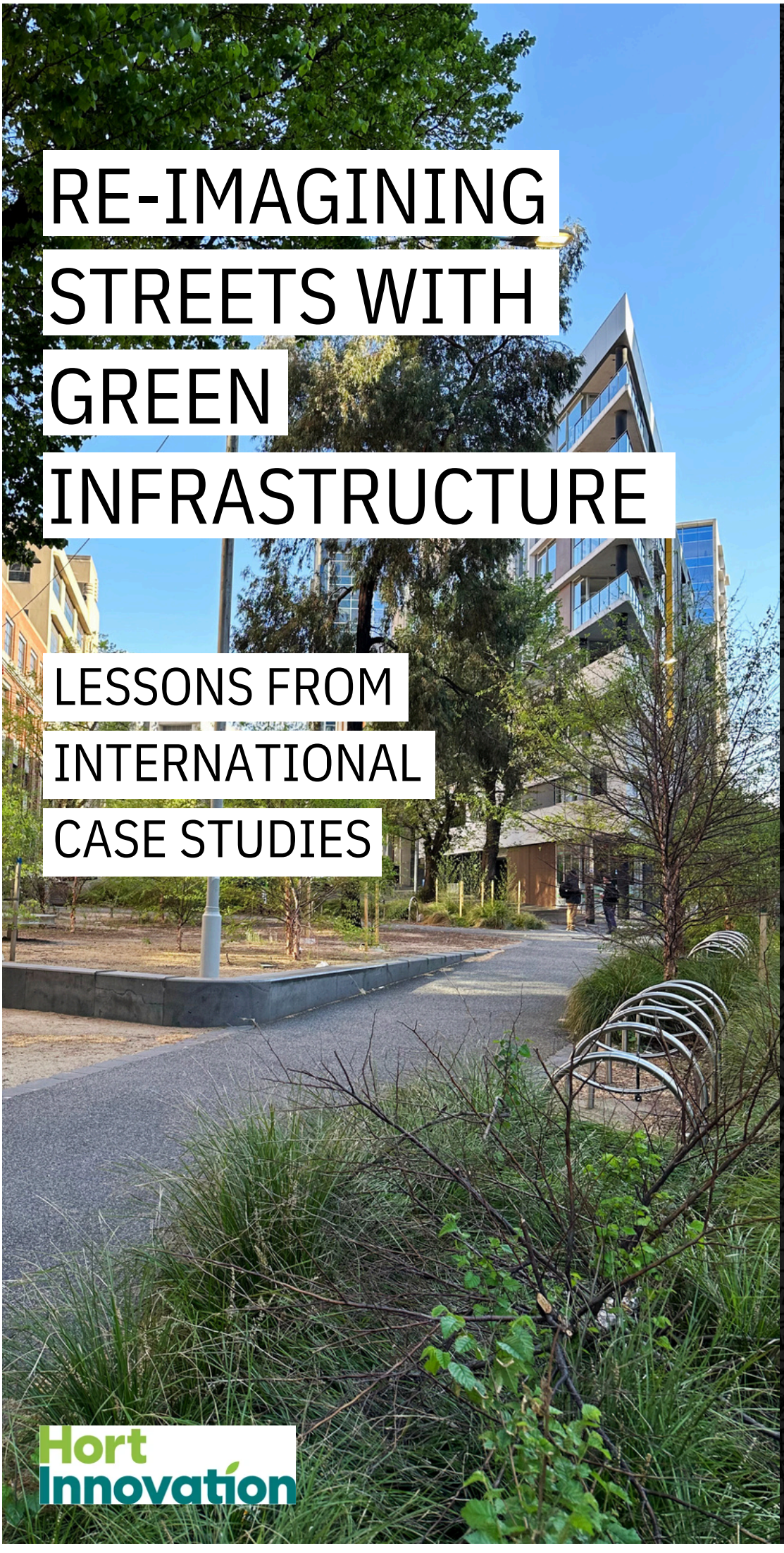

RE-IMAGINING STREETS WITH GREEN INFRASTRUCTURE

LESSONS FROM INTERNATIONAL CASE STUDIES

Hort Innovation

THE UNIVERSITY OF MELBOURNE

Melbourne Centre for Cities

RE-IMAGINING STREETS WITH GREEN INFRASTRUCTURE

LESSONS FROM INTERNATIONAL CASE STUDIES

To cite this report: Soanes, K (2024) Reimagining streets with green infrastructure: lessons from international case studies. Melbourne Centre for Cities. The University of Melbourne.

The Re-imagining Streets with Green Infrastructure project is an interdisciplinary team spanning urban greening, landscape architecture, engineering and social sciences from the University of Melbourne, in collaboration with partners from Mosaic Insights and RMIT University. The team includes Professor Sarah Bell, Dr. Kylie Soanes, Dr. Marie Dade, Dr. Nano Langenheim, Dr. Kerry Nice, Dr. Dom Blackham, and Dr. Thami Croeser. The Re-imagining Streets with Green Infrastructure (GC2011) project is funded through Hort Innovation Frontiers with co-investment from the University of Melbourne and the Victorian Government and contributions from the Australian Government. This project has human research ethics approval from the University of Melbourne Project ID #30838.

Cover image: Kylie Soanes

Hort Innovation

THE UNIVERSITY OF MELBOURNE

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INTRODUCTION

Cities around the world are harnessing the power of green infrastructure to mitigate the impacts of climate change, improve the health and well-being of residents, and provide habitat for biodiversity. Streets make up a major component of public space in cities and so present a clear target for retrofitting with green infrastructure. Yet streets also present a number of unique technical and social challenges that must be overcome if greening retrofits are to be successful.

Here, we present five case studies from around the world that showcase what can be achieved through major street retrofits:

1. Cheonggyecheon Restoration Project (Seoul, South Korea)
2. Green to Grey project (Sheffield, United Kingdom)
3. Green Corridors (Medellín, Columbia)
4. Place de Catalogne (Paris, France)
5. Superblocks (Barcelona, Spain)

The assembled case studies vary in the extent of canopy cover achieved, the incorporation of water-sensitive urban design, and the degree to which space for traffic and parking was reallocated to greening. All projects fulfilled multiple goals and had sufficient information publicly available.

COMMON ELEMENTS OF STREET GREENING RETROFITS

For each, we extracted information on ten common elements of street greening retrofits: canopy cover, hard surfaces, storm water, temperature, air quality, biodiversity, public amenity, mobility, utilities and service provision, and parking (Fig. 1). Street retrofit projects typically contend with each of these issues, seeking to maximise the benefits and minimise negative impacts. The degree to each issue was reported on varied from project to project.

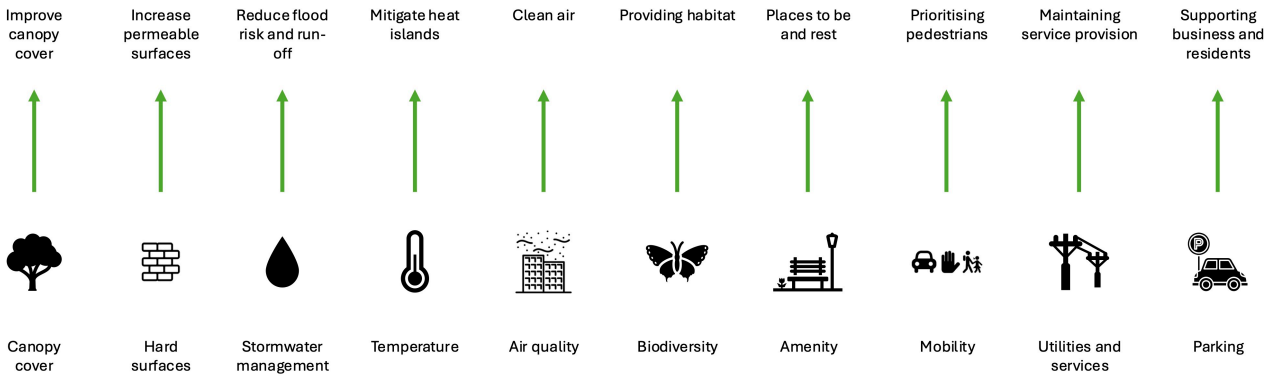

Figure 1. Common elements of street greening retrofits

WHAT DID WE LEARN?

Common features emerging across the case studies were:

- The opportunistic nature of retrofits – many took advantage of major infrastructure projects, policy changes or public demand to implement a retrofit
- Multiple functions – each project was designed to explicitly deliver at least three benefits from the greening retrofit. Common features were cooling, public amenity, pedestrian mobility, and stormwater mitigation.
- Catalysts for further change – each project included here was a catalyst for further change and ambition. The local action demonstrated what was possible, driving new norms and approaches within their cities and across the world.
- Evaluations of multiple benefits are rare – while street retrofits state multiple goals, few of these are explicitly evaluated. The extent of change in canopy cover, impacts on biodiversity, and social values for each project were rarely measured.
- To inspire and support change, publicly available data is critical – the projects included here were selected partly because they had the most available data of greening retrofits discovered in our search. However, technical details around the project design, how challenges were overcome, and the outcomes measured were difficult to source and rarely publicly available.
- Equitable access and social justice require further work – in several projects, concerns were raised about the lack of inclusive design (for example, supporting people living with disability or mobility needs), and the potential for gentrification and entrenched inequity.

FUTURE WORK

We are exploring opportunities to expand this booklet to include further case studies (including case studies from within Australia), and sections on specific technological advances that enable greening retrofits, to provide a comprehensive resource for others to explore the breadth of actions for streetscape projects.

CHEONGGYECHEON RIVER RESTORATION – SEOUL, SOUTH KOREA

Francisco Anzola CC-BY-2.0

MOTIVATION: AN AGING FREEWAY IN NEED OF REPAIR PRESENTED AN OPPORTUNITY FOR A MAJOR REINVENTION OF PUBLIC SPACE

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PROJECT SYNOPSIS

This large scale, urban renewal project involved removing two major roadways and uncovering a buried stream to create 5.8 km of public space in the Central District of Seoul. The existing elevated road and expressway created a barrier to cross-city movement. Rather than invest in significant works to repair it, the city took the opportunity to instigate a major revitalisation project. The expressway and 10-lane road were dismantled, the stream daylighted, and extensive tree planting and revegetation took place. Public greenspace and recreational areas were designed along the stream bank, including plazas and amphitheatres. Zones for biodiversity habitat were also created. The project opened in 2005.

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Major infrastructure projects can create opportunities for transformative urban greening

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PRIMARY OUTCOMES

LESSONS

- Inclusive designs must be considered early in the planning phase. The original design of walkways and seating areas were not accessible for users with limited mobility, visual impairments or other needs. Upgrades were retrofitted in response to intense community feedback.
- Improvements to public transportation networks and parking for local businesses helped moderate concerns about the removal of the roadway.
- The success of high-profile actions can become a standard for further change.

DETAILED ASSESSMENT

ELEMENT	OUTCOME AND EVIDENCE
	**Improved canopy cover** Canopy trees included in river and roadside plantings. Extent of change in canopy cover unknown.
	**Improved permeability** While no quantitative data is available, daylighting the stream and removing the expressway resulted in an overall decline in impervious surfaces. However, much of the waterway is still engineered and canalized.
	**Improved storm resilience** Stream revitalization and design provides protection from 1 in 200 year flooding sustaining a flow rate of 118 mm/hr. Areas were designed to accommodate increased flows and burst banks (e.g. riffles, terraced walls, designed wetlands). Permanent flow in the riverbed facilitated by pumping treated water from nearby river and subway.
	**Reduced heat island effect** An estimated 4.5% reduction in urban heat island effect. Temperatures in the river corridor are 3-4 degrees lower than neighboring streets just 400 m away.
	**Improved air quality** Reduced small-particle air pollution by 35% from 74 to 48 micrograms per cubic meter. Before the restoration, residents of the area were more than twice as likely to suffer from respiratory disease as those in other parts of the city.
	**Increase in biodiversity** Deliberate actions provided habitat for biodiversity, including constructed marshes, breeding grounds and habitat zones. The number of bird, amphibian and invertebrate species increased, with overall biodiversity increasing by 639% compared to pre-restoration work.
	**Improved visitation and amenity** The corridor was designed as a community space and attracts 64,000 visitors daily. Features including seating, walking and cycle paths, plazas and waterfront decks. Stepping-stones and bridges allow crossing of the river. Art and decorative elements included in the design. Fountains, waterfalls and treated wastewater allow swimming in shallows.
	**Shift from private vehicles to public transport and pedestrians** Removal of the elevated expressway to dedicate space for pedestrians and nature led to less vehicle traffic (45% decline) and an increase in bus and subway ridership (up to 15% increase). Additional paths and transport services were added to accommodate the change.
	**No data** on the impact of utilities on the retrofit
	**Increased parking specific to local businesses** Provided additional parking for local businesses, discounted parking, more loading zones to alleviate concerns about impacts on trade.
Other	Positive impacts on local businesses and land prices. Sustainability was improved by re-using construction waste in the stream construction.

GREY TO GREEN – SHEFFIELD, UNITED KINGDOM

Nigel Dunnett. www.nigeldunnett.com/

MOTIVATION: URBAN REGENERATION AND FLOOD REDUCTION THROUGH WATER-SENSITIVE URBAN DESIGN

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PROJECT SYNOPSIS

Two lanes of traffic made way for a 1.6 km corridor of greenspace, revitalising the urban area and protecting against damaging floods. Following a recent transport restructure, an inner-urban highway was identified as a candidate for deep greening retrofit. Two of the four lanes were reallocated to greenspace, including canopy forming trees, drainage swales to improve permeability, and pictorial meadows to provide attractive public space. The project is widely regarded as a leading example of water-sensitive urban design. However, the work faced criticism from advocacy groups regarding the lack of community engagement in the design, and the absence of dedicated cycling infrastructure.

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Retrofits provide an opportunity for urban resilience and community placemaking

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PRIMARY OUTCOMES

LESSONS

- **Recognised opportunities presented by a transport restructure** that rendered an inner-city ring road redundant. This allowed two lanes of traffic to be reallocated from traffic to public greenspace.
- **A high level of technical knowledge was required to implement the project and develop solutions that met multiple goals in a highly contested space.** This led to innovations in urban horticultural practices (e.g. pictorial meadows) through partnership with local universities, and allowed the construction of the UKs largest retrofit of water-sensitive urban design (e.g. Sustainable Urban Drainage Systems).
- **Designs that balance multiple benefits are difficult to achieve.** This project was designed to improve urban greening, climate resilience, and public amenity – yet tensions regarding the best use of space are still evident.

DETAILED ASSESSMENT

ELEMENT	OUTCOME AND EVIDENCE
	Canopy cover improved Design included canopy trees (40–50 from available data) however no information on the % change in canopy cover is available.
	Increase in permeable surfaces. Two lanes of highway were reclaimed as green spaces and water sensitive urban design.
	Improved resilience to flood events Sustainable urban drainage systems and bioswales were installed along the length of the project. Modelling shows major reductions in stormwater discharge.
	No data available. Monitoring currently underway
	No data available.
	Biodiversity improved Biodiverse, complex plantings and habitat structures were included in the design. Biodiversity reportedly increased by 561% when assessed using BREEAM calculator, however this data is not publicly available.
	Activated public space Aesthetics were a large part of the planting scheme, designed to ensure year-round attractiveness. Plantings were also designed to be attractive throughout establishment phase. Art and placemaking activities were included to further activate the public space.
	Reclaimed sections of dual-carriage highway Improved bus, cyclist and pedestrian access. Anecdotal reports of people altering walking routes to take advantage of revitalized street.
	Existing utilities required redesign A high-voltage cable was discovered mid-project.
	No data available
Other	

GREEN CORRIDORS – MEDELLÍN, COLOMBIA

MOTIVATION: REDUCING AIR POLLUTION AND HEAT ISLAND EFFECTS

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PROJECT SYNOPSIS

A city-wide initiative, Corredores Verdes resulted in the creation of 30 green corridors across Medellín, connecting road verges, waterways, vertical gardens, and other urban greenspace. A centrepiece of this initiative is the retrofit of Oriental Avenue, a 2.3km major road through the heart of the city. The central concrete separator was restructured, planted with more than 500 trees and thousands of other plants, allowing major greening with no reduction in parking or vehicle lanes. In other areas, vertical gardens installed on overpass pylons add greening to underused areas and redirect stormwater runoff for cooling and irrigation. A 'city gardener' program was established to train and employ socially vulnerable people to care for and maintain the green corridors. The program launched in 2016 and has seen multiple benefits, including cooling and increased biodiversity within the corridors.

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Street greening can achieve clear benefits for cooling, clean air, and biodiversity when the right technical expertise is brought into the design and long-term care

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PRIMARY OUTCOMES

LESSONS

- Tapping into public support to fund initiatives. A portion of the municipal budget is dedicated to funding projects selected by a public vote. This has enabled the community to voice their design for urban greening, leading to the implementation of projects like the Green Corridors program.
- Technical expertise in plant selection can maximise benefits. The botanic gardens helped design plantings that would thrive in intense conditions, provide habitat for native wildlife, and extract airborne pollutants.
- Leading the way. Other cities in Colombia and internationally are implementing green corridors based on the success of this program.

DETAILED ASSESSMENT

ELEMENT	OUTCOME AND EVIDENCE
	Improved canopy cover More than 8000 canopy trees were planted as part of the project. No estimates of % change in canopy cover available
	Transformed hardscapes to softscapes Along one road, more than 2 hectares of paved ground was converted into planted areas.
	Implied but not quantified. Conversion of paved areas to permeable gardens likely reduces run off. No specific water-sensitive urban design measures were identified.
	Reduced heat islands Green corridors are an average of 2 degrees cooler than surrounding areas
	Predicted benefits No current data available. However predicted benefits in reduction of PM2.5, due to inclusion of trees specifically capable of extracting airborne pollutants.
	Increase in biodiversity Plant selection was informed by experts at the Botanical Garden with specific aim to provide biodiversity habitat. Increase in wildlife reported include monarch butterflies, birds, and some mammals. However, quantitative data are not available.
	Unreported. Improved public amenity implied, however no data available on measures taken or their uptake.
	No change The project did not reallocate traffic lanes or shift to pedestrian focus. City notes that greening likely to improve the walkability and ease of cyclig.
	Unreported
	Unreported
Other	

PLACE DE CATALOGNE – PARIS, FRANCE

Guillaume Bontemps, City of Paris

MOTIVATION: INCREASING THE URBAN FOREST AND IMPROVING THE CITY'S RESILIENCE TO HEATWAVES

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PROJECT SYNOPSIS

A busy city roundabout was transformed into a new urban forest as part of the city's initiative to plant 170,000 trees by 2026. Completed in 2024, the project involved planting more than 400 mature trees on the site and closing part of the roundabout and adjoining road to traffic. The resulting 'micro forest' achieved 60% canopy cover, to be connected to nearby greenspaces via a green promenade (under construction). Further cooling is provided through 'misting' stations, designed to provide refuge from extreme heat waves. While only recently constructed, the project is already showing signs of improved climate resilience.

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Underused spaces offer high potential for high-density greening transformations and are particularly beneficial when conducted as part of a city-wide strategy

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PRIMARY OUTCOMES

LESSONS

- **Staged changes to traffic flow can improve public acceptance**. The reallocation of the roundabout occurred in several stages, first by reducing lanes, then being open to cyclists only, before finally being converted to a pedestrian promenade.
- **City-wide greening strategy supports whole of landscape change.** Place de Catalogne was identified as a heat island that, if transformed, would provide a major benefit both locally, and within the city's urban forest plan.
- **Design elements improve public engagement with greenspace.** The forest floor was raised to provide screening between the promenade and the traffic while a meadow clearing, seating and paths invite people into the forest. A planter box in the nearby public square mirrors the forest planting scheme, creating visual connection.

DETAILED ASSESSMENT

ELEMENT	OUTCOME AND EVIDENCE
	Increased canopy cover More than 450 canopy forming trees planted in roundabout and nearby square to achieve 60% canopy cover.
	Hardscapes transformed to softscapes Increased permeability with the addition of 5,525 m^2 of permeable surface area
	Improved management of storm water Swales included in the redesign to collect 54% of rainwater.
	Projected reduction in heat island effect Estimates that a 4°C drop in temperature will be achieved through the increased greening.
	Unreported.
	Potential improvements Local native plant species were included in the revegetation project. However there is no current data on the impacts of biodiversity more broadly.
	Improved amenity for public use Designed to increase amenity for public, including raised forest floor to provide buffer from traffic, a clearing of greenspace for relaxation and seating, misting areas during heat events.
	Prioritisation of pedestrians and cyclists, with areas for vehicle traffic reduced Roundabout was closed and converted to a 'horseshoe' flow, while neighbouring street was closed to traffic. Space has been reallocated as a promenade.
	Unreported
	Unreported. Parking likely reduced through traffic reallocation.
Other	

SUPERBLOCKS – BARCELONA, SPAIN

MOTIVATION: PEOPLE CENTRED PLANNING IN CITIES

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PROJECT SYNOPSIS

Superblocks are an urban planning approach to create walkable neighbourhood blocks that deprioritise traffic. Within a designated 'superblock', pedestrians take priority, roads are reallocated as open public space, and vehicle traffic is heavily restricted through reduced speed limits, one-way traffic, and limited parking. These changes create opportunities for increased greening – both through tactical installations, like above-ground pots and planters, and deeper retrofits that involve depaving. Six superblocks have been implemented in Barcelona, with hundreds more planned. There is clear evidence that Superblocks improve pedestrian mobility and public amenity, with documented benefits to social cohesion and public health outcomes. However evaluations explicitly focusing on outcomes for urban greening and resilience are scarce

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Tactical urbanism can create opportunities for greening when well-planned and supported by the community

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PRIMARY OUTCOMES

LESSONS

- Community consultation, engagement and co-design are critical to gaining support. Early trials were hampered by poor communication and misunderstandings about the design and long-term goals.
- Tactical changes may feel less risky, as they are inexpensive and reversible. However, cheap, temporary solutions can reinforce negative attitudes to change, downplaying the importance of a retrofit.
- Concerns about gentrification remain unresolved.
- Major reallocations of vehicle traffic require broader changes to the transportation system.

DETAILED ASSESSMENT

ELEMENT	OUTCOME AND EVIDENCE
	Clear outcomes for greening, however extent unclear Superblocks typically include the addition of canopy trees, either through temporary planter pots or new gardens. However, information on the extent of greening achieved is currently unavailable.
	No data available. Given that superblocks are typically achieved through non-permanent, surface level installations, changes to impervious surfaces are likely to be minimal.
	No data available. No superblock to date has reported the inclusion of water sensitive urban design approaches.
	Likely, but unquantified No evaluation of the impact of existing superblocks on temperature has been conducted. Some reports project city-wide cooling and a reduction in heat-related deaths if superblocks are implemented at a city scale.
	Improved air quality The reduction in vehicle traffic within superblocks can lower the concentration of atmospheric pollutants such as NO2 and PM10.
	No data available.
	Major gains for public open space The inclusion of formalised public amenities, such as picnic tables, play areas, and planted green space improves public perception. Surveys of residents report perceived reductions in noise, increased is tranquility, safety and socialisation.
	Prioritisation of pedestrians over vehicles Vehicle traffic is heavily restricted (one way, low speed limits, no through traffic) and walkability and cycling is improved. Estimated an increase in pedestrian space of 62%.
	Unreported. Impacts likely low as changes have rarely involved deep reconstruction of streets.
	Reduced space available for parking Roadside carparking was reallocated as public space. Resident parking available underground.
Other	Studies project health benefits from implementation of superblocks at city scale could increase longevity and prevent hundreds of premature deaths.

LINKS TO FURTHER INFORMATION

CHEONGGYECHEON RESTORATION PROJECT

Academic presentation by Dr In-Keun LEE, Seoul Metropolitan Government (ICLEI 2006)

https://www.seoulsolution.kr/sites/default/files/policy/%5BEN%5DCheong%20Gye%20Cheon%20Restoration%20Project.pdf

Global Design Cities Case Study

https://globaldesigningcities.org/publication/global-street-design-guide/streets/special-conditions/elevated-structure-removal/case-study-cheonggyecheon-seoul-korea/

National Archives – Commission for Architecture and the Built Environment UK

https://webarchive.nationalarchives.gov.uk/ukgwa/20110118114000/http://www.cabe.org.uk/case-studies/cheonggyecheon-restoration-project/description

Landscape Performance Series Case Study Brief

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https://www.landscapeperformance.org/case-study-briefs/cheonggyecheon-stream-restoration-project

Green City Blog (Jiyoon Kim, 2023)

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World Wildlife Fund Blog (Aaron Thomas, 2012)

https://wwf.panda.org/wwf_news/?204454/Seoul-Cheonggyecheon-river

Setting Mind Blog (Tim Fujio, 2023)

https://settingmind.com/how-a-highway-in-korea-was-restored-back-into-a-river/

GREY TO GREEN

Grey to Green Project Website

https://www.greytogreen.org.uk/background

Interlace Hub Case Study

A detailed write-up with links to sources for further information

https://interlace-hub.com/grey-green-sheffield

Climate ADAPT Case Study

https://climate-adapt.eea.europa.eu/en/mission/solutions/mission-stories/grey-to-green-street-design-story21

Nigel Dunnett (researcher involved in the project)

https://www.nigeldunnett.com/grey-to-green

Susdrain

Report on water-sensitive urban design features installed in the project

https://www.susdrain.org/case-studies/pdfs/suds_awards/006_18_03_28_susdrain_suds_awards_grey_to_green_phase_1_sheffield.pdf

UK100 Knowledge Base Case Study

https://www.uk100.org/projects/knowledgehub/grey-green-mitigating-flood-risk-and-regenerating-sheffields-city-centre

Landscape, the journal of the Landscape institute

https://issuu.com/landscape-institute/docs/climatejournal/s/165922

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Reasons to be Cheerful Blog (Yeung, 2024)

https://reasonstobecheerful.world/green-corridors-medellin-colombia-urban-heat/#:~:text=The%20$16.3%20million%20initiative%20led,cycle%20lanes%20and%20pedestrian%20paths.

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Ashden Climate Solutions in Action – Project Award

https://ashden.org/awards/winners/alcaldia-de-medellin/

BBC report (Gouvea de Andrade, 2023)

https://www.bbc.com/future/article/20230922-how-medellin-is-beating-the-heat-with-green-corridors

C40 Knowledge Hub Case Study

https://www.c40knowledgehub.org/s/article/Cities100-Medellin-s-interconnected-green-corridors?language=en_US

Earthly Mission Blog (Varga)

https://earthlymission.com/medellin-colombia-green-corridor-project-corredores-verdes-cooler-temperature/

PLACE DE CATALOGNE – PARIS, FRANCE

Paris City Website (via Google Translate)

Details the cities rationale and actions for the project.

https://www-paris-fr.translate.goog/pages/foret-urbaine-place-de-catalogne-la-concertation-est-lancee-19389?_x_tr_sl=auto&_x_tr_tl=en&_x_tr_hl=en&_x_tr_pto=wapp

C40 Knowledge Hub Case Study

https://www.c40knowledgehub.org/s/article/Cities100-Paris-is-using-blue-and-green-infrastructure-to-tackle-city-heat?language=en_US

Reuters News

https://www.reuters.com/business/environment/paris-plant-first-urban-forest-busy-roundabout-drive-build-garden-city-2023-12-06/

Bloomberg News

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Ecowatch Blog

https://www.ecowatch.com/paris-roundabout-urban-forest.html

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https://giam.zrc-sazu.si/sites/default/files/D2.1%20Literature%20review%20on%20superblocks'%20effects%20on%20urban%20realm_0.pdf

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https://www.ebrdgreencities.com/policy-tool/urban-planning-with-superblocks-barcelona-spain-2/

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Summarises outcomes from Barcelona Public Health Agency Study (original report not accessible)

https://www.barcelona.cat/infobarcelona/en/tema/urban-planning-and-infrastructures/superblocks-are-having-positive-effects-on-health-and-well-being_1097301.html

Vox 5-part investigative series reporting on the Superblocks plan and outcomes
https://www.vox.com/energy-and-environment/2019/4/9/18300797/barcelona-spain-superblocks-urban-plan

Academic paper – Mueller et al (2020) Changing the design of cities for health: The superblock model. Environment International, 134, 1015132.

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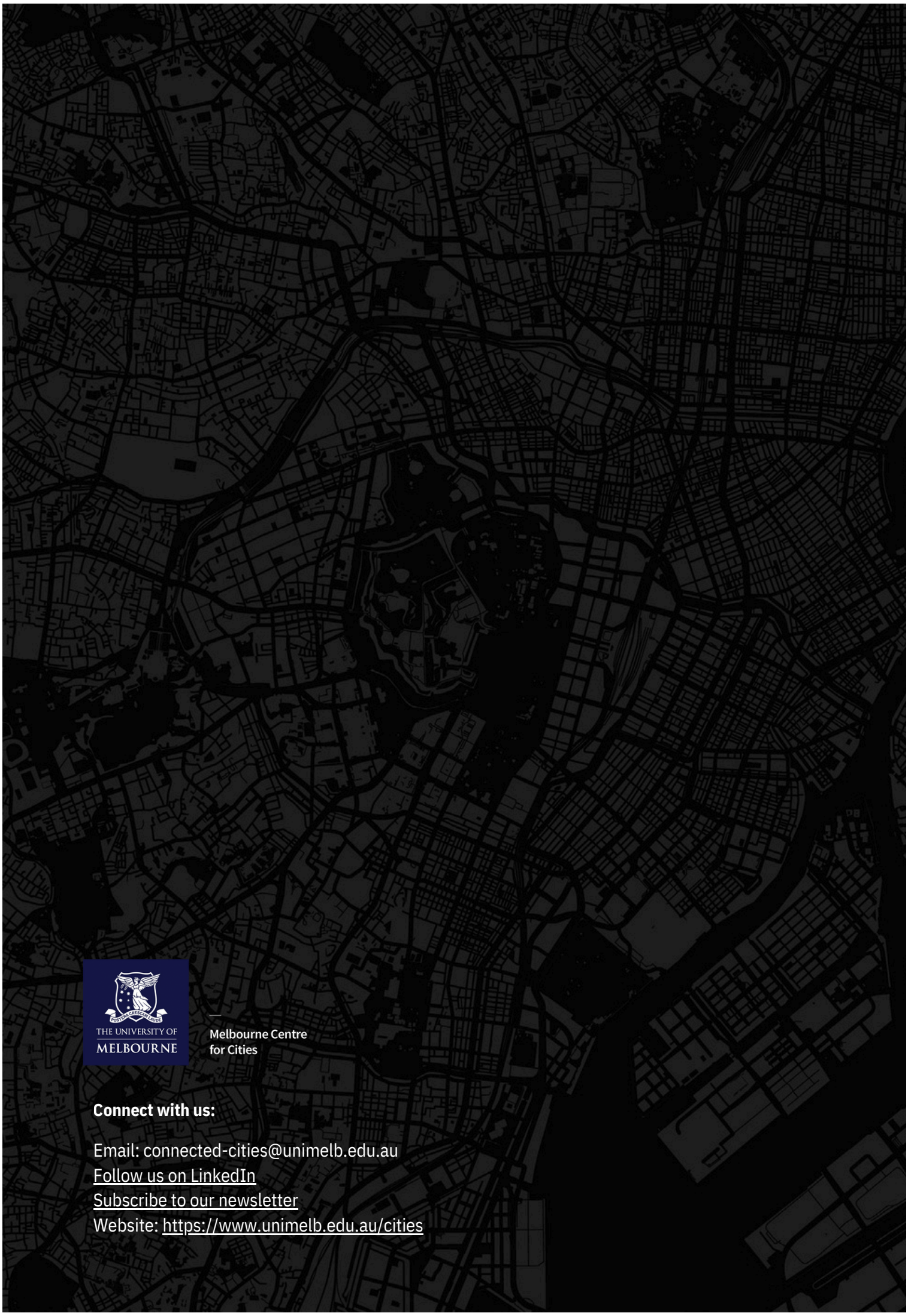

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