	40.3	41.6	41.6	38.7	39	40
Sippy Downs	39.3	35.34	34.6	35.3	35.4	41.4	38.3	41.3	42.6	42	42.6	39
Golden Beach/Pelican Waters	37.4	33.92	34.3	33.1	33.5	35.7	34.5	35.7	34.9	33.9	35.7	35
Peregian South	37.1	35.41	34.1	34.7	35.9	37.1	36.3	37.4	35.8	34	34.5	36
Mooloolaba/Alexandra Headland	36.2	33.14	31.9	33.7	34.9	38.6	37.4	38.6	38.3	37.6	38.7	36
Kawana Waters	28.2	29.64	31.4	32.2	33.8	39.1	38.3	40.2	41.3	41.1	40.8	36
Total Averages	46	44	42	42	43	46	45	47	47	45	46	45

Table 4: Annual vegetation index for each LPA (road reserve only) 2005-2015

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