I would like to begin by acknowledging the [Traditional Owner/s name] People as the Traditional Owners of the land/s that we’re meeting on today, and pay my respect to their Elders past and present.

‘Eternal Wisdom, Infinite Innovation’
artwork by Rachael Sarra, working with Gilimbaa.

ENGINEERED SHADE USING CLIMBING PLANTS

Case studies from Darwin, Cairns and Singapore

What is engineered shade using climbers?

Credit: Robert Gesink

Credit: Urban canopee

Credit: Stephen Cook



Credit: Andrew Watson

Why Use Climbers for Engineered Shades?"

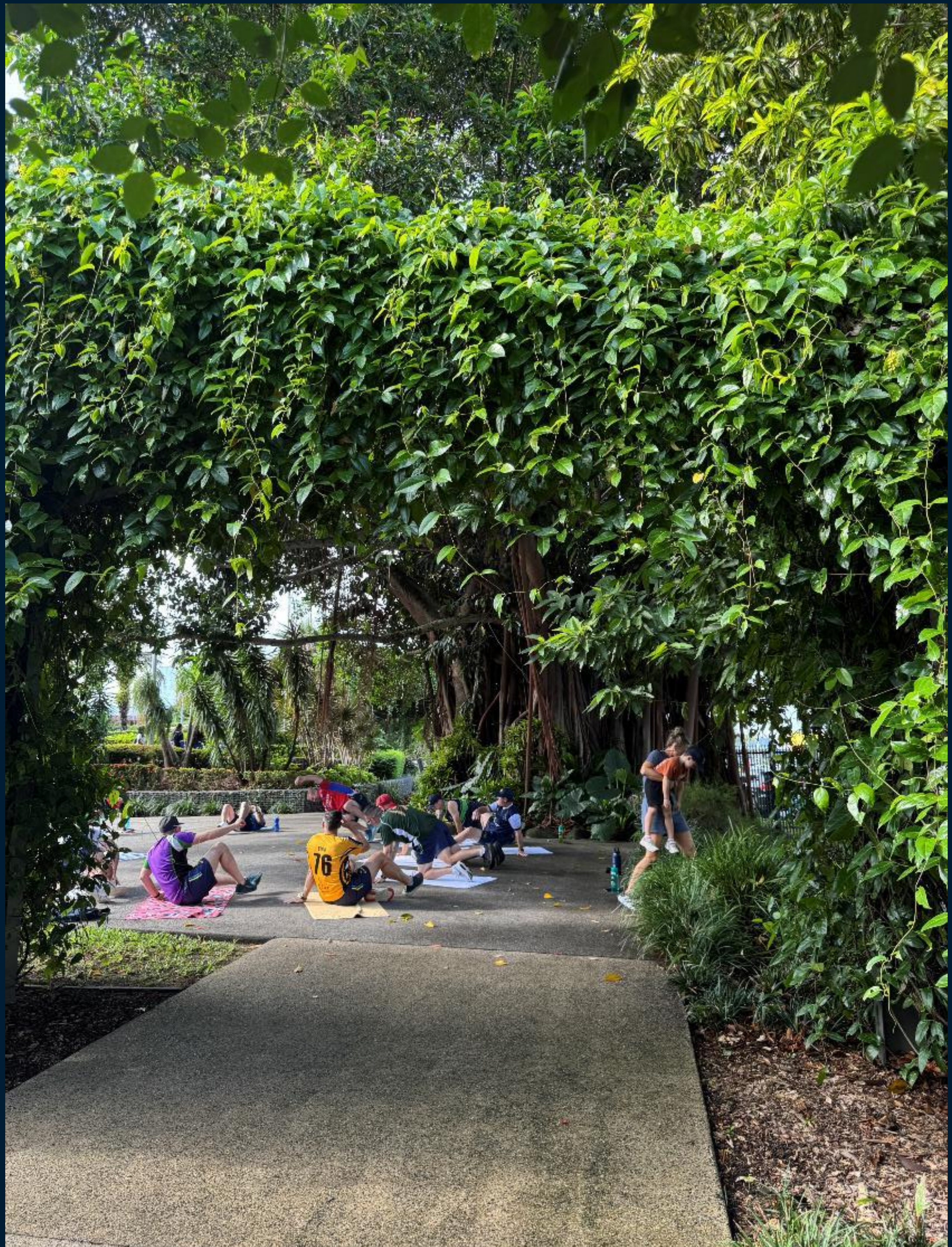
CSIRO

Urban cooling evidence

Location	Engineered shade type	Temperature Reduction Measurement (°C)	Season	Sources
Hanoi, Vietnam	Green Façade with climbing plant (*Bougainvillea*)	**Average 4.7°C** decrease in **air temperature** measured in the space just behind the climbing plants	Wet season	Nguyen et al., 2019
Penang, Malaysia	Indirect Green Façade with edible climbing plant (*Psophocarpus tetragonolobus*)	**Average 1.1 and 2.4°C** reduction in **surface temperature** at 1.5 m and 0.6 m from ground level	Dry season	Basher et al., 2016
Petaling Jaya, Malaysia	Vertical Greenery System (Cable system with *Thunbergia erecta*)	**Average 1°C** difference in temperature difference between the building surface with VGS and the control ambient temperature	Inter-wet season	Jaarfar et al., 2013
Darwin, Australia	Cullen Bay arbours (*Stephanotis floribunda*, and *Pyrostegia nervosa*)	**Average of 5.5°C** reduction in **mean radiant temperature**	Wet season	Cook et al., 2024 and 2025
	Esplanade seating trellises (various climbers)	**Average 3.1°C** reduction in **mean radiant temperature**	Dry season	
	Cavenagh Street arbours (*Pyrostegia nervosa*, and *Combretum indicum*)	**Average 0.5°C** reduction in **mean radiant temperature**	Dry season	

More than just a shade

- **Climate & Energy**
  - Microclimate Regulation
  - Energy Savings
- **Ecological & Environmental**
  - Biodiversity Enhancement
  - Acoustic Buffering
- **Community & Economic**
  - Aesthetic & Social Value
  - Economic Returns
  - Urban Agriculture



Expert-informed analysis

Objective

- To investigate the performance, design, and maintenance of climber-based shade systems to create a best-practice framework

Learning from Experience

- Selection and location of plant species
- Growth, coverage
- Structure design and performance
- Maintenance practices
- Community involvement and feedback
- Knowledge gaps

Data collection

Expert Participants:

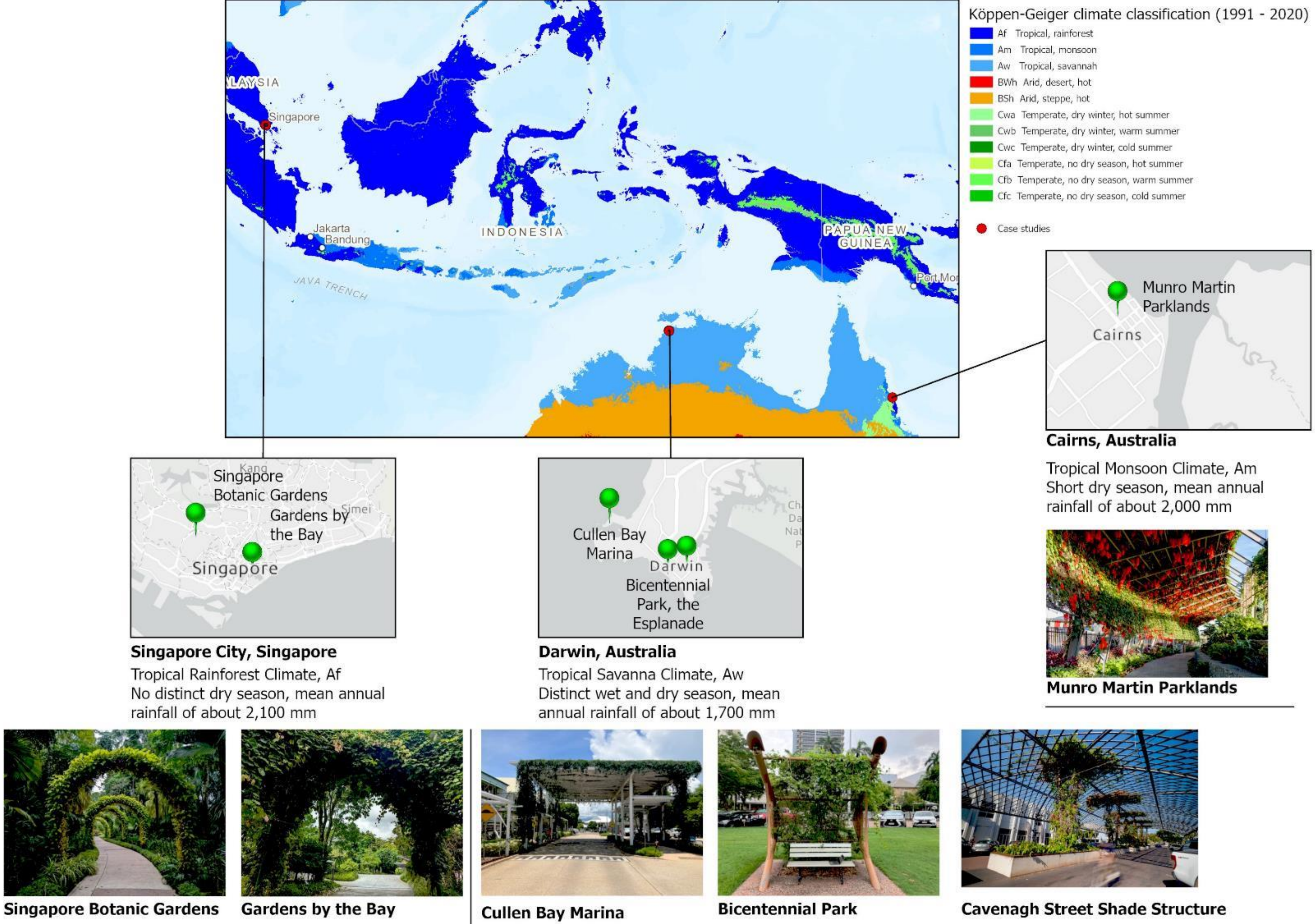
- Data was collected from 10 expert participants.
- They possessed an average of 25 years of professional experience in their fields.
- Roles included project architect, landscape architects, horticulturalist, sustainability advisor, and maintenance supervisors.

Key Insights from Interviews:

- Provided detailed understanding of the critical decisions behind establishing engineered shade with climbing plants.
- Captured practical solutions and lessons learned from on-site challenges.
- Highlighted the use of iterative, trial-and-error approaches for establishment and maintenance.

Data and Scope:

- Observations from the case studies covered six predefined thematic areas.
- Each case study had distinct motivations and achieved a range of outcomes.
- Information on community feedback and public perception was also documented.



Köppen-Geiger climate classification (1991 - 2020)
Af Tropical, rainforest
Am Tropical, monsoon
Aw Tropical, savannah
BWh Arid, desert, hot
BSh Arid, steppe, hot
Cwa Temperate, dry winter, hot summer
Cwb Temperate, dry winter, warm summer
Cwc Temperate, dry winter, cold summer
Cfa Temperate, no dry season, hot summer
Cfb Temperate, no dry season, warm summer
Cfc Temperate, no dry season, cold summer
Case studies
Singapore
Jakarta
Bandung
INDONESIA
JAVA TRENCH
PAPUA NEW GUINEA
Munro Martin Parklands
Cairns
Cairns, Australia
Tropical Monsoon Climate, Am
Short dry season, mean annual rainfall of about 2,000 mm
Singapore Botanic Gardens
Gardens by the Bay
Singapore
Singapore City, Singapore
Tropical Rainforest Climate, Af
No distinct dry season, mean annual rainfall of about 2,100 mm
Cullen Bay Marina
Darwin
Bicentennial Park, the Esplanade
Darwin, Australia
Tropical Savanna Climate, Aw
Distinct wet and dry season, mean annual rainfall of about 1,700 mm
Munro Martin Parklands
Singapore Botanic Gardens
Gardens by the Bay
Cullen Bay Marina
Bicentennial Park
Cavenagh Street Shade Structure

Case characteristics

Case Study	Main Species Used	Species Selection Criteria	Design Objective	Other observed benefits
Bicentennial Park, Darwin, Australia	*Bougainvillea sp., Cobretum indicum, Duranta repens, Mandevilla, Allamanda sp., Patrea sp.*	Resilience, appearance, ease of pruning	Shade, visual improvement in public space	High public use, visual comfort, tourist praise
Cullen Bay Marina, Darwin, Australia	*Pyrostegia venusta, Stephanotis floribunda variegata and Petraeovitex wolfei*	Seasonal resilience, base foliage, fragrance, colour	Urban comfort, revitalization, aesthetics	Increased public/commercial use, aesthetic success ; biodiversity enhancement
Cavenagh Street, Darwin, Australia	*Pyrostegia ignea, Combretum indicum*	Shade, flowering, height capability	Urban cooling, aesthetics, experiment in heat mitigation	Visual improvement, partial cooling
Munro Martin Parklands, Cairns, Australia	*Bauhinia aurifolia, Hoya australis, Ipomea horsfalliae, Mukuna bennettii, Strongylodon macrobotrys, Tristellateia australasiae*	Edge forest species, variable light tolerance	Noise buffering, Shade, aesthetics to encourage passive use of the facility, wind buffering	Recreational benefit, Partial cooling observed due to incomplete canopy coverage, biodiversity enhancement
Singapore Botanic Gardens, Singapore	*Bougainvillea sp., Mukuna bennettii, Phanera spp., Uvaria grandiflora*	Growth rate, aesthetics, compatibility with maintenance	Shade, aesthetics, biodiversity conservation, education	Shading and cooling, reduced heat, more birds & insects
Gardens by the Bay, Singapore	*Alsometra sp., Bougainvillea sp., Beaumontia grandiflora, Mukuna bennettii, Phanera* spp,	Structure size, flowering, maintenance compatibility	Shade, biodiversity, aesthetic enhancement	Changed visitor patterns, popular shaded zones for walking routes; biodiversity enhancement

Critical success factor 1: Species selection

Reasons for Failure:

- Species traits incompatible with local conditions
  - Available soil space
  - Light intensity
  - Height of support structures
- Weak plant development/over aggressive plants
- High maintenance requirements

Successful Species Traits:

- Non-invasive and resilient to local climate
- Appropriate size to the structures (weight & height)
- Low maintenance and pest-resistant
- Rapid, dense coverage, high aesthetic value

Credit: Stephen Cook

Credit: Andrew Watson

Critical success factor 2: Design and installation

Structural Design:

- Must be engineered to bear the significant weight of mature, wet vines.
- Use climate-durable materials like steel in tropical, high-rain areas; avoid wood.
- Material surfaces should minimise heat absorption to avoid scorching young plants.
- Mesh/grid size must match the plant's climbing mechanism

Installation:

- Ensure high-quality, well-draining soil in sufficient volume.
- Use automated irrigation, as consistent watering is essential for establishment.
- Protect young plants from heat stress with temporary shade cloth

Critical success factor 3: Maintenance

Key Maintenance Practices:

- Pruning & training: Regular pruning (every 3-6 months) to train vines, encourage density, and control overgrowth.
- Irrigation: Automated systems adjusted seasonally to prevent water stress.
- Soil& growing media: sufficient volume soil, organic fertilisers during establishment.
- Inspection: Annual checks for structural integrity (rust, wear) and plant health.

Common Challenges & Solutions:

- Pests: Leaf litter can attract rats; requires regular cleaning.
- Bare Stems: Prune the top of the plant to encourage lower foliage growth
- Overgrowth: Select manageable species and maintain a regular pruning schedule

Performance Frameworks

Planning

- Function & location
- Structural design
- Material selection
- Species selection

Planting & Establishment

- Soil & Root zone prep
- Climbing support
- Mitigating heat stress
- Early maintenance

Maintenance & Monitoring

- Pruning regime
- Structural support
- Irrigation
- Pest management

Removal & replacement

- Planning and execution
- Site rejuvenation
- staged renovation

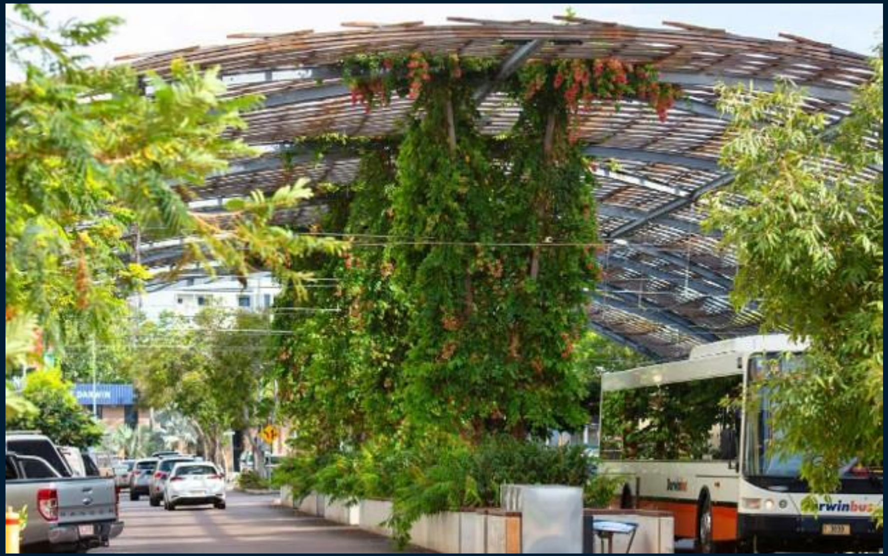
Capacity building

Knowledge gaps

- A critical lack of practical, on-the-ground data exists.
- Quantitative Data: Need long-term monitoring to measure actual thermal cooling benefits.
- Horticulture: Need species-specific field trials to document establishment rates and performance.
- Economics: Need a better understanding of long-term life-cycle costs.

Conclusion

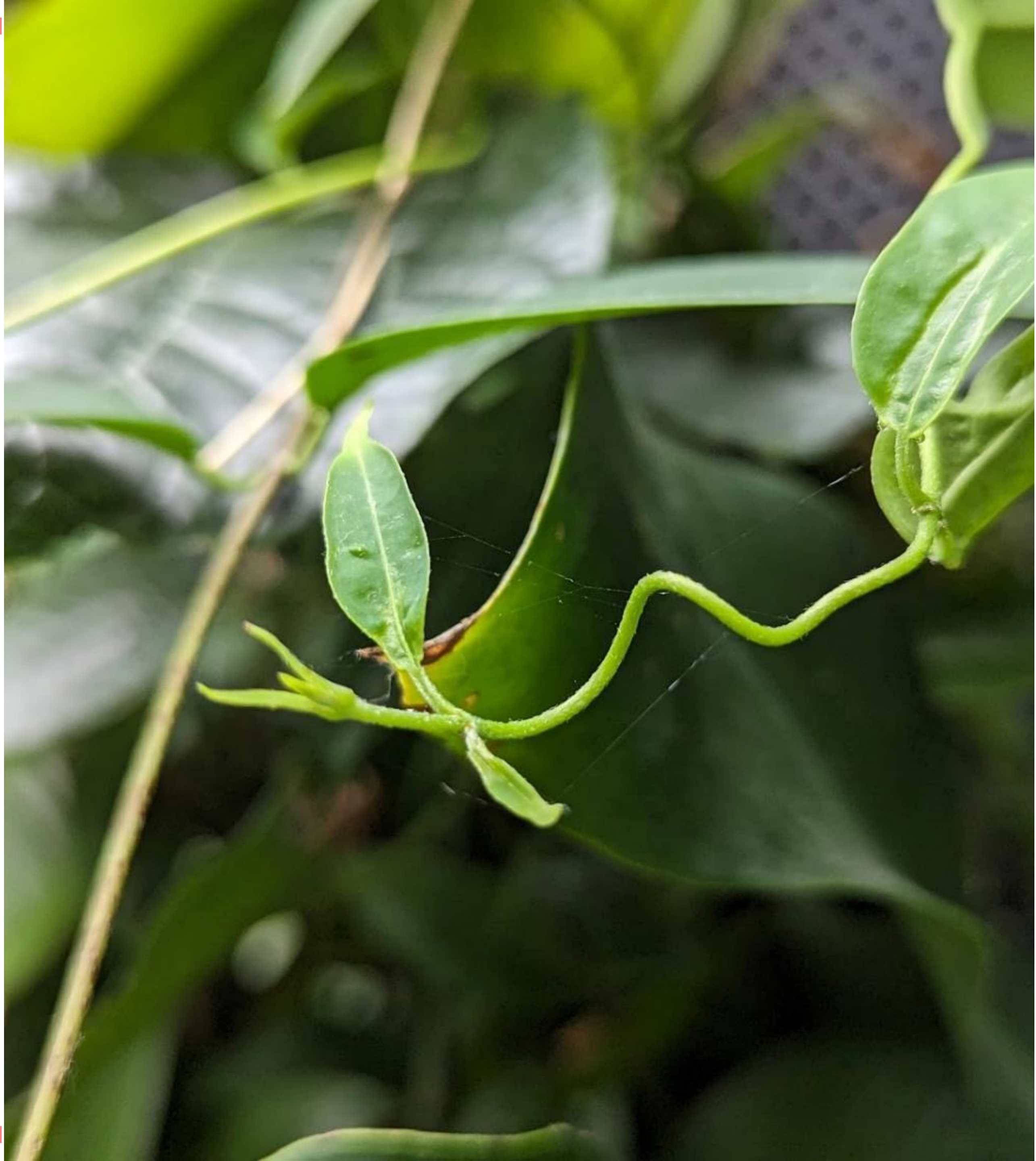
- Engineered shade with climbers is a highly effective, multifunctional solution for creating comfortable, biodiverse, and resilient urban spaces.
- Success depends on a holistic approach that integrates species selection, structural design, and long-term maintenance.
- Effective solutions are adaptive, balancing trade-offs to maximise ecological benefits while ensuring cost-effectiveness.



“Plants become climbers, in order, it may be presumed, to reach the light, and to expose a large surface of leaves to its action and to that of the free air.

This is affected by climbers with wonderfully little expenditure of organized matter, in comparison with trees, which have to support a load of heavy branches by a massive trunk.”

– Darwin (1865)



Authors and Contributors

- City of Darwin, NT, and Australian Government
- CSIRO: Natthanij Soonsawad, Stephen Cook, Tim Muster, Brenda Lin
- Darwin: Fiona Eddleston, Tony Cox, Sheree Lewis, Bastaain Kap, Emma Smith, Joan Tachado
- Cairns: Andrew Prowse, Gisela Jung, Sophie Barrett
- Singapore: Anton Stevens van der Shans, Zong Yu Ooi