



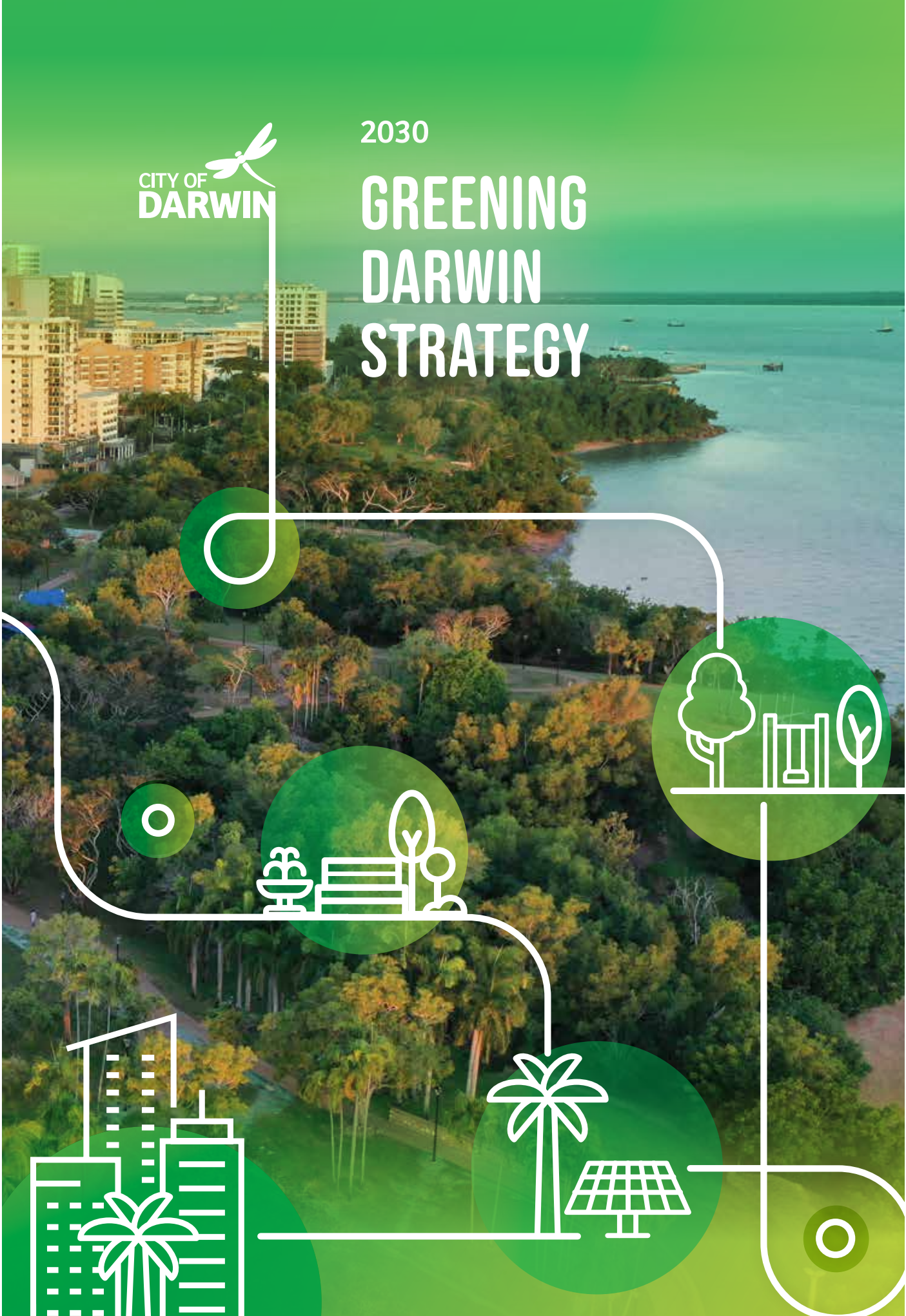
ATTACHMENTS

**Tree Advisory Committee Meeting
Under Separate Cover**

Friday, 25 November 2022

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CITY OF
DARWIN

2030
GREENING
DARWIN
STRATEGY

CITY OF
DARWIN

2030

GREENING
DARWIN
STRATEGY





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Acknowledgement of Country

City of Darwin acknowledges the Larrakia people as the Traditional Owners of all the land and waters of the Greater Darwin region.

To the Larrakia, Darwin is known as Garramilla. The original language of the Larrakia is Gulumirrgin (pronounced Goo-loo-midgin).

Often referred to as "Saltwater People", the Larrakia lived, loved, birthed, hunted and survived a life on pristine coastal and inland areas. Established 'song lines' connecting Larrakia people to Country penetrate throughout their land and sea, allowing stories and histories to be told and retold for future generations. Scientific evidence dates Aboriginal presence in northern Australia to 60,000 years.

The Larrakia culture and identity is rich and vibrant. In the footsteps of the Larrakia people, City of Darwin will continue to foster this culture and identity by creating a vibrant community together.

PHOTO COURTESY OF LARRAKIA NATION





Lord Mayor's Message

I am pleased to present to you City of Darwin's first ever 2030 Greening Darwin Strategy.

Community engagement has been at the forefront of developing this Strategy. This engagement has highlighted that the top priority our community wants to see across the Darwin municipality is a cool, clean and green city. This Strategy will help City of Darwin achieve this.

City of Darwin already has a strong focus on looking after our natural environment. We work with all levels of government, the non-government sector and the community, to improve our public spaces.

Since the devastating effects on our natural environment from Tropical Cyclone Marcus in 2018, City of Darwin has planted in total over 12,500 trees across the municipality. In 2020, The Green Army was initiated as a COVID-19 stimulus package to provide employment to people experiencing hardship. The Green Army helped in beautifying Darwin through tidying up our verges and footpaths, landscaping and irrigation along Daly Street, revitalising parks and planting trees, tidying up median strips and general removal of rubbish, mulching, pruning and weeding.

The City is looking better than ever through tree planting, shading and beautification projects, and this Strategy will help to build on what has already been started.

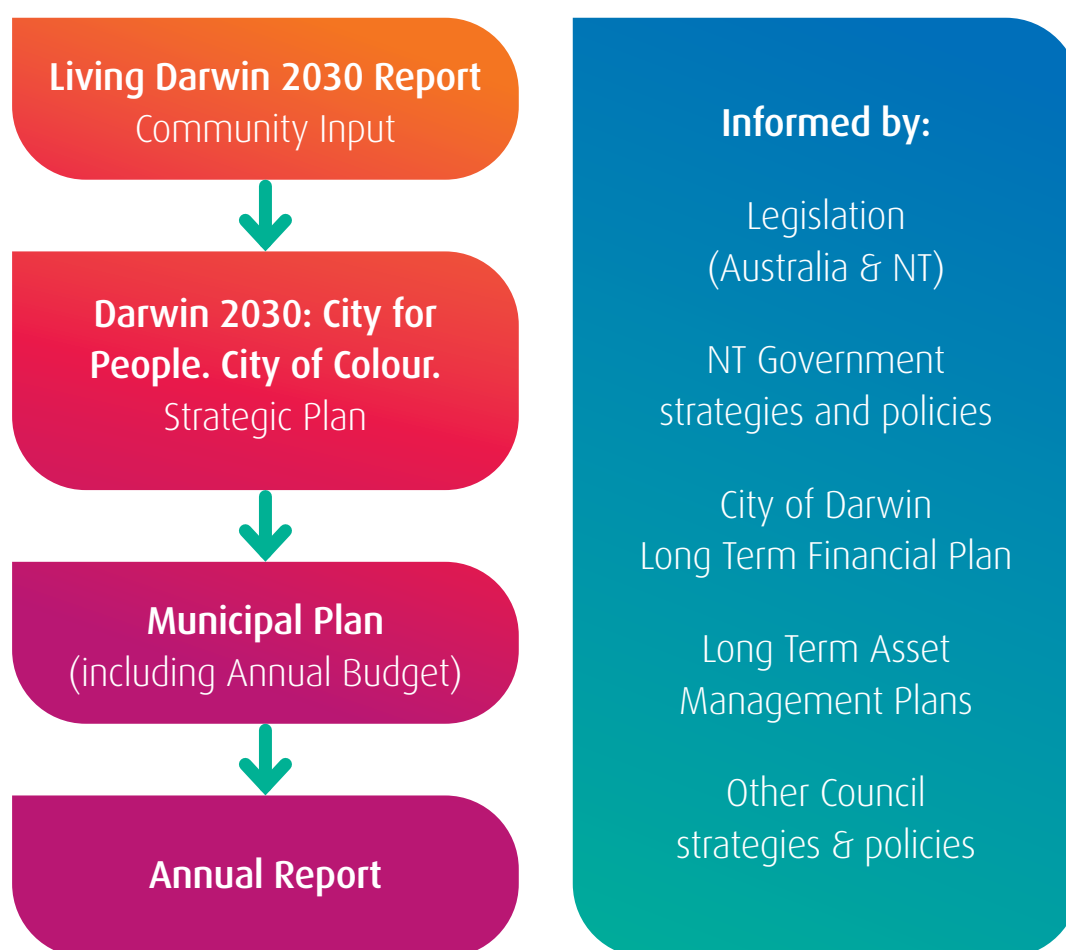
This Strategy provides an overarching framework for enhancing, preserving and protecting the natural environment of Darwin City over the next ten years. It provides the community with details of the challenges for Greening Darwin but most importantly, how Council can inspire you with visions of a 'greener future'. This can be achieved with sensible, steady and continuous improvements to make Darwin's natural environment healthier for our future generations.

THE HON. LORD MAYOR KON VATSKALIS



City of Darwin's Strategic Planning Framework

City of Darwin's strategic planning framework provides the basis for the setting and delivery of Council's priorities. The 2030 Greening Strategy (Strategy) informs the delivery of programs within this strategic planning framework.



Darwin 2030 *City for People. City of Colour.*



A capital city with best practice and sustainable infrastructure



A safe, liveable and healthy city



A cool, clean and green city



A smart and prosperous city



A vibrant and creative city

Underpinned by City of Darwin's Governance Framework

Vision and Culture

Roles and Relationships

Decision Making and Management

Accountability

Our Strategic Direction – A Cool, Clean and Green City

**TARGET: BY 2030,
DARWIN WILL BE
RECOGNISED AS A CLEAN
AND ENVIRONMENTALLY
RESPONSIBILITY CITY.**

City of Darwin already has a strong focus on looking after our natural environment. Our public spaces will increasingly offer shade to encourage increased use of our parks, ovals, walkways and cycling paths. Working with all levels of government and the community, Council is committed to long-term environmental sustainability through planning and engagement.



SD3 – A cool, clean and green city



Council has put in place three key strategies that will guide the actions and targets Council aims to achieve by 2030 as it strives for a cool, clean and green city. The strategies are outlined below and through their implementation will deliver on strategic direction 3 as outlined in the *Darwin 2030 City for People. City of Colour. Strategic Plan*.



**CLIMATE
EMERGENCY
STRATEGY**



**Greening
Darwin
Strategy**



**Waste and
Resource
Recovery
Strategy**

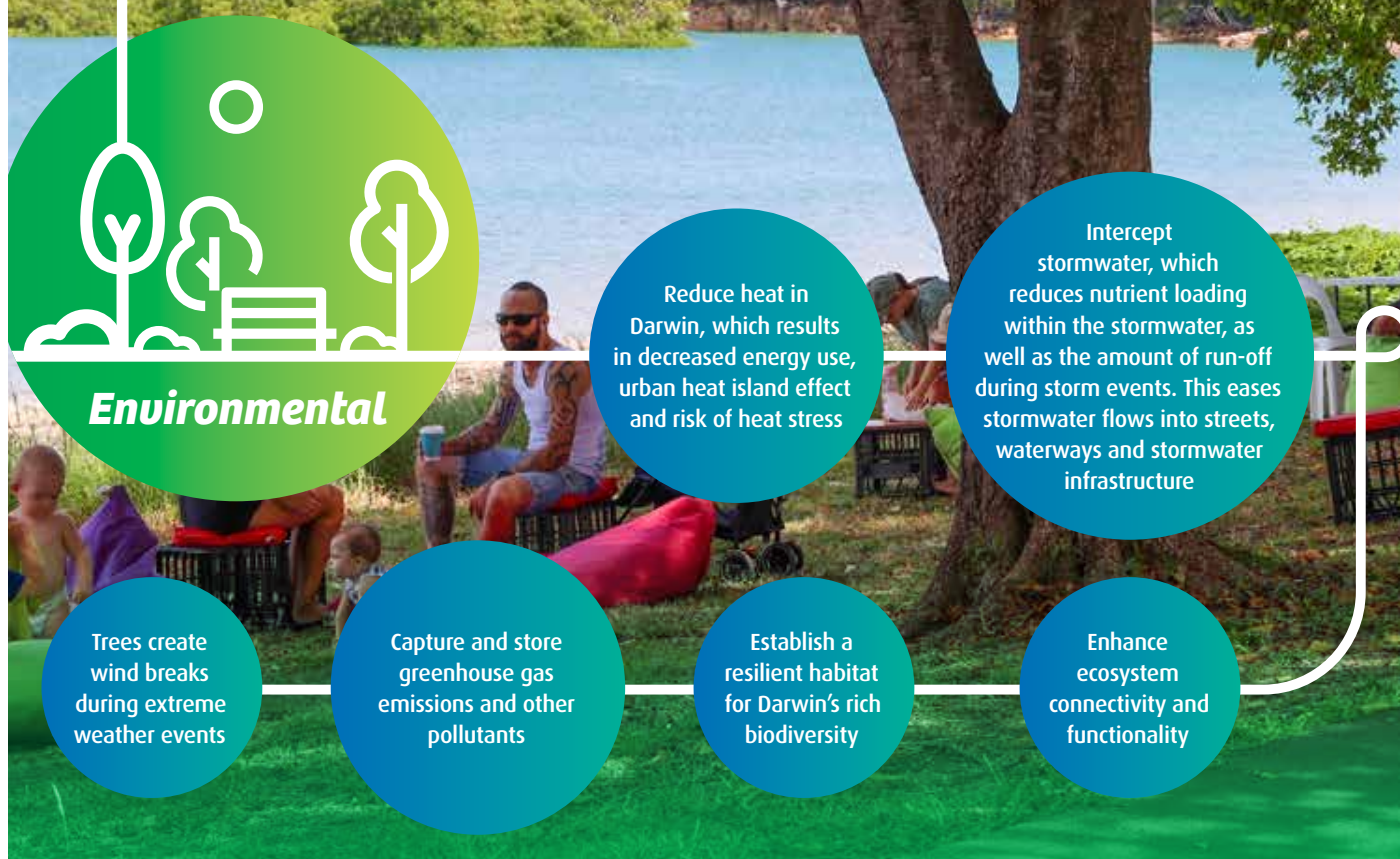
Environmental Management System
Innovate Reconciliation Action Plan
Darwin City Centre Master Plan
Movement Strategy

Benefits of Greening Darwin

The greening of Darwin through the ongoing development of our urban forest provides such an important role in creating a cool, clean and green city. Darwin's urban forest is at the heart of our vibrant character and is a core asset in attracting people to the region to live, work and visit. The urban forest is comprised of all trees and vegetation that grow within the municipality, including those in streets, parks, conservation reserves, along walkways and those that occupy private and other public property.

A wide array of benefits can be unlocked with a healthy and resilient urban forest, such as providing shade and cooling, supporting biodiversity, capturing and storing carbon, developing streetscape amenity, mitigating stormwater flows, increasing cyclone resilience and improving community connection to nature. A range of trees and other plantings of varying ages and attributes are needed to create diverse plantings. Such a diverse collection is an important aspect of a resilient urban forest.

GREENING DARWIN CAN DELIVER MULTIPLE BENEFITS:



Social and cultural

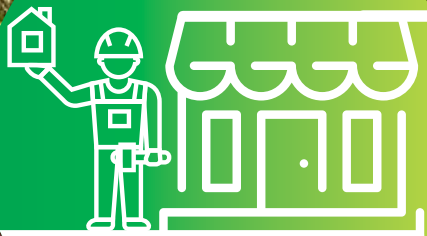


Encourage active transport such as walking and cycling

Improve mood, and decrease levels of stress, anxiety and depression

Provide places for community connection and gathering

Provide a sense of place and local identity



Economic

Create jobs through the establishment and maintenance of the urban forest

Increase surrounding property values

Attract industry and economic benefit by encouraging people to stay longer in well-vegetated commercial, retail and recreational areas

On Saturday 17 March 2018 Tropical Cyclone Marcus impacted Darwin and its environs with extensive damage to the urban forest. The City of Darwin's public open space and road reserve areas were significantly impacted. As a result, the opportunity was undertaken to identify the risks to our natural assets and understand the tree species that were most resilient in the Darwin municipality in re-establishing the urban forest. This was achieved through the establishment of the Tree Reestablishment Advisory Committee (TRAC) to provide recommendations on suitable tree species for replanting and best practice in re-establishing trees in the municipality. The recommendations included the identification of 194 species of trees on a preferred planting list for Darwin.

As part of the Darwin 2030 Strategic Plan, City of Darwin conducted extensive community consultation about what makes Darwin's CBD and suburbs unique, vibrant, welcoming and enjoyable. The consultation included a Place Score, which helped identify what people in the community believe make a city and its suburbs great places to visit and spend time in. The Care Factor (CF) requires respondents to prioritise the place attributes that are most important to them and the Place Experience (PX) assessments asks users of an area to assess each place attribute in terms of its impact on their personal enjoyment of the space.

A key result of the Place Score was that Darwin residents have a high priority for a cool, clean and green city and that increased greening can enhance place experience and modal diversity. By understanding the community values and the role of the urban forest in fostering these values, Council can set priorities on where to focus on enhancing urban forest initiatives. The following graphics show the outcomes of the place score survey in relation to where the City of Darwin should invest in vegetation and protecting natural features in order to maximise town centre place experience.





In which town centre catchments should the City of Darwin invest in vegetation and protecting natural features in order to maximise town centre place experience?

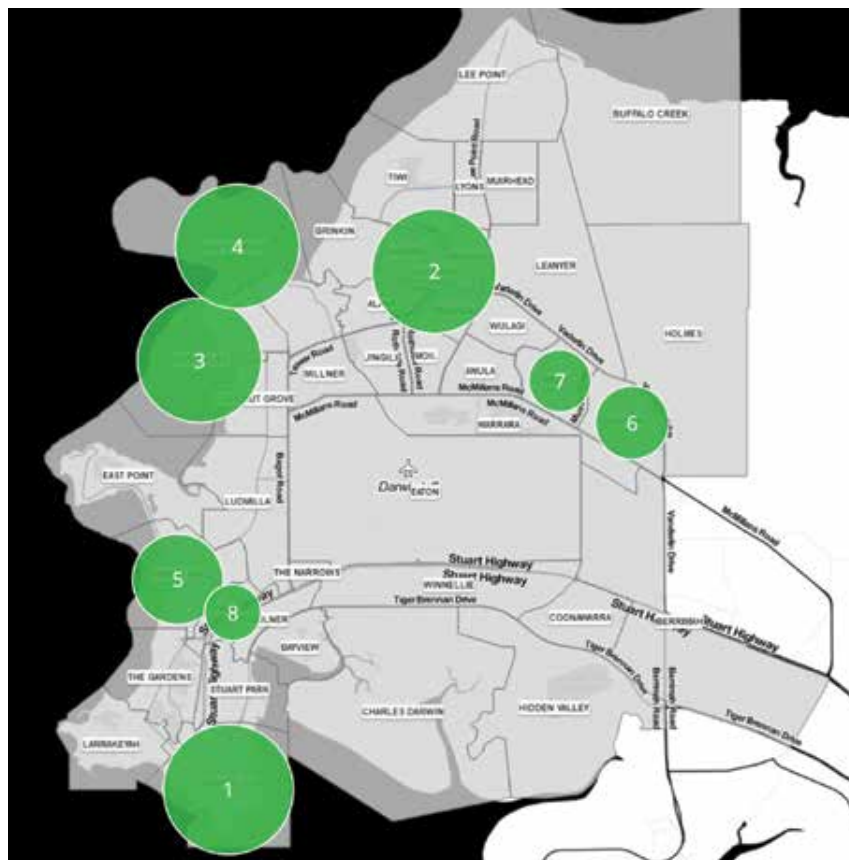
The following table ranks town centre catchment to plant in to improve place experience and community satisfaction:

PRIORITIES BY CENTRE

The table compares the ranking of town centre catchments by order of priority for investment based on community values and performance. These planting priorities are determined by the 1,125 CF and 449 PX responses collected from the Darwin community relating to nature and vegetation and the public realm. The higher the Core Factor and the lower the PX rank the higher the priority for investment and the more likely investment is to have a positive impact on place experience.

	CF Rank	PX Rank
Darwin LGA	3	19
1 City Centre	4	27
2 Casuarina	4	26
3 Nightcliff	3	25
4 Rapid Creek	2	24
5 Fannie Bay	4	20
6 Karama	5	18
7 Malak	3	14
8 Parap	3	13
NATIONAL	3	23

Priorities by Town Centre Catchment: The map illustrates the hierarchy of nature and vegetation community priorities for catchments across the Local Government Area (LGA).



Outcome of Place Score Surveys

The below graphics highlight the three main themes that came out of the Place Score Survey, being:

- An abundance of unique green spaces and natural features
- Attractive and well maintained public spaces
- Social and safe shared environments.

Of the six top priorities identified through the survey, three related to greening.

CF	PRIORITY
7	Maintenance of public spaces and street furniture
1	Cleanliness of public space
3b	General condition of vegetation, street trees and other planting
3c	Vegetation and natural elements (street trees, planting, water etc.)
8	Outdoor restaurant, cafe and/or bar seating
2	Elements of the natural environment (views, vegetation, topography, water etc.)

2019 Values

Based on the Care Factor survey results, three main themes were identified as being an essential part of the Darwin community's ideal town centre:

An abundance of unique green spaces and natural features

Three of the Darwin LGA's top 5 Care Factors are related to nature and greenery. Your community highly values elements of the natural environment and how humans look after them.



Attractive and well maintained public spaces

Cleanliness is Darwin's #1 Care Factor. The Darwin community also identified the maintenance of public spaces and street furniture as being important to them.



Social and safe shared environments

The Darwin community values spaces where everyone can feel safe and welcomed. Public events and outdoor trading play a strong role in the community's ideal town centre.



In 2019 Council declared a climate emergency. Following this, a Climate Emergency Roundtable, was held which contributed to building a shared understanding of, and pathways for, a city-wide response to the impacts of climate change. Many of the identified concerns are in part addressed by achieving the objectives in this Strategy, including issues relating to keeping people cool through rising temperatures, resilience to changing climate-related conditions and enhancing biodiversity. Following the round table City of Darwin developed a discussion paper and draft Climate Emergency Response Strategy that went through extensive community and stakeholder consultation which has highlighted the need to nurture rich biodiversity in Darwin's urban forest.



Natural Environment

The urban forest is at the heart of Darwin's Natural environment and is a core asset in attracting people to the region to live, work and visit.

Canopy Cover

Canopy cover is one of the most effective indicators to measure the extent of Darwin's urban forest. Canopy cover can be measured by suburb or by land use and ownership. As shown in Figure 1 and Table 1, canopy cover varies considerably across land-use types in Darwin.

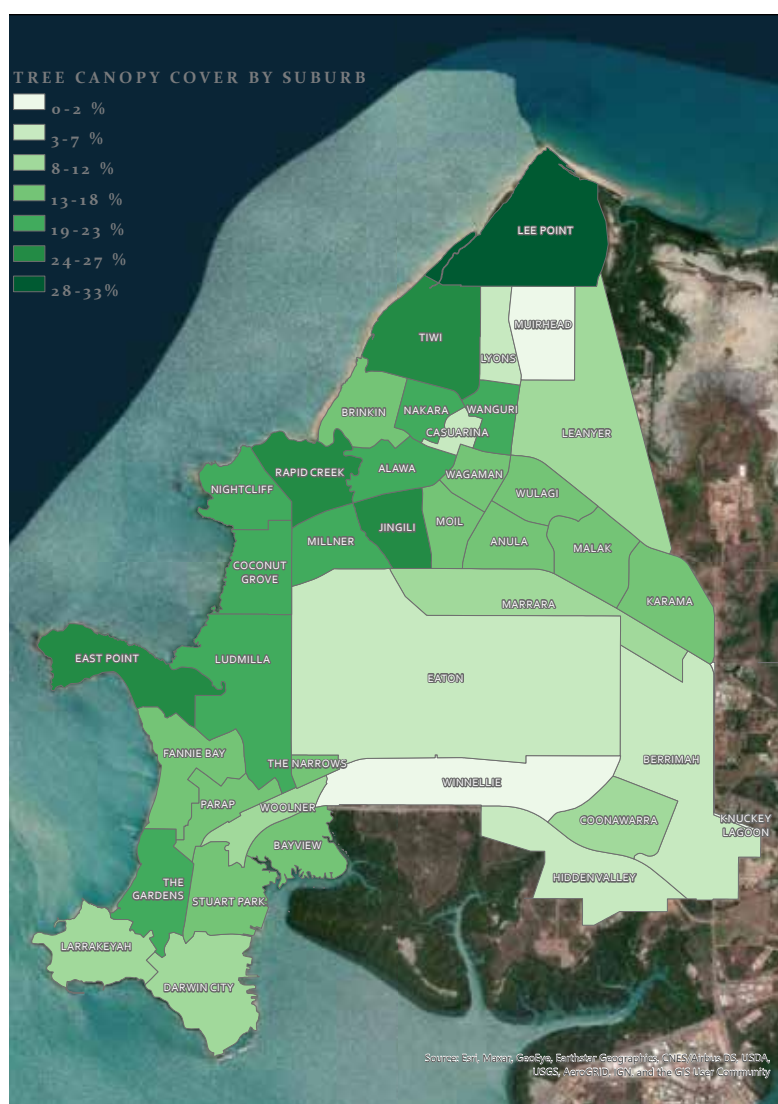


Figure 1: Tree canopy cover by suburb



Table 1 shows Darwin's tree canopy cover by various land uses and ownership based on 2020 data. It is noted that the suburbs of Holmes and Buffalo Creek are not captured in this dataset.

Table 1: Tree canopy cover across Darwin

Land Use/Town planning zone	Total Area (m2)	Canopy Cover (m2)	% Canopy Cover
All Public land	41,003,460	5,693,832	14%
All Private land	38,745,912	6,363,276	16%
Total Municipal Area	90,446,732	13,211,020	15%
Open Space	7,825,240	1,860,104	24%
Roads (all)	8,959,684	746,048	8%
Footpaths (all)	965,908	138,296	14%
Residential zone	22,822,532	4,479,976	20%
Residential Roads	5,380,240	479,796	9%
Darwin City (Suburb)	2,722,976	310,840	11%
Darwin City Roads	408,624	37,804	9%



Habitat and Biodiversity

Biodiversity refers to the variety of the life around us. Darwin's rich ecosystems, of which the urban forest is a fundamental component, host a unique and diverse variety of plants, animals and insects. Maintaining this diverse variety of species is vital to support Darwin's rich ecosystems. In Darwin, maintaining a rich biodiversity is influenced by the ability of wildlife to move from one area of the urban forest to another. Ecosystems that are interlinked facilitate the movement of wildlife. These biodiversity corridors are sprawled across the Darwin municipality (Figure 2).



Figure 2: Major biodiversity corridors in Darwin.



Heat Mitigation Benefits

Darwin is hot and is getting hotter (Figure 3). Increasing temperatures primarily compromise human health and wellbeing in Darwin through heat stress.

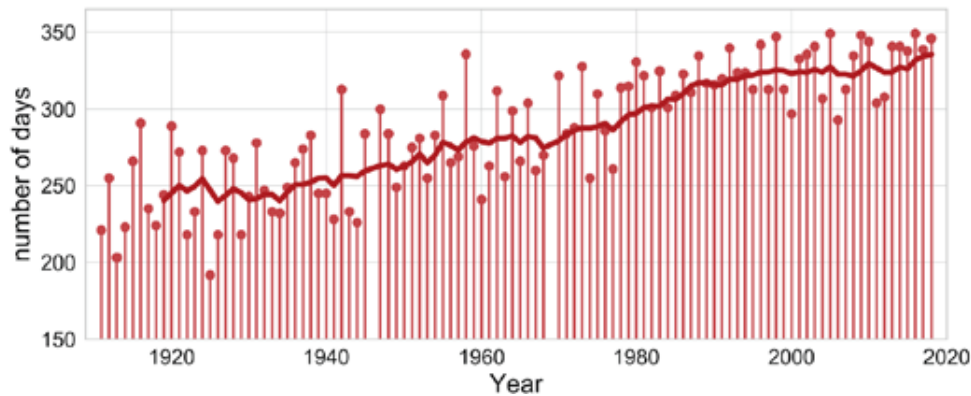


Figure 3: Days above 30°C Each Year in Darwin¹.

Increasing temperatures, exacerbated by Darwin's Urban Heat Island effect, impacts different areas of Darwin at varying levels of intensity (Figure 4). Darwin's urban forest plays a major role in cooling through shade and evapotranspiration. Dense and expansive canopies cool nearby areas as cooler air from green spaces is drawn into hotter areas by rising air currents, which generate breezes.

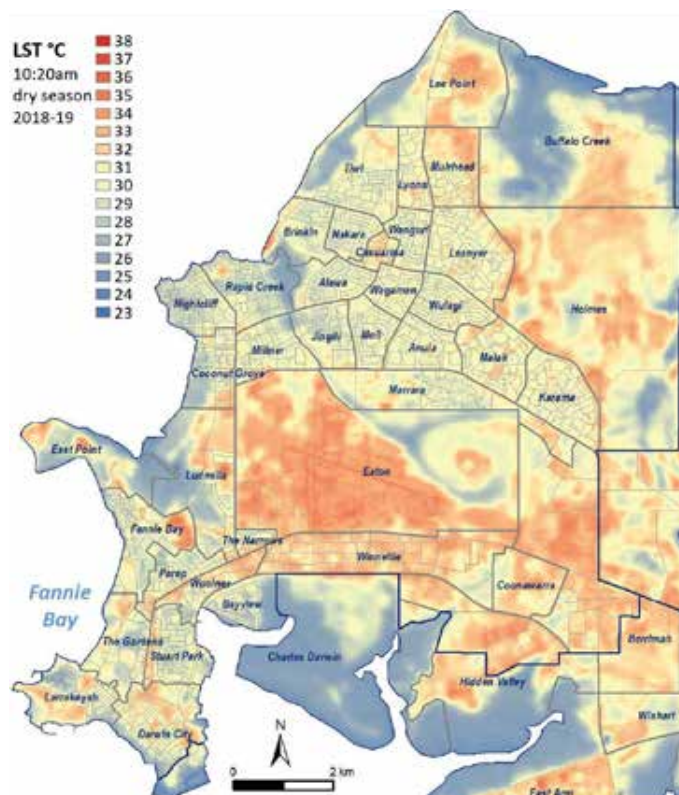


Figure 4: Dry season land surface temperatures at 10:20 a.m. from Jun–Aug 2018–19².

¹ Source: Bureau of Meteorology, & CSIRO. (2019). *Regional Weather and Climate Guide: Top End, Northern Territory*.

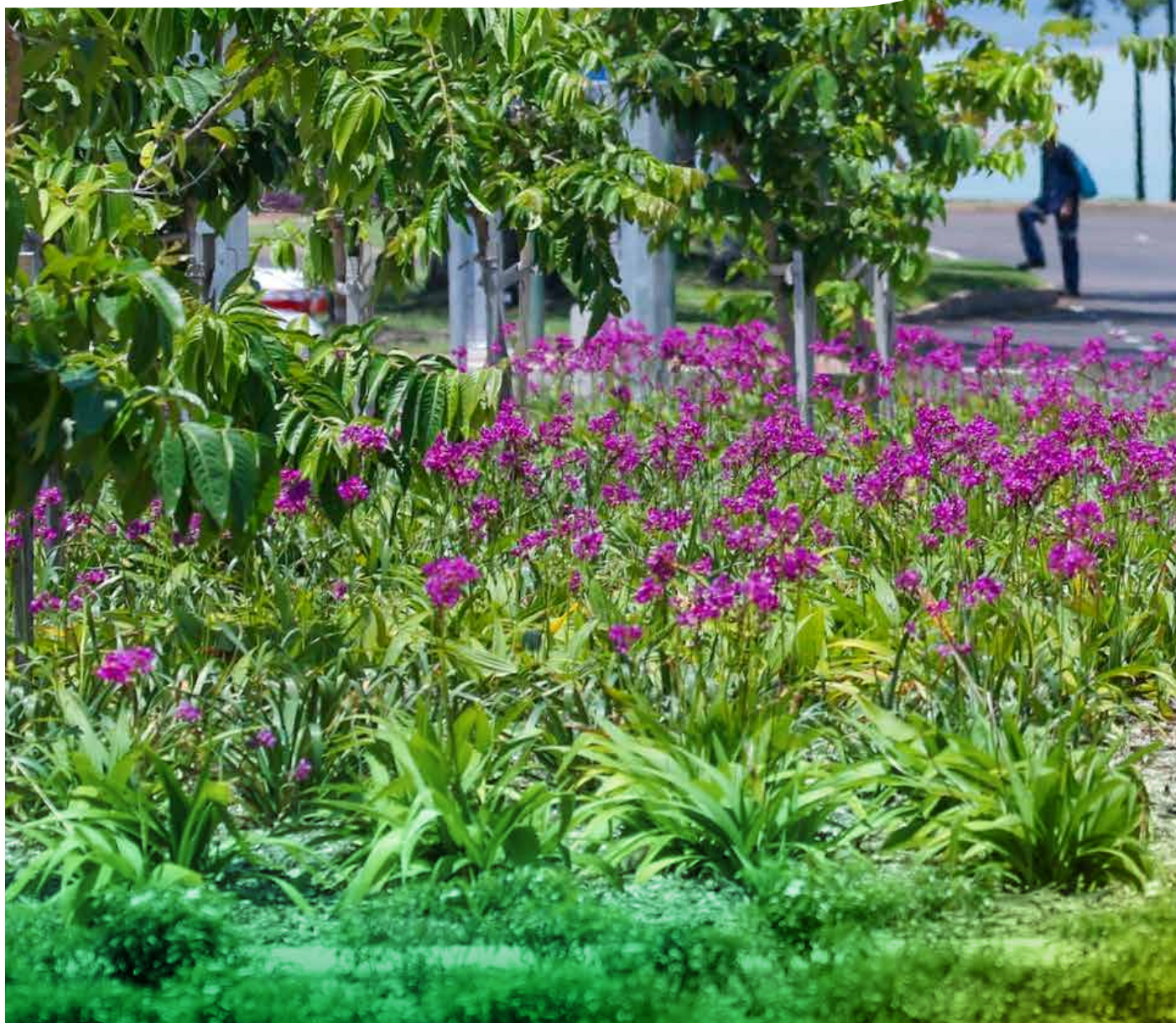
² Source: Meyers et al. (2020). *Mapping land surface temperatures and heat vulnerability in Darwin*. CSIRO.

Delivering Economic Benefits

Darwin's urban forest delivers colossal ecosystem services with measurable economic benefits. These benefits were reported within a study conducted in 2019 using i-Tree Eco model using a dataset of 3617 of Council's trees located throughout the Darwin municipality. Results revealed that these 3617 trees within Darwin's urban forest:

- Have a total structural value of \$80.5m
- Store 14 million tonnes of carbon worth \$317,000
- Sequester an additional 228 tonnes of carbon each year worth \$5,000
- Remove 3 tonnes of other air pollutants each year worth \$7,000
- Avoid 11,000 cubic metres of stormwater run-off, worth \$24,000.

Extrapolating this data across Council's urban forest, which is comprised of more than 100,000 trees, means that Council is likely to be managing a living asset worth hundreds of millions of dollars.





Key Challenges for Greening Darwin

Darwin's urban forest faces existing and emerging challenges that have historically constrained the potential of our tropical urban ecosystem.

Historic Net-loss of Canopy Cover

In recent years, Darwin's urban forest has been undergoing a consistent net-loss of canopy cover. A key driver of this net-loss is that removal of trees (approximately 500 per year) has marginally outweighed planting of new trees (approximately 450 per year). Compounding this, Tropical Cyclone Marcus severely diminished canopy cover in 2018 in every Darwin suburb. Canopy cover analysis conducted by Council revealed a significant decrease between 2017 and 2018. These historic declining trends were reversed in 2019 with the planting of over 7000 trees. Since Cyclone Marcus City of Darwin has planted in total over 12,500 trees.

Climate Change

Darwin's urban forest, like all ecosystems will continue to be impacted by a changing climate. Environmental changes include:

- Increasing temperatures
- Longer, more frequent and more intense dry spells and heat waves
- Changes in the timing, frequency, extent and intensity of annual rainfall
- Increased evapotranspiration (the process by which water is transferred from the land to the atmosphere by evaporation from the soil and transpiration from plants)
- Changes in the frequency and severity of wildfires.

These changes, which are projected to intensify, affect every aspect of life and are already causing a range of challenges including impacts on:

- Public health and wellbeing
- Environmental health, including biodiversity in Darwin's urban forest
- Water availability.

In addition to environmental changes, people that are already marginalised, vulnerable and often bear the brunt of these climate-related impacts as they are disproportionately exposed and are constrained in their capacity to respond to environmental extremes. Of particular concern, in Darwin, heat stress disproportionately impacts a range of population groups, including those that are elderly, very young, living with chronic illnesses and those who are homeless.

Fluctuating Water Availability

Water is life. Without sufficient water, Darwin's urban forest would wither thus decreasing the important benefits it provides. Water availability in Darwin is strongly influenced by the seasonal nature of rainfall in the wet/dry tropics, the variability of rainfall from year to year, climatic drivers and changes associated with climate change. Driven by climate change, consecutive poor wet seasons could result in insufficient recharge to the region's principal water supply source, the Darwin River Dam. Compounding these changes, if population and urban densification increases, this will continue to place further pressure on Darwin's water systems. The implications for increased water scarcity range from the short-term inability to meet community expectations of a 'green' municipality if the urban forest withers, to the longer-term decimation of the urban forest as irrigation needs surpass water availability for extended periods.

Conflicts between the Urban Forest and the Built Environment

Conflicts between Darwin's urban forest and built environment are common. Historically, the urban forest has felt the brunt of these conflicts. There are several reasons for this, including:

1. The City of Darwin Municipality is in a state of constant flux, which demands that urban development accommodates the infrastructure and service needs of Darwin's transforming landscape
2. Today's city has inherited the consequences of sustained poor urban forest management decisions such as, poor planting locations and species selection
3. The urban forest is currently treated as a liability, not an asset, in terms of infrastructure cost benefit assessments. As a result the multiple benefits that Darwin's urban forest deliver are not captured and factored effectively into decision making
4. Urban forest protection mechanisms within the public realm are currently inadequate
5. Gaps in community understanding of the vital importance and benefits of Darwin's urban forest.

As a result, Darwin's urban forest has been left fragmented, which isolates biodiversity and compromises the ability of different species to fulfil their role in the ecosystem and support other species.



Knowledge Gaps

Robust datasets are invaluable management tools. They pave the way for evidence-based decision making, proactive management of trees and vegetation, and highlight valuable opportunities to improve existing programs. While City of Darwin holds various parcels of data for our urban forest, there are numerous gaps in knowledge that still exist including:

- Which species are vulnerable to environmental change and how they are distributed among Darwin's urban forest
- Where to prioritise tree planting to effectively cool areas for Darwin's most vulnerable populations
- Additional datasets on how different user groups in Darwin interact with green spaces and how their needs and preferences for amenities and benefits vary.

These knowledge gaps create barriers to nurturing Darwin's urban forest of the future. Bridging these knowledge gaps will assist in fully realising this Strategy.

Resource Constraints

Resource constraints are tightly coupled with gaps in evidence based decision making. In order to implement this Strategy, Council must allocate sufficient funds and staffing resources to improve its existing program. Darwin's urban forest has not historically been prioritised because the true costs and benefits are not well integrated into decision making. A key factor of this is that the urban forest is currently conceptualised as a financial liability, which creates difficulties in allocating appropriate investment.

Weed Infestation

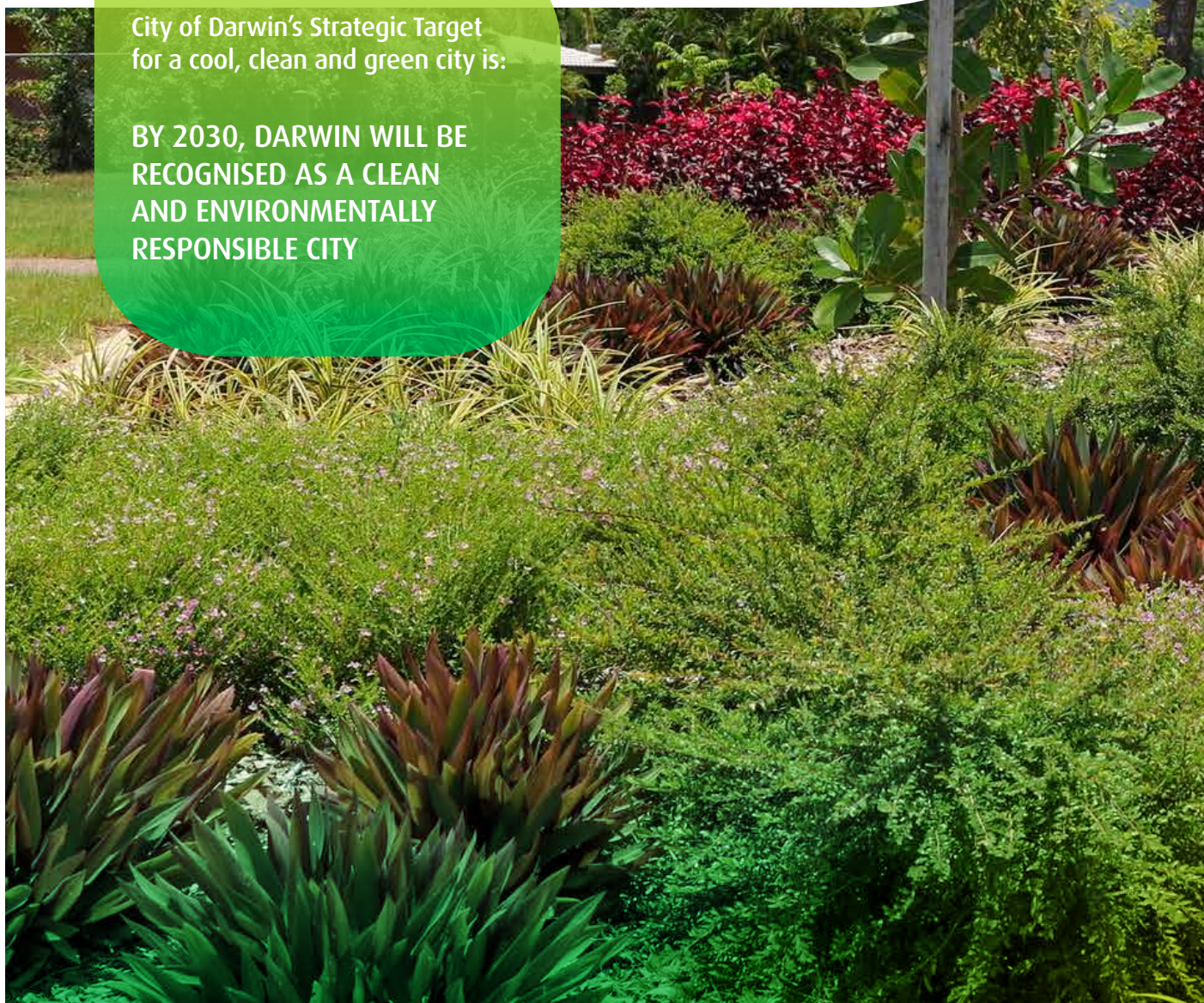
Weeds in the Darwin region present challenges to the successful implementation of the 2030 Greening Darwin Strategy. A 2013 review of weeds in East Point Reserve, for example, revealed that 77 species of weeds were present in the area, including one weed of national significance – Bellyache Bush (*Jatropha gossypifolia*) and two Class B species – coffeebush (*Senna obtusifolia*) and Hyptis (*Hyptis suaveolens*), that require growth and spread to be controlled. Gamba Grass (*Andropogon gayanus*), is also widespread. These and other weeds undermine the health and resilience of Darwin's urban forest.

Greening Darwin Key Deliverables and Priority Actions

City of Darwin's framework to achieve a cool, clean and green city is integrated as shown in the diagram on page six. This means that one initiative or action may contribute to the achievement of deliverables, targets or outcomes outlined in other City of Darwin strategy and planning documents.

City of Darwin's Strategic Target
for a cool, clean and green city is:

**BY 2030, DARWIN WILL BE
RECOGNISED AS A CLEAN
AND ENVIRONMENTALLY
RESPONSIBLE CITY**





The strategic target will be achieved by delivering a number of strategic and operational actions which will provide measurable outcomes for people, place and environment. Operational actions are outlined in the 2030 Greening Darwin Strategy Action Plan. The action plan is a flexible document that will be updated from time to time over the 10 year life of this Strategy.

The two most common ways to set measurable targets for greening strategies are to set targets based on canopy coverage and/or a net-gain of trees and other plantings planted across the municipality. City of Darwin will use a combination of both methods throughout the life of this Strategy. Key benefits for using a net gain of trees and other plantings as a key methodology is because City of Darwin:

1. Maintains direct control over the amount of trees planted and removed; in contrast, we maintain less control over the outcome (i.e. canopy coverage), particularly due to environmental events such as tropical cyclones which have the potential to decimate canopy coverage outcomes
2. Knows the requirements for amount of trees planted assists in understanding and allocating appropriate resources to achieve measurable targets
3. Understands that nurturing an urban forest is a long-term effort. Indeed, many of the trees and other plantings planted within the timeline of this Strategy won't fully realise their place in Darwin's canopy until after this Strategy has expired. Setting targets based on net-gain of trees planted therefore recognises the long-term effort required to nurture a strong and resilient urban forest in Darwin.

Changes in canopy cover, however, remains an important metric to understand and monitor. City of Darwin will use a mix of methods, including satellite imagery and scenario modelling, to understand actual and projected changes in canopy cover over time.

There are a number of headline actions for the City of Darwin to implement to achieve our strategic directions (Table 2).

Table 2: Headline Actions for the 2030 Greening Darwin Strategy

Headline Actions
Net gain of 18,000 street and park trees over 10 years.
Net gain of 900 shading trees near key transit routes over 10 years.
Net gain of 225 city centre hardscape trees over 10 years.
Increase in canopy cover over 10 years.
Collaborate with Larrakia Nation to combine Traditional Ecological Knowledge with western science to enhance knowledge and decisions to support biodiversity.
Develop a two-year prioritised planting plan by December 2022.
Develop scenario model to understand canopy coverage projections though time.
Deliver a long term scenario model to inform future tree canopy across Darwin.
Develop a prioritised planting plan with considerations for ecosystem diversity.
Further develop the list of priority species that have a broad resilience to a range of environmental extremes.

The following describes key strategic and innovative solutions to implement through the Strategy.

Challenges:
Climate Change,
Fluctuating Water
Availability

Plant for a Future Climate

Solution: Trees that are planted in the coming years as part of this Strategy will need to thrive in a rapidly changing climate. In the context of Darwin's urban forest, key environmental changes include; increased severity and prolonged periods of heat and water scarcity and increased intensity of cyclones.

As such, Darwin's urban forest needs to be resilient to a broad range of environmental conditions. Strong on-going management including risk management, care and maintenance will underpin a far more resilient urban forest in the future. Care also needs to be taken to select species that will continue to perform under changing climatic conditions. Species that are vulnerable to stress and decline in a changing climate must be identified and planned for renewal to ensure that trees live for many decades, fulfilling their role in Darwin's urban forest.

Challenge:
Resource
Constraints

Define Darwin's Urban Forest as an Asset

Solution: Defining Darwin's urban forest as an asset and recognising the myriad of social, environmental, cultural and economic benefits that the urban forest delivers will help to overcome the challenge of allocating appropriate resources to grow and maintain Darwin's urban forest. To do this, City of Darwin will update and integrate available datasets into the forthcoming Asset Management System. This will allow the economic values of the urban forest to be considered alongside a tree's whole-of-life costs to ensure long term sustainability. This consideration will incorporate cost differences among various planting areas (the costs associated with planting trees in the CBD are a lot more expensive than a tree in a park, for example). Ultimately, re-conceptualising Darwin's urban forest as an asset will allow appropriate allocation of resources to undertake activities required to nurture a thriving and robust ecosystem.

Challenge:
Knowledge
Gaps, Resource
Constraints

Deploy Smart Technologies

Solution: Increased efforts to close knowledge gaps, coupled with rapid advancements in technology, will produce a wealth of biophysical, social and economic information to enhance evidence-based decision-making for Darwin's urban forest. City of Darwin has already deployed a variety of smart technologies through the Switching on Darwin program, which represents the transition to a data-driven, people-oriented city.

Solution in the Spotlight:

Develop a Digital Twin of Darwin to Monitor and Navigate Change

Led by CSIRO through the Darwin Living Lab, the development of a Digital Twin project will enable City of Darwin to monitor change and explore interactions among key indicators and test the impact of changes in assets, systems and processes. Existing datasets will be collated, integrated and modelled to estimate a baseline distribution of living and built infrastructure in Darwin. The initial application of the Digital Twin will involve evaluating the economic value and return on investments of cooling and greening initiatives, specifically around establishing and maintaining Darwin's urban forest.



**Challenge:
Knowledge
Gap****Incorporate Traditional Ecological Knowledge and western scientific knowledge to enhance Decisions**

Solution: To mobilise City of Darwin's *Innovate Reconciliation Action Plan* and Article 7 of the Paris Agreement within the United Nations Framework Convention on Climate Change, City of Darwin will enhance our decision-making for Darwin's urban forest by integrating Traditional Ecological Knowledge (TEK) and western scientific knowledge. In line with international best practice, incorporating both knowledge systems allows for an enhanced knowledge base to achieve the outcomes of this Strategy. City of Darwin emphasises the importance of bringing Aboriginal and Torres Strait Islander voices to the forefront in decision making processes and will make use of cutting-edge technologies to develop rich datasets, which will facilitate strong, evidence based decisions for Darwin's urban forest.

Solution in the Spotlight:**Larrakia-led Darwin Biodiversity Values Research Project**

In collaboration with CSIRO through the Darwin Living Lab, Larrakia Traditional Owners and Larrakia Rangers are compiling a working list of Larrakia biodiversity values, habitats and native plant species that should be considered for Darwin urban greening and protection. This collaborative study of Darwin's biodiversity will serve as a baseline assessment and provide recommendations enhance biodiversity in Darwin through implementing this Strategy.





Generate Darwin-specific Solutions

Solution: While drawing lessons from our southerly neighbours provides invaluable insights, Darwin's urban forest exists in a unique climatic context for an Australian capital city. As a result, City of Darwin must employ a unique combination of solutions to achieve the objectives of this Strategy. Little information exists about urban greening in a savanna ecosystem so City of Darwin must heavily engage in the research and development required to strengthen our urban forest in our unique and changing context.

Challenge:
Knowledge
Gaps

Create a Resilient Urban Forest

Solution: Darwin's urban forest is a living organism, forever changing. Some changes happen slowly, such as the aging and the inevitable end-of-life of trees, others happen fast, such as tropical cyclone events that can decimate extensive sections of the urban forest in an afternoon. These events, whether they occur fast or slow, present opportunities to build back better. An important activity is to identify which species were lost and why. This will help to reveal solutions forward, including replacing lost species with species that are more resilient, or implementing changes to infrastructure, such as tree cells to support root systems.

Challenges:
Historic Net-loss
Canopy Cover,
Climate Change,
Fluctuating Water
Availability,
Conflicts between
the Urban Forest
and the Built
Environment

Enhance Collaboration with Stakeholders

Solution: Darwin's urban forest expands across a mosaic of public and private realms. City of Darwin must therefore perform a variety of roles to enhance the whole urban forest through both direct and indirect influence. To carry out these roles, City of Darwin must work across all agencies, with all levels of government and the educational and private sectors. City of Darwin will continue to collaborate with a broad variety of stakeholders, including private land owners, NT Government, Larrakia Nation and community-driven environmental management and advocacy groups.

City of Darwin already engages in crucial collaborations such as with the Darwin Living Lab (a collaboration between the CSIRO, Australian Government, NT Government, and the City of Darwin), which is an initiative of the Darwin City Deal. The Darwin Living Lab was established to foster improvements to the liveability, sustainability and resilience of Darwin and aims to:

1. Accelerate the development and validation of innovative approaches for heat mitigation in Darwin;
2. Improve urban design for the dry tropics; and
3. Build the city's resilience to the current and future climate.

Challenges:
Knowledge
Gaps, Resource
Constraints,
Conflicts between
the Urban Forest
and the Built
Environment

Solution in the Spotlight:

Gardens for Wildlife

Gardens for Wildlife is an education-based voluntary program for Darwin land owners who are interested creating wildlife habitat on their property. City of Darwin works with participants to investigate ecosystem options to enhance habitats for a variety of wildlife. The program contributes to increasing:

1. Connectivity of wildlife corridors across Darwin
2. Local understanding of our unique environment and wildlife.

ANOTHER HAPPY GARDENS FOR WILDLIFE PARTICIPANT



Solution in the Spotlight:

East Point Advisory Committee

The East Point Reserve is a significant public open space in the Darwin urban area managed by the City of Darwin. The reserve is subject to range of interacting management concerns for multiple different stakeholders. As part of City of Darwin's East Point Reserve Biodiversity Plan 2019-2024, an *East Point Advisory Committee* was established to:

1. Bring together stakeholders to share knowledge and experience, whilst identifying opportunities to enhance the reserve and improve collaboration
2. Inform and advise Council of issues within and around the reserve
3. Monitor the implementation of the East Point Reserve Biodiversity Management Plan 2019-2024.



Figure 5: Assets and services at East Point Reserve

Reforest Residences

Challenges:
Conflicts between
the Urban Forest
and the Built
Environment,
Historic Net-loss
of Canopy Cover

Solution: Darwin's urban forest expands across a mosaic of public and private realms. While each individual residential property only hosts a small fraction of Darwin's total municipality, these pockets make up almost one quarter of Darwin's municipality. It is, therefore, imperative to support Darwin residents to nurture their individual pockets of Darwin's urban forest. City of Darwin plays an indirect influence in this realm and can carry out several functions such as provision of educational advice and native plants to enhance our outcomes.

Solution in the Spotlight:

Native Plant Giveaway

To enact City of Darwin's influence on the urban forest in the private realm, a Native Plant Giveaway Program will be delivered to the Darwin community. Planting local native plants has many benefits including the provision of food sources and habitat to support local biodiversity. Local native plant species also generally require less water than introduced plant species, which will increase resilience in times of extended drying periods.





Connect Biodiversity Corridors

Solution: In Darwin, maintaining a rich biodiversity is influenced by the ability of wildlife to move from one area of the urban forest to another. Interlinked ecosystems that facilitate movement of wildlife (biodiversity corridors) sprawl across the Darwin municipality. Darwin's mosaic of public-private ownership, however, has resulted in the fragmentation of biodiversity corridors, which compromises ecosystem resilience. Reconnecting, protecting and managing these corridors with a variety of resilient species is fundamental to implementing this Strategy.

Challenges:
Conflicts between
the Urban Forest
and the Built
Environment,
Historic Net-loss
of Canopy Cover

Solution in the Spotlight:

Land Acquisition to Connect Biodiversity Corridors

For City of Darwin to appropriately reconnect, protect and manage biodiversity corridors in the Darwin municipality, options to strategically acquire parcels of land required to reconnect biodiversity corridors will be investigated. This activity reflects ongoing trends from councils across Australia that are acquiring land for conservation purposes. Biodiversity corridors unlock major opportunities to develop recreation and eco-tourism initiatives throughout the Darwin municipality. Options for raising funds for land acquisition in Darwin will be investigated.



Challenge: Climate Change

Equitably Distribute the Urban Forest

Solution: Investigations into the impacts of heat stress among Darwin's population have been carried out using physical and socioeconomic characteristics. A Neighbourhood Heat-Health Vulnerability Index (Figure 6) was generated to identify which neighbourhoods have a higher risk of heat-related illness, have fewer economic resources to cool their homes and are exposed to higher urban temperatures. This revealed that strategically prioritising planting of trees offers an equitable solution to heat stress in Darwin. Such analysis will be expanded to ensure that Darwin residents have equitable access to the urban forest and the services that they provide.

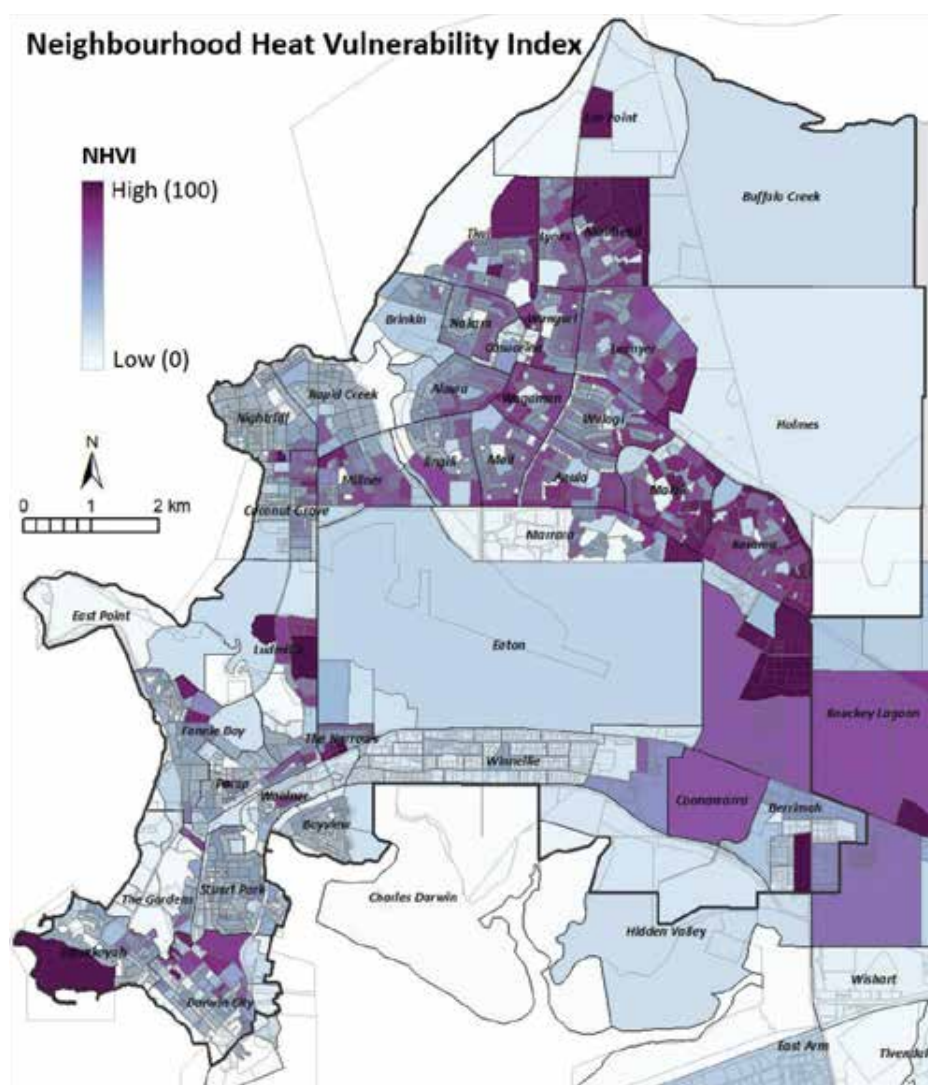


Figure 6: Neighbourhood Heat-Health Vulnerability Index in Darwin³.

³ Source: Meyers et al. (2020). Mapping land surface temperatures and heat vulnerability in Darwin. CSIRO.

Solution in the Spotlight:

Enhanced Understanding of Community Needs for Darwin's Green Spaces

Led by CSIRO through the Darwin Living Lab, research is currently being undertaken to understand how different user groups in Darwin interact with green spaces and how their needs and preferences for amenities and benefits vary. Complementing previous community engagement activities, this research will inform decision-making to reflect the diversity of community values and needs in Darwin.



Greening Darwin Action Plan

ACTIONS	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Net gain of 2,000 street and park trees.		✓	✓	✓	✓	✓	✓	✓	✓	✓
Net gain of 100 shading trees near key transit routes.		✓	✓	✓	✓	✓	✓	✓	✓	✓
Net gain of 25 city centre hardscape trees.		✓	✓	✓	✓	✓	✓	✓	✓	✓
Increase in Canopy Cover.	Over the life of the Strategy									
Continue annual re-vegetation program across the municipality.	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Develop a Remnant Vegetation Management Policy.	✓									
Develop a dedicated communications and engagement plan.	✓									
Undertake a hazards risk assessment to inform the City of Darwin emergency management response plans.	✓									
Review and update the Trees on Verges policy to include the urban forest and ensure the policy informs continuous improvement of the City of Darwin Asset Management Plans (AMPs).	✓	✓								
Partner with CSIRO to deliver the Digital Twin of Darwin program.	✓	✓								
Update inventory of significant Council owned trees into the forthcoming Asset Management System (AMS).	✓	✓								



ACTIONS	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Collect tree data from various sample sites around Darwin to inform a profile of Darwin's urban forest, including tree valuations.	✓	✓								
Ensure City of Darwin's website includes updated urban forest data and shows progress against the Strategy deliverables.	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Develop and implement a Native Plant Giveaway Program.	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Through the Darwin Living Lab program, collaborate with Larrakia Nation and CSIRO to develop a baseline vulnerability assessment of biodiversity.	✓	✓	✓							
Collaborate with key stakeholders to develop a 10-year urban forest planting plan for the CBD.	✓	✓	✓							
Review and update the City of Darwin publication titled: <i>Creating Habitats for Darwin Gardens</i> .		✓	✓							
Investigate options to strategically acquire parcels of land required to reconnect biodiversity corridors.		✓	✓							
Review and update the works permits process to ensure the protection and audit of trees during development works.		✓	✓							
Introduce requirements for Project Management Plans to assess and disclose potential damages to vegetation.		✓	✓							

ACTIONS	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Undertake a risk assessment for trees across the municipality, implement treatment plans and include provisions for regular review of outcomes.		✓	✓			✓				✓
Work with Larrakia Nation to expand on the TRAC Committee preferred trees list to include trees that are of cultural significance.		✓	✓							
Develop a prioritised 10-year urban forest planting plan.		✓	✓							
Develop Best Practice Urban Forest Management Technical Guidelines.		✓	✓							
Include trees as a defined asset class within the Asset Management Framework to:		✓	✓							
• Undertake a condition assessment and valuation of trees across the municipality			✓	✓						
• Factor renewal, replacement and maintenance costs into the long term financial plan;				✓						
• Review City of Darwin's insurance coverage for trees and natural disaster impacts.				✓						
Investigate a partnership with community groups to enhance the urban forest in areas not owned by City of Darwin or the NT Government.			✓	✓						
Develop a Best Practice Tree Management Guide for Developers.				✓	✓					
Review of Strategy deliverables.					✓					✓

[illegible]



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ESTABLISHING A RESILIENT URBAN FOREST FOR DARWIN



Best Practice Guidelines



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Reference No: 3777063
Version: 29 October 2018_Rev C



Cyclone Marcus 2018

Executive Summary

Cyclone Marcus went over Darwin on 17th March 2018. For a category 2 cyclone with wind gusts up to 130 km/hour, the damage seemed disproportionately high. The visual impact of the number of very large trees uprooted and subsequent power interruptions and infrastructure damage will remain with many residents as the indelible memory of Cyclone Marcus. A review was required to understand why so many trees failed.

The review firstly established that regardless of the best efforts and following of best practice, the community must acquire an acceptance of, and an expectation that some tree failures and losses will occur during storm events. Tree risk management options are presented in the 'Whole of Life Tree Management' section. This is an area recommended for further community consultation and education.

This report presents an assessment of 219 tree species against several attributes that contribute to cyclone resilience. Appendix A is the preferred tree list for Darwin with 194 species. Whilst a heavy weighting has been placed on observed cyclone resilience, in selecting tree species for a location it is not solely about cyclone resilience. A tree species with low or medium cyclone resilience may have a particular attribute, such as form, colour, wildlife attractant etc. that is desirable in that landscape design for a location. Some low cyclone resilience species are small and unlikely to cause damage in the event of uprooting. Appendix A therefore includes a mix of species with high, medium and low cyclone resilience. The use of any of these species needs to be tempered by an understanding of their performance in storm events and the conditions of the planting site.

Appendix B contains 25 species not recommended for planting in Darwin. This includes many with a low cyclone resilience. In addition, there are species that are highly cyclone resilient but are not recommended for planting in particular locations for other reasons such as being allergenic/poisonous, are invasive, or have nuisance fruit.

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Tree Selection



Darwin Urban Forest

To achieve the outcome of a stable tree that has a high resilience to cyclonic events requires attention to the entire life cycle of the tree. This starts with the selection of the most appropriate species through to the whole of life management of the mature tree. This report discusses the best practice options at each of the stages of plant selection, plant procurement and supply, tree installation, and whole of life tree management and provides many technical suggestions and recommendations to improve tree stability in storm events.

To facilitate future selection of tree species a matrix template of factors to be considered for any species has been developed as an aid to decision-making. These fields are presented in Appendix C and the matrix is available in the form of an Excel spreadsheet.

Some tree species appear to be more susceptible to failure in storms and others appear to have some inherent characteristics that make them more resistant, however, the majority of tree failures during storms across the Greater Darwin region can be attributed to lack of maintenance such as pruning, or root disturbance caused by cutting or damage. The report discusses tree protection and maintenance regimes. These are identified as the critical and predominant factors in improving tree stability with the clear message that a priority should be given to adopting mechanisms that avoids such damage to trees.

While the report has a focus on individual tree species there is also a discussion around the concept of developing an urban forest and the recognition of the numerous benefits that not only individual trees bring but also when trees form an urban forest. A range of trees of varying ages and attributes will collectively have a greater cyclone resilience. Such diversity is an important aspect of a resilient urban forest.

Recommendations

A summary of the key recommendations is presented grouped under the headings found within the report.

Plant Selection

1. *THAT* further evaluation should be done on the tree species in numerous individual planting sites in addition to the evaluation of many potentially suitable species that are not currently represented in the Darwin region.
2. *THAT* ongoing trials and research on potential new tree species for landscaping in Darwin could be supported by City of Darwin and undertaken collaboratively with various stakeholders in Darwin.
3. *THAT* most of the tree species in Appendices A and B are 'Unknown' for climate change resilience. This is an area in need of further research that could be promoted by City of Darwin.
4. *THAT* City of Darwin has the opportunity to liaise with the community and assess community attitudes about trees being replanted, what species, where they should be planted, and what their idea of a walkable liveable cool suburb is.

Tree Lists

5. *THAT* City of Darwin officers over time complete the desired attribute fields nominated in Appendix C to the tables shown in Appendix A and B.

Plant Procurement and Plant Supply

6. *THAT* City of Darwin prefer tree supply be given to Nursery Industry Accreditation Scheme Australia Accredited nurseries. The accreditation provides an audited best practice system for production nurseries that ensures high quality plant stock.

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Pre-order and lead times

7. *THAT* City of Darwin continue with the contract for the supply of container grown trees.

Tree Installation

8. *THAT* City of Darwin follow the Australian Standard AS 4419-2003 *Soils for Landscaping and Garden Use* with the use of “Sandy Loam” in the tree pit.

Irrigation, water harvesting

9. *THAT* City of Darwin stipulate for all tree management that watering should deliver a suitable volume of water in such a way that it penetrates the soil profile to a depth of at least 450mm.
10. *THAT* City of Darwin stipulate in civil design projects that stormwater harvesting using storm water collection inlets should be installed wherever possible, and mandatory within the CBD.

Tree data base and data collection

11. *THAT* City of Darwin use a database to systematically inventory park and street tree assets. Goal is 100% of trees in the City of Darwin municipality be identified and plotted over a 3-year period.
12. *THAT* City of Darwin program reassessment of every tree every 3 years.
13. *THAT* City of Darwin provide appropriate Council officers and arborists with adequate resources for emergency operational data gathering to react promptly following an event.
14. *THAT* City of Darwin regularly review this report and the associated tree lists every 3 years or after a significant storm event.

Ongoing maintenance and associated funding – trees are a valuable community asset

15. *THAT* City of Darwin adopt the City of Melbourne tree valuation methodology.
16. *THAT* City of Darwin actively manage the loss of trees in the municipality to maintain and increase current canopy cover levels in public open space to a minimum of 50% by 2030.
17. *THAT* City of Darwin review the Tree Management Plan to ensure it reflects the findings of this report and any recommendations endorsed by council.
18. *THAT* City of Darwin reviews its resources to maintain the urban forest to a satisfactory level.
19. *THAT* City of Darwin updates its existing policy, procedures and processes for all tree related management to meet the organisational requirements for tree risk management, tree condition assessment, tree removal, tree retention, tree replacement and development consent.
20. *THAT* City of Darwin prepare a citywide, long-term Strategic Urban Forest Management Plan.

Pruning

21. *THAT* City of Darwin adopt AS4373-2007 *Pruning of Amenity Trees* as the standard for maintaining trees.

Monitoring/ risk management/ acceptable risk thresholds

22. *THAT* City of Darwin adopts an industry standard, peer reviewed, tree risk assessment system.

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23. *THAT* City of Darwin conduct further community consultation and education to ensure the community understands the balance between an acceptable level of tree risk and the type of landscape that is envisaged for Darwin.

Tree protection

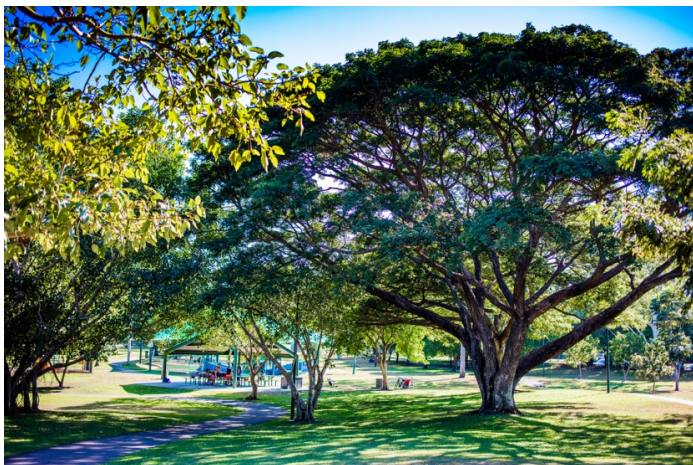
24. *THAT* City of Darwin adopt AS4970-2009 Protection of Trees on Development Sites as the standard.

25. *THAT* City of Darwin adopt mechanisms to enforce tree protection.

26. *THAT* City of Darwin review existing measures in other LGAs such as by-laws, Tree Protection Orders, Vegetation Protection overlays, tree removal/pruning permit systems, development consent requirements and the associated need for resourcing of such systems, including enforcement and surveillance.

Education

27. *THAT* City of Darwin develop and deliver tree management education programs to tree management staff, tree workers, parks crews, all contractors, (including irrigation), development assessment staff, customer service staff, high level decision makers and the wider community.



Jingili Water Gardens Urban Forest



Lake Alexander Urban Forest

Introduction

The development of an urban forest for Darwin that has improved cyclone resilience requires an explicit recognition of the numerous contributions that trees make to a city and the community. These benefits are discussed in the section on *‘Why Plant Trees?’*. The Darwin community needs to recognise that there will always be risks associated with trees and storm events but a city without trees would be an unthinkable outcome. The community needs to understand the balance between an acceptable level of risk and type of landscape that is envisaged for Darwin. Tree risk management options are presented in the Whole of Life Tree Management section. This is an area recommended for further community consultation and education.

To achieve the outcome of a stable tree that has a high resilience to cyclonic events requires attention to the entire life cycle of the tree. This starts with the selection of the most appropriate species and includes the processes of procurement, propagation, tree installation and then the whole of life management of the mature tree. A tree can be compromised at any one or more of these stages resulting in an inherently less stable tree. This report discusses the best practice options at each of these stages. This in turn will also maximise the value of trees as essential urban infrastructure and a community asset.

Presented in this report is a list of 219 tree species that have been assessed primarily for their cyclone resilience (Appendices A and B). Cyclone resilience is not the only factor that should influence the selection of trees within Darwin. There is no one perfect tree for Darwin. A range of trees of varying ages and attributes are needed to create diverse plantings that, collectively, have a greater cyclone resilience. Such a diverse tree collection is an important aspect of a resilient urban forest. There are species that are highly cyclone resilient but are not recommended for planting in particular locations for other reasons such as being allergenic/poisonous, invasive, or having nuisance fruit. These species are included in Appendix B.

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Yanyula Park

Conversely, a tree with low cyclone resilience may have an attribute such as form, colour or wildlife attractant that is desirable in a location. Where these trees are small, such as many Grevilleas and Acacias, and unlikely to cause damage in the event of uprooting, they have been included in Appendix A. The use of these species needs to be tempered by an understanding of their performance in storm events. Choosing the right trees for a site is also about factors such as proximity to infrastructure, space constraints, soil type and depth, watering regime and purpose of tree.

To facilitate future selection of tree species a matrix template of factors to be considered for a species has been developed as an aid to decision-making. These fields are presented in Appendix C and the matrix is available in the form of an excel spreadsheet. The fields relating to cyclone resilience, geographic origin, invasiveness and height x spread have been completed. It is recommended that this task should be completed for the remaining fields. Appendix C also presents a further list of attributes that should be considered in an expanded matrix tool.



Cyclone Marcus 2018

Trees and cyclone resilience

“Species have been reported to show differences in resistance to Tropical Cyclone force winds. But wind resistant species only buys you so much protection. I think the more important factors are:

- 1) soil and site conditions, and*
- 2) tree defects in the crown and root system;*

I think these outweigh the importance of species, perhaps by a lot. Lists of wind tolerant trees vary because factors 1 and 2 above over-ride species so often.

So let’s dispel the myth that we can solve wind related tree failure by selecting the right species alone

..... There is much to this and simply recommending species does a great disservice to our community.”¹

- 1. <https://hort.ifas.ufl.edu/woody/wind.shtml>*

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Shallow Roots



Resilient Forest

While cyclones pose an enduring threat to Darwin, this does not mean yards and public spaces should be without large trees. All large trees in Darwin are sufficiently mature to have survived at least one cyclone, and many trees have endured through many severe cyclonic and storm events. The wind speed, direction, duration, and the level of soil saturation are all involved with tree failure under high wind loads.

Many tree failures during storms can be attributed to lack of formative pruning and associated tree defects, such as bark inclusions on co-dominant stems, as well as wounds resulting in decay columns causing mechanical weakness. Soil saturation from heavy rain events leads to soil failure causing root plate destabilisation. Other factors include root disturbance, cutting or damage with associated fungal infections prior to a storm which contribute to root plate failure. By avoiding such damage to trees, cyclone resilience will clearly be improved.

Room for tree roots to anchor, through appropriate tree pit design and tree planting techniques, coupled with the selection of quality trees for planting will have a significant impact in reducing tree failure during storm events. Careless maintenance causes fungal infections of root systems which in turn lead to mechanical weaknesses. These issues can generally be rectified by appropriate design and thoughtful maintenance. Tree installations, with a focus on the most suitable tree for the location, combined with sensible and sustainable design and appropriate arboricultural maintenance will improve urban forest resilience against severe tropical storms and cyclones.

The community must acquire an acceptance of, and an expectation that some tree failures and losses will occur during storm events. It is impossible to have trees around people without any risk at all. In severe storm events, some trees will fall over, some will break apart, others will damage fences, cars, and buildings and other infrastructure. Many will also stand and continue to provide shade and environmental functions long after the storm has passed.



Physiological, sociological, economic and aesthetic benefits.

A resilient urban forest

The concept of an Urban Forest is utilised in the City of Darwin (CoD) CBD Master Plan (2015) and is a concept supported in this report. The following is a quote from the Darwin CBD Masterplan.

“The Urban Forest comprises the trees and vegetation throughout the Darwin City Centre, inclusive of all tree types and irrespective of whether they are on streets, in parks or on private land.

The Urban Forest, measured as a canopy cover percentage of the total land area, is recognised as a primary component of the urban ecosystem (LGA NSW 2003). It is one component of the complex-built environment along with roads, car parks, buildings, footpaths and services. Urban forests in and around urban communities provide physiological, sociological, economic and aesthetic benefits.

They are one of the most effective means of cooling a city and have been shown to greatly reduce urban heat island effects. Streetscapes and public realm open space will play a key role in the Urban Forest.

It is important that adequate provision in terms of space (above ground and underground) is made for trees.

In addition to the initial capital costs of installing trees, there should be realistic ongoing funding for tree maintenance and management to ensure the potential benefits are fully realised.

The development of individual sites by the private sector has an impact on the potential benefits of the urban forest through tree planting, green roofs, increased reflection of heat.”²

² City of Darwin CBD Masterplan 2015

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Change

Adoption of an Urban Forest concept brings with it a fundamental change to the approach in the way trees are viewed and managed. The following table summarises these changes to the approach to urban trees in Darwin:

<ul style="list-style-type: none">• Where we have been... Traditional Urban Tree Management• Trees as ornaments• Focus on individual trees• Trees treated with low priority• Trees have no monetary or economic value• Focus on smaller and ornamental species• Individual tree maintenance• Aesthetic based design only• Legal boundaries determine tree management	<ul style="list-style-type: none">• Where we need to be... Modern Urban Forestry Model• Trees viewed as critical infrastructure• Focus on overall canopy cover and forest• Trees have equal priority to other urban infrastructure such as roads and services• Economic value of forest recognised and valued• Focus on larger longer-lived canopy trees• Overall forest management• Ecological and aesthetic based design• Urban forest seen as continuous resource regardless of ownership boundaries
------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------	-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------

Table: Traditional versus modern urban forest approach (Source: North Sydney Council 2011)



Muirhead Park

WHY PLANT TREES?

"It is a sign of a great civilisation when old men and women plant trees that they may never sit under to enjoy the shade"

Greek Saying

It is true, that planting a tree is an investment in the future. It is also true that trees have much greater value than just providing a shady spot to sit and socialise. In our developing cities, trees provide multiple benefits and recent studies indicate that their value to society can be significant. Preliminary research for the Darwin CBD trees undertaken in 2016 valued the trees at \$2.4M.

In cities around Australia and the world, trees are increasingly being recognised as important Green Infrastructure, and the development of Urban Forests within our cities is becoming mainstream policy.

In our tropical city, trees are a key aspect of reducing temperatures. Dense shady tree canopies can reduce surface temperatures by up to 25 degrees and assist in reducing the overall ambient temperature. Studies have shown that this cooling effect can reduce air-conditioning costs for adjoining properties by thousands of dollars per year.

Trees are an important part of our culture, identity and character. Within Darwin, the Tree of Knowledge, the large Boab in the Post Office Carpark and numerous other Milkwoods, Banyans and Beauty Leafs are distinct and highly valued by the community. They have been meeting places providing shade and amenity for many years. They have also survived at least 4 cyclones - in 1917, 1937, 1974 (Tracy) and more recently 2018 (Marcus). Numerous surveys and public consultation undertaken by NTG and City of Darwin testify to the public's support for 'a lush, shady, tropical' city. There is widespread appreciation of tree lined shady streets and parks.

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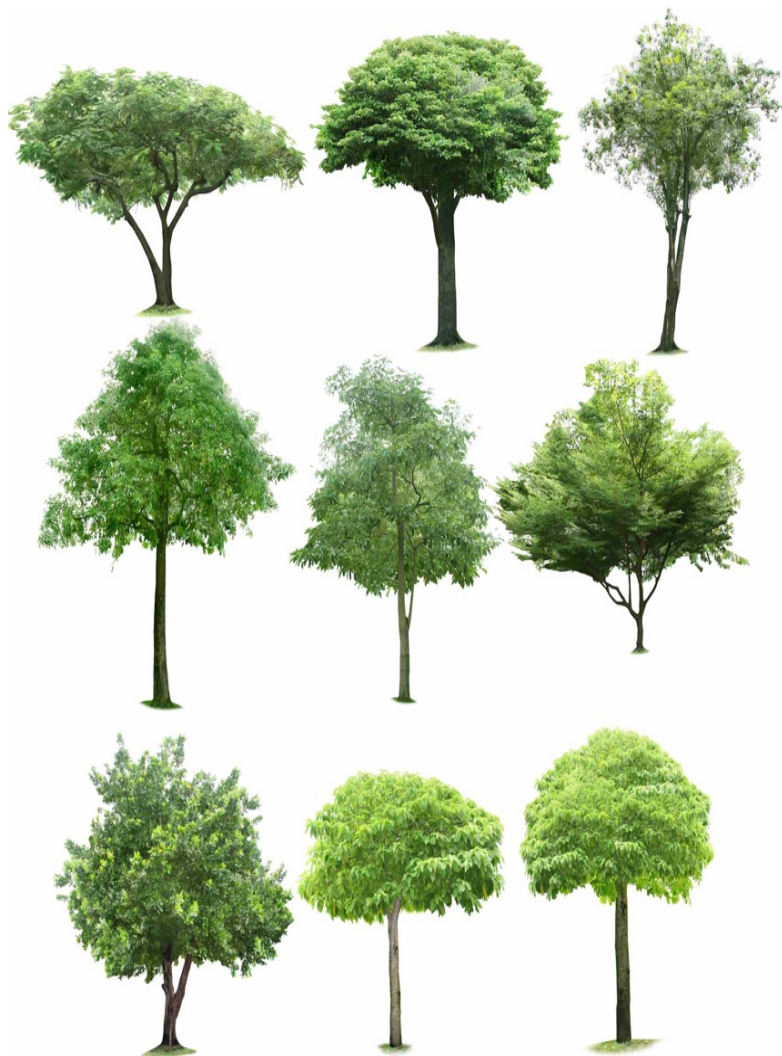


Darwin Botanical Gardens

Numerous studies within Australia and internationally demonstrate that well treed streets and suburbs are also those with higher property values. They are an investment with good returns for both private property owners and the community.

Trees provide valuable environmental benefits. Models developed and used in Australia demonstrate that the annual environmental contribution of a large, evergreen tree can be in the order of \$10,000 and higher. This is in the areas of storing carbon (counteracting carbon emissions), removal of air pollutants and particles, water retention and cleansing. Trees can also contribute to infrastructure savings by reducing flooding levels and extending the life of road pavements.

Open space, parks and trees all make important contributions to the health and well-being of residents and visitors. Shady streets and parks promote physical and social activities. This translates directly to improved physical and mental health and has been shown to result in significant reductions in health costs.



Characteristics of trees

PLANT SELECTION

Plant selection is the first and most important step in the process of establishing a healthy, resilient tree. The golden rule should always be “The right tree for the right place”.

Consider the Strategic Aspects of an Urban Forest

- Life cycle (e.g. succession planting) considerations.
- Climate change considerations.
- Species diversity as part of a resilient urban forest. Many councils have a diversity plan along the lines of no more than 30% of one family, 20% of one genus and 10% of one species. This will help stagger growth rates of trees, avoid repeating past mistakes, (too many of one species of a similar age around the entire area) assist with allowing for climate change predictions and provide a more diverse selection of options.
- Maintenance and tree establishment commitment – resources and costs.

Consider the Physical Site Characteristics

Trees take time to develop and mature – they are living systems and their environment will greatly impact on how well they establish, mature and survive. Consider:

- Existing soils, natural drainage and water movements.
- Irrigation – permanent, temporary, establishment only or none.
- Shading and exposure arising from other trees, buildings and structures.
- Fast growth or long-term stability – these are often at odds.
- Available space – both above ground and below ground – refer to ‘Tree Installation’ section.
- Constraints such as underground and overhead services and the associated authority guidelines.

ESTABLISHING A RESILIENT URBAN FOREST FOR DARWIN:
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Raintree Park



Nature Playgrounds

Consider the Functional Requirements of Trees

- Shade to buildings, streets parks and open space.
- Creation of comfortable microclimates within outdoor spaces.
- Opportunities to educate (science studies, animal and plant interaction such as caterpillars, basis for art lessons, caring for land and Indigenous studies) and demonstrate sustainable land management practices.
- Indigenous local plantings provide habitat for native fauna and increase biodiversity values in the local area.
- Planting in the playground can inspire exploration, social interaction, learning and controlled risk taking for children.
- General; amenity and appearance.

From the above it can be seen that there are many aspects to be considered in plant selection. The Appendices to this report provide guidance on tree selection in respect of cyclone resilience, weed risk and other limiting factors, but this should only be the starting point in refining the final tree selection.

Appendices A and B are primarily a review of the list tree species that are known to be planted in and around Darwin. As such it is a limitation of the report. Further work should be done in relation to the evaluation of the myriad of individual planting sites along with the evaluation of many potentially suitable species that are not currently represented in the Darwin region. Included here would be also those species in the 'Inconclusive' category of cyclone resilience in Appendix A.

These species represent possible options to increase the diversity of species available for planting and may also represent species with favourable attributes under future climate scenarios. This is a field for ongoing trials, research and risk assessment that could be supported by City of Darwin and undertaken collaboratively with various stakeholders in Darwin.



Tree Canopy Adds to Walkable Neighbourhoods

The consideration of tree selection in future climate change scenarios is of increasing importance. Will tree species planted today cope with the temperature, rainfall and storm events predicted under future climatic conditions predicted for Darwin? Kendal *et al.* (2017) provide data on the risk of temperature rises due to climate change on trees in the Darwin CBD. Alarming, all of the 41 tree species assessed were flagged as at risk with temperature rises under a 'business as usual' scenario by 2070. Climate change resilience has been included in the tree selection matrix in Appendix C. However, it must be noted there is a paucity of data available for tropical trees. Most of the species in Appendices A and B are City of Darwin as 'Unknown' for climate change resilience. This is an area in need of further research that could be carried out in Darwin.

There is also the aspect of educating and responding to community aspirations for tree selection. The City of Darwin has the opportunity to liaise with the community and assess community attitudes about trees being replanted, what species, where they should be planted, and what their idea of a walkable liveable cool suburb is.

ESTABLISHING A RESILIENT URBAN FOREST FOR DARWIN:
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City of Darwin Nursery



Nursery Stock

PLANT PROCUREMENT AND SUPPLY

It is recommended that preference for supply be given to Nursery Industry Accreditation Scheme of Australia accredited nurseries. The accreditation provides an audited best practice system for production nurseries that ensures high quality plant stock.

Pre-order and lead times

The lead time and pre-ordering of stock is critical to ensure availability of quality stock at time of planting. As an example, 25 litre plants typically take 12-18 months to grow, larger plants require even longer lead times. Even tube stock/starter plants can require 12 months lead time due to constraints of seeding times, seed availability and species selection.

Issues around delays in construction projects provides many examples where plant stock has been held by nurseries for extended times which has led to the supply of stock that has been compromised by extended holding time. End users need to know tree stock has a use-by date and contracts for supply need to state these dates and put financial liability for unused, no longer suitable, ordered stock on the end user. Specifications around *AS 2303-2015 Tree Stock for Landscape Use*, in particular relating to container type, growing media and pruning/form need to be clear and adhered to by suppliers and enforced by end users. High tree quality according to *AS 2303-2015 Tree Stock for Landscape Use* should be the expectation of all end users. It is noted that a lack of alternative quality stock regularly forces end users to use poor quality stock.

There is a need for limited quantities of high-quality stock of a pre-determined species list to be available at other times. The City of Darwin should continue with the contract for the supply of container grown trees.



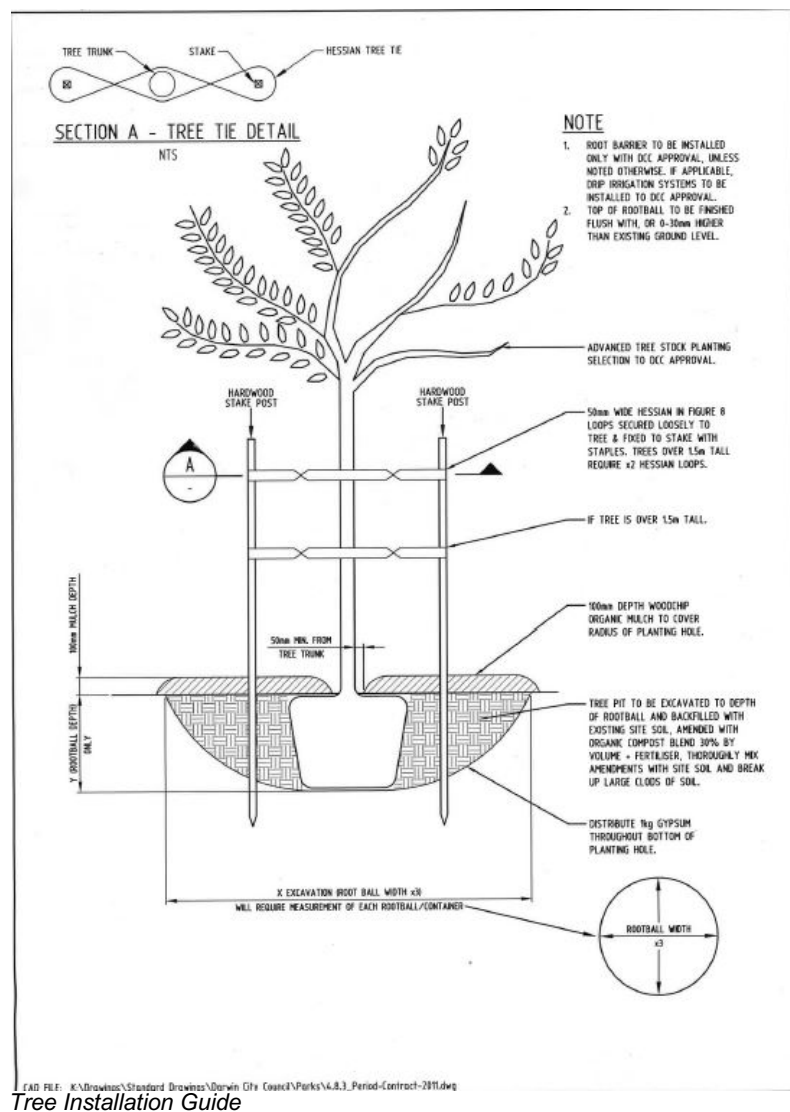
Planting

Planting sizes (initial impact v long term viability)

Current research shows that smaller propagation container size produces a better outcome over larger containers. Research has also supported that air root pruning, regardless of propagation container size will produce superior quality stock.

Smaller plants are more prone to theft, vandalism, lawn mower/whipper snipper damage though it was noted that DIPL are getting good results with tube stock if in association with appropriate plant protection. City of Darwin has found that 25-50 litre propagation container size has been the most successful planting size.

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TREE INSTALLATION

Tree planting specification – Turf/Garden areas

Tree planting in turf/Garden areas should be in accordance with the standard drawing below. Tree planting holes should be three times the diameter of the tree root ball and of the same depth. Root barrier or other impediments to lateral root growth must not be used at any time. Planting holes shall be excavated to ensure the sides of the hole are not glazed, compacted or otherwise hardened, as this has the effect of guiding the tree roots around the edge of the planting hole, causing circled and girdling roots which will have a negative effect on the trees long term resilience to high wind events.

Tree pit considerations – Size, volume, soil types, soil microbiome, drainage in urban landscapes

Ensure the maximum soil volumes possible but with minimum soil volumes specified. Industry publications and scientific findings in relation to both canopy diameters and recommended minimum soil volumes for tree rooting capacity can assist to provide specification to tree pit size and soil volume requirements for urban trees. Details are provided in Appendix E.

The Australian Standard AS 4419-2003 *Soils for Landscaping and Garden Use* should be followed with the use of “Sandy Loam” in the tree pit. The incorporation of humates and beneficial microbes prior to planting has been shown to be beneficial and can reduce the need for further fertilising.

Tree pits should be connected to stormwater or natural drainage. Woodchip mulch is preferable to paving and tree grates are preferable to permeable paving within 1500mm of tree trunks. The maximum area possible of permeable surface treatment over the structural root zone is preferred to facilitate water ingress and gas exchange.



In Ground Irrigation

Irrigation, water harvesting

In-ground irrigation is preferred over manual irrigation. Water truck irrigation is available. Drip irrigation can supply the recommended volumes. Whichever irrigation method is used watering should deliver a suitable volume of water in such a way that it penetrates the soil profile to a depth of at least 450mm.

Trees in hardscapes require watering each dry season.

The City of Darwin shall undertake a continuous 6-month watering program over the first 3 years following installation of any tree to irrigate installed trees. The works program schedule should be provided by the City of Darwin to staff and contractors engaged in watering trees. Due to varying climatic conditions, alteration of the start/finish time of the watering program and any additional watering may be advised.

Trees are to be watered via water truck or by drip line irrigation during the first three years following planting, with the following frequency:

- Three (3) times per week for the first Four (4) weeks only, after the planting date.
- Three (3) times per week for the duration of the first dry season (May 1st – October 31st)
- Two (2) times per week for the duration of the second dry season (May 1st – October 31st)
- Once (1) times per week for the duration of the third dry season (May 1st – October 31st)

At each watering event in the first-year irrigation supplied should match the volume of the container the tree was in prior to planting, for example:

25 litre tree = 25 litres per water

50 litre tree = 50 litres per water

In years 2 and 3, water volume should be a minimum of 30 litres per tree, per water event. The tree watering program should be carried out utilising qualified horticulturalists and used as an opportunity to identify issues such as pruning and pest and disease outbreak.

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Trees and Services

Stormwater harvesting using storm water collection inlets should be installed wherever possible, and mandatory within the CBD. Water sensitive urban design options that relate to Darwin rainfall patterns can be considered to create a water bank, reduce runoff and optimise tree performance. Where tree pits utilise stormwater harvesting, they should also be connected to the stormwater system to ensure positive drainage is retained in tree pits to prevent waterlogging.

Working around services

It is acknowledged that trees are essential in the CBD despite potential conflict with services. A design review involving all stakeholders would facilitate infrastructure and tree coexistence. Such a review would be particularly relevant to nature strip situations and should maximise and optimise uninterrupted soil volumes and crown space for tree establishment.

Conflict with services could be reduced by:

- Locating CBD trees in the road pavements where space in verges is restricted due to underground services or other constraints.
- Referring to the relevant service authority requirements for clearances.
- Consolidating services on one side of the street. In many suburban streets overhead lines are down one side of the road, water and sewer down the other making conflict with trees inevitable.
- Mapping high priority power/water infrastructure and ensure plantings will not interfere with main delivery lines under any circumstances.
- Defining an acceptable level of risk to infrastructure.
- Using a tree valuation method to realistically compare values with infrastructure costs.



Maintaining the Urban Forest

Establishment (Year 3) including fertilising program and formative pruning

- A fertiliser program for new plantings should be developed that provides 2 applications annually of a suitable fertiliser and 2 applications during the dry season of an appropriate soil wetting agent.
- Where possible, it is preferable to provide fertiliser and wetting agents by means of liquid application, via a water truck. Granular products may be used where necessary.
- Each tree should be mulched as per the planting specification at least once annually or as required using high quality, aged woodchip mulch with a maximum of 10% fine particles (10mm in diameter)
- Formative pruning shall be undertaken annually, and pruning must be in accordance with AS 4373-2007 – *Pruning of amenity trees*.
- Pests and diseases will be treated as required to ensure trees remain healthy and establish to their full potential.

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Location of trees affected by Cyclone Marcus 2018

WHOLE OF LIFE TREE MANAGEMENT

Tree data base and data collection

The use of a data base to systematically inventory park and street tree assets is recommended and it is noted that City of Darwin has made progress in this aspect. There needs to be a systematic approach to ensure all Council areas are covered. It is recommended that 100% of trees in the municipality be identified and plotted over a 3 year period. There should be a programmed reassessment of every tree every 3 years. The management of the tree inventory data requires dedicated software that provides the required functionality and that can interface with other IT platforms used by City of Darwin. The committee notes that *Treeplogger* software is one option that meets City of Darwin requirements.

Such an approach will assist City of Darwin with their tree management plans. Knowing what you have, and its location is a prerequisite to manage assets in a cost effective and proactive manner. TC Marcus has provided a unique opportunity for City of Darwin to conduct an inventory as there are now many thousands less trees. The inventory data is a foundation to build operational plans and will assist City of Darwin with future planning and planting plans.

Council should also use the report on TC Marcus and its data format as a basis for gathering data following future storm/cyclone events. An additional data field that should be included in future reports is to record observations on why an individual tree has failed e.g. root damage, poor pruning, disease etc. Several Council officers and arborists should be trained and allocated for emergency operational data gathering with adequate resources to react promptly following an event. Accumulating information in such a way and conducting regular reviews of this report and the associated tree lists every 3 years or after a significant storm event will continue to improve the cyclone resilience of tree plantings in Darwin.



Increasing Canopy Cover

The tree inventory, data base and resultant improved planning will facilitate a shift from reactive tree management to a proactive modern urban forest model which will result in fewer customer requests, better tree health and structure and more cost-effective operations.

Ongoing maintenance and associated funding – trees are a valuable community asset

If mature trees are properly valued, then the decision making for works in proximity to trees becomes a straight forward cost benefit analysis. The cost of activities such as realigning irrigation trenches or design and placement of footpaths can then be compared with the properly assessed value of a mature tree which may be in the tens of thousands of dollars. Added to that value can be the assessment of damage to infrastructure should the works compromise the tree stability in a future storm event.

There are tools for valuing trees in an urban setting and a good example that is relatively simple to use is the system developed by the City of Melbourne.

<https://www.melbourne.vic.gov.au/SiteCollectionDocuments/Tree-valuations.DOC>

The committee recommends that City of Darwin should review the current resource allocation concerning tree management and its ability to provide a satisfactory level of service to the Councils tree assets, and community's tree population.

City of Darwin should actively manage the loss of trees in the municipality to maintain and increase current canopy cover levels in public open space to a minimum of 50% by 2030.

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Tree Management

The committee recommends that City of Darwin should review all tree related policy and process and assess for their ability to meet the organisational requirements for tree risk management, tree condition assessment, tree removal, tree retention, tree replacement and development consent, and for their performance against contemporary best practice urban forest management models and existing/future strategic outcomes. A citywide, long-term Strategic Urban Forest Management Plan is required.

Following the endorsement of this report and any recommendations that are accepted by council the *Tree Management Plan* should be reviewed to ensure that the *Tree Management Plan* accurately reflects the findings of this report and any recommendations endorsed by council.

Irrigation/ supplementary watering

Watering regimes for the first 3 years are discussed under the Tree Establishment section. After 3 years most, trees should be sufficiently established to survive without additional watering. There may be locations where additional watering is needed but this should be assessed on a case by case basis.

City of Darwin in conjunction with other stake holders should investigate the use and installation of storm water collection inlets for storm water harvesting and watering of street trees.

Pruning

For long term management of trees AS4373 *Pruning of Amenity Trees* is recommended.

Monitoring/ risk management/ acceptable risk thresholds

The community needs to understand and have an expectation and acceptance of tree failure(s) during cyclonic and major storm events; it is inevitable.



Tree Management

Therefore, a tree risk threshold needs to be defined and understood by the community and this may require some effort in community education. What level of tree risk is acceptable and what level is not, and what level of risk requires intervention. In the development of risk thresholds there must be a consideration of cyclonic strength wind events. This should be balanced by the demonstrable benefits that trees provide during cyclonic events. A tree risk inspection program that identifies and consequently mitigates tree risk to avoid or reduce exposure to legal liability claims is integral to such a risk management strategy.

It is recommended City of Darwin adopts an industry standard, peer reviewed, tree risk assessment system. The International Society of Arboriculture Tree Risk Assessment Qualification (TRAQ) method (Dunster 2017) and the Quantified Tree Risk Assessment system (QTRA 2018) are two methods worth considering. A tree risk assessment system would be used to develop risk thresholds and points where intervention is required and lead to a balanced and proportionate tree risk management approach.

Tree protection

The management and care of the below ground portion of a tree is as important as the management of the above ground portion. If tree roots are not protected, then it is irrelevant what species are planted. Damage to large portions of any tree root system will compromise the tree and contribute significantly to instability and uprooting in a storm event.

There is an Australian Standard - *AS4970-2009 on Protection of Trees on Development Sites*. This should be followed but more importantly Council should consider mechanisms to enforce tree protection. One effective means to protect public trees could be achieved by integrating the requirements of *AS4970-2009 Protection of Trees on Development Sites* into council development processes.

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Tree Management

AS4970-2009 should be incorporated into City of Darwin council's works permit system. Works within 3 meters of any tree less than 5 meters in height, or within the Tree protection zone of any tree greater than 5 meters in height must have a works permit issued, with conditions in place to ensure the protection of the tree as per the standard in place. City of Darwin should encourage all other NT government departments to follow suit.

The committee recommends that Council should review existing measures in other LGA's such as by-laws, Tree Protection Orders, Vegetation Protection overlays, tree removal/pruning permit systems, development consent requirements and the associated need for resourcing of such systems, including enforcement and surveillance. The establishment of a bond on tree assets for protection has been used by City of Darwin during construction of the Raintree Park upgrade. The implementation and success of this should be reviewed by Council as a possible option for all construction activities in proximity of trees on Council land.

Education

It is recommended that City of Darwin develop and deliver tree management education programs to tree management staff, tree workers, parks crews, all contractors, (including irrigation), development assessment staff, customer service staff, high level decision makers and the wider community. This would include educating all stake holders on the importance of the recommendations in this document and the repercussions if these guidelines are not adhered to.



Gardens Road

Conclusion

Darwin needs its urban forest as the effects of climate change, the need to attract and retain population and tourism continue to grow. Adoption by City of Darwin of the full cycle of tree management recommended in this report, assists City of Darwin to retain and increase its urban forest well into the future, even in the event of cyclones such as Marcus 2018.

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AS 4419-2003 Soils for landscaping and garden use.

<https://www.standards.org.au/standards-catalogue/sa-snz/consumer/cs-037/as--4419-2003>

AS 4970-2009 Protection of trees on development sites.

<https://www.standards.org.au/standards-catalogue/sa-snz/agriculture/ev-018/as--4970-2009>

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APPENDICES

APPENDIX A

PREFERRED TREES FOR DARWIN

A tree with low cyclone resilience may have an attribute such as form, colour, wildlife attractant that is desirable in a specific location. Where these trees are small, such as many Grevilleas and Acacias, and unlikely to cause damage in the event of uprooting, they have been included in Appendix A.

Similarly, trees that have been recognised as having a medium cyclone resilience because of issues with branch drop or trunk splitting are included here. The use of these species needs to be tempered by an understanding of their performance in storm events and careful consideration of the planting location.

Genus Name	Species Name	Common Name	Origin	Cyclone resilience
Acacia	dunnii	Elephant Ear Wattle	NT Native	Low
Acacia	torulosa		NT Native	Low
Acacia	latescens		NT Native	Medium
Adansonia	gregorii	Boab	NT Native	High
Adansonia	digitata	African Boab	Exotic	Medium
Adenanthera	pavonina	Red Bead Tree	NT Native	Medium
Aidia	racemosa	Archer Cherry	NT Native	High
Albizia	lebeck	White Siris	NT Native	Medium
Albizia	saman	Rain Tree	Exotic	Medium
Allosyncarpia	ternata	Allosyncarpia	NT Native	Medium
Alphitonia	excelsa	Red Ash	NT Native	Medium
Alstonia	actinophylla	Northern Milkwood	NT Native	High
Antidesma	ghaesembilla		NT Native	High
Araucaria	cunninghamii subsp. cunninghamii	Hoop pine	Australian Native	Medium
Archontophoenix	alexandrea	Alexandra Palm	Australian Native	High

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Genus Name	Species Name	Common Name	Origin	Cyclone resilience
Arfeuillea	arborescens	Hop Tree	Exotic	High
Asteromyrtus	magnifica		NT Native	High
Asteromyrtus	symphyocarpa	Liniment Tree	NT Native	High
Banksia	dentata		NT Native	High
Barringtonia	asiatica	Poison tree	Exotic	High
Barringtonia	acutangula	Freshwater Mangrove	NT Native	Medium
Bauhinia	variegata	Purple Bauhinia	Exotic	Low
Berrya	cordifolia	Trincomalee	Exotic	Inconclusive
Bismarkia	nobilis	Bismark Palm	Exotic	Medium
Bombax	ceiba	Kapok Tree	NT Native	High
Brachychiton	diversifolius	Kurrajong	NT Native	High
Brachychiton	rupestris		Australian Native	Inconclusive
Brownea	spp.		Exotic	Medium
Browneopsis	ucayalina		Exotic	High
Buchanania	arborescens	Little Gooseberry Tree	NT Native	High
Buchanania	obovata	Green Plum	NT Native	High
Caesalpinia	ferrea	Leopard Tree	Exotic	Medium
Callistemon	viminalis	Weeping Bottlebrush	Australian Native	High
Callitris	intratropica	Northern Cypress Pine	NT Native	High
Calophyllum	inophyllum	Beauty Leaf	NT Native	High
Calophyllum	sil		NT Native	High
Canarium	australianum	Melville Island White Beech	NT Native	High
Carallia	brachiata	Bush Current	NT Native	High
Cassia	nodosa	Rainbow Shower	Exotic	High
Castanospermum	australe	Black Bean	Australian Native	High
Casuarina	equisetifolia	Coastal She-Oak	NT Native	Medium
Casuarina	papuana		Exotic	Medium

Genus Name	Species Name	Common Name	Origin	Cyclone resilience
Casuarina	cunninghamiana	Riverine Casuarina	NT Native	Inconclusive
Celtis	philippensis		NT Native	High
Citharexylum	spinosum	Fiddlewood	Exotic	Medium
Citrus	latifolia	Lime	Exotic	High
Clerodendrum	floribundum	Clerodendrum	NT Native	Medium
Coelospermum	reticulatum		NT Native	Low
Cordia	subcordata	Kerosene Wood	NT Native	Medium
Corymbia	ptychocarpa	Swamp Bloodwood	Australian Native	Medium
Corymbia	polycarpa	Long-Fruited Bloodwood	Australian Native	Medium
Corymbia	bleeseri	Smooth stemmed bloodwood	NT Native	Medium
Corymbia	jacobsiana	String Barked Bloodwood	NT Native	Medium
Corymbia	arnhemensis	Katherine Gorge Bloodwood	NT Native	Medium
Corymbia	papua	Ghost Gum	Australian Native	Medium
Corymbia	polysciada	Apple Gum	NT Native	Medium
Corymbia	bella	Ghost Gum/White Gum	NT Native	Medium
Cupaniopsis	anacardioides	Tuckeroo	NT Native	High
Cyclophyllum	schultzii	Canthium	NT Native	High
Denhamia	obscura	Denhamia	NT Native	High
Dillenia	alata	Red Beech	NT Native	Medium
Dillenia	indica	Elephant Apple	Australian Native	Medium
Diospyros	compacta	Australian Ebony	NT Native	High
Diospyros	maritima	Broad Leaved Ebony	NT Native	High
Diospyros	nigra	Black Sapote	Exotic	Medium
Dodonea	platyptera	Hop Bush	NT Native	Low
Dyopsis	lutescens	Golden Cane	Exotic	High
Dyopsis	madagascariensis	Malagasy Palm	Exotic	High

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Genus Name	Species Name	Common Name	Origin	Cyclone resilience
Elaeis	guineensis	African Oil Palm	Exotic	High
Erythrina	variegata	Coral tree	NT Native	Medium
Erythrophleum	chlorostachys	Ironwood	NT Native	High
Eucalyptus	apodophylla	White bark	NT Native	High
Eucalyptus	alba	White Gum/Salmon Gum	NT Native	Medium
Eucalyptus	herbertiana	Herbert's Gum	NT Native	High
Eucalyptus	nesophila	Melville Island Bloodwood	NT Native	High
Eucalyptus	bigalerita	Northern Salmon Gum	NT Native	Medium
Eucalyptus	miniata	Darwin Woollybutt	NT Native	Medium
Eucalyptus	oligantha	Broad-leaved Box	NT Native	Medium
Eucalyptus	phoenicea	Scarlet Gum	NT Native	Medium
Eucalyptus	tectifera	Darwin box	NT Native	Medium
Eucalyptus	tetradonta	Northern Stringybark	NT Native	Medium
Eucalyptus	tintinnans	Hills Salmon Gum	NT Native	Medium
Fagraea	racemosa	Fagraea	NT Native	Inconclusive
Ficus	scobina	Sandpaper Fig	NT Native	High
Ficus	virens	Banyan	NT Native	High
Ficus	coronulata	Peach-Leaf Fig	NT Native	High
Ficus	opposita	Sandpaper Fig	NT Native	High
Ficus	racemosa	Cluster Fig	NT Native	High
Ficus	rubignosa	Port Jackson Fig	Australian Native	Medium
Ficus	longifolia	Narrow Leaf Fig	Exotic	Medium
Ficus	brachypoda	Rock fig	NT Native	Inconclusive
Ganophyllum	falcatum	Scaly Ash	NT Native	Medium
Gardenia	megasperma		NT Native	High
Gardenia	fucata		NT Native	Medium
Grevillea	angulata	Holly Leaf Grevillea	NT Native	High

Genus Name	Species Name	Common Name	Origin	Cyclone resilience
Grevillea	heliosperma	Rock Grevillea	NT Native	High
Grevillea	parallela	Silver Oak	NT Native	Low
Grevillea	pteridifolia	Fern-Leaved Grevillea	NT Native	Low
Grevillea	refracta	Silver-Leaf Grevillea	NT Native	Medium
Grevillea	decurrens	Clothes-peg Tree	NT Native	Medium
Helicia	australasica	Helicia	NT Native	Inconclusive
Hibicus	tiliaceus	Beach Hibiscus	NT Native	Medium
Hibicus	tiliaceus var. rubra	Red Beach Hibiscus	NT Native	Medium
Horsefieldia	australiana	Nut Horsfieldia	NT Native	High
Hydriastele	wendlandiana	Florence Falls Palm	NT Native	High
Hyophorbe	verschaffeltii	Spindle palm	Exotic	High
Jacksonia	dilatata	Jacksonia	NT Native	High
Kigelia	pinnata	Sausage Tree	Exotic	High
Lagerstroemia	indica	Crepe Myrtle	Exotic	High
Lagerstroemia	speciosa	Pride Of India	Exotic	Medium
Latania	loddigesii	Blue Latan Palm	Exotic	High
Leptospermum	madidum	Weeping Tea Tree	NT Native	High
Licuala	ramsayii	Queensland Fan palm	Australian Native	High
Livistona	benthamii	Benthams Fan Palm	NT Native	High
Livistona	humilis	Sand Palm	NT Native	High
Livistona	inermis	Whispy Fan Palm	NT Native	High
Livistona	mariae subsp. rigida	Mataranka Fan Palm	NT Native	High
Livistona	muelleri	Northern Cabbage Palm	Australian Native	High
Lophostemon	grandiflorus subsp. riparius	Northern Swamp Box	NT Native	High
Lophostemon	lactifluus	Swamp box	NT Native	High
Lyrata	pandurata	Fiddleleaf fig	Exotic	Inconclusive
Mangifera	indica	Mango	Exotic	Medium

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Genus Name	Species Name	Common Name	Origin	Cyclone resilience
Maniltoa	lenticellata	Silk handkerchief tree	Australian Native	High
Maranthes	corymbosa	White Cloud Tree	NT Native	High
Melaleuca	leucadendra	Weeping Paperbark	NT Native	High
Melaleuca	argentea	Silver-Leaved Paperbark	NT Native	High
Melaleuca	bracteata	Black tea tree	NT Native	High
Melaleuca	cajuputi	Paperbark	NT Native	High
Melaleuca	dealbata	Paperbark	NT Native	High
Melaleuca	minutifolia	Paperbark	NT Native	High
Melaleuca	nervosa	Fibre bark	NT Native	High
Melicope	elleryana	Euodia	NT Native	Low
Micromelum	minutum		NT Native	High
Miliusa	brahei	Miliusa	NT Native	High
Millettia	pinnata	Indian Beech	NT Native	Medium
Mimusops	elengi (cultivated)	Mimusops Red Condoo	Exotic	High
Mimusops	elengi (NT native)	Mimusops	NT Native	High
Mimusops	elengi cv. Street Elegance	Mimusops "Street elegance"	Exotic	High
Monoon	australe	Northern Territory Polyalthia	NT Native	Medium
Morinda	citrifolia	Rotten Cheese fruit	NT Native	High
Myoporum	acuminatum	Boobialla	Australian Native	Inconclusive
Myristica	insipida	Wild Nutmeg	NT Native	High
Nauclea	orientalis	Leichardt Tree	NT Native	High
Peltophorum	pterocarpum	Yellow Flame Tree	NT Native	Medium
Persoonia	falcata	Milky plum	NT Native	High
Petalostigma	pubescens	Quinine Tree	NT Native	High
Phaleria	clerodendrum	Butterfly Tree/Scented Daphne	Australian Native	High

Genus Name	Species Name	Common Name	Origin	Cyclone resilience
Pittosporum	moluccanum		NT Native	Medium
Pittosporum	angustifolium	Native Apricot	NT Native	Inconclusive
Planchonia	careya	Cocky Apple	NT Native	High
Pleiogynium	timoriense	Burdekin plum	Australian Native	High
Plumeria	obtusa	Singapore Frangipani	Exotic	High
Plumeria	rubra	Frangipani	Exotic	High
Polyalthia	longifolia	Polyalthia	Exotic	Medium
Polyalthia	longifolia subsp. pendula	Indian Mast Tree	Exotic	Medium
Pterocarpus	indicus	PNG Rosewood	Exotic	Medium
Ptychosperma	macarthurii	Macarthur palm	NT Native	High
Roystonea	regia	Cuban Royal Palm	Exotic	Medium
Saraca	spp.		Exotic	Medium
Schefflera	actinophylla	Umbrella Tree	NT Native	Medium
Schleichera	oleosa	Ceylon Oak	Exotic	High
Staphylea	pinnata	European Bladdernut	Exotic	Medium
Sterculia	quadrifida	Peanut Tree	NT Native	High
Sterculia	holtzei		NT Native	Inconclusive
Syzygium	forte	White Bush Apple	NT Native	High
Syzygium	nervosum	Daly River Satinash	NT Native	High
Syzygium	suborbiculare	Red Bush Apple	NT Native	High
Syzygium	minutuliflorum	Gove Satinash	NT Native	Medium
Syzygium	armstrongii	Bush Apple	NT Native	High
Syzygium	fibrosum	Small Red Bush Apple	NT Native	High
Syzygium	cumini	Java Plum	Australian Native	Low
Syzygium	angophoroides	Satinash	NT Native	Medium
Syzygium	jambos	Rose Apple	Exotic	Inconclusive
Syzygium	eucalyptoides subsp. eucalyptoides		NT Native	High

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Genus Name	Species Name	Common Name	Origin	Cyclone resilience
Tabebuia	aurea	Silver Trumpet Tree	Exotic	Medium
Tabebuia	rosea	Rosy Trumpet Tree	Exotic	Medium
Tabebuia	pallida	Pink Trumpet Tree	Exotic	Medium
Tabebuia	palmerii		Exotic	Medium
Tabernaemontana	orientalis	Iodine bush	NT Native	High
Tamarindus	indica	Tamarind	Exotic	High
Tectona	grandis	Teak	Exotic	Medium
Terminalia	ferdinandiana	Billy Goat Plum	NT Native	High
Terminalia	microcarpa	Damson Plum	NT Native	High
Terminalia	catappa	Indian Almond	NT Native	High
Terminalia	platyphylla	Wild Plum	NT Native	Medium
Terminalia	arostrata	Nutwood	NT Native	Inconclusive
Terminalia	belliricia	Bahera	Exotic	Inconclusive
Terminalia	melanocarpa		Australian Native	Inconclusive
Timonius	timon	Tim-Tim	NT Native	High
Veitchia	merillii	Manilla palm	Exotic	High
Vitex	glabrata		NT Native	Inconclusive
Wrightia	pubescens	Wrightia	NT Native	Low
Xanthostemon	paradoxus	Bridal Tree	NT Native	High
Xanthostemon	chrysanthus	Golden Penda	Australian Native	High

APPENDIX B

TREES RECOMMENDED NOT TO BE PLANTED

Most of the species with a low cyclone resilience have been recommended to be avoided in plantings in Darwin. In addition, there are species that are highly cyclone resilient but are not recommended for planting in particular locations for other reasons such as being allergenic/poisonous, are invasive, or have nuisance fruit. These species are also included here in Appendix B.

Genus Name	Species Name	Sub species	Common Name	Notes
Acacia	auriculiformis		Black Wattle	Low cyclone resilience and high risk to property and life
Alstonia	scholaris		White Cheesewood	Highly allergenic
Artocarpus	altilis		Breadfruit	Large dangerous fruit
Artocarpus	heterophyllus		Jackfruit	Large dangerous fruit
Averrhoa	carambola		Star Fruit	Environmental weed
Azadirachta	indica		Neem	Declared weed
Carpentaria	acuminata		Carpentaria Palm	Caustic fruits
Caryota	spp.		Fishtail Palm	Low cyclone resilience and environmental weed
Cascabela	thetia		Yellow Oleander	Low cyclone resilience and environmental weed
Cassia	fistula		Golden Shower	Environmental weed
Cassia	siamea		Siamese cassia	Environmental weed
Cocos	nucifera		Coconut Palm	Large dangerous fruit
Delonix	regia		Poinciana	Environmental weed
Eucalyptus	camaldulensis		River Red Gum	Low cyclone resilience and high risk to property and life

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Genus Name	Species Name	Common Name	Origin	Cyclone resilience
Ficus	benjamina		Weeping Fig	Low cyclone resilience and high risk to property and life
Ficus	microcarpa	hillii	Hill's Weeping Fig	Low cyclone resilience and high risk to property and life
Gauzuma	ulmifolia		West Indian Elm	Environmental weed
Gmelina	arborea		Gmelina	Environmental weed
Khaya	senegalensis		African Mahogany	Low cyclone resilience and high risk to property and life
Khaya	grandifoliola		Big Leaf Mahogany	Low cyclone resilience and high risk to property and life
Khaya	nyasica		African Mahogany	Low cyclone resilience and high risk to property and life
Psidium	guajava		Guava	Environmental weed
Pterocarpus	indicus	pendula	Weeping Rosewood	Low cyclone resilience and disease prone
Spathodea	campanulata		African Tulip	Low cyclone resilience and environmental weed
Wodyetia	bifurcata		Fox Tail Palm	Low cyclone resilience and high risk to property and life

APPENDIX C TREE SELECTION MATRIX (TEMPLATE)

Family Name

Genus Name

Species Name

Sub species Name

Common Name

Overall Species rating – select from ‘Preferred’, ‘Not to be planted’

Origin – select from ‘NT Native’, ‘Australian Native’, ‘Exotic’

Cyclone resilience – select from ‘High’, ‘Medium’, ‘Low’, ‘Unknown’

Cyclone Resilience source – select from ‘Marcus report’, ‘Yasi Report’, ‘Tracy report’, ‘Committee consensus’, ‘Personal observation’

Climate change resilience – select from ‘High’, ‘Medium’, ‘Low’, ‘Unknown’

Species Leaf Type – select from ‘Evergreen’, ‘Deciduous’

Form – select from ‘Large tree (excurrent)’, ‘Large tree (decurrent)’, ‘Medium tree (excurrent)’, ‘Medium tree (decurrent)’, ‘Small tree (excurrent)’, ‘Small tree (decurrent)’, ‘Shrub’

Growth Rate – select from ‘Fast’, ‘Moderate’, ‘Slow’, ‘Unknown’

Longevity – select from ‘>50 years’, ‘20 - 49 years’, ‘10 - 19 years’, ‘<10 years’, ‘Unknown’

ESTABLISHING A RESILIENT URBAN FOREST FOR DARWIN:
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Height - meters

Spread - meters

References

Habitat – select from ‘Wet rainforest’, ‘Dry Rainforest’, ‘Eucalypt woodlands’, ‘Savannah’, ‘Coastal Wetlands’, ‘Riparian forest’

Succession category – select from ‘Pioneer’, ‘Intermediate’, ‘Climax’, ‘Unknown’

Suitable for large parks – select from ‘Suitable’, ‘Unsuitable’

Suitable for small parks – select from ‘Suitable’, ‘Unsuitable’

Suitable for road reserves – select from ‘Suitable’, ‘Unsuitable’

Suitable for Urban landscapes – select from ‘Suitable’, ‘Unsuitable’

Suitable for drainage swales – select from ‘Suitable’, ‘Unsuitable’

Irrigation requirement – select from ‘Dryland’, ‘Turf Irrigation’, ‘Deep watering’

Weed Status – select from ‘Non-invasive’, ‘Invasive – Undeclared’, ‘Declared Class A+C’, ‘Declared Class B+C’, ‘Unknown’

Notes

A further series of attributes are potentially useful and could be added to the selection matrix to aid in species selection. The following Table lists those attributes for consideration. However, for many of these attributes there are no or little data available particularly for native Top End trees. These attributes are listed primarily as an indication for future research.

Tree Species Additional Selection Criteria

- Water requirement (Drought tolerance)
- Water requirement (Waterlogging tolerance)
- Soil compaction tolerance
- Soil Ph. requirement
- Soil Volume requirement
- Soil Elements requirement
- Heat tolerance (temperature)
- Wind tolerance
- Pollution tolerance
- Light requirement (Shade tolerance)
- Mature Crown Size (Canopy cover potential)
- Paved Area tolerance
- Past Urban Performance (Adaptability)
- Shade Density
- Mature Crown Form
- Maintenance requirements
- Tree litter production
- Pathogen and pest susceptibility
- Allergen potential
- Power line (overhead) proximity suitability
- Stock quality
- Stock availability
- Aesthetic/Flowering attributes

APPENDIX D

PLANT PROCUREMENT CONTRACT TEMPLATE

CITY OF DARWIN – TREE PROCUREMENT SPECIFICATIONS
SINGLE PROJECT – SUPPLY OF PLANTS/TREES

Trees are generally the most visible element in the landscape. They are both living organisms and potentially very large structures that may live for many decades or even centuries.

It makes sense that trees that are ordered from growers should be of the best possible quality to ensure that they establish and succeed in the landscape. Money well spent at the early stages of a landscape project assists in more rapid returns on investment.

One of the most common reasons for the failure of newly planted trees to grow and establish in the landscape is poor quality stock, especially below ground. Girdled and kinked root systems limit the ability of the tree to take up water and nutrients and may provide inadequate support. Stems with inadequate taper cannot support themselves and encourage the use artificial supports such as stakes and ties. Tall plants in undersized containers generally have insufficient root volume to support them both biologically and physically.

Growing quality trees takes skill and care. Trees are living organisms that respond uniquely to their growing environment, including that of the nursery. Plants grown in containers can quickly reach their 'use by date' and must be sold, planted or potted-on to remain viable. Unlike manufactured items, they cannot be stored indefinitely and there will always be a degree of variability between even the most closely specified trees.

It is important to note that well-grown trees in themselves are not a guarantee of success in the landscape. The quality of trees is only one part of the process and must be combined with good planning and design, appropriate species selection, correct planting and establishment techniques and ongoing maintenance.

The majority of this Tree Procurement Contract's Specifications are derived from *Specifying Trees: a guide to assessment of tree quality* by Ross Clark, published in 2003 by NATSPEC/Construction Information, Milsons Point. It is based on extensive measurement and assessment of nursery-grown trees.

CONDITIONS OF CONTRACT

CONTAINER TYPE AND PRODUCTION SPECIFICATION

All trees included in this growing contract are to be grown throughout all stages in 3 dimensional air root pruning containers. Standard smooth walled pots are not acceptable for this contract. Exact pots to be used are to be agreed to by City of Darwin prior to contract commencement.

Propagation from seed/cutting in seed trays is permissible, but production methods must have strict quality control mechanisms when pricking out to ensure no J-rooting or other root defects occur.

Potting-on of trees throughout various pot sizes throughout the production phase must be conducted during optimal root colonisation periods. Where possible, pot directly into the largest pot practical for plant growth and uninterrupted root development. Girdling roots or unconsolidated rootballs will not meet the required quality standard, and will be rejected.

Potting media is to conform with AS 3743-2003.

ABOVE GROUND STANDARD

The above ground qualities of a landscape tree are what is seen by the client, and generally what the trees will be judged on by the public. Maintaining an aesthetically pleasing crown, branches, and stem provides a desirable outcome. Correct nursery production of crown, branch and stem can also provide improved health, improved safety, and longer life expectancy to landscape trees.

The above-ground quality shall comply with the following requirements:

True to type

Individual trees and batches shall be clearly labelled. Correct botanical nomenclature is preferred.

Health and vigour

- (a) *Health*—Foliage size, texture and colour at time of delivery shall be consistent with the size, texture and colour shown in healthy specimens of the nominated species.
- (b) *Vigour*—Extension growth shall be consistent with that exhibited in healthy specimens of the species nominated.

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Pest and disease

In general, trees shall show no evidence of pests or disease. However, a small amount of insect attack is common for native species (as they grow with their native pests).

Injury

Trees shall be free from injury, such as: damage caused by ties, stakes and labels, sunburn, rough handling or storms.

Self-supporting

Trees shall be self-supporting without the mechanical support of stakes/ties.

Stem taper

The stem diameter at any given point on the stem shall be greater than the stem diameter at any higher point on the stem.

Pruning

Pruning practices in the nursery impact on the aesthetics, the structural integrity or the health of the tree. It is important that pruning practices benefit the tree's development.

- (c) All pruning shall be clean-cut at the branch collar.
- (d) Any pruning has been carried out in such a way as to allow the tree to quickly seal the pruning wound, without long-term damage to the tree. Pruning should be in compliance with 'natural target' pruning undertaken as given in AS 4373.
- (e) Pruning trees just before shipment should be minimized. Tree's shall been grown to conform with a specified clear stem height requirement throughout it's production, rather than having the lower branches removed just before shipment.
- (f) Stress on the trunk is reduced, healthy growth rates are maintained and adequate stem taper is maintained by not lifting the crown of the tree too high.

Apical dominance

For trees with an excurrent form, trees supplied shall have a defined central leader with the apical bud intact.

Crown symmetry

Difference in crown distribution on opposite sides of the stem axis shall not exceed 20%.

Stem structure

For trees with excurrent form, there shall be a single stem in the centre of the crown.

For trees with decurrent form, the central stem shall not be divided at any point lower than the clean stem height specified and the stem junction at the point of division must be sound.

For all trees, branch diameter should be less than or equal to one-half of the stem diameter immediately above the branch junction.

Included bark

Included bark in crotches is a common cause of structural weakness in the branch or stem junction and can result in breakages during storms. Many failures in mature trees occur as a result of increased leverage on weakly attached stems or branches.

The branch/stem bark ridges at junctions between stems and branches and between City of Darwin dominant stems shall be convex.

Trunk position

To allow the development of the root system symmetrically about the trunk it is important that the trunk of the tree is in the middle of the rootball.

The distance from the centre of the trunk to the extremity of the rootball shall not vary by more than 10%. The smallest dimension must not be less than 90% of the largest dimension.

Indication of North

The correct orientation of a tree can be important to the success of that tree in its new location (i.e. ensuring that the cambium sheltered from the sun in the nursery is not exposed on planting). This is particularly important in large trees. For trees in containers larger than 100 L, the northerly aspect in the nursery must be clearly indicated in such a way as to not be erased or misplaced in transit.

BELOW GROUND STANDARD

The tree below ground (the root system) is what we do not see and specifications generally do not deal with it well, if at all. The root system, however, is just as important as the tree above ground and, as such, should receive the same amount of attention. The root system of a landscape tree must have enough overall surface area, and be sufficient to take up water and nutrients. Importantly, it must also be well structured so it can grow-on and support the tree indefinitely.

The below-ground quality shall comply with the following requirements:

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Root division

Two important aspects of root division are:

Total division.

Pattern of division.

The ability of a root system to take up moisture and nutrients is directly related to the surface area of the root system, which, in turn, is directly related to root division. Roots must divide and divide again (total division). Root systems with inadequate division not only suffer from a reduced surface area but also offer too few points for new roots to develop.

Not only should roots divide repeatedly but the pattern of this division is also important. Division should be outwardly progressive (primary division) to ensure a strong structural base for any later root development. Trees held too long in containers (above ground or in-ground) may exhibit excessive non-directed division. While this may provide root surface area, it adversely impacts on root structure and makes the rootball hydrophobic.

For small trees, the entire rootball must be occupied by fibrous roots. However, for large trees it is possible to use a range of techniques in the early and intermediate stages of growth, providing that there is enough division within the rootball to support the tree adequately at the time of sale.

For trees in containers less than 45 L, roots must have undergone primary division at not more than 100 mm intervals.

For trees in containers greater than or equal to 45 L, roots within the outer 50% of the rootball must also have undergone primary division at not more than 150 mm intervals.

Root direction

Roots, from the point of initiation, should generally grow in an outwards (radial) or downwards direction. Any deviation from the established direction must not exceed 45°.

During below-ground inspection, no evidence of kinked taproots or of circling roots shall be found within the rootball.

Rootball occupancy

On shaking or handling the unsupported rootball at least 90% of the soil volume must remain intact.

Rootball depth

For trees in containers over 45 L, rootballs shall have a diameter greater than or equal to their depth.

Height of root crown

The root crown is the junction between the belowground parts and aboveground parts of the tree. Regardless of the size of the tree the root crown belongs at the surface of the rootball. Burying the root crown can lead to fungal infections, serious disruptions of the root system's structure and function or to the death of the tree.

The root crown shall be at the surface of the rootball, and not below.

Rootball protection in transit

The combination of container and handling system shall deliver the rootball intact.

INSPECTION AND SAMPLING

All trees included in this growing contract will be subject to inspection and/or sampling.

The grower is to complete inspections at 3 monthly intervals and report to City of Darwin using the tree inspection form (see Appendix).

Prior to dispatch/shipment from grower, City of Darwin Arborist/Project Manager shall conduct an inspection using the tree inspection form (see Appendix).

Non-compliance may lead to rejection of the entire batch, and/or payment withheld for all/non-compliant individual trees from batch.

INSPECTION SAMPLING TABLE

Number of trees per batch	Number of trees to sample
0–20	1
21–50	2
51–100	4
101–500	4 for the first 100 + 2% of balance of order
501–2000	12 for first 500 + 1% of balance of order
2001+	27 for the first 2000 + 0.5% of balance of order

Inspection shall include visual assessment based on the tree inspection form criteria, and the following steps:

- Step 1 Remove any stakes. If the tree is then not self-supporting, reject the tree. If the tree is self-supporting and less than 45 L, proceed to step 2. If the tree is self-supporting and greater than or equal to 45 L, proceed to step 3.
- Step 2 Place the tree on a level surface ensuring that the root ball is well watered. Hold the stem at 80% of the total stem height. Bend the stem

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making sure that the pressure is always at right angles to the position of the stem. The stem should be able to be bent 30° side to side without the root ball lifting off the ground (see Figure B1). If the root ball rocks such that it lifts off the ground then the root ball is too small to be able to support the tree without stakes.

- Step 3 Holding the stem at 25% height above the rootball surface, rock the stem vigorously from side to side. There must be no evidence of movement of the stem within the rootball and there must be no evidence of cracks in the rootball at the edge of previous container(s). These indicate previous pottings, which were not correctly rootpruned, or a lack of root division at that point.
- Step 4 Remove the tree from the container or remove the hessian or in-ground container or otherwise peel back any wrapping to expose the exterior of the rootball.¹ Check that any confused or circling roots at the outside of the rootball have diameter of less than 25% of the stem diameter at ground level for trees of less than 40 mm and less than 10 mm in diameter for trees with a stem diameter at ground level of 40 mm or more. Investigative inspection usually takes two basic forms: destructive (complete) or partial.

Destructive and partial rootball inspections

With destructive rootball inspection, all of the soil from the rootball is washed away (using water or compressed air) to give a clear picture of how the root system has developed. However, as this destroys the tree destructive inspection will generally be carried out infrequently.

Where destructive inspection is deemed necessary, trees will be sacrificed. (The trees sacrificed will be in addition to the number of trees required.) The cost of these plants can either be built into the supplier's price when quoting for supply or itemised as an additional cost.

Where sacrifice of plants is a nominated expense they should be paid for:

1. By the purchaser, if the batch is found to conform.
2. By the supplier, if the batch fails to conform.

With partial rootball inspection, a section of the rootball, sufficient to enable inspection of the root development from the stem to the outer extremity of the rootball (generally a wedge-shaped section), is washed away (using water or compressed air).

Removal of a wedge-shaped section of the rootball of trees in 5-100 L sizes is generally practical. In such cases, ensure that sufficient media is removed to inspect the root development in the upper 150-200 mm of the rootball, from the stem to the extremity, and the outer section of the rootball – top to bottom.

Balance Inspection for Small trees

Balance (small trees) assessment requirements:

- (a) Tubes or plant cells: height above rootball surface must be between 1.5 and 2.5 times the height of the tube or plant cell.
- (b) Trees in containers < 45 L (other than tubes or plant cells) or ex-ground trees of Size Index < 57 (e.g. 1.9 m high × 30 mm calliper); height must fall within the range indicated for the container size in **Small container-grown trees table**.
- (c) Containers/rootballs (other than tubes or plant cells) must remain flat on the ground when the stem, held at 80% of height above the rootball surface, is deflected 30° from the vertical, side to side.

Exempt: Species that naturally produce hard inflexible wood in the early stages of their development.

SMALL CONTAINER-GROWN TREES TABLE

Container size (or minimum rootball diameter)	Height range (m)	
	Thin stemmed species	Thick-stemmed species
Tubes or plant cells	Tree height between 1.5 and 2.5 × container height	
150 mm (1.8L)	0.4 – 0.6	0.3 – 0.5
180 mm (2.6L)	0.5 – 0.7	0.4 – 0.6
200 mm pot (4L)	0.7 – 0.9	0.6 – 0.8
200 mm bag (5L)	0.8 – 1.0	0.7 – 0.9
240 mm (8L)	1.0 – 1.2	0.8 – 1.0
300 mm (15L)	1.2 – 1.5	1.0 – 1.2
330 mm (25L)	1.5—1.9	1.2—1.6
400 mm (35L)	1.8—2.2	1.4—1.9

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Balance inspection for Large trees

Balance (large trees) assessment requirements:

- (g) For trees grown in containers ≥ 45 L, the Size Index must lie within the range for the nominal container size shown in the **Common container volumes – Size index range table**.

COMMON CONTAINER VOLUMES – SIZE INDEX RANGE

Size index	Nominal container volume (L)	Size index	Nominal container volume (L)
57–74	45	453–587	550
77–99	60	495–640	600
83–107	75	533–716	700
111–143	100	632–818	800
154–200	150	711–921	900
194–251	200	791–1023	1000
227–314	250	842–1089	1100
273–353	300	918–1188	1200
289–373	350	1148–1485	1500
330–427	400	1530–1980	2000
371–480	450	1913–2475	2500
412–518	500		

Size Index is an indicator of the tree's size above ground expressed as a simple number. Size Index is calculated by multiplying the height (m) by the calliper (mm, measured at 300 mm above ground), as follows:

$$\text{Size Index} = \text{height (m)} \times \text{calliper (mm)}$$

APPENDIX 1. OF PLANT PROCUREMENT CONTRACT

TREE INSPECTION FORM

General

Date	Reference/Purchase Order No.
Purchaser	
Supplier	Inspected by (supplier/purchaser/agent)
Species	Batch identification
Number of trees in batch	Container/rootball size
Height range	Calliper range
Special requirements	

Above ground

Labelling	<input type="checkbox"/>
Health and vigour	<input type="checkbox"/>
Freedom from pests and disease	<input type="checkbox"/>
Freedom from injury	<input type="checkbox"/>
Self-supporting	<input type="checkbox"/>
Stem taper	<input type="checkbox"/>
Pruning	<input type="checkbox"/>
Apical dominance	<input type="checkbox"/>
Crown symmetry	<input type="checkbox"/>
Stem structure	<input type="checkbox"/>

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Included bark	<input type="checkbox"/>
Trunk position	<input type="checkbox"/>
Compatibility of graft unions	<input type="checkbox"/>
Indication of north	<input type="checkbox"/>
Below ground	<input type="checkbox"/>
Inspection method used	<input type="checkbox"/> External only
	<input type="checkbox"/> External plus investigative
	<input type="checkbox"/> destructive <input type="checkbox"/> Partial
Number of trees in sample	<input type="checkbox"/>
Root division	<input type="checkbox"/>
Root direction	<input type="checkbox"/>
Diameter nonconforming roots at rootball extremity	<input type="checkbox"/>
Rootball occupancy	<input type="checkbox"/>
Rootball depth	<input type="checkbox"/>
Height of root crown	<input type="checkbox"/>
Non-suckering rootstock	<input type="checkbox"/>
Balance	
Balance	<input type="checkbox"/>

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Plant Schedule

Genus	Species	Quantity	Container volume (L)	Height (M)	Calliper (mm)	Supply Date	Unit Price (inc.GST)	Species Total Price (inc.GST)

APPENDIX 2. OF PLANT PROCUREMENT CONTRACT
SUPPLY OF TREES/PLANTS FOR CITY OF DARWIN PROJECT

(Standing Offer)
The Chief Executive Officer
City of Darwin

I/We the undersigned hereby offer to supply the goods as described in the attached document for the period stated and subject to the conditions/specifications prescribed herein. I/We agree to supply the goods within the delivery time and in accordance with the delivery terms stated.

Signed	
---------------	--

Print Name	
-------------------	--

Date	
-------------	--

On Behalf of	
---------------------	--

ABN	
------------	--

Postal Address	
-----------------------	--

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Telephone		Facsimile	
Signature of Witness			
Print Name			
Date			

APPENDIX E TREE PLANTING SPECIFICATIONS - TREE PIT SOIL VOLUMES

Tree pit volumes should be calculated using the formula from the NATSPEC Specification for landscape trees (www.natspec.com.au)
Required soil volume (m³) = (Height (m) X DBH (mm) divided by 100.

e.g. the required soil volume for a *Mimusops elengi* would be 10(m) X 450(mm) divided by 100 = 45m³

In locations with constraints where the NATSPEC specified volumes cannot be met, tree pit volumes must be at least 60% of the calculated volume, or a smaller tree species should be selected.

Trees planted in turf or garden areas without physical restrictions on the growth of tree roots are exempt from this calculation.