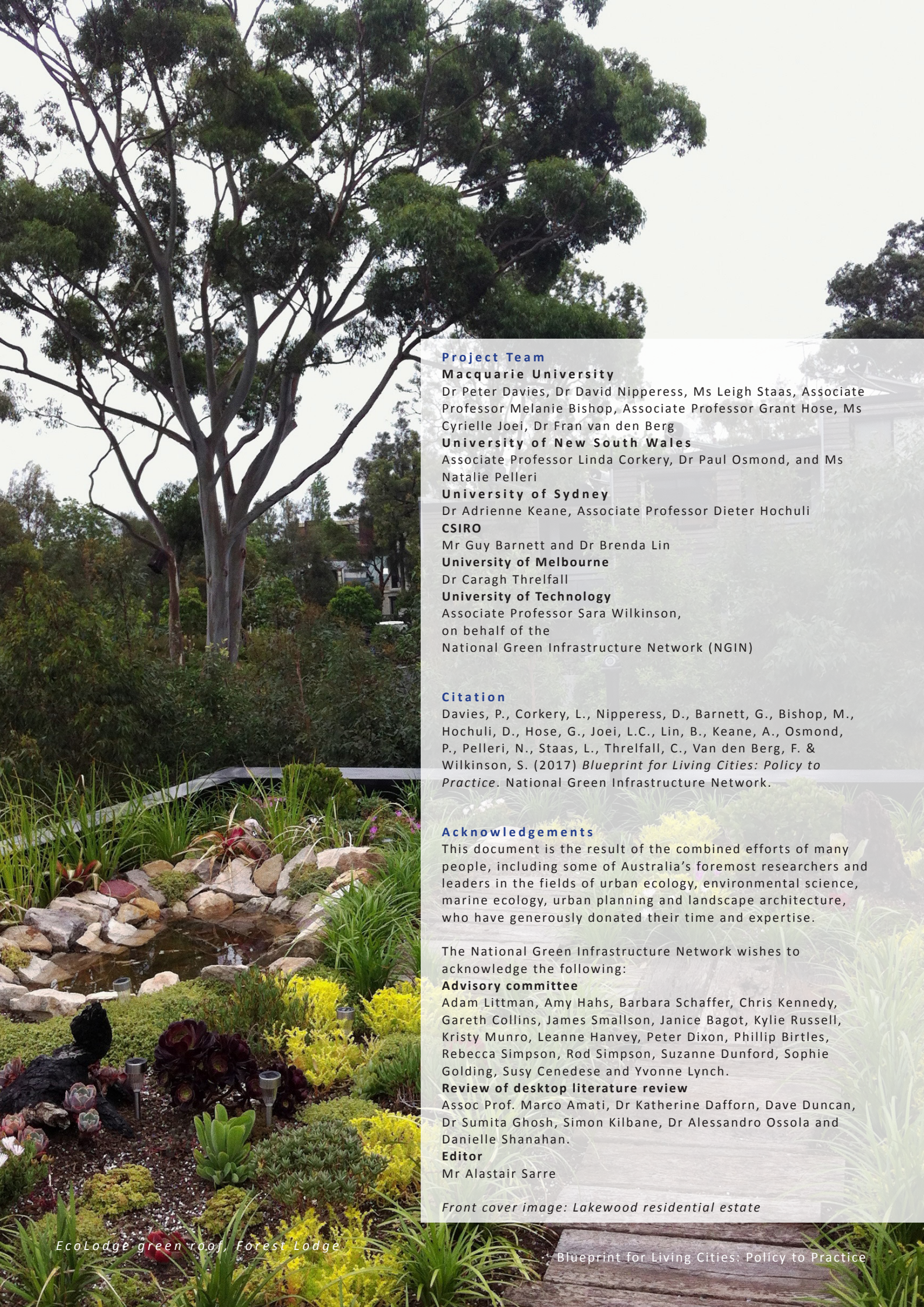
BLUEPRINT FOR LIVING CITIES: POLICY TO PRACTICE

MAY 2017

URBAN ECOLOGY RENEWAL INVESTIGATION PROJECT

NSW GOVERNMENT | NSW Environmental TRUST

THE NATIONAL GREEN INFRASTRUCTURE NETWORK



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Front cover image: Lakewood residential estate

EcoLodge green roof, Forest Lodge

NATIONAL GREEN INFRASTRUCTURE NETWORK

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BLUEPRINT FOR LIVING CITIES: POLICY TO PRACTICE

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Executive Summary

Blueprint for Living Cities: Policy to Practice will support and enhance the leadership of New South Wales (NSW) in the management of liveable and thriving cities. This document, adaptable for use by any urban stakeholder, shows the way for sustainable urbanisation in NSW.

Blueprint for Living Cities announces seven priority areas for action based on scientific evidence and best-practice examples. These priority areas establish the underlying principles and nominate the exact strategies that will guide decision-making, establish new benchmarks and address existing challenges in urban development in NSW.

Blueprint for Living Cities challenges the status quo. It shows how changes can be made within the existing planning and regulatory systems at multiple temporal and spatial scales. It presents actionable objectives and identifies tools for demonstrating the ways in which urban ecological outcomes support better governance, improve the wellbeing of communities, and ensure NSW's attractiveness as a place to live and work. *Blueprint for Living Cities* also presents ideas that, to the best of our knowledge, are yet to be implemented elsewhere.

The principles and strategies in this document are informed by a review of literature and inputs from practitioners involved in planning, designing, building and maintaining cities. The desktop literature review, *Urban Ecology: theory, policy and practice in New South Wales, Australia*, provides the evidence base and foundation for *Blueprint for Living Cities*. The researchers reviewed over 1,250 pieces of primary, secondary and grey literature, including guidelines, reports, peer-reviewed journals articles as well as government policies and publications. The desktop study provides in-depth and specific information such as possible metrics and further research to help drive evidence-based decision making in NSW. The document *What We Heard: documenting the stakeholder workshops* captures inputs from practitioners and shows how governments, industry and communities care for, manage and can control their impacts on the natural environment.

Cities are constantly changing. Although they are highly modified systems, they rely on ecosystem services to provide environmental, social and economic benefits. In many ways, the cities of Sydney, Wollongong and Newcastle are defined by their environmental character – their relationships with the coast, with the waterways that flow within them, and with the bushland that exists within them and at their peripheries. To ensure the long-term sustainability of these cities, there is a collective responsibility to manage and enhance their ecosystems and natural assets.

This is an enabling document: implementing the strategies and actions within it will bring about extraordinary, timely and needed changes to sustain our cities. Its implementation at the local to regional scales, through policies, laws and best practices, and by governments, industry, community groups and individuals will benefit the people of Sydney, Newcastle and Wollongong, now and well into the future.

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SETTING THE SCENE

Bioswales help manage urban stormwater and create habitat at Victoria Park, Zetland

The project

The NSW Environmental Trust commissioned the National Green Infrastructure Network (NGIN) to undertake the Urban Ecology Renewal Investigation Project, to develop an evidence-based case for embedding urban ecology into decision-making frameworks in the major cities of NSW. It defined major cities as those with a population of more than 100,000; therefore they comprise Sydney, Wollongong and Newcastle.

The need for the project reflects the ongoing and cumulative impacts of urban development on terrestrial and aquatic ecology, human health and wellbeing, and the future liveability of urban areas. Given current trajectories and estimates of population increases due to the intensification and expansion of major cities in NSW, further losses in the number and diversity of terrestrial and aquatic species, communities and habitats can be expected in the absence of effective action.

The objective of this investigation is to improve knowledge and understanding of the pressures, gaps and opportunities that exist to improve urban ecological outcomes in Sydney, Newcastle and Wollongong. It provides an evidence-based case for the establishment of guiding principles and a list of strategies and actions to change the ways in which urban areas are planned, designed, built and lived in.

The context

Planning for Sydney, Newcastle and Wollongong envisages these cities as home to many new residents and businesses, which will involve urban expansion into greenfield areas and the intensification of existing suburbs through urban renewal. This outward and upward expansion will place additional pressure on terrestrial and aquatic systems, and the loss of biodiversity and natural habitats will reduce the cities' resilience in the face of change. Cumulatively, such losses will affect the health and wellbeing of residents and the productivity, liveability and sustainability of the three cities.

- With 4.8 million people in 2014, Sydney is Australia's most populated city. Its population is projected to increase by 1.74 million by 2036 and it could be as high as 8 million in 2056. A significant proportion of the new residents will live in western Sydney[1].
- Newcastle and Wollongong are Australia's 7th- and 10th-largest cities, respectively. By 2036, the population of Newcastle is projected to increase to more than 180,000[2] and the population of Wollongong is projected to increase to more than 253,000[3].
- The Greater Sydney Commission (GSC) is responsible for strategic planning in Sydney, including its six districts. The metropolitan and district plans will inform the planning by local councils.
- The NSW Department of Planning and Environment are responsible for regional planning for Newcastle through the Hunter Regional Plan and for Wollongong through the Illawarra-Shoalhaven Regional Plan.
- Major urban renewal and redevelopment projects in the Sydney metropolitan area include the Bays Precinct, the Greater Parramatta and Olympic Peninsula, and the South Creek Catchment, incorporating the northwest and southwest urban growth corridors.
- The proposed Western Sydney Airport at Badgerys Creek will be a catalyst for future residential and commercial development in the peri-urban areas of western Sydney.
- Newcastle is undergoing a transformation from an industrial to a service-based economy, as reflected in investments in the renewal of the city centre. New housing areas in the north, south and west will continue to support the growth of the city.
- Wollongong is bound to the east by the coast and to the west by the Illawarra escarpment, with new urban-release areas pushing south towards Dapto. The renewal of the city centre will continue as the city builds on its tourism, services, education, freight and manufacturing sectors.

Sydney

Newcastle

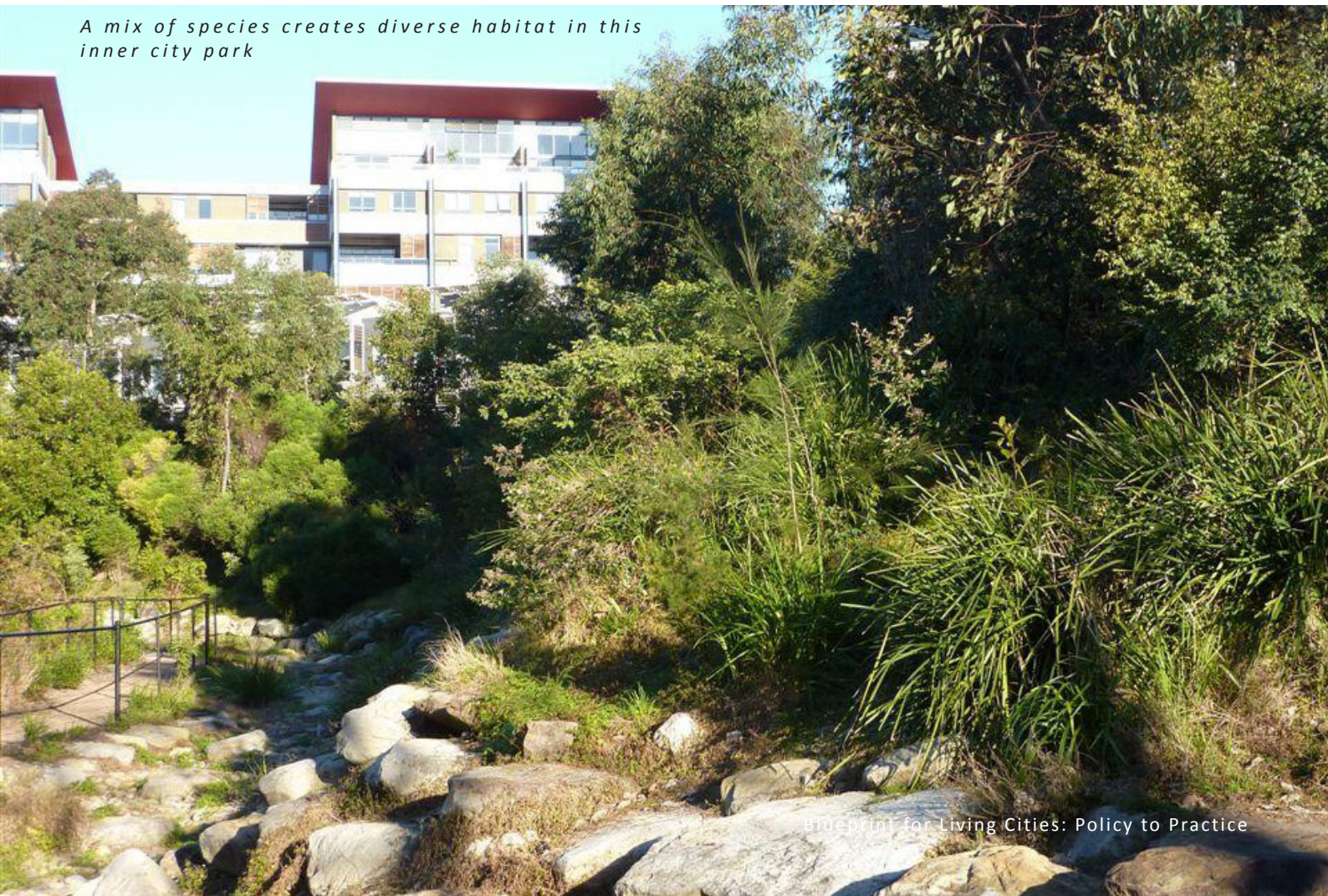
Wollongong

What is urban ecology?

Urban ecology encompasses all living organisms (people, plants and animals) in urban environments[4]. It is concerned with the distribution, abundance and behaviour of organisms and their interactions with the environment and each other. Of particular importance in urban ecology is the interaction between humans and the rest of biodiversity, including the benefits provided by biodiversity through ecosystem services and the impacts of urbanisation on biodiversity.

Urban ecology conceptualises cities as ecosystems[5]. It recognises that humans are inseparable from nature and that nature occurs throughout cities, not just in green patches and waterways[6]. Urban landscapes comprise complex and fragmented patterns of built and natural features, within which species respond in diverse ways – some adapt and thrive, and others do not. The science of urban ecology requires an integrated approach in which cities are viewed as complex and dynamic systems that encompass the natural environment and social and technological considerations[7].

A mix of species creates diverse habitat in this inner city park



Why urban ecology matters

More than 75% of Australians live in the country's 20 largest cities, which include Sydney, Newcastle and Wollongong. The trend of increasing urbanisation has been occurring for more than a century in Australia, reflecting a global trend of people moving from towns and rural areas to cities[8]. Globally, the land area occupied by cities is expected to triple by 2030, with the direct and immediate loss of agricultural and industrial lands and of natural habitats[9].

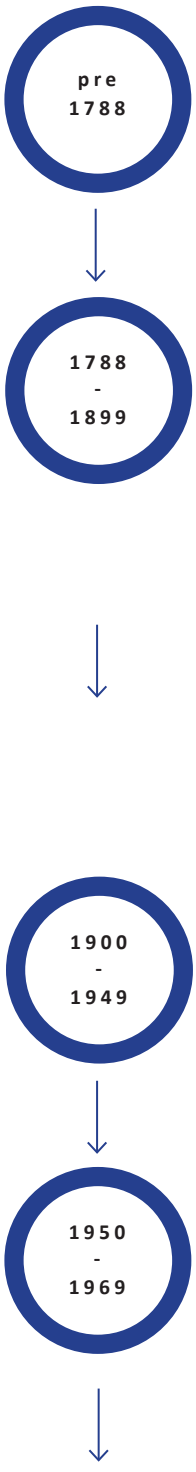
Ecologists[10] and urban planners[11] acknowledge that 'the city' has become the primary habitat for humans. Even before the start of the present century, it was known that human actions were having profound impacts on biodiversity: for example, about one-quarter of bird species had been driven to extinction[12].

There are many drivers of biodiversity loss in cities, including habitat removal, disturbance, invasive species, climate change, and the pollution of land, air and waterways. Such impacts are the outcomes of a combination of factors, including past and present laws and the priorities of governments, the practices of industry, and the ways in which urban residents collectively interact with and value the natural environment.

To arrest the trend of urban biodiversity loss, a transformation is required involving substantial shifts towards liveability, sustainability and resilience. In such a transformation, industry is more sensitive to the impacts of urban development; governments drive priorities and coordinate their laws, policies and plans; and communities understand and place greater value on nature. To this end, urban ecology is an increasingly significant field of research for understanding how urban processes affect the natural environment and how the natural environment affects humans.

The effects of urbanisation in Lane Cove, in 1943 and 2016

Events that have shaped urban ecology in NSW

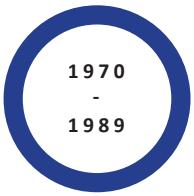


- **pre 1788:** Indigenous peoples lived a hunter–gatherer lifestyle and used fire to manage land. Approximately 700 languages were spoken on the continent, and the population was estimated at between 315,000 and more than 1 million people

- **1788:** Sydney settled as penal colony, with a population of 859 (Aboriginal and Torres Strait Islander people were counted but not incorporated in official population counts until 1971 census)
- **1804:** Newcastle founded
- **1816:** Sydney's Royal Botanic Gardens opens
- **1834:** Wollongong founded
- **1841:** City of Wollongong population is 2,999
- **1850:** Population of NSW is 266,900
- **1857:** Parramatta Park created
- **1879:** Royal National Park established
- **1885:** Newcastle proclaimed as a city
- **1888:** Sydney's Centennial Park opens
- **1888:** Prospect Reservoir completed as part of Upper Nepean Scheme
- **1894:** Ku-ring-gai Chase National Park established

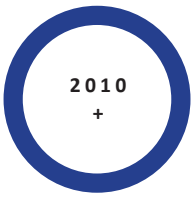
- **1900:** Population of NSW is 1,360,305
- **1901:** Population of Wollongong is 14,119
- **1913:** Construction of Newcastle Steelworks begins
- **1931:** Steelmaking in Port Kembla begins
- **1935:** BHP buys Port Kembla steelworks

- **1950:** Population of NSW is 3,241,057
- **1951:** County of Cumberland Plan adopted
- **1959:** Blue Mountains National Park established
- **1960:** Warragamba Dam completed
- **1961:** City of Wollongong population is 131,754
- **1963:** State Planning Authority created, replacing Cumberland County Council
- **1965:** County of Cumberland Greenbelt land released for housing
- **1968:** Sydney Region Outline Plan released



- **1970:** Introduction of specific pollution laws to NSW: State Pollution Control Commission Act, Clean Waters Act
- **1970:** Population of Sydney is 2,751,830
- **1971:** Population of Newcastle is 146,000
- **1974:** Australia signs Convention on Wetlands of International Importance (Ramsar Convention)
- **1974:** National Parks and Wildlife Act enacted
- **1975:** Sydney Harbour National Park established
- **1979:** Environmental Planning and Assessment Act enacted
- **1980:** Illawarra Escarpment State Conservation Area gazetted
- **1986:** Hunter Region Botanic Gardens opens and SEPP 19 Bushland in Urban Areas gazetted
- **1988:** Bicentennial Park and Mount Annan Botanic Gardens open

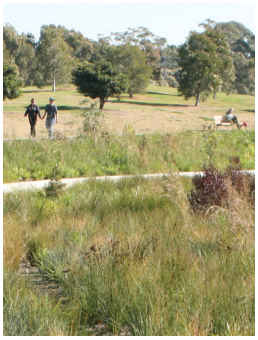
- **1990:** NSW Environment Protection Authority (EPA) established
- **1992:** Council of Australian Governments endorses National Strategy for Ecologically Sustainable Development
- **1993:** EPA releases first 'state of the environment' report
- **1995:** Threatened Species Conservation Act enacted
- **1999:** Environmental Protection and Biodiversity Act enacted
- **1999:** BHP closes Newcastle steelworks
- **2000:** Greater Blue Mountains Area established as an UNESCO World Heritage Site; Commonwealth Environmental Protection and Biodiversity Conservation Act enacted
- **2000:** Environmental Planning & Assessment Regulation, Water Management Act enacted
- **2006:** Western Sydney Parklands established
- **2007:** Hunter Wetlands National Park gazetted
- **2008:** Biodiversity banking and offset scheme introduced in NSW



- **2010:** Population of Sydney is 4,555,516, Newcastle is 153,542 and Wollongong is 192,418
- **2012:** Guidelines for Riparian Corridors on Waterfront Land updated
- **2014:** A Plan for Growing Sydney released, with reference to the Sydney Green Grid and Urban Green Cover Technical Guidelines for NSW
- **2014:** 10/50 vegetation clearing scheme introduced following 2013 bushfires
- **2015:** GSC established under Greater Sydney Commission Act
- **2015:** BHP leaves Illawarra region
- **2015:** Department of Planning and Environment releases Illawarra-Shoalhaven Regional Plan
- **2016:** Department of Planning and Environment releases Hunter Regional Plan 2036
- **2016:** GSC releases draft district plans for Sydney
- **2016:** Biodiversity Conservation Act (repealing Threatened Species Conservation Act 1995)

Why act now?

Urban sprawl in north-western Sydney



Wetlands in Sydney Park, St Peters

Mature fig tree in Parramatta

A range of factors, discussed below, is exerting pressure on major cities in NSW with the potential to cause significant net losses of urban biodiversity and ecosystem services and to negatively affect human health and socioeconomic values. Reforming planning and bolstering resilience are two ways to avert these negative outcomes.

Population growth

Urban populations are predicted to continue increasing in Australia. The population of Sydney is expected to grow from 4.8 million in 2014 to 8.0 million in 2056[13].

Urban sprawl

Natural environments are affected when cities spread into greenfield areas. Increasing urban density can help mitigate the impacts of such urban 'sprawl' if developments are well designed to protect ecosystem functions and incorporate green infrastructure in open spaces and street designs.

Land clearing

Greenfield developments, for example in the new urban-release areas in western Sydney, are putting intense pressure on critically endangered ecological communities, such as the Cumberland Plain woodland, and on local streams, such as South Creek. These ecological communities and waterways need protection because they provide important ecosystem services and contribute to urban liveability.

Planning reforms

The NSW government is reviewing the Environmental Planning and Assessment Act 1979 and various environmental planning instruments. One of the aims of the review process is to place greater importance and statutory weight on strategic planning to link regional plans with development outcomes and controls at the local level. This process presents an opportunity to advance urban ecology principles in city-to-local planning and to improve enforcement.

Health and well-being

Urban greening provides spaces for recreation, social gatherings, rest and relaxation. Studies show that access to green spaces improves human physical, social and mental health.

Climate change

Climate change will increase pressure on built and natural environments. Extreme weather events such as heatwaves and storms will have increasing impacts on urban populations, and longer-term increases in median and high sea levels will affect coastal areas.

Resilience

Integrating urban ecology principles into urban development will increase a city's resilience in the face of change. For example, the urban heat island effect is

Former BP site park, Waverton

Camperdown Commons community garden, Camperdown

likely to increase due to global climate change, without effective urban ecology measures.

Ecosystem services

The natural environment provides a host of urban ecosystem services that benefit human populations. Urban biodiversity provides crucial ecosystem services, including pollination, carbon sequestration, air-quality improvement, stormwater management, energy-use reduction, habitat provision, and improvements in local climate. These services result contriute to a range of economic benefits.

Local commerce

Urban greening and the aesthetics of well-landscaped streets and precincts improve local commerce and property values, demonstrating that improved environmental outcomes and economic gains can be mutually supportive. A recent study revealed that a 10 percent increase in the leaf canopy of street trees could increase the value of properties by an average of $50,000[14].

STRATEGIES FOR LIVING CITIES

Southeast False Creek in Vancouver is a model of sustainable urban development

Positioning for success

Regardless of the approach taken to achieve better outcomes for our cities, the following five principles must underpin decision-making:

One
Healthy, functional urban ecosystems are essential parts of our cities and are crucial for the wellbeing and resilience of people and the environment

Two
Urban development creates risks and opportunities for ecosystems

Three
The renewal of urban ecosystems must be evidence-based

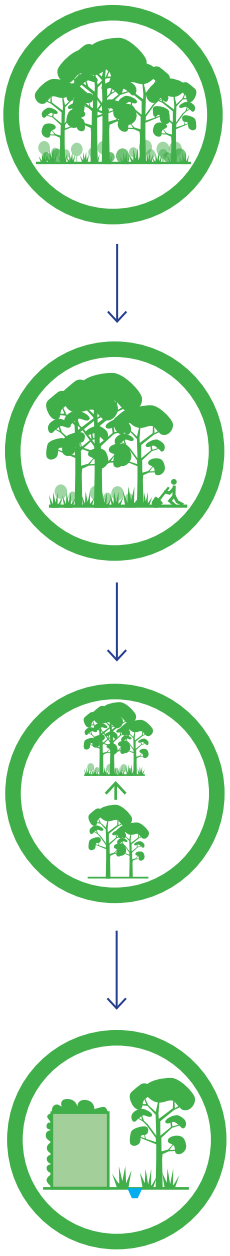
Four
Achieving urban ecological renewal requires collaborative and inclusive partnerships across sectors and scales

Five
Innovation is needed to capitalise on opportunities for urban ecological renewal

Mangroves at Sydney Olympic Park provide food, breeding, nursery and habitat for a variety of animal species

Urban ecology hierarchy

There is a hierarchy of priorities to enable better urban ecological outcomes through planning, design and practice. These priorities are as follows:



Protect and conserve
The protection and conservation of remnant ecosystems, where they exist, is crucial. In an increasingly urbanised world, such remnants provide important habitat and biodiversity.

Restore
Where ecosystems have been disturbed, restoration is the preferred option. Restoration includes bush regeneration and weed management in existing ecosystems.

Enhance
Where few existing ecosystems are available for restoration, improving green spaces is the next best option. This can be done by increasing the area of green spaces and the diversity and density of vegetation.

Create
If none of these options is available, new ecosystems must be created. Green infrastructure and water-sensitive urban design (WSUD) elements such as green roofs and bioswales can provide habitats and ecosystem services.

Urban ecology strategies

Sydney Park wetlands

Blueprint for Living Cities establishes seven interconnected strategies that recognise the importance of scale and address the roles of stakeholders involved in and influencing urban ecological outcomes.

The seven urban ecology strategies are:

STRATEGY ONE
Retain and enhance habitats to support biodiversity in cities

STRATEGY TWO
Reform city planning to embed urban ecology in decision-making

Street verge planting in Marrickville

STRATEGY THREE
Connect biodiversity across cities through green and blue networks

STRATEGY FOUR
Design and deliver green and blue cities

STRATEGY FIVE
Create new habitats to support biodiversity and human wellbeing

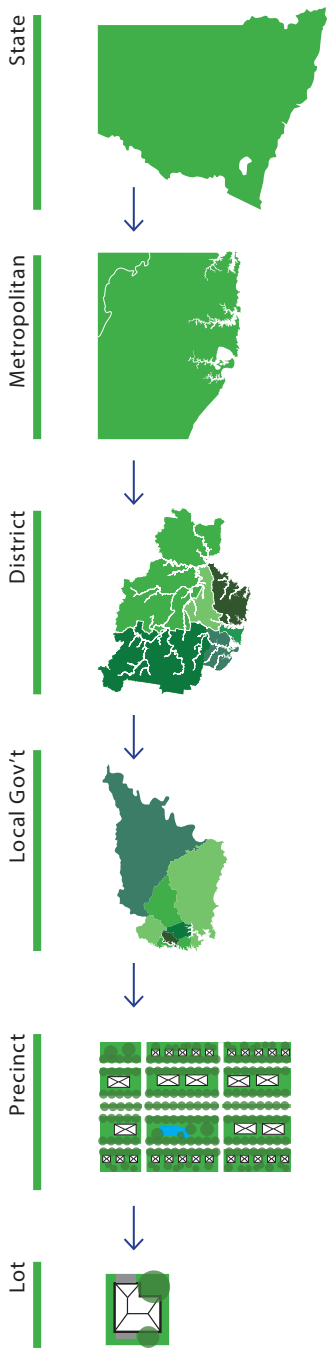
Tunks Park, Cammeray

STRATEGY SIX
Develop and implement engagement programs to increase education and involvement across all sectors

STRATEGY SEVEN
Align urban ecology policies and practices at all levels of government

Scale-based actions

Blueprint for Living Cities specifies a series of actions for implementing the seven urban ecology strategies, according to the scale at which they can be applied. Impacts can be achieved at a variety of spatial scales, from the state to the individual lot.



At the state scale, legislative and regulatory reforms are crucial for setting the framework and direction of urban ecology actions at smaller scales. To change business-as-usual practice, the policies and plans of the NSW government must provide top-down support for urban ecology.

At the metropolitan scale, strategic metropolitan planning must incorporate urban ecological outcomes. City planning for Sydney, Newcastle and Wollongong must aim to protect and increase urban biodiversity and urban ecosystem services.

Sydney is composed of six districts. Coordinated, holistic planning within and between these districts will improve urban ecological functioning.

At the local scale, councils must implement plans, policies and guidelines to improve urban ecological outcomes within local government areas (LGAs). The public can assist with implementation and establish grassroots initiatives to apply urban ecology principles locally.

State and local government planning must facilitate urban ecology at the precinct scale. Smaller reserves will play increasingly important roles as habitats for isolated and less-mobile species and as biodiversity 'stepping stones' and corridors.

At the scale of individual lots, the actions of homeowners and property developers can have a significant cumulative effect.

S1 STRATEGY ONE

Protect and conserve

Enhance

Retain and enhance habitats to support our biodiversity in cities

EVIDENCE BASE

Biodiversity is declining in Sydney, Newcastle and Wollongong, due in part to the loss of green spaces. A healthy urban environment supports the wellbeing of city dwellers. In general, the area of green space decreases as urban density increases, with cumulative and detrimental ecological impacts. Planning and design strategies, therefore, must strive to maintain and strategically increase green spaces and habitat.

IN PRACTICE

State planning and policy legislation does not go far enough in supporting habitat retention, stymying the intentions of practitioners, such as local planning authorities, to support urban ecological outcomes. Moreover, there is little or no enforcement of existing plans. Policies and legislation are required that include enforceable compliance requirements for the protection and enhancement of urban ecosystems.

Practitioners acknowledge conflicts in land-use decision-making as major barriers to the retention of urban ecological values, and they point to opportunities for increasing the leverage of existing programs and tools in the protection and enhancement of urban ecosystems. Such programs and tools include those that use mapping to identify key habitats for protection or enhancement (at both fine and broader scales). The Sydney Green Grid is a district-level mechanism which has the potential to support the connectivity of protected, remnant and valuable habitats; it requires green and blue grids at the local and precinct levels to support urban ecological outcomes.

Biobanking is a market-based tool for protecting and managing habitats, but it is often applied to the detriment of habitats of lesser value. A new tool that better captures and values ecosystem services, liveability and land values and which can be applied in strategic and development assessment processes would greatly improve the deployment of urban ecology principles.

The strategic actions in the table below incorporate both existing programs and tools and new ideas, as identified in a review of the literature, in national and international case studies, and in discussions with practitioners. These strategic actions will work to retain and enhance habitats and biodiversity and support healthy cities.

S1A1	Action 1	Scale
Process	**Explicitly assess the impacts on biodiversity of proposed changes to land-use zoning and the use of public land (e.g. community to operational)**	
S1A2	**Action 2**	
Process	Incorporate mechanisms in the development application and assessment process that support biodiversity outcomes	
S1A3	**Action 3**	
Process	Establish threshold levels for ecological communities for which no further development can be considered	
S1A4	**Action 4**	
Research	Complete the mapping of the location and condition of terrestrial and aquatic habitats, assess their recovery potential and prioritise opportunities for protection and restoration	
S1A5	**Action 5**	
Process	Consolidate and make publicly available all habitat and species mapping undertaken by governments, industry and researchers	
S1A6	**Action 6**	
Research	Undertake monitoring and evaluation programs at all relevant scales to assess changes to terrestrial and aquatic urban habitats	

STRATEGY ONE PRIORITY ACTION

S1A1. Explicitly assess the impacts on biodiversity of proposed changes to land-use zoning and the use of public land (e.g. community to operational)

Example: scenario modelling for South Creek

Projet overview

South Creek is Sydney's longest freshwater creek; it drains into the Hawkesbury River and runs through a 630km² catchment. According to A Plan for Growing Sydney[15], and the draft district plans[16] (Sydney's metropolitan strategy), the South Creek catchment will undergo significant transformation. New development to accommodate 1 million additional people and 4,300 hectares of 'employment land' will be established across the six districts by 2050. At present, only 20% of the catchment is developed, but even this has more than doubled the annual stream flow of South Creek. Under a business-as-usual development scenario, the projected growth to 2050 will double the flow rate again, leading to further declines in waterway health.

In 2015, the Sydney Water Corporation commissioned an investigation of options for developing the South Creek catchment in ways that maintained liveability and waterway health, consistent with the Corporation's responsibility to provide safe and healthy water and wastewater services in association with its role in co-creating a liveable city. The investigation modelled master-planning options for catchment development and generated development scenarios that visually demonstrate the potential impact on biodiversity of land-use and zoning changes.

Benefits provided by urban ecology

Catchment development planning using liveability and water health as key drivers provides the following co-benefits:

- Improved condition of riparian corridors and ecological functioning of remnant bushland, achieved by retaining remnant natural areas.
- Increased active and passive recreation opportunities, achieved by providing open-space buffers between residential areas, bushland and the creek and by constructing shared pathways along green corridors.
- Improved urban stormwater management: WSUD helps slow, manage and treat urban stormwater.
- Increased habitat: WSUD provides increased habitat in wetlands, bioswales and raingardens.
- Natural swimming sites for the community: large water bodies such as ponds and wetlands can be used to slow and treat stormwater and to provide public swimming places.
- Additional sources of non-potable water supply, achieved through the design of WSUD elements for stormwater reuse and wastewater recycling schemes.
- Improved landscape and biodiversity outcomes on public and private land, achieved by designing a mix of housing opportunities and densities and creating tree-lined streets and paths to enhance user experience and provide shade.
- Reduced urban heat island effect, achieved by increasing urban green spaces, including street-tree planting.

Implementation risks and barriers

- Development decision-making processes are driven by initial capital costs, not the accrued and long-term benefits for future residents.
- Local governments need to manage elements such as bioswales and street trees within existing maintenance budgets.
- Strategic urban planning decision-making processes lack inter- and intra-government agency cooperation on water and ecological planning.
- Existing governance arrangements around catchment and waterway management are overly complex.
- The existing business-as-usual greenfield model of development typically doesn't consider landscape outcomes or community health and wellbeing as drivers of development.
- There is a failure to use life-cycle costing frameworks that overcome current simplified 'least capital cost' analysis.
- Some people fear nature, perhaps because of a lack of understanding or unpleasant previous experiences.

Mechanisms to reduce risks and barriers

- Engaging with the community on the conservation of iconic species, using the community's knowledge of the existing ecosystem (e.g. the Australian bass living in the lower reaches of the creek).
- Engaging with and ensuring collaboration across state government agencies.
- Engaging with the community to reduce the fear of nature.
- Providing professional development programs for engaging industry and revealing the importance and benefits of urban ecosystems, including waterway management and green infrastructure.
- Collaborate between levels of government to ensure sustainability and liveability planning outcomes are realized in parallel with infrastructure and development construction
- Apply water and wastewater strategies to manage riparian health, connect residents to their waterways and protect valuable ecosystems and species.

Opportunities for implementation in Newcastle and Wollongong

The key elements of this example can be drawn on to expand the NSW government's Hunter development integrated infrastructure planning tool.

New housing in the Wollongong region will continue to be focused in the major regional greenfield release areas of West Lake Illawarra and Nowra-Bomaderry. There is an opportunity to incorporate urban ecology and liveability principles in the design, construction and management of these new suburbs by applying the scenario modelling approach employed by Sydney Water in South Creek to assess changes to the hydrology and how these can be managed through various development and water management approaches. The waterfront redevelopment of Shell Cove could focus on ecotourism, including by supporting the protection and creation of marine habitats. Sydney Water and Hunter Water could partner with local councils and the Department of Planning and Environment in such efforts.

South Creek development scenario

What nature needs to thrive when planning for greenfield developments

1. Apply a risk-based assessment methodology to evaluate development scenarios and land-use controls to maximise urban ecological benefits and waterway health.
2. Protect important scenic lands, riparian areas and ecological communities using conservation agreements, and progressively connect them to the green and blue grid.
3. Set catchment and subcatchment water and biodiversity targets that reflect needs and conditions.
4. Explore inter- and intra-catchment-based offsetting schemes designed primarily to optimise urban ecological outcomes in the South Creek catchment development area and the area's ecological role in the Sydney Basin bioregion.
5. Apply regulatory instruments to address diffuse water pollution and the cumulative loss of vegetation and habitats.
6. Collaborate among levels of government to ensure the realisation of sustainability and liveability planning outcomes in parallel with infrastructure and development construction.
7. Apply water and wastewater strategies to manage riparian health, connect residents to their waterways, and protect valuable ecosystems and species.

Brickpit Ring at Sydney Olympic Park is an urban haven for the endangered Green and Gold Bell Frog

Constructed wetlands along Caddies Creek, Rouse Hill manage and treat urban stormwater, provide recreation opportunities and create urban habitat

A grass meadow at Prince Alfred Park, Sydney replaced turf with native grasses, reducing maintenance and increasing urban biodiversity

S2 STRATEGY TWO

Enhance

Reform city planning to embed urban ecology in decision-making

EVIDENCE BASE

There is no apex policy in NSW identifying urban ecology as a priority. Such an overarching government policy priority would help reverse the inconsistent and ineffective coordination of conservation policies and practices across and between levels of government, which, in the past, has been a significant cause of negative urban ecological outcomes. Although several policies and city plans exist that aim to contribute to or promote urban ecology, they lack compliance and enforcement.

IN PRACTICE

Better coordination is needed of policies and decision-making processes. The policy, compliance and enforcement components of land-use decision-making are inherently flawed because they lack attention to urban ecology. Planning legislation needs strengthening: for example, the use of environmental planning instruments such as the Building Sustainability Index (BASIX) state environment planning policy (SEPP) as part of the development assessment process should be a priority. The development of such instruments must consider spatial priorities (such as proximity to core remnants or the green grid), be flexible (performance-based) and enable the use of specific controls to support individual species, communities and habitats. They must highlight the economic benefits of urban ecology and ecosystem services.

A combination of top-down and bottom-up approaches is required to achieve the greatest gains for urban ecosystems in Sydney, Newcastle and Wollongong. The identification and rectification of horizontal mismatches in governmental policies and practices is also needed.

The GSC is reinforcing urban ecology as an important planning outcome in sustainability principles. Connecting the practice of urban ecology to the creation of a liveable and productive city will give more weight to policy reform. There is also an opportunity for strategic planning to link to the United Nation's Sustainable Development Goals, thereby reinforcing the importance of scale and the need for both top-down and bottom-up approaches to address reforms.

The strategic actions in the table below incorporate both existing programs and tools and new ideas, as identified in a review of the literature, in national and international case studies, and in discussions with practitioners. These actions will reform planning for better urban ecological outcomes.

S2A1	Action 1	Scale
Policy	**Develop an environmental planning instrument that contains performance-based criteria (such as the BASIX SEPP) or design criteria (such as Design Quality of Residential Apartment Development SEPP 65) to incorporate urban ecology in design, construction and performance at the lot to precinct scales**	
S2A2	**Action 2**	
Strategy	Prepare street-tree master plans that include urban ecology principles in all central business districts, regional city centres, priority precincts and strategic centres in Sydney, Newcastle and Wollongong to provide green corridors	
S2A3	**Action 3**	
Process	Effectively resource regulation and compliance activities to ensure the realisation of urban ecological outcomes after development approval	
S2A4	**Action 4**	
Policy	Ensure that new local environment plans (LEPs) arising from district plans contain spatially relevant controls that support urban ecological outcomes	
S2A5	**Action 5**	
Process	Ensure that metropolitan water planning and district land-use planning incorporate programs and funding opportunities for water reuse and recycling, stream health and recreation	
S2A6	**Action 6**	
Process and/or Research	Review state agency policies to identify inconsistencies and conflicts affecting urban ecological outcomes	

S2A7	Action 7	Scale
Process	Develop a new approach to calculating green-space requirements that reflects location, community needs for passive and active green spaces, and ecological requirements	
S2A8	**Action 8**	
Research	Develop quantifiable standards for urban greening at a building (e.g. green roofs and green walls), lot (front and back yards), street and subdivisional scales that maximise urban ecological outcomes	
S2A9	**Action 9**	
Policy	Re-word landscape requirements in the standard LEP template to proactively promote urban ecological outcomes and create subordinate development control plan standards on how urban ecological outcomes can be achieved	
S2A10	**Action 10**	
Process	Promote green infrastructure and biodiversity outcomes in urban design guidelines such as the Urban Design Better Placed policy (Office of the Government Architect)	
S2A11	**Action 11**	
Process	Develop a transparent and robust multicriteria analysis that places equal weight on environmental, economic and social outcomes and which can be applied in strategic (metropolitan, district and local planning) and statutory (development assessment) processes	
S2A12	**Action 12**	
Policy	Review funding mechanisms (e.g. Section 94 contribution plans) to support the acquisition, development and maintenance of green spaces that support ecological and social outcomes	

What nature needs to thrive in our parks

Ecologically sensitive lighting in urban areas
Artificial lighting changes the duration and wavelengths of light in urban environments, potentially affecting the circadian rhythms of organisms, altering behaviours, changing vegetation structure, and increasing the mortality of animals attracted to light (e.g. moths). For example, the microbat Nyctophilus gouldi (pictured left) is especially sensitive to artificial lighting.

Key design principles include:
Planning
- Conserve dark spaces within a city by restricting new developments requiring artificial lighting in areas with a lux of less than five.
- Plan lighting strategies to maintain or reduce lux levels at a distance of 10–200m from proposed developments.
- Survey nocturnal, crepuscular (species active at dawn and twilight) and diurnal animals known to be sensitive to artificial lighting

Design and construction
- Use the minimum amount of light needed for safety. Increase the spacing and decrease the height of lights and limit the times at which they are on.
- Consider using alternatives to lighting, such as pavements with light-emitting diodes or fluorescent paint.
- Minimise light spill through fixture selection.
- Use narrow-spectrum light bulbs, selecting the spectrum based on the needs of species active in an area.
- Avoid reflective surfaces under lights.
- Use barrier mounds or densely planted vegetation to limit the penetration of artificial light.
- Reduce glare from streetlights by using flat-glass aeroscreens instead of reflector glass covers.
- Increase the reflectivity of signs and road stripping (retroreflectivity) to reduce the need for lighting.
- Restrict the installation of artificially lit advertising adjacent to ecologically sensitive areas.

Use and maintenance
- Provide contact numbers for residents to use if lights or motion sensors malfunction along pathways.
- Monitor initial and long-term changes in fauna activity or distribution due to the installation of new lights and the replacement of existing lights with habitat-friendly lighting strategies. Where possible, engage community members through citizen science and make data publicly available.

Large-eared Pied Bat (*Chalinolobus dwyeri*) and Tawny Frogmouth (*Podargus strigoides*)

STRATEGY TWO PRIORITY ACTION

S2A1. Develop an environmental planning instrument that contains performance-based criteria (such as the BASIX SEPP) or design criteria (such as Design Quality of Residential Apartment Development SEPP 65) to incorporate urban ecology in the design, construction and performance at the lot to precinct scales

Example: Malmö redevelopment, Sweden

Project overview

Malmö, Sweden's third-largest city, has undergone major redevelopment in the last 15 years, in which an industrial city has transformed into a best-practice model for economically, environmentally and socially sustainable urban development. The framework for redevelopment includes the Green Plan for Malmö 2003 and its 'green area ratio' development tool, which calculates the required green space on private land and ensures that green spaces are not removed in future developments. The Comprehensive Plan for the City of Malmö supports the Green Plan for Malmö[17] by articulating and focusing on the development of a green city and social sustainability (targeting gentrification and wealth-related gaps). The green city concept is achieved through the application of urban design principles that aim to create a compact, green urban structure. Sustainable urban design and infrastructure practices encouraged in Malmö include urban greening, renewable energy, sustainable stormwater management, urban agriculture and community gardening. Malmö has used ecological development as a driving force for economic growth and social innovation.

Some districts in Malmö are new and others have been retrofitted. Bo01 was the first district in the city to be redeveloped by integrating sustainability features such compact city design principles and 100% renewable energy. Bo01 was also the first area to use a local 'green space factor' to promote biodiversity, incorporating local vegetation and urban stormwater management. The use of a green space factor was first proposed by the City of Berlin as a way of defining the percentage of a given development parcel that must be 'permeable'. Developers in Bo01 were required to achieve a green space factor of 0.5 (50%) or greater by including elements such as green roofs, permeable pavements, gardens and green open spaces. A green points system was also established for the Bo01 development in a collaborative process between the council, developers and the public, whereby developers were required to implement at least 10 of 35 'green point' options on their sites. The options had a biodiversity focus, and included the provision of bird boxes for every apartment and ensuring year-round food for birds in courtyards. Malmö's Ekostaden Augustenborg district was retrofitted with WSUD elements, which residents now consider a major amenity. The key features are flowering perennials, native and fruit trees, and wetlands, and bat and bird boxes provide additional accommodation for biodiversity on the housing estate. The district has more than 30 living roofs, including the Augustenborg Botanical Roof Garden and 2,100m² of green roofs on residential properties.

The benefits of urban ecology

Urban ecology in the Malmö redevelopment provides the following co-benefits:

- Bioremediation: ecological processes were used to remove pollutants from the soil, which was

contaminated from the site's former industrial uses.

- Urban stormwater management: the use of WSUD and green infrastructure directs water collected from roofs and impervious surfaces into canals, bioswales and wetlands to prevent flooding, treat water and reduce the burden on the sewer system.
- Increased biodiversity: green roofs, residential gardens and courtyards, green open spaces and WSUD elements such as constructed wetlands and bioswales provide new or improved habitats for biodiversity.
- Increased amenity: residents now consider green infrastructure elements as major local amenities.
- Increased space for passive and active recreation: green spaces provide opportunities for social gatherings and recreation, thereby improving the health and wellbeing of the community.
- Improved reputation: the innovative redevelopment has improved Malmö's reputation and positioned it strategically as an attractive place in which to live and work.

Malmö's development process faced many challenges, including the following:

- The conflict over land between development and green space: redevelopment agencies engaged local communities and developers early in the process. The Commission for Socially Sustainable Malmö notes the importance of stakeholder involvement and sense of ownership in resolving issues surrounding green space.
- Funding for large-scale redevelopment projects: the City discovered that although funding can be obtained from developers, such funding is limited, and Malmö could benefit from public financing. Planning regulations allow the City to claim financial compensation from developers to design and install green spaces in new development projects, which helps to implement the regional green space plan.
- Managing urban water: a problem highlighted by residents in the Augustenborg district was recurrent flooding in basements and car parks in heavy rains, which was solved by replacing the stormwater system with WSUD elements. Green roofs and open stormwater channels now lead into ponds, which divert flooding in the area and increase amenity and biodiversity. Augustenborg has 6km of canals and water channels. Ninety per cent of the stormwater from roofs and hard surfaces enters the open stormwater system in the housing area. The Environmental Building Code (Malmö City Council) requires an impervious-surface to green-space ratio of 1:1 for all developments. This helps achieve green goals by encouraging green elements such as green roofs, green walls and open green spaces.



Malmö features a range of green infrastructure elements which increase urban biodiversity, reduce the urban heat island effect, manage stormwater, and increase opportunities for passive and active recreation.

Implementation risks and barriers

Implementing a development approach similar to Malmö's in NSW would likely face similar risks and barriers, as well as the following:

- There is an existing focus on housing affordability and on reducing regulations thought to increase house construction costs and development assessment times. This is particularly relevant in Sydney.
- The existing approach focuses on the first purchase of properties (i.e. the capital cost) rather than on benefits linked to liveability and ecology that accrue from greener and more sustainable houses and subdivisions. The success of the BASIX SEPP provides a precedent for an effective, performance-based regulatory approach that can change business-as-usual practice.

Mechanisms to reduce risks and barriers

- Community engagement that involves residents in genuinely participatory processes.
- Strong political leadership that champions the issues.
- Collaboration among state agencies, local councils and other key stakeholders, such as communities and local businesses.

Opportunities for implementation at the state level

At the state government level, regulatory (such as those in the BASIX SEPP) or design (such as Design Quality of Residential Apartment Development SEPP 65) criteria could be amended to incorporate urban ecology design, construction and performance requirements at the lot to precinct scales. This approach could be applied across the entire metropolitan area, as defined by the environmental planning instrument.

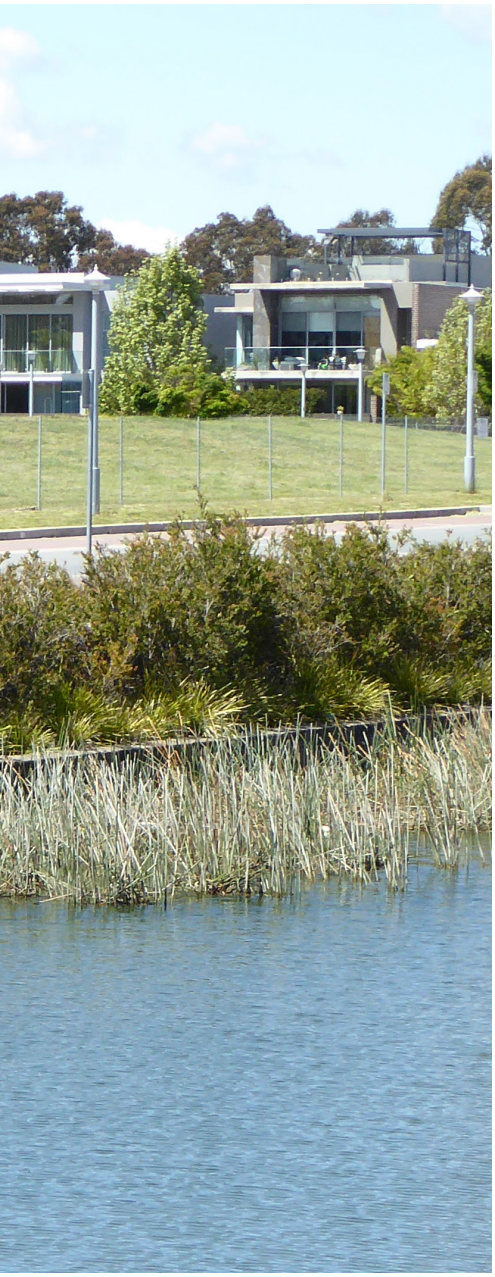
Opportunities for implementation in Sydney

The approach taken for the redevelopment of Bo01 and Augustenborg in Malmö could be a best-practice model for ecologically sustainable development in Sydney. Local councils could incorporate a green points system and a green space factor in its strategic plans and development control plans to encourage environmentally sustainable development on key development sites, including the Bays Precinct, Parramatta North and the Camellia Precinct.

Opportunities for implementation in Newcastle and Wollongong

The City of Newcastle could incorporate a green points system and a green space factor in its strategic plans and development control plans to encourage environmentally sustainable development on key redevelopment sites identified in the Revitalising Newcastle Program led by UrbanGrowth NSW and Transport for NSW.

The City of Wollongong could incorporate a green points system and a green space factor in its strategic plans and development control plans for the LGA to encourage environmentally sustainable development on key redevelopment sites in the city.



Planting along the Kingston Foreshore, Canberra increases urban ecological outcomes

Street trees along Newington Boulevarde, Newington create an urban green corridor

Rouse Hill Town Centre, Rouse Hill features street trees which provide shade, increase the visual amenity and reduce urban temperatures

S3 STRATEGY THREE

Enhance

Connect biodiversity across cities through green and blue networks

EVIDENCE BASE

Core habitats connected by corridors are vitally important for enhancing biodiversity in cities. Networks of green and blue corridors, rather than 'stepping stone' habitats, are crucial, and they need to cross both public and private land. Multiple strategies are required, including changes to land-use planning policies and regulations to protect and extend existing, and establish new, corridors, supported by education, incentives and public policy.

IN PRACTICE

There is a need for a holistic, coordinated approach to the creation of green and blue networks across urban areas. Terrestrial-based green networks represent a significant opportunity to enhance urban biodiversity. While the Sydney Green Grid is often referred to as an example of how such a network could be implemented, it has yet to incorporate a robust ecological layer.

It is important that any network is a well-connected blue and green grid for urban ecological health, to give the opportunity to include pedestrian and cycle paths along corridors, connecting communities through enhanced accessibility. Offsetting mechanisms could also be leveraged to secure key areas for ecological connectivity.

S3A1	Action 1	Scale
Policy	**Ensure that city planning integrates green and blue grids to improve terrestrial and aquatic biodiversity outcomes**	
S3A2	**Action 2**	
Policy	Plan and manage assets to support biodiversity corridors and urban waterway health	
S3A3	**Action 3**	
Strategy	Leverage offsetting mechanisms to strategically identify, protect and restore areas that optimise the ecological connectivity of green and blue grids	

Wolli Creek fishway

What nature needs to thrive in our waterways

Fishways and ladders

Weirs, dams and causeways in waterways can form impassable barriers for many fish species. Migration along lengths of rivers, such as from estuaries to freshwater sections (and back), is crucial for the development and reproduction of many Australian native fish species. Fishways (also called fish ladders and fish passes) are engineered solutions constructed on or around barriers to allow fish migration. Detailed information is available on the design and operation of fishways[18] .

Each weir, dam and causeway presents different issues for fish passage, depending on the setting, size and location of the waterway and the size, swimming ability and life history of the affected species. Fishways need to provide sufficient water depth for large fish to pass and ensure a suitable water velocity for smaller fish, which may be weaker swimmers.

Fishway designs vary in complexity and expense; they include 'pool' fishways (e.g. Wolli Creek, Sydney), which consist of a series of interconnected, gently sloping pools; 'steps', which enable fish to bypass obstructions; and 'trap and transport' fishways or elevators (e.g. Tallowa Dam and the Shoalhaven River), which attract fish to holding areas from which they are mechanically transported across the barrier and released.

STRATEGY THREE PRIORITY ACTION

S3A1. Ensure that city planning integrates green and blue grids to improve terrestrial and aquatic biodiversity outcomes

Example: The Sydney Green Grid

Project Overview

The Sydney Green Grid is a framework for creating an interconnected network of open spaces throughout metropolitan Sydney, including parks, bushland, natural areas, waterway corridors and tree-lined streetscapes[19]. It aims to increase the quality of open spaces and improve and enhance the quality of life in the region. A Plan for Growing Sydney notes that delivering a city-wide Green Grid would promote a healthier urban environment, improve community access to recreation and exercise opportunities, encourage social interaction, support walking and cycling connections and improve the resilience of Greater Sydney. The Sydney Green Grid necessarily requires planning and coordination at the Metropolitan and District scales and implementation at a Local scale.

The GSC is establishing the Sydney Green Grid through the plans developed for the six districts in the metropolitan Sydney area; these district plans constitute the mechanism for delivering the Sydney Green Grid, including prioritised actions for each district[20]. Local governments are to undertake local green grid planning for their LGAs, which could be linked to existing or proposed urban forest and urban biodiversity strategies.

Achieving improved biodiversity outcomes is not the primary goal of the Sydney Green Grid project. The potential exists, however, to use the project to connect biodiversity by linking vegetation remnants and reserves via green corridors and by providing novel habitats through new plantings. Connecting and restoring riparian vegetation as part of green corridors, including links to shorelines, can help in establishing blue networks. To achieve positive biodiversity outcomes, the co-benefits of green corridors, such as the expansion of recreational opportunities, must be balanced with the need to provide good-quality habitat. The provision of habitat has co-benefits (and risks), such as creating more opportunities for the public to connect with nature.

Important opportunities for connecting biodiversity through the Sydney Green Grid project include the following:

- The incorporation of a 'biodiversity layer' (e.g. the extent, type and condition of native vegetation) into spatial planning at the metropolitan, district and local scales: this would allow the identification of the best opportunities for connecting biodiversity via green spaces. The Office of Environment and Heritage's detailed vegetation mapping (Native Vegetation of the Sydney Metropolitan Area v2.0) provides an important basis for such a biodiversity layer (although it lacks coverage in parts of western Sydney).
- Landscape design that ensures the sparing of natural habitats and the provision of novel habitats (restoration projects and artificial structures) and balances these requirements with the need for recreational open space.
- Maintenance guidelines that ensure habitat complexity (e.g. vegetation with a dense understorey), successional planting (to maintain canopy cover in the long term), and a reduction in mowing and pesticide use.

- The integration of riparian zones and shorelines into the Sydney Green Grid to ensure links between green and blue networks.

Benefits provided by urban ecology

- Improved public health and wellbeing: urban ecology approaches provide increased recreational opportunities, which can help address public health issues such as increasing obesity.
- Reducing the urban heat island effect: conserving, enhancing and creating additional urban green spaces reduces urban temperatures.
- Reducing pollution: the use of urban ecology approaches reduces the quantities of airborne and aquatic contaminants, thereby improving air and water quality.
- Urban water management: green infrastructure, including WSUD, helps in managing urban water.
- Economic benefits: the provision of green spaces and greater greencover can increase property values, reduce heating and cooling bills, and increase consumer spending.
- Aesthetic and visual benefits: increased urban green space helps strategically position cities as attractive places in which to live, work and play.

Implementation risks and barriers

- The most obvious and significant strategic risk relates to the unique cross-scale and cross-jurisdictional nature of rolling out an integrated green grid at the metropolitan, district and local scales. Such a rollout will necessitate the development and maintenance of a robust framework that supports close communication and collaboration among relevant state agencies, the GSC and local councils in Sydney, Newcastle and Wollongong, as well as ensures continued engagement with local communities and other stakeholders.
- Procedural and technical challenges include resolving conflicts among the competing demands for habitat provision and recreational green space (e.g. crime prevention through environmental design considerations); competing priorities for the use of road corridors (e.g. parking and above- and below-ground utilities), which can lead to reduced or modified plantings and adverse maintenance outcomes; and ensuring appropriate maintenance protocols and ongoing funding for the maintenance and replacement of street trees and other green grid elements.

Mechanisms to reduce risks and barriers

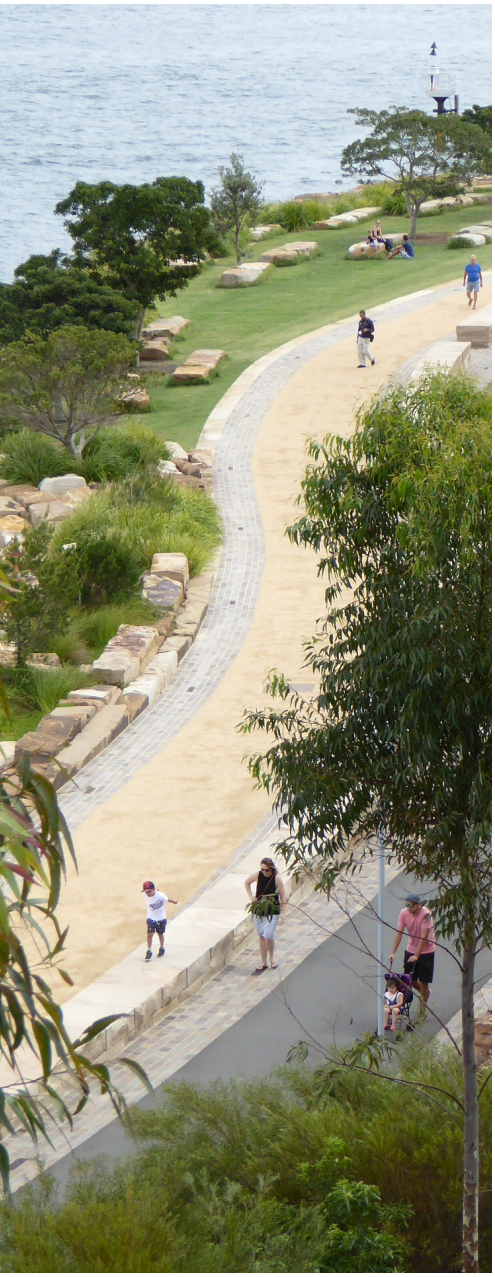
- Mapping current and potential corridors at the district to local scales.
- Genuine public engagement: participatory processes that engage communities in meaningful ways.
- Strong political ambition and leadership: the Sydney Green Grid needs support from key political stakeholders and all levels of government.
- Collaboration across state government agencies and local councils: this is crucial for reducing barriers during the implementation of the Sydney Green Grid.
- The allocation of dedicated maintenance funding and support for existing and new habitats.

Opportunities for implementation in Newcastle and Wollongong

The Department of Planning and Environment can establish a green grid at the district scale, and the City of Newcastle can provide the granular detail as part of its urban forest and biodiversity strategies. A 'biodiversity layer' will need to be generated using available sources to enable the best placement of green corridors for ecological connectivity. Guidelines for landscape design and management can be adapted from the Sydney Green Grid.

The Department of Planning and Environment can establish a green grid at the district scale, and the Wollongong City Council can provide the granular detail as part of its Wollongong Urban Greening Strategy or biodiversity strategy. A 'biodiversity layer' will need to be generated using available data to enable the best placement of green corridors for ecological connectivity. Guidelines for landscape design and management can be adapted from the Sydney Green Grid.

The Sydney Green Grid



Barangaroo Headland Park in the Sydney CBD improves terrestrial and aquatic biodiversity outcomes and provides opportunities for recreation

Urban greening acts as a green corridor through this town centre

The green roof at MONA, Hobart contributes to urban greening in Hobart

S4 STRATEGY FOUR

Create

Design and deliver green and blue cities

EVIDENCE BASE

The planning and development of cities to achieve urban ecological outcomes should be based on maximising the retention and size of green spaces and remnant vegetation. Cities with large areas of green spaces are more resilient to change, support better urban ecological outcomes, and contribute more to the liveability of cities. The protection and conservation of green spaces and remnant vegetation requires that development outcomes consider cumulative and spatial impacts, from the lot to metropolitan scales.

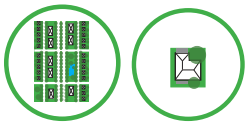
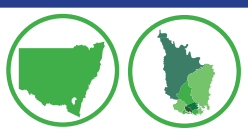
Urban ecosystems must be managed seamlessly across public and private land. This requires greater coordination, accountability and clarity of roles and responsibilities among government agencies and councils than now exists. It also requires a shared understanding among governments and communities of how a 'green and blue' city can improve liveability and urban ecological outcomes.

IN PRACTICE

Urban sprawl is destroying ecological communities, including threatened communities such as the Cumberland Plain Woodland. Although policies such as Biobanking are in place to protect habitats, such policies are perceived as having a negative impact on overall urban biodiversity.

Lot sizes are decreasing while house sizes increase, leaving less room for residential gardens. In creating more compact cities, greater consideration should be placed on street design and landscaping, and the relationships of such green elements with private lots.

Actions at the community level to drive change generally improved a community's understanding of the benefits of the local environment and its ecosystems. Increasing or streamlining the uptake of green infrastructure and retrofitting it into mainstream applications is essential in delivering compact, resilient and sustainable cities.

S4A1	Action 1	Scale
Policy	**Protect, restore, enhance and create habitat when planning, designing and managing precinct-level redevelopments**	
S4A2	**Action 2**	
Policy	Identify and protect areas and habitats that provide ecosystem services that enhance resilience	
S4A3	**Action 3**	
Strategy	Develop technical guidelines and specifications to support the integration of urban ecology principles in buildings, streets, parks and public spaces	
S4A4	**Action 4**	
Process	Develop and implement incentive mechanisms to prioritise urban ecological outcomes in the building and construction sector (e.g. with faster development assessment times and floor-space bonuses) to transition to new business-as-usual practices	
S4A5	**Action 5**	
Research	Develop a rating scheme that incentivises the retrofitting of buildings and public spaces to incorporate urban ecological outcomes	
S4A6	**Action 6**	
Process	Make provisions in existing voluntary sustainable building rating schemes (e.g. Green Star Communities) to incorporate urban ecology and resilience	
S4A7	**Action 7**	
Process	Use nature-based solutions to enhance the resilience of infrastructure to the impacts of climate change	
S4A8	**Action 8**	
Research	Review and evaluate landscape design compliance	

STRATEGY FOUR PRIORITY ACTION

S4A1. Protect, restore, enhance and create habitat when planning, designing and managing precinct-level redevelopments

Example: Barangaroo Reserve

Project Overview

Barangaroo Reserve is an integral component of a major redevelopment of formerly industrial land in Sydney's central business district[21]. As part of the redevelopment of the precinct, public open space was created in what was once an expanse of concrete and container wharves. Given the location and scale of the site, the NSW government led the delivery of the project via the Barangaroo Development Authority, together with developer Lend Lease. Following a design competition and inputs from key stakeholders, a decision was made to re-create the site's former headland, which had been significantly altered. The creation of this headland park provided an opportunity to enhance urban biodiversity in the centre of Sydney.

Opened in 2015, Barangaroo Reserve is an important exemplar of a redevelopment that creates urban habitat on a previously significantly degraded site. The 6-hectare park combines recreational open space with green and blue habitat. The revegetation plan sought to reflect the species composition of native vegetation found on the Sydney Harbour foreshore, including the structural complexity (grasses, shrubs and trees) needed to support terrestrial biodiversity. More than 75,000 native trees and shrubs have been planted, including transplanted mature trees. Inspired by the natural sandstone water edges throughout Sydney Harbour, 10,000 sandstone blocks have been placed along the foreshore at Barangaroo Point to provide a dynamic 'soft' natural shoreline. These blocks provide complex habitats that mimic natural rocky shorelines and support a rich variety of aquatic invertebrates.

Although the scale and scope of this project is unique, elements of the design of Barangaroo Reserve can be used as a precedent for the design and construction of smaller parks in Sydney, Newcastle and Wollongong.

Benefits gained from urban ecology

The design and construction of Barangaroo Reserve is generating the following co-benefits:

- Improved public health and wellbeing: increased recreational opportunities help address public health issues, such as increasing obesity.
- Reducing the urban heat island effect: conserving, enhancing and creating additional urban green spaces reduce urban temperatures.
- Improved urban resilience: the creation of a 'soft edge' along the foreshore using sandstone blocks will increase the resilience of the site to extreme weather events and sea-level rise.
- Increased awareness of nature: the use of native plants throughout the design helps increase public awareness of the uniqueness and character of Australian native species.

Implementation risks and barriers

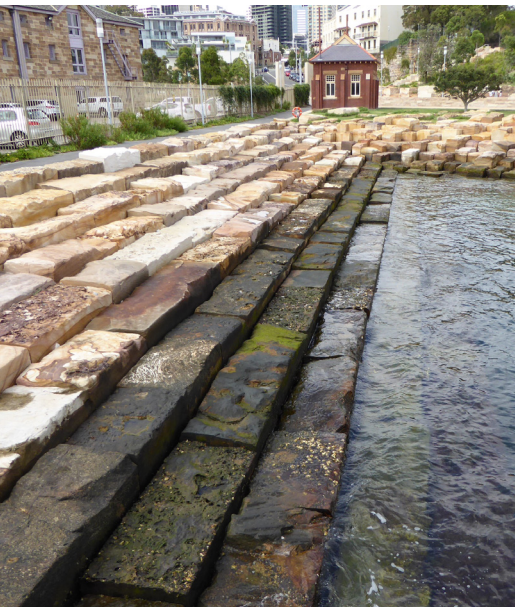
- Strategic urban planning decision-making processes lack inter- and intra-government agency cooperation.
- There is conflict over land use for development and green spaces.
- Ensuring sufficient plant stock, as specified in tender documentation: plant availability is crucial

when using large quantities of plants and locally indigenous species that aren't commonly grown in wholesale nurseries.

- Existing business-as-usual development typically does not consider landscape outcomes and community health and wellbeing as drivers for development.
- Mass planted garden beds with the structural complexity of those at Barangaroo may be perceived as a safety risk, and crime prevention through environmental design principles need to be accommodated. The use of dense planting on the terraced slope of the site, which people do not access, reduces this risk at Barangaroo.
- A fundamental barrier is the cost of sparing land and foreshore from development for habitat. This includes the conflict between open recreational space and the creation of structurally complex habitat capable of supporting high levels of biodiversity. Pathways that follow the shoreline form a barrier between green and blue habitats, and careful design is needed to limit the impact.
- There is a risk that landscape architects do not acknowledge the importance of urban ecology in their approaches to design.

Mechanisms to reduce risks and barriers

- Strong political leadership that champions the urban ecology, including the dedication of a portion of land as public open space.
- Collaboration between state agencies, local councils and other key stakeholders, such as the community and local businesses, to set the design vision and realise this in construction and maintenance.
- Professional development programs that inform and educate designers and decision-makers about the value of urban ecology and the construction industry on building and maintaining urban green and blue infrastructure.
- The appropriate use of crime prevention through environmental design guidelines based on a thorough analysis of risks and design.
- Ensuring the availability of locally suitable native vegetation for planting.
- Professional development programs and events to raise awareness of urban ecology and the importance of urban biodiversity and the ecosystem services provided.



Design features at Barangaroo Reserve improve habitat opportunities and urban biodiversity, and increase resilience

Opportunities for implementation in Sydney

Sydney Harbour, Botany Bay and adjoining estuarine rivers present many opportunities to re-establish green and blue habitats during redevelopment, especially where developments adjoin existing protected areas. A key opportunity is the creation of and filling in of missing links for biodiversity and recreation corridors such as Manly to Palm Beach walk (missing links) and South Creek (new proposed development area that could link to regional and district parks).

Opportunities for implementation in Newcastle and Wollongong

A key opportunity is the creation and infilling of biodiversity and recreation corridors along the Newcastle shorelines. Newcastle represents significant opportunities to integrate urban ecology principles into coastal urban renewal projects, as the economy transitions from industry to service based and land is redeveloped as part of this transition.

A key opportunity is the creation and infilling of biodiversity and recreation corridors along the Wollongong shoreline - for example, integration of additional shoreline and terrestrial habitat along and adjacent to the Foreshore Blue Mile project (Stuart Park to Wollongong Golf Club) in Wollongong.

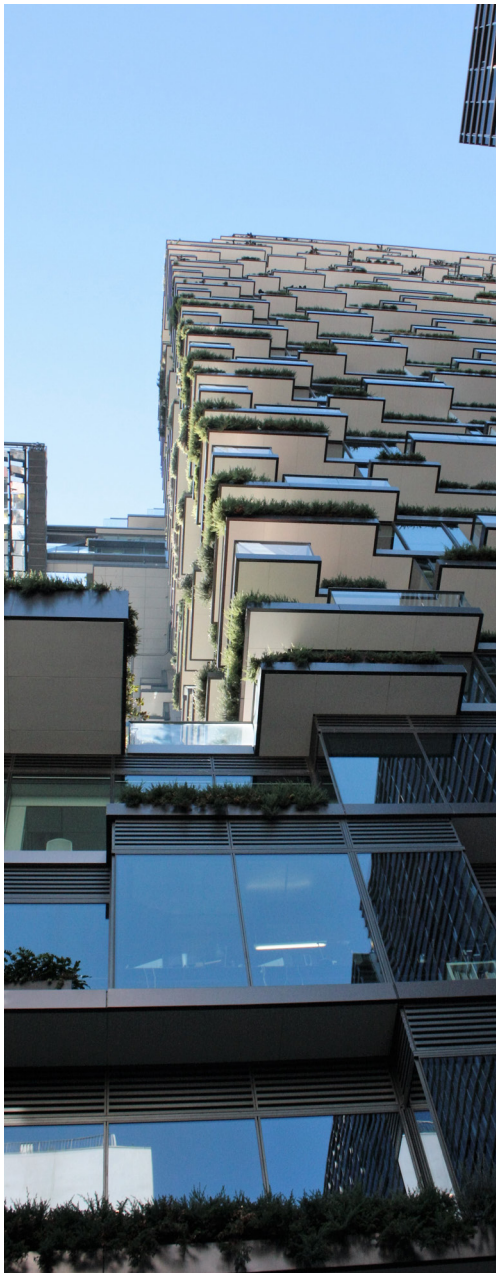
The waters edge at Barangaroo Reserve

What nature needs to thrive at the intersection of terrestrial and aquatic systems

Key actions for redevelopments that protect, restore, enhance and create green and blue habitats on waterfronts in Sydney, Newcastle and Wollongong include the following:

- Assess the extent, type and condition of existing habitats before redevelopment and protect and restore habitats of ecological significance.
- Provide light wells and boardwalk windows in waterfront promenades to maximise the penetration of light beneath structures.
- Where seawalls cannot be 'designed out' of redevelopments, design them to provide habitat for marine species and, where possible, slope them. Design seawalls with enhancements that increase habitat complexity, such as 'fins' and complex rocky habitats that mimic natural rocky shorelines.
- Create habitats at a range of depths (responsive to the influence of tides) by including habitat 'benches'.
- Use ecologically responsible materials in building artificial habitats.
- Connect green and blue habitats by planting native vegetation to the water's edge.
- Reduce contaminants and stormwater runoff through practices such as WSUD and green roofs.
- Engage local communities in the creation of habitats (e.g. through Bushcare groups).
- Provide interpretive signage to increase knowledge and awareness of the natural environment among the public.
- Monitor flora and fauna before, during and after redevelopments to detect changes in biodiversity over time.
- In maintaining green and blue habitats, seek to retain habitat complexity and be informed by ongoing monitoring.

The design of Wentworth Common playground at Sydney Olympic Park integrates mass planted garden beds with a diversity of plant species



Vertical greening is integrated into the balcony design at One Central Park, Chippendale

Mass planting throughout this residential development in Sydney Olympic Park creates habitat for plant and animal species

S5 STRATEGY FIVE

Create

Create new habitats to support biodiversity and human wellbeing

EVIDENCE BASE

Urbanisation can reduce the availability of specific habitats in urban areas, for example in the form of rock pools, tree hollows, fallen logs and dense shrubby vegetation, leading to a decline in the suitability of the urban matrix for certain species. The identification of key habitats and structures that are limited or absent in urban areas can enable the development and implementation of strategies to address this.

IN PRACTICE

The building and maintenance of new habitats and structures, including WSUD treatments, are two very different propositions. Trials and best-practice examples are key to demonstrate how urban ecology can best be integrated into cities, but there is concern over how such projects would be maintained over the long term. This is particularly relevant to the local government sector, but it is also seen as an emerging issue for strata building managers, who may not prioritise funding for maintaining green infrastructure such as green walls and water recycling facilities. Thus, support for innovative and exciting demonstration projects as a means for influencing decision-makers is tempered by the question of how such projects are to be maintained in the longer term.

One new practice to consider is ‘biophilic catalytic acupuncture’, which aims to identify interventions whereby the creation of new habitats can address multiple issues and generate the greatest flow-on effects for sustainability and liveability outcomes. A shift in business as usual practices can only be supported by a unified communication strategy demonstrating how urban ecology benefits people’s lives. This vital upfront step will encourage the inclusion of habitat creation in planning and development processes across scales.

S5A1	Action 1	Scale
Process	**Coordinate and implement an urban forest strategy that benefits biodiversity and ameliorates the urban heat island effect and associated heat stress**	
S5A2	**Action 2**	
Policy	Recognise street verges as community land under the Local Government Act and manage these areas under management plans to advance urban ecological outcomes	
S5A3	**Action 3**	
Process	Include natural areas and waterways in open space and recreation needs analyses to provide intrinsic ecological benefits and recreational opportunities	
S5A4	**Action 4**	
Process	Prioritise grant funding for integrated, long-term urban ecology projects with effective monitoring and evaluation programs	
S5A5	**Action 5**	
Policy	Require that Biobanking sites create new and supportive habitats of equivalent or greater ecological condition as part of ongoing maintenance and management plans	
S5A6	**Action 6**	
Process	Support the construction of new habitats through government funding schemes to deliver urban ecological and liveability outcomes	

STRATEGY FIVE PRIORITY ACTION

S5A1. Coordinate and implement an urban forest strategy that benefits biodiversity and ameliorates the urban heat island effect and associated heat stress

Example: Urban Forest Strategy, Melbourne

Project Overview

Melbourne was one of many Australian cities that suffered the 12-year 'millennium drought' from 1997 to 2009. This, coupled with significant population growth and increasing urban temperatures, compelled the City of Melbourne to recognise significant policy gaps in efforts to ensure long-term sustainability and liveability for the residents of Melbourne. Drawing key lessons from New York City's 2006 Million Trees Urban Forest Project, the City of Melbourne developed its Urban Forest Strategy: Making a Great City Greener 2012-2032 with the aim of developing city landscapes that are resilient, healthy and diverse and which meet community needs.

One of the key drivers of change for the City of Melbourne was recognition of the environmental, economic and social benefits of its trees. The more than 70,000 trees in the city's parks and streets have an estimated value of $700 million in amenity value alone. The Urban Forest Strategy was developed to protect these assets through strategies on canopy cover, forest diversity, urban ecology, soil moisture, water quality and community engagement.

All levels of government and residents were integrated into the implementation plan, thereby creating accountability. Initiatives included the following:

- Melbourne's 70,000 trees were mapped in a project called Urban Forest Visual, with each tree assigned an identification number.
- The 10 existing 'tree precinct' plans were subject to ongoing measurement, monitoring and review.
- 'Citizen foresters' were trained to tend the urban forest and improve urban ecosystems by carrying out essential advocacy, monitoring and research tasks.

At the core of the Urban Forest Strategy is the City of Melbourne's vision to create a 'resilient, healthy and diverse forest'. The strategy has two scenarios: one in which trees are replaced when they reach the end of their useful lives by new trees to maintain canopy cover over time in areas with limited space; and the second in which, in addition to replacing existing trees as they die, more trees are planted where space allows, thereby increasing canopy cover over time. The strategy's emphasis on planting a diversity of species is likely to yield better biodiversity outcomes.

The Urban Forest Strategy has the following six key targets:

1. The City of Melbourne's canopy cover will be 40% by 2040.
2. The City of Melbourne's urban forest population will be composed of no more than 5% of one tree species, no more than 10% of one genus, and no more than 20% of any one family.
3. 90% of the City of Melbourne's tree population will be healthy by 2040.
4. Soil moisture levels will be maintained at levels to provide healthy growth of vegetation.
5. The protection and enhancement of urban ecology and biodiversity will contribute to the delivery of healthy ecosystem services.
6. The community will have a broader understanding of the importance of the urban forest, increase their connection to it and engage with its process of evolution

The strategy was developed over six years of continuous stakeholder engagement, intergovernmental

partnerships and policy implementation. The approach was underpinned and aligned with other policies, including the Greenhouse Action Plan 2006-2010, the Climate Change Adaptation Strategy 2009, WSUD Guidelines 2009, and the Zero Net Emissions by 2020 Strategy.

The Australian Government invested $30 million in the initiative and this, combined with stakeholder engagement, provided the public with confidence and gave the Urban Forest Strategy legitimacy. The strategy's objectives were clear, and its targets and action items were supported by international and local case studies. Providing evidence through demonstration sites created accountability for levels of government and the public.

Benefits provided by urban ecology

- Improved public health and wellbeing: increased urban green infrastructure provides increased recreational opportunities and health benefits and shade for pedestrians, diminishes traffic noise, and reduces fine airborne particulates.
- Habitat and a food source for urban fauna.
- Reductions in stormwater flow and runoff, the quantity of polluting particulate matter entering waterways, and soil erosion.
- Improved thermal comfort, air quality and microclimate in urban areas.
- Economic benefits, such as increased property values, reduced heating and cooling bills, and increased consumer spending.

Implementation risks and barriers

- Government bodies and councils tend to be risk-averse and attempt to minimise risks, which can act as a barrier to broad strategies such as the Urban Forest Strategy.
- Securing long-term funding and commitment for the implementation of the strategy was difficult.
- Pressure for land is an immediate issue in urban areas. There is a constant struggle with

An urban forest visual website was created as part of the Urban Forest Strategy project

developers to maintain land as open space for public use.
- Local governments need to manage features such as bioswales and street trees within existing maintenance budgets.
- Strategic urban planning decision-making processes lack inter- and intra-government agency cooperation.
- There is a lack of acknowledged economic value of trees, other than the cost of maintenance. Their roles in promoting human wellbeing, mitigating the urban heat island effect, and stormwater management are often unaccounted.

Mechanisms to reduce risks and barriers

- Strong political leadership that champions the issues.
- Collaboration among state agencies, local councils and other key stakeholders, such as communities and local businesses.
- Strong stakeholder engagement to demonstrate the economic and biodiversity value of trees.
- Professional training for councils and industry on the importance and benefits of urban forests.

Where and how this action could be applied in Sydney

Councils in the greater Sydney region can use the momentum gained through the Sydney Green Grid and the GSC's district plans to prepare interconnected urban forest strategies to support the Green Grid. An opportunity also exists to use council mergers to upgrade existing urban forest policies to strategies in the new LGAs. Using stakeholder consultations undertaken in collaboration with the GSC could help ensure an efficient process in producing urban forest strategies. Demonstration projects provide opportunities to showcase best practices and co-benefits with on-the-ground examples.

Opportunities for implementation in Newcastle and Wollongong

The City of Newcastle could upgrade its urban forest policy to a strategy to ensure that trees are replaced as they die. There is also potential for the City to cordon off spaces for recreation and parks to ensure that environmental and liveability objectives are reached. Parallel to advancing an urban forest strategy, Newcastle could benefit from strong education and engagement programs highlighting the co-benefits of trees. In particular, locally significant benefits could be emphasised, such as the mitigation of the urban heat island effect and heatwaves, improved mental health outcomes, and increased premium property prices. Demonstration projects provide opportunities to showcase best practices and co-benefits on the ground.

With an area of 684km², the City of Wollongong could have a huge impact if it were to implement an urban forest strategy. The locally significant benefits of a denser urban forest could be highlighted: for example, initiatives could emphasise the capacity of trees and forests to reduce coastal erosion and, by reducing stormwater runoff, to mitigate flash-floods in heavy storms. Demonstration projects provide opportunities to showcase best practices and co-benefits on the ground.

Sydney Park wetlands in St Peters helps to manage urban water, and provides opportunities for urban biodiversty and recreation

Street tree planting at Victoria Park, Zetland contributes to urban tree cover

Open green space in The Domain, Sydney provides opportunities for recreation, which improves human health and well-being

S6 STRATEGY SIX

Develop and implement ongoing engagement programs to increase education and involvement across sectors

EVIDENCE BASE

Initiatives that combine regulatory, financial and educational measures are more likely to achieve urban ecological and liveability goals. Such initiatives require multifaceted approaches that engage governments, industry, professional bodies, teaching and research institutions, and communities. Changes in behaviour should be supported by a combination of bottom-up (community-initiated) and top-down (state government-led) approaches in which community-based planning sets the vision for an area, which is then supported by enforceable standards and controls.

IN PRACTICE

There are multiple opportunities and entry points for engaging with the various sectors, to increase understanding of urban ecology. There is a need to engage with 'time poor' community members using technologies such as mobile phone apps and through activities such as 'bioblitzs' (intense surveys involving local communities with the goal of recording all species in an area). School-based environmental education is also a complementary pathway for encouraging understanding of urban ecology among primary and secondary students, although this has been part of the environmental education curriculum for some time. Changing minds through education, including professional development for built-environment professionals such as landscape architects, planners, project managers and engineers, is crucial for generating change. Linked to this, is the importance of integrating urban ecology content in university programs that train such professionals.

Engagement and educational programs are essential for instigating broader change on the valuing of urban ecosystems. It is important that local councils share knowledge and cooperate to bring about changes in behaviour. In delivering education, tools and training, different audiences require specific approaches to achieve maximum effect. Community strategic plans developed by councils in NSW could be better connected with state government processes.

S6A1	Action 1	Scale
Process	**Develop education programs that integrate and demonstrate the co-benefits of urban ecology at multiple scales, including health and wellbeing and resilience**	
S6A2	**Action 2**	
Policy	Support a network of citizen science programs to promote community engagement with nature	
S6A3	**Action 3**	
Process	Develop and implement a 'park care program' focused on public open spaces to complement existing community-based environmental engagement programs (e.g. Bushcare, Urban Landcare and Dune Care)	
S6A4	**Action 4**	
Process	Establish 'living labs' in and across urban areas for place-based learning about the environment	
S6A5	**Action 5**	
Policy	Assess urban ecology projects for biodiversity outcomes and co-benefits by developing quantifiable approaches	
S6A6	**Action 6**	
Process	Develop an urban ecology best-practice award program for governments, communities and industry	
S6A7	**Action 7**	
Process	Coordinate community environmental education programs for primary, secondary and tertiary sectors, adult education, and professional development	
S6A8	**Action 8**	
Process	Support community collaborative planning and engagement in neighbourhoods	

STRATEGY SIX PRIORITY ACTION

S6A1. Develop education programs that integrate and demonstrate co-benefits of urban ecology across multiple scales, including health and wellbeing and resilience

Example: CSIROs Urban Living Labs

Project Overview

CSIRO is developing a portfolio of 'urban living labs' across Australia to foster new ways of collaboration and engagement in urban planning and development[23]. Urban living labs are urban developments that have been carefully selected to span a range of urban types from greenfields on the urban fringe to inner city locations.

Studying cities and their complex interactions is hard, so CSIRO has decided to take its research, and the lab, to the people. Working with developers on real urban projects in real world-contexts, urban living labs inform the design and building of communities from the ground up, providing best-practice models for sustainable and resilient cities. Once built, people choosing to live in these communities will become part of a collaborative effort to improve and adapt their urban environment through new technologies and innovation. Through this process, CSIRO is developing partnerships to support co-learning that are based on monitoring and evaluation.

The living labs will offer a new way in which researchers, industry, communities and governments can come together and co-design liveable, sustainable and resilient cities in which ideas are tested in real-world settings for their environmental impact, social acceptability and economic cost. By testing ideas in these living labs, CSIRO can reduce the barriers to adoption that are commonly cited i.e. lack of time, money and risk appetite.

Urban living labs will provide the space for testing innovation such as the reuse of treated wastewater in urban green spaces and automated driverless garbage collection. The ideas that flow from these collaborations can be put to the test in new or redeveloped urban areas, as well as at existing CSIRO sites that will also serve as living labs. Some innovations will prove themselves quickly, while others may take years to come to fruition.

Benefits provided by urban ecology

One of the first locations being established as an urban living lab is the Ginninderra Field Station, which is a 701-hectare area of land owned by CSIRO in Canberra. The vision is to partner with a developer to construct a sustainable urban community that sets new standards in the ways in which it handles energy, water, waste, housing, affordability, transport, heritage and conservation. An early focus of this lab is a community-led project investigating how fire and other management methods can be used to recover native grasslands. The experiment involves four treatments, include mowing six times per year (common practice in the Australian Capital Territory), an 'autumn burn' treatment every 2-3 years, a second autumn treatment every 4-6 years, and a control. This research aims to determine the most cost-effective methods for restoring and managing various qualities of native grassland habitat, of which only 5% remains in the Australian Capital Territory. The Lab is providing significant opportunities for the local community to engage with science, to undertake novel research on grassland management, and improve

the conservation values of the Ginninderra site and beyond.

Implementation risks and barriers

The main barriers encountered with Urban Living Labs are identifying the right partners and creating a culture of experimentation and risk-taking, where it is considered 'safe to fail' in pushing the boundaries of innovation. To succeed, Urban Living Labs need a significant level of commitment from partners and the community, and this includes regular and ongoing communication and engagement to bring people along to appreciate and advocate for urban innovations in their neighbourhoods. Ultimately the Labs aim to attract residents that are open to urban innovations and new technologies being tested and undertaken within their neighbourhoods.

Interest from industry and government partners is also a key requirement to establish Urban Living Labs. Partners need to see the value of Urban Living Labs to engage with the concept. Reliance on Government funding is a key limitation and risk and requires extended commitment to support these long-term projects.

Implementation risks and barriers

- The main barriers to the urban living labs are the large-scale nature of implementing innovation and ensuring community buy-in to and advocacy for environmental innovations. Ultimately the aim is for the labs to attract residents interested in systems thinking and innovations and who are open to the testing and adaptation of new technologies in their neighbourhoods. This requires lots of stakeholder coordination and management.
- Partnerships with industry and governments are also a key requirement for establishing living labs. Partners need to see the value of labs if they are to engage with the concept. Reliance on government funding is a key limitation and risk, and long-term political commitment is required to support activity of the labs long-term.

Mechanisms to reduce risks and barriers

- Incentivising partnerships with industry and government by emphasising knowledge-sharing and the value of engaging the public to create positive associations with science and the pathways for urban innovation.
- Finding alternative sources of funding through partnerships that support innovation and experimentation as well as build community ownership and capacity (e.g. co-governance with grassroots organisations).

Where and how this action could be applied in Sydney

CSIRO has partnered with the developer Celestino to establish an urban living lab at Sydney Science Park in Western Sydney. This 280-hectare mixed-use development is set to become one of the country's largest centres of research and development, employing 12,000 staff, educating 10,000 students in key science and technology disciplines, and providing 3,000 homes. Key emerging foci of the urban living lab at Sydney Science Park are mitigating the urban heat island effect through appropriate urban planning and design, and building resilience to the more frequent and severe heatwaves predicted under climate change. While still in the formative stages, this living lab is likely to provide significant opportunities to develop and test a range of prospective urban ecological innovations for mitigating extreme heat and improving urban liveability.

Having one lab within Sydney will support the development of a culture of innovation and experimentation. Many of the learnings from the urban living labs at Sydney Science Park could be transferred and applied to other parts of Sydney following successful demonstration and 'proof of concept'. The pathway for this would be through active engagement with established science hub networks such as Inspiring Australia's NSW Regional Science Hubs and specifically the Western Sydney Science Hub, the Macarthur Science Hub, the Southern Sydney Science Hub, the Eastern Sydney Science Hub and the Inner Sydney Science Hub.

Opportunities for implementation in Newcastle and Wollongong

Newcastle City Council is already familiar with and applying 'living lab' thinking in the pursuit of its smart cities agenda and through collaborations with the University of Newcastle, CISCO and others. While opportunities for urban ecology have not been explored, Newcastle City Council are viewing smart cities as about urban liveability and quality of life, with technology and digital innovation a key focus but not the only consideration. Connections between people and nature are clearly important, with Newcastle well-placed to link its focus on living labs with the many active, well-established environmental organisation in the Hunter and Central Coast.

Additional urban living lab sites could be established in Wollongong through partnerships with developers and state and local government authorities. Educational institutions such as the University of Wollongong could also lead or collaborate on some such projects. Many of the learnings that are being gleaned from the growing portfolio of CSIRO urban living labs in other locations could be transferred to developments in Wollongong.
More broadly, there are opportunities throughout NSW to partner or share information with well-established organisations, local grassroots initiatives and programs such as Birdlife Australia, ClimateWatch and Wildlife Spotter. Similarly, there are opportunities for collaborating and innovating with established science hub networks such as Inspiring Australia's NSW Regional Science Hubs, specifically in the Hunter and Illawarra.

The proposed Sydney Science Park in Western Sydney

The Demonstration Garden at Camperdown Commons engages the local community and is an education opportunity

Interpretive signage can engage and educate the community

Signage about habitat restoration at Federal Park, Glebe helps educate the community and increase awareness about urban ecology

S7 STRATEGY SEVEN

Align urban ecology policies and practices at all levels of government

EVIDENCE BASE

The ways in which biodiversity is governed across scales and by state agencies and local government are unclear. There is considerable evidence that protecting and managing urban ecosystems is essential, but, this is not matched by political legitimacy or the priority afforded urban ecology in city planning and development control decision-making processes. At the legal and policy levels, there are many conflicting interpretations of how biodiversity should be managed and considered. As a consequence, laws and policies are applied inconsistently and continually tested in local and state governments and through the NSW Land and Environment Court. Guidelines exist on the design, implementation and management of urban ecology measures, but these are applied inconsistently and often lack robust reporting and evaluation frameworks.

IN PRACTICE

There is insufficient coordination among and within state agencies and local governments. This lack of coordination is compounded by a lack of awareness of who is doing what, which has led to duplications and gaps. The biodiversity reform process completed in 2016 was perceived as a missed opportunity to address some of these inconsistencies and structural issues. A formal cross-agency group could bring together key stakeholders as a way of improving communication and better coordinating urban ecology-related policies. Some 'region of councils' alliances appear more effective in bringing together councils to improve urban ecological outcomes.

To better align policies and practices, guidelines that clearly define urban ecology and how it should be measured and reported, including across scales and levels of government are needed. A review of metrics should build on the Biodiversity Assessment Methodology being developed by the NSW government, as well as on local, state and national state-of-the-environment reporting.

S7A1	Action 1	Scale
Policy	**Ensure that apex plans of the state (such as the State Plan and Premiers Priorities) feature biodiversity as a key priority**	
S7A2	**Action 2**	
Research	Research and develop new models of ecological governance to provide greater protection for biodiversity	
S7A3	**Action 3**	
Process	Align government policies that affect urban ecosystems to ensure they are complementary	
S7A4	**Action 4**	
Process	Develop a standard protocol and evaluation framework for the monitoring of urban biodiversity by state and local government	
S7A5	**Action 5**	
Research	Evaluate existing state and local government guidelines and operating procedures to identify urban ecology best practices	
S7A6	**Action 6**	
Process	Align the activities of local governments and state agencies to ensure they prioritise water quality and river health outcomes in planning and maintenance	
S7A7	**Action 7**	
Process	Introduce reporting on biodiversity to state agency and local government annual reports	
S7A8	**Action 8**	
Process	Incorporate biodiversity outcomes in term-of-government reporting on strategic priorities to enable the review and evaluation of policy, funding and legislative reforms	

STRATEGY SEVEN PRIORITY ACTION

S7A1. Ensure that apex plans of the state (such as the State Plan and the Premiers Priorities) feature biodiversity as a key priority

Example: Singapore

Project Overview

Singapore is a compact, high-rise, high-density island city-state covering 719km². Political drive has played an important role in its development, demonstrating the power of a clear vision backed by effective urban planning policies and a supportive legal framework, along with effective governance.

The development of institutions to operationalise greening policies has supported Singapore's goal of becoming a 'garden city'. The first Green Plan, produced in 1992, focused on strengthening 'clean and green' performance and a vision of the city-state as a 'model green city'. In 1999, a review of the plan was undertaken to account for new knowledge and issues (such as climate change and other environmental concerns), resulting, in 2002, in Singapore's Green Plan 2012[24]. This plan was exhibited to the public, and it involved stakeholder consultations such as internet surveys that obtained comments from more than 17,000 people. The plan moved Singapore's vision towards sustainability.

Another review in 2005 resulted in an update of the Green Plan 2012. The revised plan focuses on six clusters: 1) air and climate change; 2) water; 3) waste management and recycling; 4) nature; 5) public health; and 6) international environmental relations. In the 'nature' cluster, the plan sets the following targets:

- consolidate and update databases on flora and fauna through biodiversity surveys; and
- increase connectivity of the green grid by increasing the number of parks.

The Inter-Ministerial Committee on Sustainable Development was established in 2008 to implement Singapore's national strategy for sustainable development. Among other things, this committee has developed the Singapore Index on Cities' Biodiversity, which enables cities to monitor and evaluate their conservation progress using a self-assessment tool that compares the city's biodiversity with a baseline using 23 indicators. The indicators include points for urban native biodiversity, ecosystem services provided by biodiversity, and the governance and management of biodiversity.

Singapore's National Biodiversity Strategy and Action Plan[25] consists of five strategies, each with an action plan:

1. Safeguard our Biodiversity
2. Consider Biodiversity Issues in Policy- and Decision-making
3. Improve Knowledge of our Biodiversity and the Natural Environment
4. Enhance Education and Public Awareness
5. Strengthen Partnerships with all Stakeholders and Promote International Collaboration.

Various incentive programs help in achieving the garden city vision. For example, the goal of the Skyrise Greenery Incentive Scheme, introduced in 2009, is to increase by 50 hectares the area of new green building spaces by 2030 by financing up to 50% of green roof and green wall installation costs. Since its introduction, the scheme has assisted in greening more than 110 existing buildings by retrofitting them

with green roofs, edible gardens, recreational roof top gardens and green walls.

Singapore's Urban Redevelopment Authority introduced the Landscaping for Urban Spaces and High-Rises program in 2009, the aim of which is to consolidate existing and new green initiatives and to encourage more 'skyrise' greenery in private developments. The program encourages building owners and developers to provide well-planted and designed communal green spaces at the ground and upper levels of buildings, such as sky terraces. To further encourage urban greening, the National Parks' Streetscape Greenery Master Plan provides a blueprint for optimising available green spaces along roads. The plan provides planning and design guidelines that aim to maximise the landscaping of streets for variety and character.

Benefits provided by urban ecology

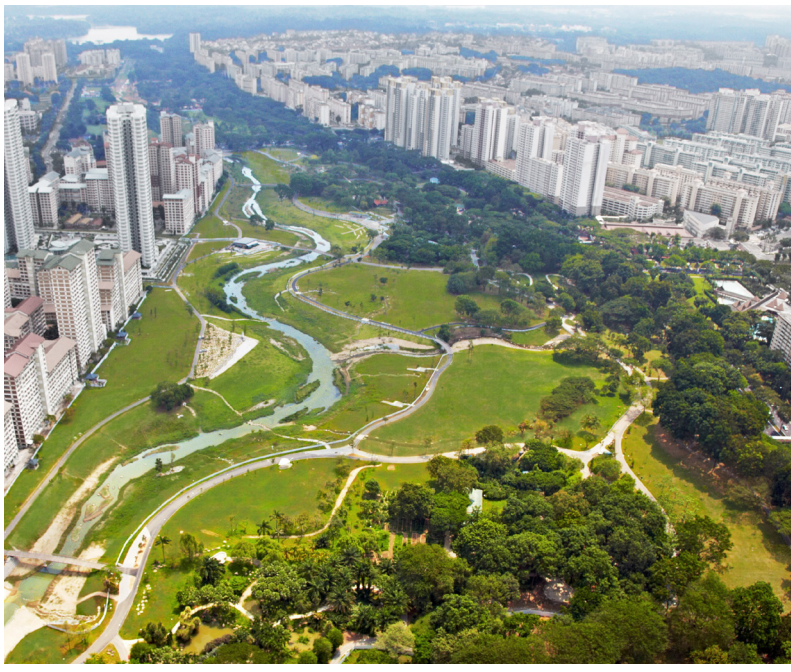
Singapore's Green Plan has resulted in an improvement in biodiversity trends. Co-benefits from implementing a similar plan for NSW include:

- Enhance resilience to pollution and climate change from improved biodiversity.
- Improved connectivity of green spaces and parks encourages residents to undertake physical outdoor activities.
- Promoting shift in industry practices with green infrastructure installations on buildings providing energy and cost savings.
- Improved air and noise filtration.
- WSUD practices improving water demand and dependency issues as well as reducing need for stormwater treatment and sewerage overflow issues.
- Creating advocacy and socio-cultural change by allowing people to connect with nature and various native species.

Implementation risks and barriers

A NSW apex plan such as Singapore's Green Plan is likely to encounter the following risks and barriers:

- Lack of political will



The HDB Car Park Roof at 180 Edgefield Plains and Bishan Park are examples of urban ecology in Singapore

- Challenge of growing population and demand for land
- Need buy-in to be implemented and enforced

Mechanisms to reduce risks and barriers

- A political champion for urban ecology could help to pioneer a State plan.
- Consulting stakeholders to improve commitment and likelihood of enforcement.
- Running education campaigns in parallel to raise awareness on loss of biodiversity and the repercussions of resilience, climate change adaptation and health issues such as pollution and UHI.
- Demonstrating the benefits of incorporating urban ecology in development considerations.
- Implementing incentive mechanisms alongside a state plan to encourage developers and homeowners to participate and complement efforts to improve urban biodiversity and ecology.

Where and how this action could be applied across New South Wales

The NSW Government could support the adoption of planning and design targets for new low to medium density developments and subdivisions, such as a minimum % of tree canopy cover (at a lot or precinct level) and green roof cover standards for higher density development areas. These targets would need to be codified in local planning policies and relate to sustainability and liveability goals established by the local council and through the district planning process.

Community members interact with nature at Bishan Park, Singapore

Constructed wetlands in a residential development have many co-benefits including environmental, social and economic

Recreation opportunities in Sydney Park, St Peters increase human health and well-being

APPENDIX

This constructed wetland is a key component of the water sensitive urban design strategy to treat and reuse stormwater at the Sydney University Darlington Campus

Glossary

Biodiversity
The variability among living organisms, including terrestrial, marine, and other aquatic ecosystems. Biodiversity includes diversity within species, between species, and between ecosystems'[26].

Ecosystem services
The benefits for humans that are derived from the functioning of natural ecosystems.

Green corridor
A strip of land and supports habitat and the movement of wildlife. Examples include a vegetated riparian area, a continuous row of street trees or vegetation along a utility easement.

Greenfield development
The construction and development for residential use of land previously undeveloped. Greenfield development is typically at the urban fringe where the existing land use may comprise of natural bushland or farmland.

Green infrastructure
An adaptable term used to describe an array of products, technologies and practices which use natural systems – or designed systems which mimic natural processes – to enhance environmental sustainability and human habitability (quality of life). Includes green and blue infrastructure.

Liveability
A broad term encompassing all of the things that contribute to quality of life and make a city enjoyable to live in[27].

Remnant vegetation
Patches of native vegetation or bushland that can include all forms of vegetation and occur on public and private land.

Urban ecology
The 'investigation of living organisms in relation to their environment in towns and cities'[28]. The scientific discipline that studies the abiotic and biotic components of ecosystems situated in urban areas and the interaction between these components.

Urban forest
The 'sum of all urban trees, shrubs, lawns, and pervious soils (...) located in highly altered and extremely complex ecosystems where humans are the main drivers of their types, amounts, and distribution'[29].

Urban resilience
'The ability of an urban system-and all its constituent socio-ecological and socio-

technical networks across temporal and spatial scales-to maintain or rapidly return to desired functions in the face of a disturbance, to adapt to change, and to quickly transform systems that limit current or future adaptive capacity.'[30].

Water Sensitive Urban Design (WSUD)

WSUD is the 'capturing of stormwater for local use, which then limits the deterioration of creeks, streams and receiving waters associated with the influx of sediment, oil, litter and other pollutants from roads, drains and gutters'[31]. In the UK, WSUD is known as Sustainable Urban Drainage Systems (SUDS), in the US it is known as Low Impact Development (LID) and in China it is known as Sponge Cities. Arguably, other design approaches which enhance the health of waterways and their ecological communities can be considered as WSUD.

Urban green cover

Urban green cover is 'the integration of vegetation with permeable and reflective surfaces to minimise local temperatures and encourage evaporation from soil and plants into the urban environment'[32]. It includes a broad range of strategies such as green open space, green streets, green walls and green roofs.

Urban renewal or urban regeneration or infill development

Redevelopment of land in areas of medium to high density. This is typically in the inner and middle ring suburbs and may involve changing the use of land, such as industry to residential, changing the density or construction of new infrastructure.

Stakeholder Engagement

List of participating organisations

AECOM
Allied Tree Consultancy
Ashfield Council
Aspect Studios
AUSGRID
Australian Association of Bush Regenerators
Australian Institute of Landscape Architecture Fresh
Bankstown Council
Biosis
Birds in Backyards
Blacktown City Council
Botanic Gardens & Centennial Parklands
Bush-it Pty Ltd
Central Coast Council
City of Canterbury-Bankstown
City of Parramatta Council
City of Sydney
Clean Air and Urban Landscapes Hub, University of Melbourne
Conservation Volunteers Australia
Cooks River Alliance
Corkery Consulting
Department of Environmental Sciences, Macquarie University
Department of Planning and Environment
EcoLogical Consultants Australia
e2 Design Lab
Frasers Property Australia
Fungimental
Gecko Plantscapes
Georges River Combined Councils Committee Inc.
Greater Sydney Commission
Green Roofs Australasia
Hornsby Shire Council
Horticulture Innovation Australia
Hunter Development Corporation
Infrastructure Sustainability Council of Australia
Junglefy
Ku-ring-gai Council
Lake Macquarie City Council
Landscape Architecture Program, Faculty of the Built Environment, UNSW
Leichhardt City Council
Macquarie University

Maitland Council
MidCoast Council
Mirvac
National Parks Association of NSW
Nature Conservation Council of NSW
Newcastle City Council
NSW Department of Primary Industries
Northern Beaches Council
Office of Environment and Heritage
Parramatta River Catchment Group
Penrith City Council
Property Council
Rockdale City Council
Shellharbour City Council
Southern Sydney Region of Councils
Sustainable House
Sutherland Shire Council
Sydney Coastal Councils Group Inc.
Sydney Environmental and Soil Laboratory
Sydney Olympic Park Authority
Transport for NSW
Urban Biodiversity Illawarra
University of Newcastle
University of Wollongong
Waverly Council
Western Sydney Parklands Trust
Wollongong City Council

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