

Greenery as a Nature-Based Solution for Heat Mitigation

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*Lead agency for
greenery management,
biodiversity conservation,
animal health & welfare, and
wildlife management*



6 million trees (2 million urban trees)

3,347 ha of nature reserves

400 parks and gardens

380 km of park connectors

210 km of Nature Ways

...and a multitude of **conservation, animal and wildlife management**, and **community outreach** programmes



- Hot, humid tropical climate
- With tropical rainforests & mangroves
- City-state (Area: 735km²; Population: 5.92mil)
- Rich diversity of flora and fauna



Singapore is an unusually green city

A green environment as a cornerstone of Singapore's development approach

The Singapore story

>60 years of greening efforts

Green city ideal had different names, different aspirations:

- Garden City
- City in a Garden
- City of Gardens and Waters
- Biophilic City in a Garden
- **City in Nature**





City in Nature as a Paradigm for Greening Singapore

City in Nature

Restoring nature into the city for liveability, sustainability and wellbeing

Applying nature-based solutions towards achieving:

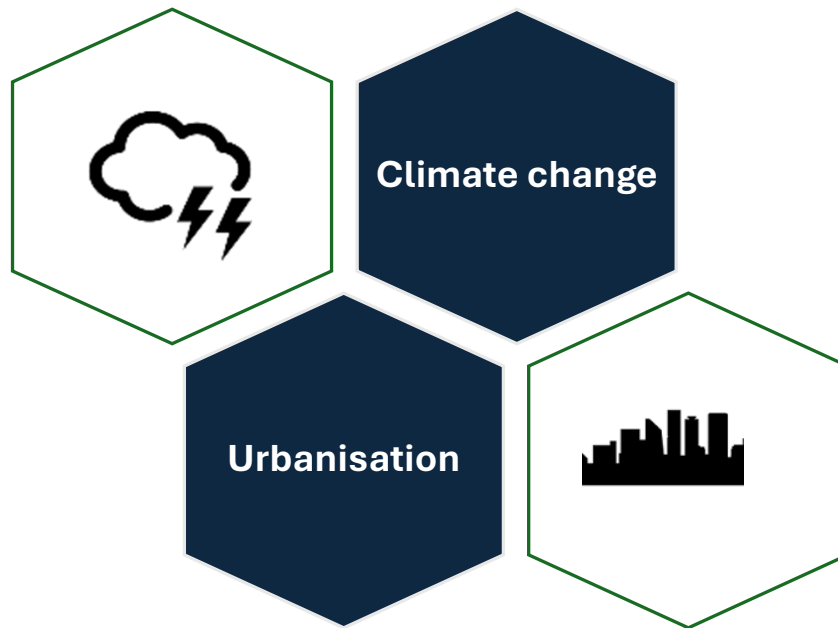
Climate Resilience

Ecological Resilience

Social Resilience

Responding to key challenges

how do we **mitigate the impacts** of climate change and **build resilience**?



how do we **ensure a quality living environment** amidst urbanisation?

TODAY World

MENU ▾



S'pore among world's major cities to face 'unprecedented' climate conditions by 2050

TODAY Singapore

MENU ▾

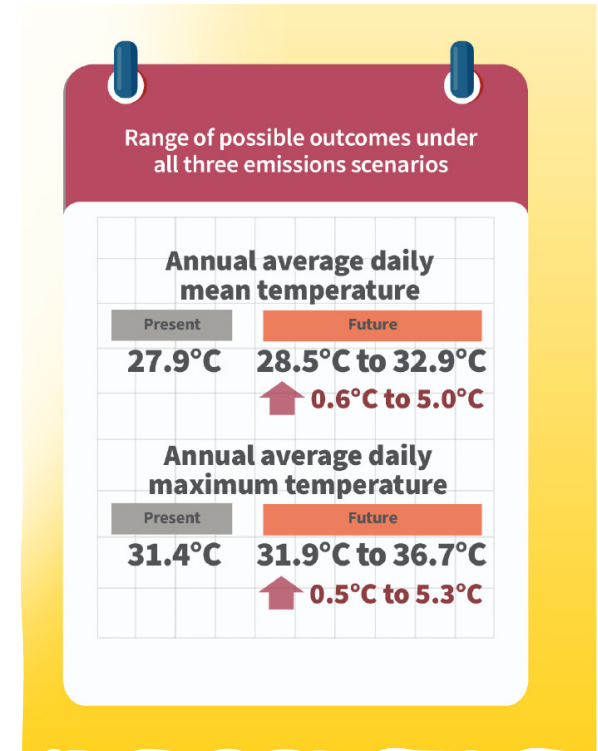
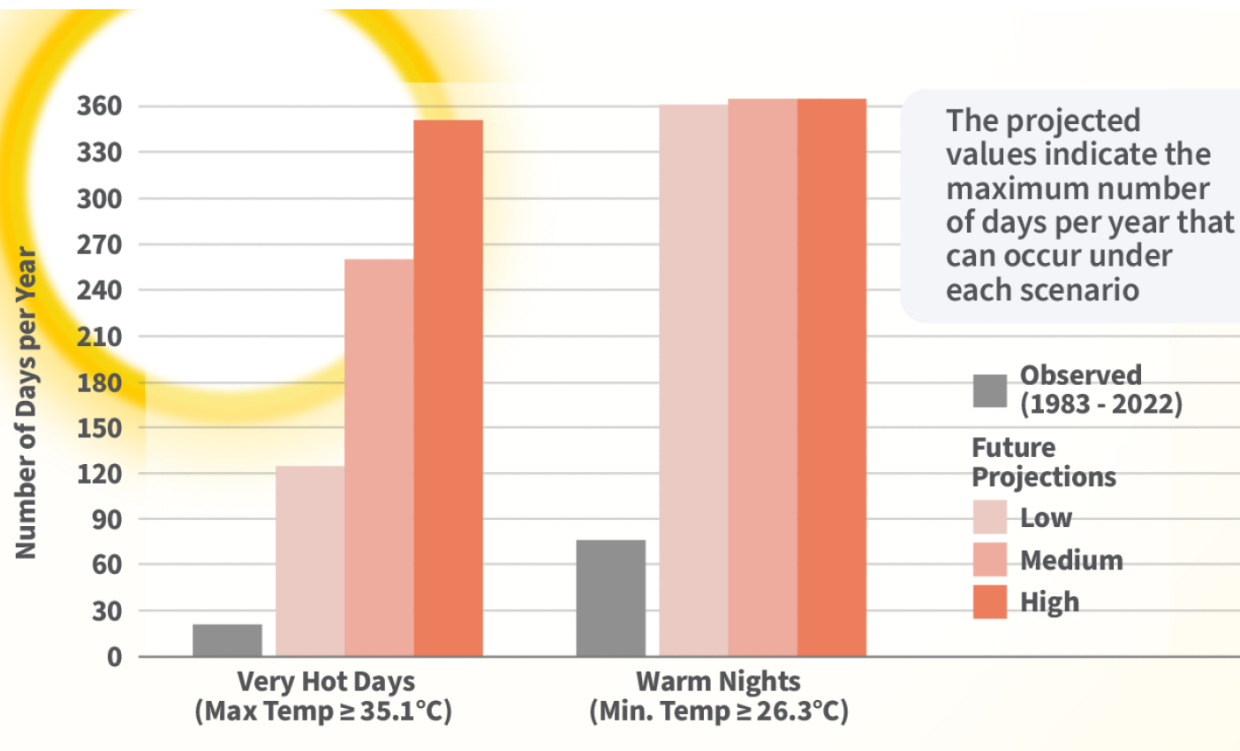


Temperatures in Singapore could hit 40°C as early as 2045: Scientists



Singapore

2024 was Singapore's joint-warmest year on record; temperature highs in April, July and December



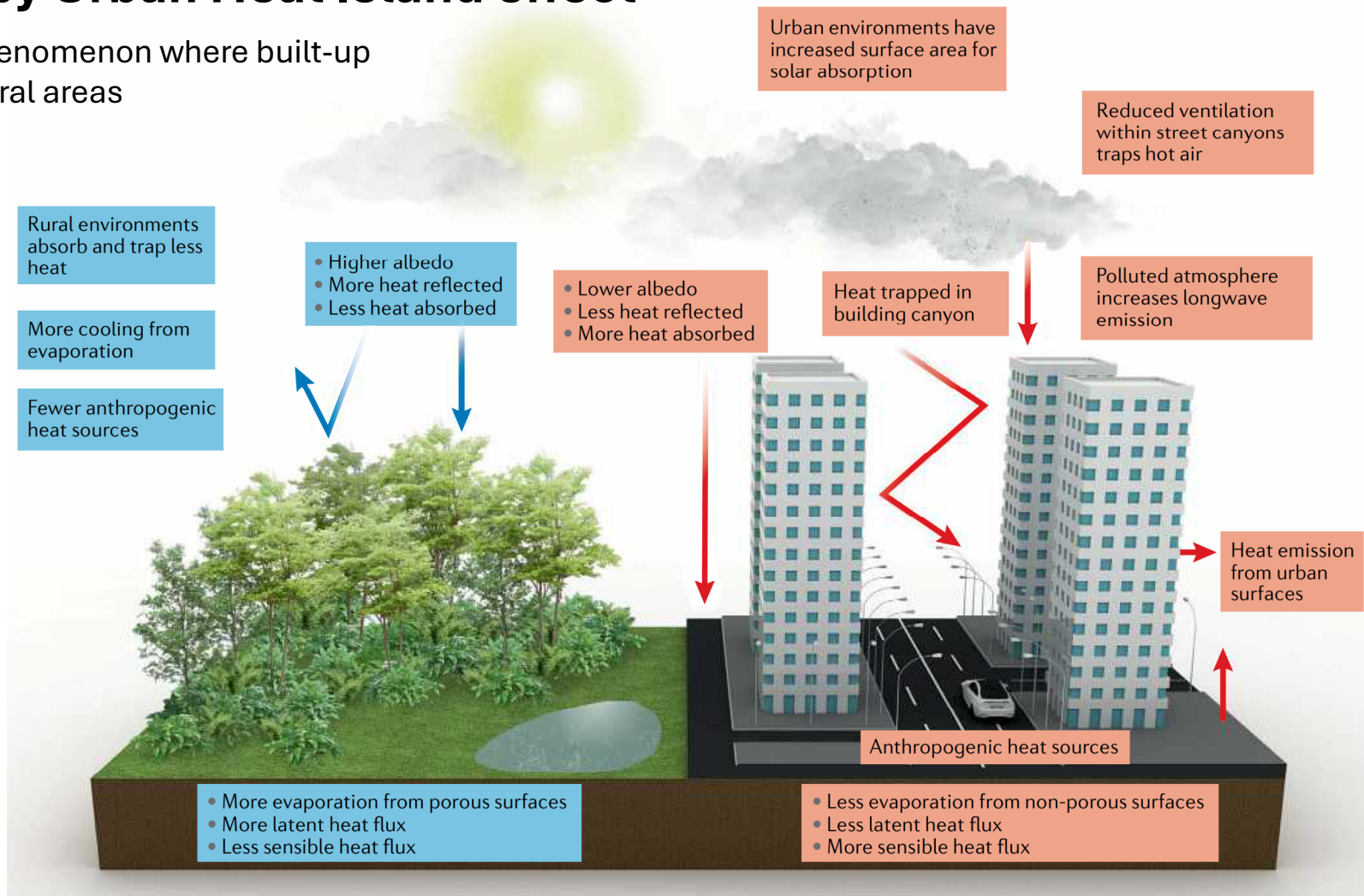
Very hot days and warm nights will be the new normal by end-century

The Third National Climate Change Study (V3) was conducted by the Government to support Singapore's effort to understand the effects of climate change and develop long-term plans for climate resilience. The V3 report was released in Jan 2024.

SSP1-2.6 SSP2-4.5 SSP5-8.5

Compounded by Urban Heat Island effect

The UHI effect is the phenomenon where built-up areas are hotter than rural areas



Wong, N.H., Tan, C.L., Kolokotsa, D.D. et al. (2021) Greenery as a mitigation and adaptation strategy to urban heat.

Various City in Nature targets subsumed under SGP30



Becoming a City in Nature

Key Strategies

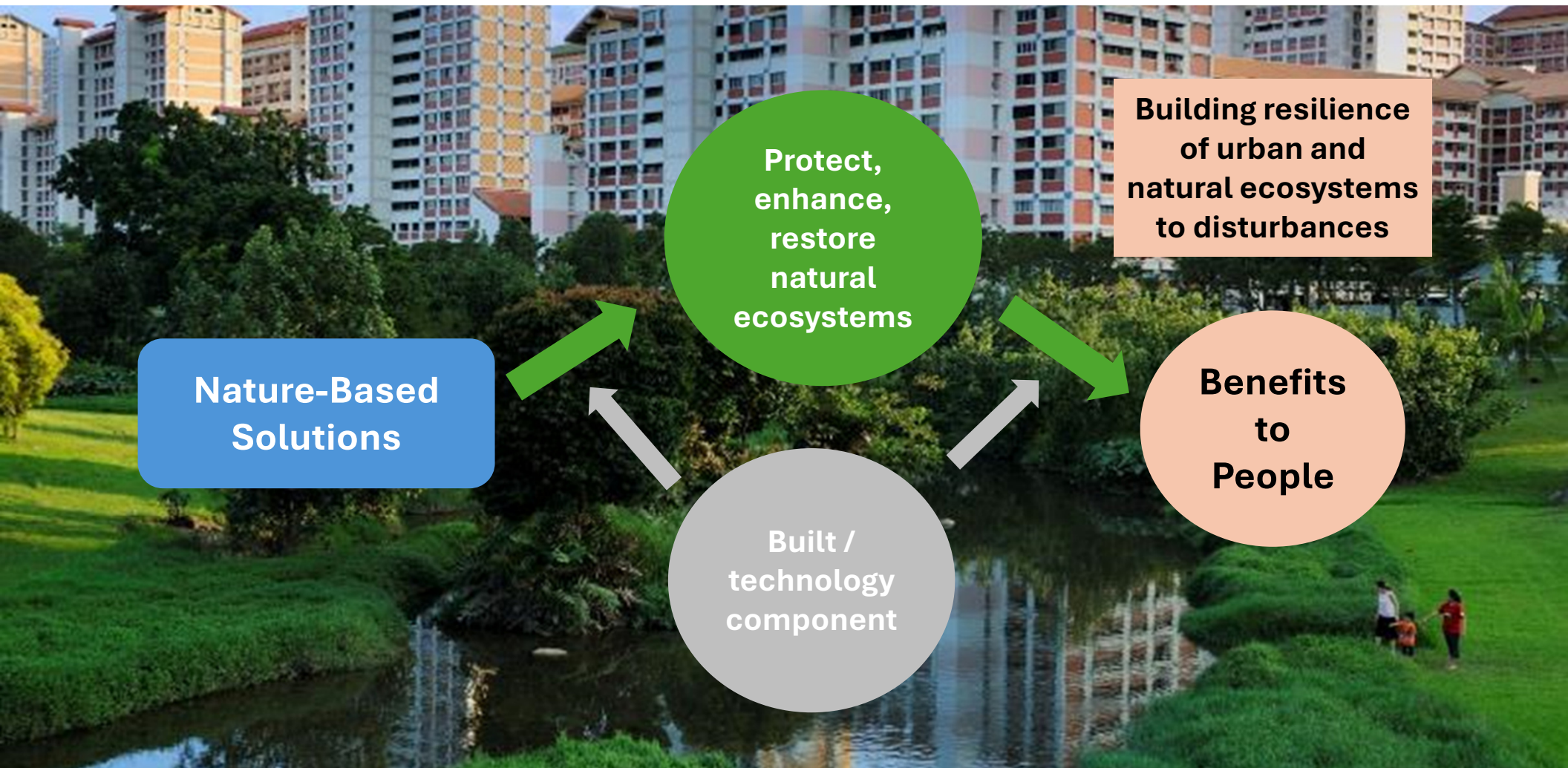
- 1 Conserve and Extend our Natural Capital
- 2 Intensify Nature in our Gardens and Parks
- 3 Restore Nature into the Urban Landscape
- 4 Strengthen Connectivity between our Green Spaces
- 5 Enhance Veterinary Care and Animal Management

**Implementation of
Nature-Based Solutions**

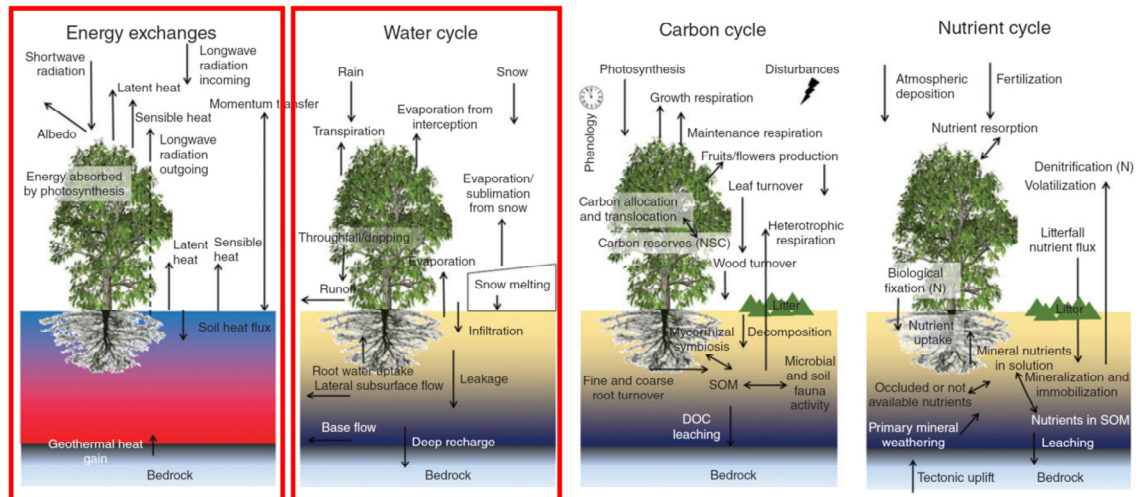
Community Stewardship

Advancing Digitalisation, Science & Technology, Industry

Becoming a City in Nature



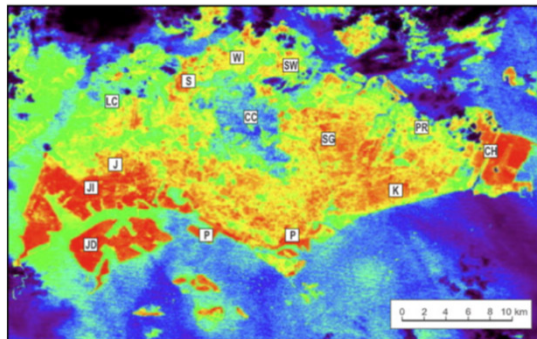
Greenery as a NBS for heat mitigation



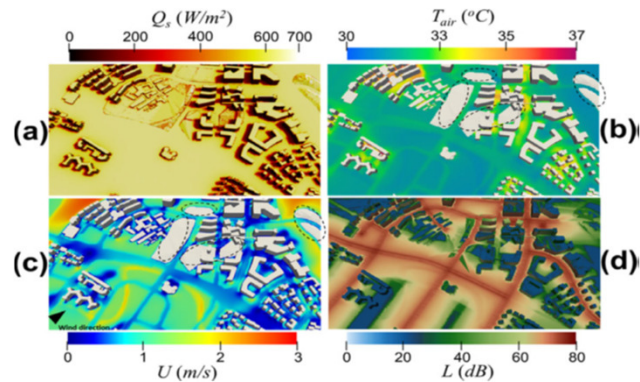
Fatichi, S., Pappas, C., & Ivanov, V. Y. (2016). Modeling plant–water interactions: an ecohydrological overview from the cell to the global scale. *WIREs Water*, 3(3), 327–368.

- Urbanization disrupt natural cycles → applications of NBS in urbanized settings helps to restore key processes
- Greenery in the urban environment provide shades, evapotranspiration cooling and increases albedo

A layered multi-scalar approach across the infrastructure gradient is needed



City scale



District scale



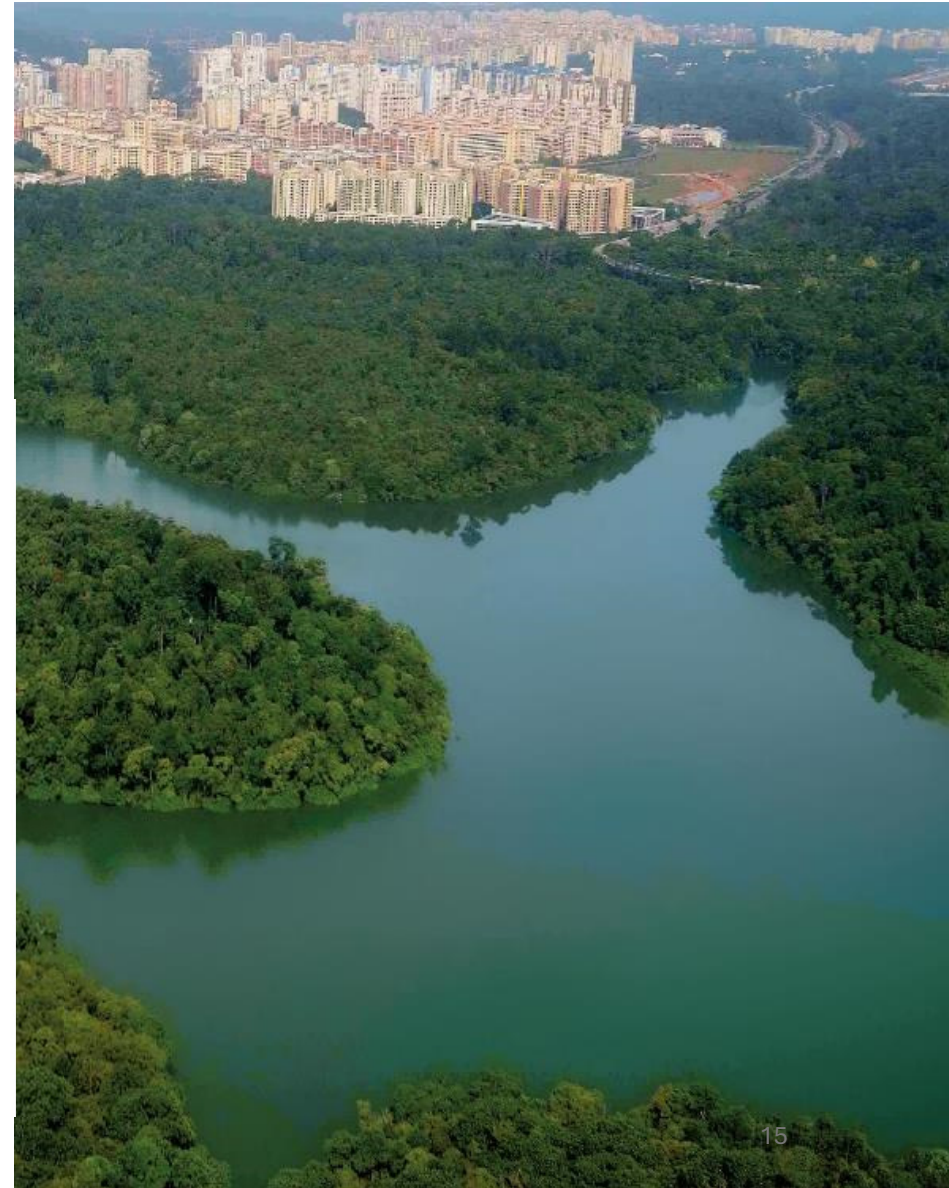
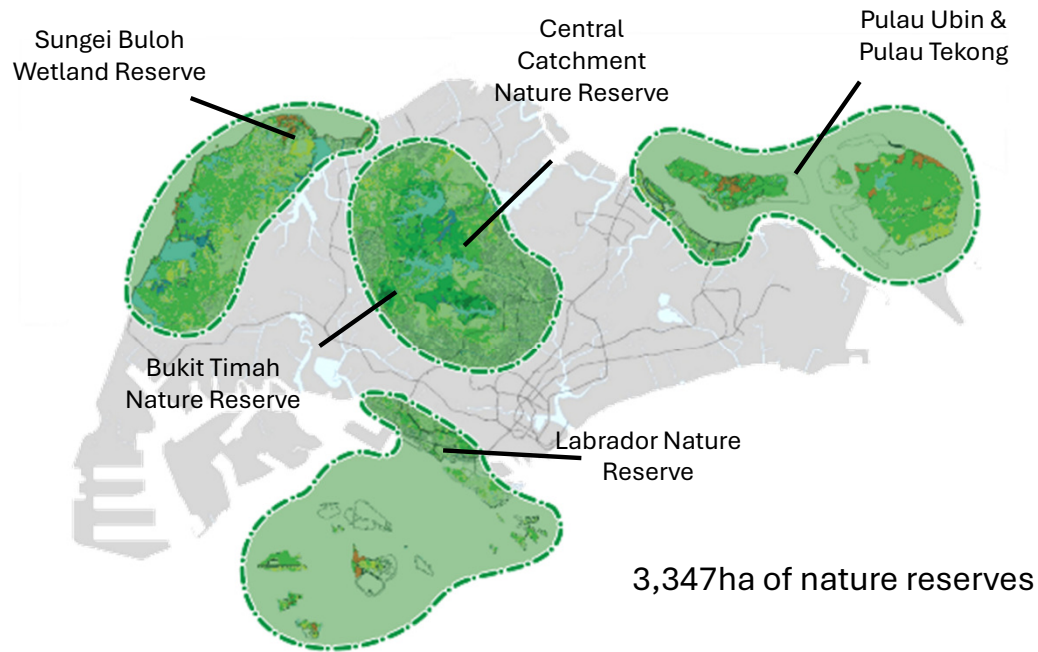
Building scale

Different strategies for different scale of application

1

Conserving and extending our natural capital

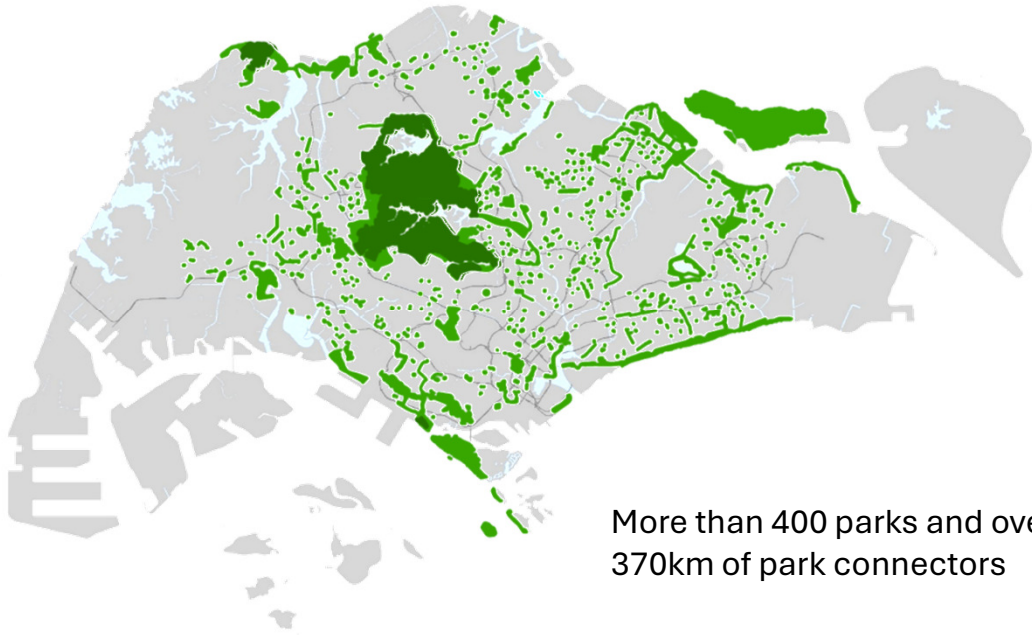
Safeguarding and strengthening core habitats such as nature reserves and other nature areas



1

Conserving and extending our natural capital

Growing our network of parks and park connectors



More than 400 parks and over 370km of park connectors



Incorporating greening as a key national land use planning strategy

DRAFT MASTER PLAN 2025 PUBLIC ENGAGEMENT

Making Singapore a liveable, inclusive and enduring home for all

Long-term planning has helped us manage our scarce land resources and shape the city we live in today.

In 2021, we journeyed with Singaporeans in the Long-Term Plan Review to reimagine how Singapore can meet our diverse needs and aspirations over 50 years and beyond.

We are now coming together to build on these shared conversations to map out detailed plans for the next 10 to 15 years.

Join us in shaping our city together:
www.go.gov.sg/URADraftMasterPlan

HAPPY HEALTHY CITY

Shape a Happy Healthy City where all can live well, play delightfully and move efficiently. We will develop plans to meet our collective aspirations and grow stronger communities.

- More liveable and inclusive homes for everyone
- A more connected and accessible active mobility network
- More spaces to unwind and keep active daily
- Neighbourhoods that support ageing-in-place
- Remaking our heartlands to be more sustainable and enduring



SUSTAINABLE GROWTH

Enable Sustainable Growth with a vibrant economy that provides quality Work opportunities.

- Flexibility to adapt to new economic trends
- More mixed-use spaces for workers and businesses
- Sites with different lease tenures and densities to support innovation and new trends



URBAN RESILIENCE

Strengthen Urban Resilience to combat climate change and optimise our limited land resources, to sustain a good quality of life.

- Capitalise on our sea, underground and underutilised spaces and co-locate multiple use
- Integrate nature-based solutions with infrastructure for innovative urban solutions



STEWARDSHIP

Steward our Nature and Heritage to enhance our natural capital and built heritage, shaping a home that we cherish.

- Strengthen the distinctive character and heritage of our towns
- Enhance green and blue spaces, and strengthen ecological connectivity
- Bring nature closer to people



LEVERAGE TECHNOLOGY

Tap On Technological Opportunities to further efforts in land optimisation, and enhance our quality of life.

- Improve how we live, work and play by leveraging emerging technologies
- Enhance land optimisation through innovative design and policies





Urban Redevelopment Authority

Draft Master Plan
 Shaping our dreams

Stewarding nature is one of the 4 key themes in the Draft Master Plan 2025

[illegible]

Parks and green spaces – a key focus area in the Recreation Master Plan as part of the Draft Master Plan

2

Intensifying nature in our gardens and parks

Making our gardens and parks more natural



3

Restoring nature into the urban landscape

Planting more trees along the roadsides, with multi-tiered forest-like planting approach



3

Restoring nature into the urban landscape

Intensifying greenery within residential and industrial estates



3

Restoring nature into the urban landscape

Planting one million trees by 2030, with the community



3

Restoring nature into the urban landscape

Greening up our buildings and infrastructure



200ha of skysrise greenery by 2030

3

Restoring nature into the urban landscape

Greening up our buildings and infrastructure



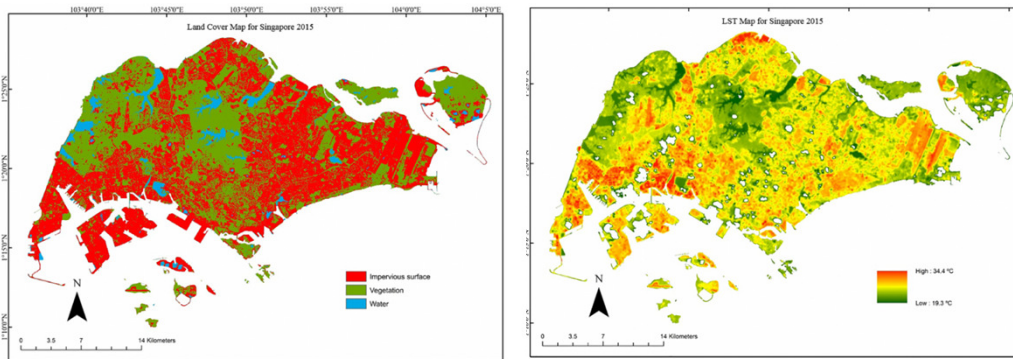


Research as a foundation for operationalizing and optimizing NBS

- Effects of vegetation in mitigating heat in urban areas is an active area of research
- Building up localized evidence base is key to “push” and guide the development of effective intervention

Building up localized scientific evidence for intervention

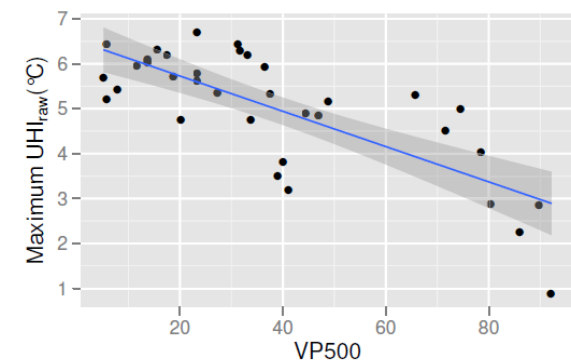
Urban green spaces



Increasing amount of UGS **reduces**
land surface temperature in cities

Masoudi & Tan 2019

Green cover

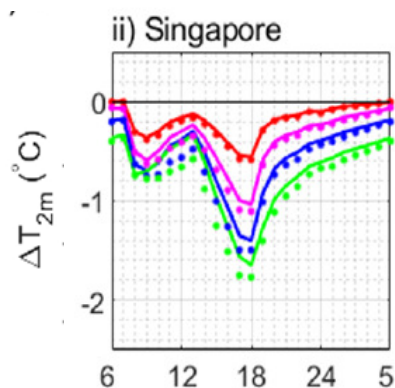


At the scale of local climate zones
(500m), a **10% increase in**
vegetation cover reduces UHI by
0.4°C

Li 2012

Building up localized scientific evidence for intervention

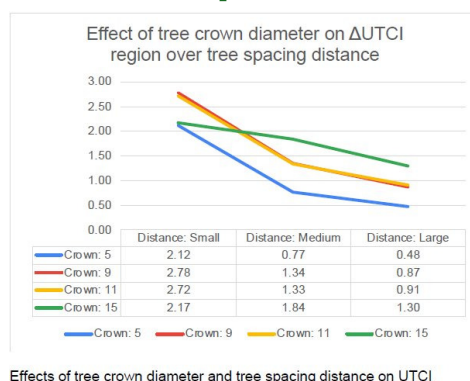
Tree cover



Higher tree cover leads to more cooling. **20% tree cover** reduces temperatures by **0.6°C** while **80% tree cover** can cool up to **1.6°C** at 6pm

Meili et al 2021

Tree species



Trees with **higher leaf area index, tree crown radius, trunk height, larger canopy size** provide **better thermal comfort**

NParks, unpublished data

Multi-tiered planting



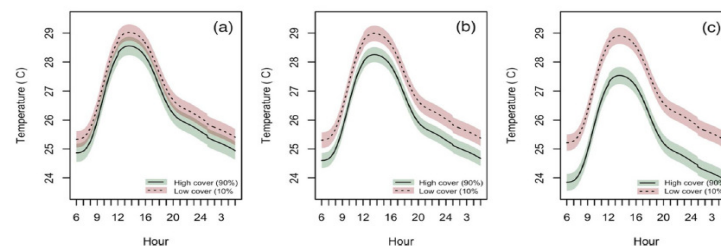
Tree canopy



Canopy over shrub



Secondary forest

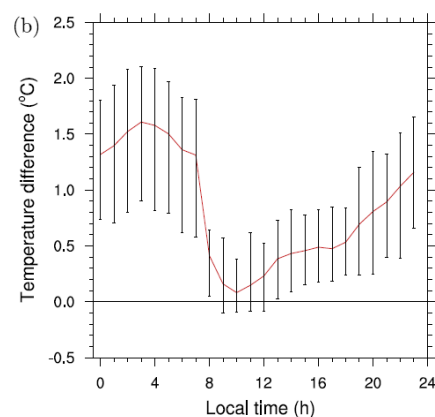


Tree canopy reduces temperatures by **0.6°C**; **canopy over shrub** by **0.9°C**; **secondary forest** by **1.7°C** at 1pm

Richards et al 2020

Building up localized scientific evidence for intervention

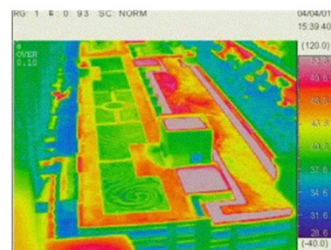
Green roofs



Green roofs provide a cooling effect of up to **0.3°C (midday)** and **1.6°C (night)**

Li & Norford 2016

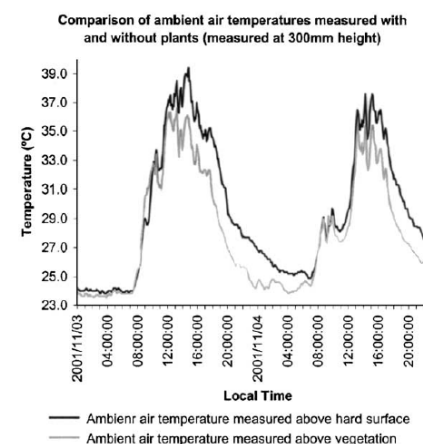
Green roofs



Green roof can **reduce surface temperature up to 18 °C**. It can also **reduce over 60% of heat gain** by the building

Wong et al 2007

Roof gardens



Dense vegetation decreases **ambient air temperatures by ~3°C (midday)** and up to **4.2°C at 6pm**, 30cm above surface

Wong et al 2003

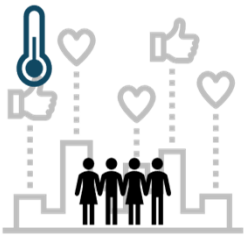
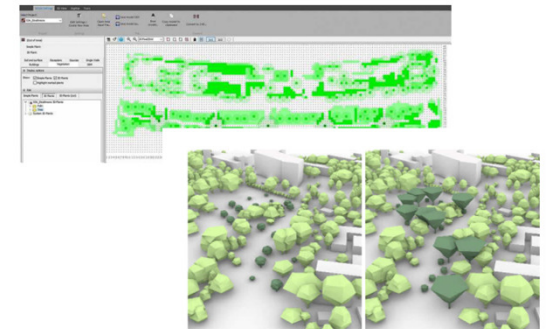
To optimize heat mitigation, more work is needed



Deploy microclimatic sensor network to assess and monitor the effectiveness of varying vegetation density across urban morphology

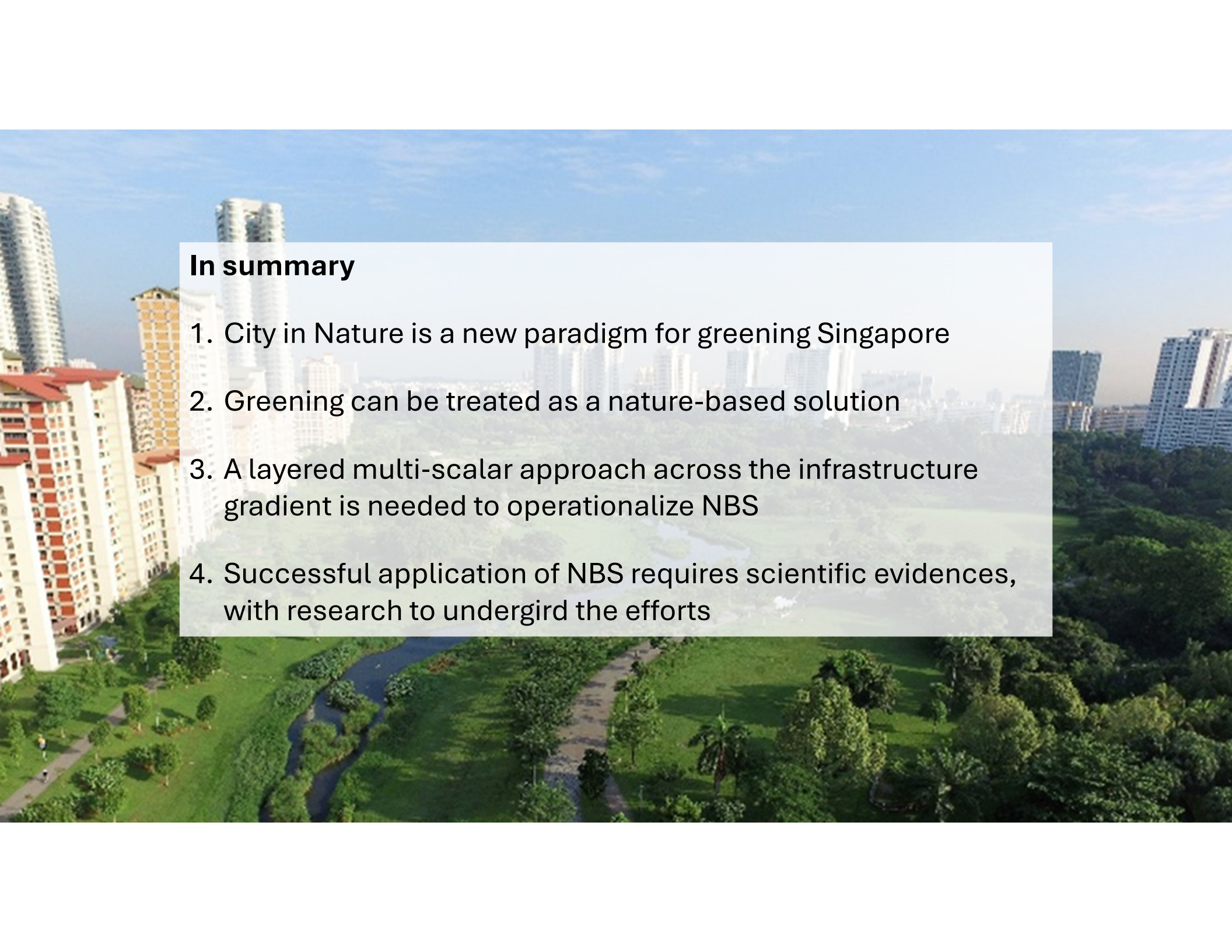


Develop microclimate models to better account for the cooling contribution of vegetation



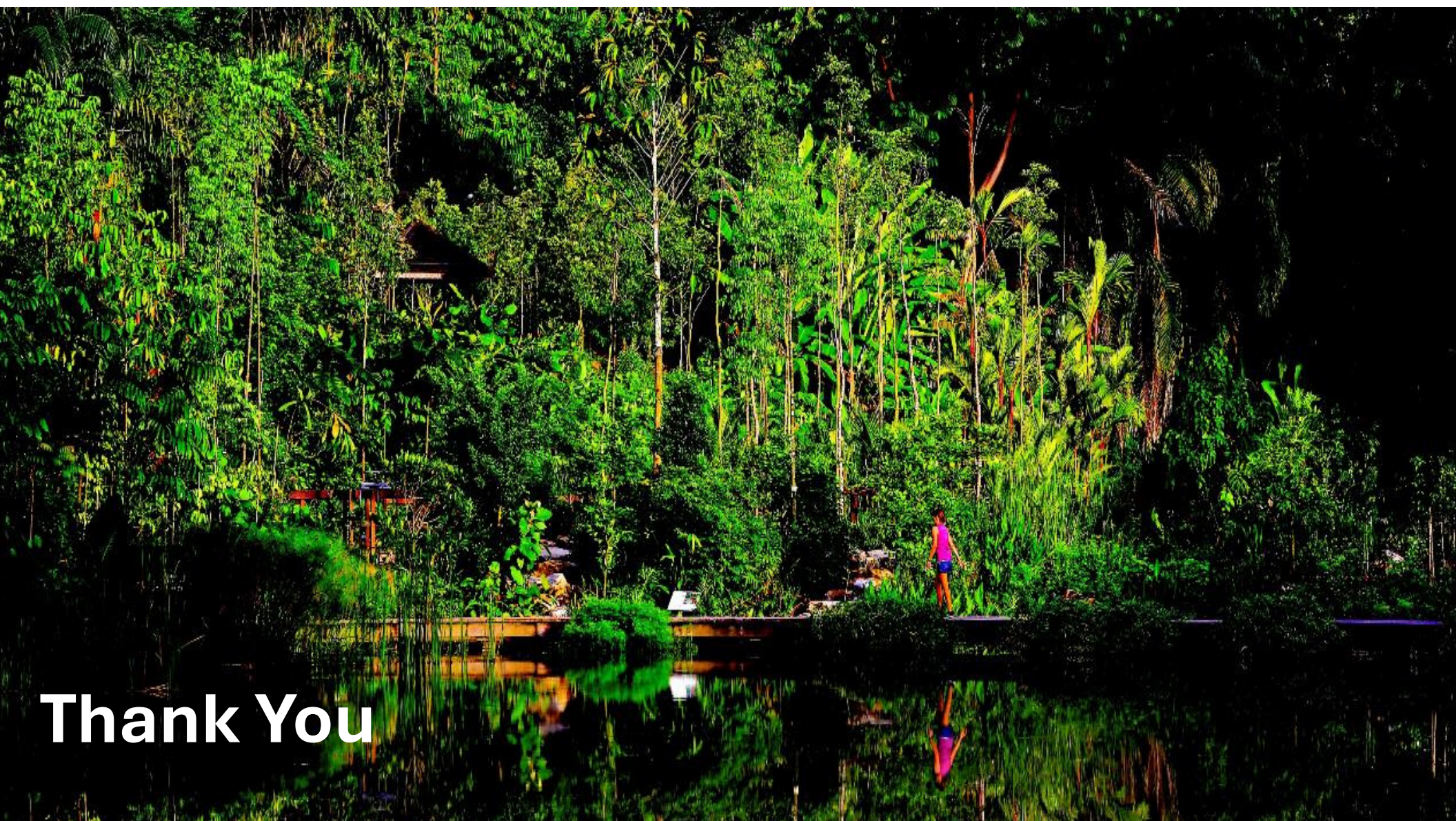
Examine how different types and experiences of greenery can moderate thermal comfort perception



An aerial photograph of a lush green park with a winding river, surrounded by dense urban development and high-rise apartment buildings under a clear blue sky.

In summary

1. City in Nature is a new paradigm for greening Singapore
2. Greening can be treated as a nature-based solution
3. A layered multi-scalar approach across the infrastructure gradient is needed to operationalize NBS
4. Successful application of NBS requires scientific evidences, with research to undergird the efforts



Thank You