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.

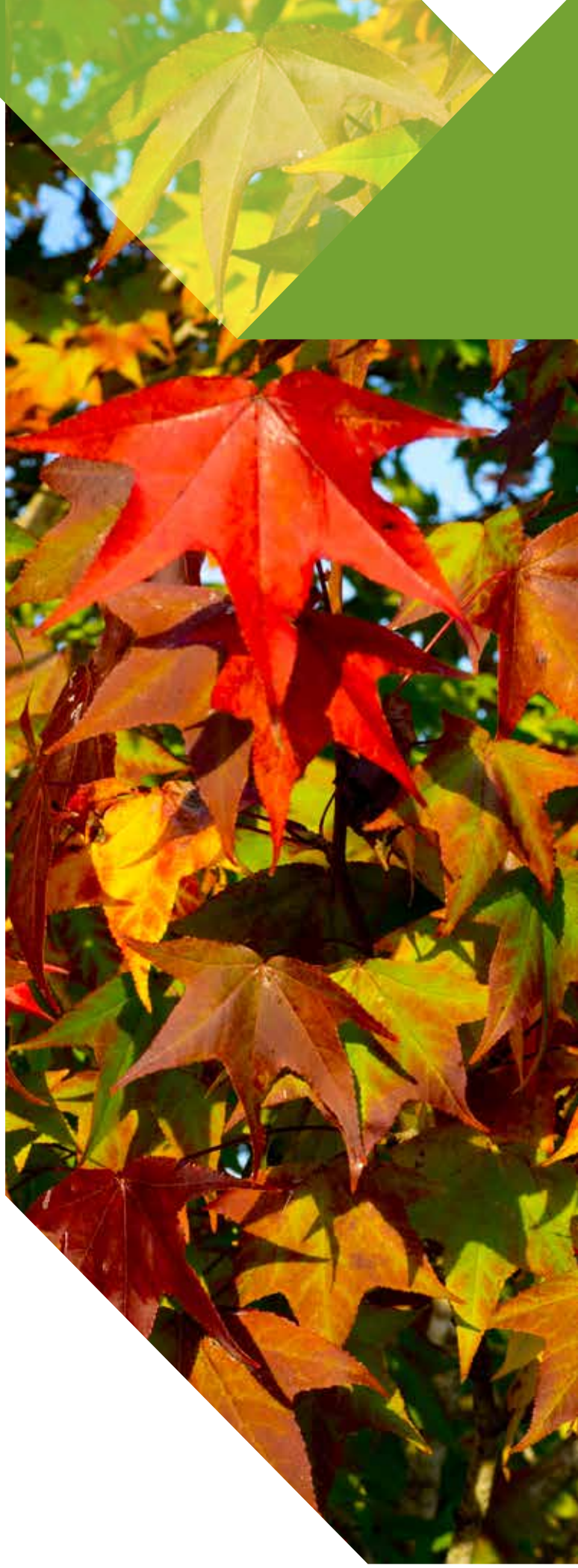
A diversity of broad-leaved species in a street tree population is ideal for heat mitigation because of increased shade and cooling function as an outcome of greater leaf surface areas. Rainforest type trees and those that come from moist environments have higher rates of evapo-transpiration and greater 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.