Can biophilic urbanism deliver strong economic and social benefits in cities?

An economic and policy investigation into the increased use of natural elements in urban design

Sustainable Built Environment National Research Centre

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Synopsis

Biophilic urbanism, or urban design that reflects humanity's innate need for nature, stands to make significant contributions to a range of national, state and local government policies related to climate change mitigation and adaptation, by investigating ways in which nature can be integrated into, around and on top of buildings. Potential benefits of such design include reducing the heat island effect, reducing energy consumption for thermal control, enhancing urban biodiversity, improving well being and productivity, improving water cycle management, and assisting in the response to growing needs for densification and revitalisation of cities. This report will give an overview of the concept of biophilia and consider enablers and disablers to its application to urban planning and design. The paper will present findings from stakeholder engagement and a series of detailed case studies, related to a consideration of the economics of the use of biophilic elements (direct and indirect).

Acknowledgement

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Front cover: Singapore's Khoo Tek Puat Hospital is both 'a hospital in a garden', and 'a garden in a hospital', mirroring the City's biophilic ambitions. Nature is used therapeutically to aide in the healing process, to preserve biodiversity and healthy ecosystems, and to provide food for the hospital kitchen. Image: P Newman, 2012.

Executive Summary

As urban populations grow and the economic drivers for large, dense cities become more evident biophilic urbanism is emerging as a critical response to the increasing density of cities. Biophilic urbanism will ensure that urban residents receive their 'daily dose' of nature. Thus merging E.O. Wilson's concept of '*Biophilia*'[1] – that there is an innate emotional affiliation of human beings to nature – with the imperatives of urban development, biophilic urbanism focuses on the greater use of natural elements in the design and function of cities. Such elements range from green roofs, green walls and indoor plantings, to green verges, green islands and green corridors, from urban farming to regenerated waterways.

These natural elements are being shown to deliver a range of benefits when applied throughout cities. They reduce the urban heat island effect, lessen heating and cooling loads in buildings, improve air quality, allow urban food production and improve stormwater management. Furthermore, such elements provide aesthetically pleasing surroundings that have been shown to enhance urban liveability, reduce crime and violence, reduce depression, and encourage greater community connectivity. Biophilic urbanism has also been linked to reduced stress, improved health and well-being, increased cognitive abilities, higher productivity, and enhanced early childhood development.

This project has focused on responding to three key industry needs expressed by project stakeholders, namely, for the project to:

1. Provide a clear description of a range of biophilic urbanism options,
2. Investigate the costs and benefits of various biophilic urbanism programs, and
3. Investigate policies and programs that can inform efforts to achieve biophilic urbanism in Australian cities.

The project has included a detailed investigation of five leading 'biophilic cities', Berlin, Chicago, Portland, Singapore, and Toronto, with a detailed case study developed for each (including interviews with key persons involved), as outlined in this report. The mainstreaming and development of metrics on biophilic urbanism outcomes appear to be the next phase in this new phenomenon.

About the Research Team:

Professor Peter Newman led an experienced research team from Curtin University and the Queensland University of Technology, which was managed by emerging sustainability authors Charlie Hargroves (Curtin University) and Dr Cheryl Desha (QUT). The team includes outstanding sustainability doctoral researchers Angela Reeve, Omniya Baghdadi, Megan Bucknum, and Mariela Zingoni, Jana Soderlund, and Rob Salter. Professor Newman is the John Curtin Distinguished Professor and is the Director of the Curtin Sustainability Policy (CUSP) Institute. Newman is the co-author of nine books and over 200 papers on sustainability, is on the Board of Infrastructure Australia, and is the current Lead Author for Transport on the IPCC. As part of The Natural Edge Project, Hargroves and Desha have worked with a range of co-authors to publish four international books on sustainable development, selling over 80,000 copies in 4 languages. The books have received a Prime Minister's Banksia Award, and have been ranked 5th and 12th amongst the *'Top 40 Sustainability Books of 2010'* by the Cambridge University Sustainability Leadership Program.

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Pictured above: Brisbane, Australia has around one third natural forest cover throughout the City. Image: Brisbane City Council, 2012

Introduction

The Importance of Biophilic Urbanism

Cities around the world are growing dramatically as they provide unprecedented economic and social opportunities. The importance of scale and density in creating these opportunities is now well understood.[2] But there has been a parallel emergence of the evidence of the need for people to be more closely linked to nature, and to create cities that are more sensitive to natural systems. Thus an increasing number of cities are now actively engaged in the process of incorporating nature into their design and function to an increasing extent. Rather than just focusing on urban beautification or even environmentally sensitive design, these cities are seeking to capitalise on a range of direct and indirect benefits from the use of nature as an intentional functional design element that can be brought into the daily lives of urban dwellers. As the Prime Minister of Singapore has said, we need to '*bring nature to our doorsteps*'.[3] This new approach is called 'biophilic urbanism'.

Biophilic urbanism is bringing tangible benefits to cities, ranging from improved stormwater management, reduced air-conditioning loads, reduced urban temperatures, improved health and well-being, lower crime rates, and increased productivity. It is providing a way to continue the great urban experiment which has created so much economic value by balancing the concrete and steel urban infrastructure with innovative and well-integrated forms of urban nature that ensure urban environments remain aesthetic, liveable and attractive to existing and future residents. Such considerations are driving efforts that are seeing nature spreading rapidly across well-known cities around the world, such as Berlin, Chicago, Portland, Singapore and Toronto.

> *'Biophilic urbanism is an important emerging design principle for buildings, featuring a suite of natural design features that address multiple pressures related to climate change, increasing urban populations, finite resources, and our inherent need for contact with nature. The principle directs the creation of urban environments that are conducive to life, delivering a range of benefits to stakeholders including building owners, occupiers and the surrounding community.'*[4]

Increasing interest in biophilic urbanism can be understood by looking at two key issues of our time: the increasing risks and impacts from climate change, and the threats from mounting population pressures. The impacts of both climate change and population growth can be significantly mitigated through embedding nature within urban areas:

- **Climate Change:** Australia's temperatures are projected to increase by as much as 1.0˚C by 2030 and up to 5˚C by 2070[5] (with significant variation in estimates depending on the emission scenario). As a result of this, Australian cities are expected to be impacted by more frequent and intense tropical cyclones and heat waves that will degrade infrastructure and have public health implications. Changes in average precipitation are also expected to result in more climatic extremes, with areas in which rainfall increases expected to see more extremely wet years, and those in which rainfall decreases expected to have more droughts.[6] Australia's agriculture and forestry may initially benefit from longer growing seasons and increased atmospheric CO_2 concentrations, but the Intergovernmental Panel on Climate Change anticipates that agriculture and forestry will over time decline throughout southern and eastern Australia by 2030 due to increased drought and fire. A further decline in average precipitation in southwest and southeast Australia is predicted, with increases in precipitation in the northwest.[7]
- **Population Pressures:** Australia has one of the most urbanised populations in the world, with more than 75 per cent living in cities and large towns.[8] According to Treasury the Australian population is forecast to grow from 23 million to some 35 million in 2050.[9] While this will increase the labour force, it will also place greater pressure on the country's energy and water supplies, infrastructure, food production and distribution, services, and the environment.[10] These pressures have led to widespread concern that our cities are becoming overcrowded and dysfunctional.

Increasing the extent of nature within cities addresses both these issues. Landscaping around buildings 'air conditions' the city and thus reduces energy use, while allowing people to connect regularly with nature is thought to reduce their sense of population pressure. Hence as Australia's cities grow to accommodate a burgeoning population, and respond to climate change, it will be increasingly important to find innovative ways to include nature within cities, and to reach a balance between the levels of nature necessary for health and well-being, and the performance demands of city infrastructure.

Singapore airport green wall. Image: G Impolex, 2009.

The Application of Biophilic Urbanism

E.O. Wilson first popularised the concept of 'biophilia' in the early 1980s with his seminal book of the same name,[11] using the term to mean '*the innately emotional affiliation of human beings to other living organisms*'. Having been used in psychology and interior design, biophilia is now being applied to urban design, and leaders in this area such as Tim Beatley and Peter Newman have created the field of '*biophilic urbanism*', or '*nature loving cities*'.[12] Landscape architecture has sought to bring nature into cities for hundreds of years, especially through works like *Design with Nature* by Ian McHarg in 1966. But as with many attempts by the environmental movement to bring environmentally sensitive design into cities from the 1970s on, this has been largely anti-urban, and has not tried to embrace the broader built environment. Thus early efforts in biophilic urbanism focused mainly on the landscaping of individual buildings using green roofs and green walls, but their success in delivering a range of benefits has prompted investigations into the wider application of biophilic principles across the fabric of cities around the world. This has included complete canopy covers over roads and the conversion of concrete drains into living streams in urban water management.

For its literature review the project has categorised biophilic urbanism into three scales, namely, the building, neighbourhood, and city scales, as summarised in Table 1. Particular biophilic design elements can provide different benefits at different scales. For example at the building scale, green roofs and green walls reduce energy demand and improve water management, while at higher scales biophilic elements help to alleviate the urban heat island effect and improve air quality and the microclimate. The greatest benefits will be derived from implementing biophilic design elements across all scales in cities. The many applications of biophilic urbanism present exciting opportunities for the design of cities and communities around the world, with a growing number of politicians gaining significant public support for programs to increase nature within cities. For example, former Chicago Mayor Richard Daley presided over a 22 year focus on urban greening, and the former Mayor of Seoul Lee Myung-bak oversaw numerous greening programs including the demolition of over 8 kilometres of freeway covering the Cheonggyecheon River and the regeneration of the area as an urban river park. Lee Myung-bak later became the 17th President of Korea.

A green roof in Berlin's Potsdamer Platz, where a range of biophilic elements are used to capture, filter and beneficially use rainwater. Image: Secretariat, S., 2010.

Table 1: Overview of the elements of Biophilic Urbanism

Element		Forms	Specific Benefits	Common Benefits
Building	Indoor Plants	• Pot plants, on desks, around office, or in banks of pots • Indoor living walls, including pots within a mess frame (also see Green Walls) • Indoor planted vegetation, such as atriums and large planted installations	• Reduces illness • Increases productivity • Improves air quality	• Responds effectively to growing need for densification of cities
Neighbourhood	Green Roofs	• '*Intensive*': Soil deeper than 200mm and vegetation up to the size of trees • '*Extensive*': Soil up to 200mm with ground cover vegetation	• Improves building energy efficiency • Water management • Space efficiency • Food production • Sound insulation • Increases roof/wall lifespan • Vertical urban farming	• Revitalises urban environments • Alleviates urban heat island effect • Improves air quality • Improves microclimate • Sequesters carbon/ reduce greenhouse gas emissions • Increases biodiversity • Improves water cycle management • Provides amenity • Enhances well-being/ reduces stress • Recreation • Reconnects with nature • Revitalises cities • Increases property value • Enhances tourism
	Green Walls	• *Panel System*: Pre-planted structural panels that are secured to wall and have an in-built watering system • *Felt System*: Pre-fabricated structural panel with felt planting pockets that is planted onsite and kept moist • *Container/Trellis System*: Pre-fabricated structural panel with planting pots and drip irrigation system for the pots		
	Green Verges	• Street trees and canopies chosen depending on physical properties • Shade planting for buildings placed to remove heat load • Green streets and alleys that create cool pervious greenways • Rain gardens and bio-swales integrated into stormwater management plan and consisting of pervious channels • Green permeable sidewalks	• Reduces traffic / encourages walking, and cycling • Reduces building cooling/ heating energy use • Windbreak • Water management • Food production	
	Green Islands	• Urban parks and gardens placed close to transportation routes • Community farms close to homes • Residential backyards with space for food production • Lawns and gardens reducing UHI effects • Waterways and streams uncovered and rehabilitated	• Reduces traffic / encourages walking and cycling • Food production • Reduces reflection • Community sense • Education	
City	Green Corridors	• Green corridors (biodiversity corridors) reaching outside the urban area • Highway crossings and migratory routes • Backyard commons that can be part of the green corridor • Buffer protection from storms surges along coastal areas	• Links biophilic elements • Reduces traffic / encourages walking and cycling • Connectivity • Increases tourism • Cognitive way finding	
	Urban Farming	• Community gardens • City farms • Urban and peri-urban agriculture	• Food production • Creates employment • Education	
	Water Ways	• Wetlands • Constructed wetlands • Ponds and lakes • Day-lighted streams • Vegetated swales and drainage corridors • Infiltration basins • Mangroves	• Water management • Water treatment • Water storage • Filtration / enhance water quality • Protects downstream water bodies	

A growing number of cities internationally have a strong focus on biophilic urbanism and thus receive a range of direct and indirect benefits, summarised in this report. These cities include:

- **Berlin:** The City of Berlin has a long history of integrating nature into the built environment, and has some of the most advanced and sophisticated urban greening policies and programs in the world. These are strongly supported by citizens and developers, whose experiences of urban nature have led to an inherent understanding of their financial and broader social, environmental, and personal benefits. As a result, approximately one third of greater Berlin is natural habitat and green space, and nature continues to be added to the city. The Berlin Senate Department for Urban Development and the Environment boasts, '*The appearance of the city is defined as much by open space as by individual buildings or architectural ensembles. They are responsible for the feeling of well-being and ease which the city provokes, and are crucial for the sense of identity the inhabitants have with their city*'. This is all within one of the densest cities in Europe.

- **Chicago:** Over more than 20 years, driven by former Mayor Richard Daley, the city has created numerous plans, ordinances, policies, and programs to encourage the use of various forms of nature in urban design, and this has transformed it from its industrial roots to become one of the world's greenest cities. In Chicago there are now over 600 green roofs covering over 5 million square feet;[13] over 1,300 acres of new open space;[14] over 500,000 trees planted, and a network of over 110 miles of landscaped median strips.[15] The Millennium Park is one of Chicago's most recent biophilic urbanism projects and is a popular destination for tourists and residents, attracting around 19 million people since its opening in June 2004,[16] and contributing to the city's status as America's most popular tourist destination in 2006.[17] Significant tourism revenue is expected over the next ten years with hotels associated with the park expected to generate as much as $580 million, restaurants $865 million and retailers some $710 million.

- **Portland:** The City of Portland has a highly comprehensive urban greening program, largely driven by stormwater management concerns. However, as experience with urban greening tools and technologies has grown, the city has been able to recognise broader benefits that can leverage further support for urban greening. The use of demonstration sites, public education and public policy has underpinned Portland's urban greening activities. The evaluation, quantification, and communication of the performance of urban greening installations have been an integral component of the success of these projects. Successful programs such as the 'Grey to Green Initiative' introduced in 2008 have accelerated urban greening, and by 2011 had resulted in an additional 6.5 acres of green roof space with approvals for an additional 8.4 acres, 8,500 trees planted in private yards and 9,000 street trees,[18] and 546 new green street projects, and well as 261 acres of land purchased for conservation and open space,[19] and the beginnings of restoration of over 2,800 acres of natural area in the region.[20]

- **Singapore:** The greening of the city-state of Singapore began with the 'Garden City' campaign under the auspices of then Prime Minister Lee Kuan Yew in the 1960s, well before the international focus on the benefits of

biophilic urbanism. Lee recognised that urban parks and greenery contribute to the city's quality of life and can be a decisive factor in its global competitiveness, reflecting in 1996, '*In wooing investors, even the trees matter*'.[21] Today, Singapore is arguably the world's best example of a 'biophilic city'. Natural elements are an intentional, mainstream and integrated component of urban design, and are well supported by policies, programs and the community. Singapore has a vision of becoming a 'City in a Garden', where natural elements are integrated into the built environment to create '*a city that is nestled in an environment of trees, flowers, parks and rich bio-diversity*'.[22] It has faced the challenge of finding a balance between development, density and the presence of nature in the city. The population nearly doubled from 2.7 million to over 5 million in the 25 years between 1986 and 2010, and yet the city has simultaneously managed to increase the green cover from 36 to 47 per cent.[23]

- **Toronto:** Toronto has a population of 2.7 million people, making it the largest city in Canada and the fifth most populous in North America. Toronto is facing numerous environmental challenges commonly associated with urban development, such as poor air quality, increased urban heat island effects and stormwater management issues.[24] The city has taken many environmental initiatives to address these issues, such as a 'Green Development Standard', a 'Green Economic Sector Development Strategy', a 'Climate Change, Clean Air and Sustainable Energy Action Plan', a 'Climate Change Adaptation Strategy', and an 'Environmental Plan'.[25] In May 2009, Toronto became the first city in North America to adopt a by-law that requires and governs the construction of green roofs, and this applies to all building applications for new residential, commercial, institutional, and industrial developments. The by-law requires green roof coverage of 20 to 60 per cent on all new developments above 2,000m^2 of gross floor area.

Gardens by the Bay is a 101-hectare site that brings people, nature and technology together. This is the Supertree Grove – the metallic structures are covered in plants and epiphytes, and you can climb the stairs inside for a view of the area. Image: P Newman.

The Value of Biophilic Urbanism

Industry Led Outcomes

As part of the Sustainable Built Environment National Research Centre's (SBEnrc) focus on industry-led research, two stakeholder workshops were held in the early stages of the project, hosted by SBEnrc Core members, the Western Australian Department of Finance in Perth, and Parsons Brinckerhoff in Brisbane. The workshops involved the research team presenting the findings of the literature review and working with a total of 25 key stakeholders to identify areas of interest for the project to develop. The result of the workshops was a project scope that investigated key areas of interest to partners, areas that would provide clear benefits to industry and government. The workshop format was based on the methodology of '*Collective Social Learning*', created by Emeritus Professor Valerie Brown,[26] which guided participants through a process to consider, firstly, a vision for a '*nature loving city*' and, secondly, factors that either enable or obstruct the achievement of such a vision. Three key challenges identified as important to bear in mind in the scope of the research were:

- *The lack of understanding of the associated costs and benefits*: Stakeholders expressed a need to see greater evidence of the feasibility of urban greening projects, in order to assist decision makers in making informed decisions around appropriate application in Australian cities. While primarily concerned with the direct economic performance, stakeholders also wanted to find out more about other financial and non-financial benefits.
- *The lack of understanding of options for effective government policy and programs*: Stakeholders expressed a view that existing regulations and planning requirements generally didn't support urban greening initiatives. They were interested in learning about successful policies and programs, especially ones that involved multiple departments and agencies.
- *The lack of understanding of and involvement in such programs by the community*: Stakeholders perceived a general disconnection of the community from the natural environment, such that there may be a common lack of appreciation of the benefits of nature. Stakeholders expressed interest in learning about key ways to engage communities in urban greening programs and initiatives, and in learning about the benefits being achieved by such programs.

A clear result of the workshops was that stakeholders felt that the project focus should be less on the technical nature of installing and maintaining natural elements, such as green walls and roofs, and more on solutions to key systemic impediments to biophilic urbanism that are well-grounded in current social, political and economic realities and supported by international precedent.

Based on this industry engagement the project has focused on:

1. Providing a *clear description* of a range of biophilic urbanism options. This was done through a literature review of key elements of biophilic urbanism, as summarised in Table 1.

2. Investigating the *costs and benefits* of various biophilic urbanism programs. This was undertaken through a literature review and the development of five detailed cases studies of leading biophilic cities, as summarised in this report, and

3. Investigating *actual urban greening policies and programs.* This was also done through a literature review and consideration of the same five cases studies.[1]

[1] The cities investigated were Berlin, Brisbane, Chicago, Portland, Singapore and Toronto, and include interviews with key persons.

Benefits to Industry of the 'Biophilic Urbanism' Project

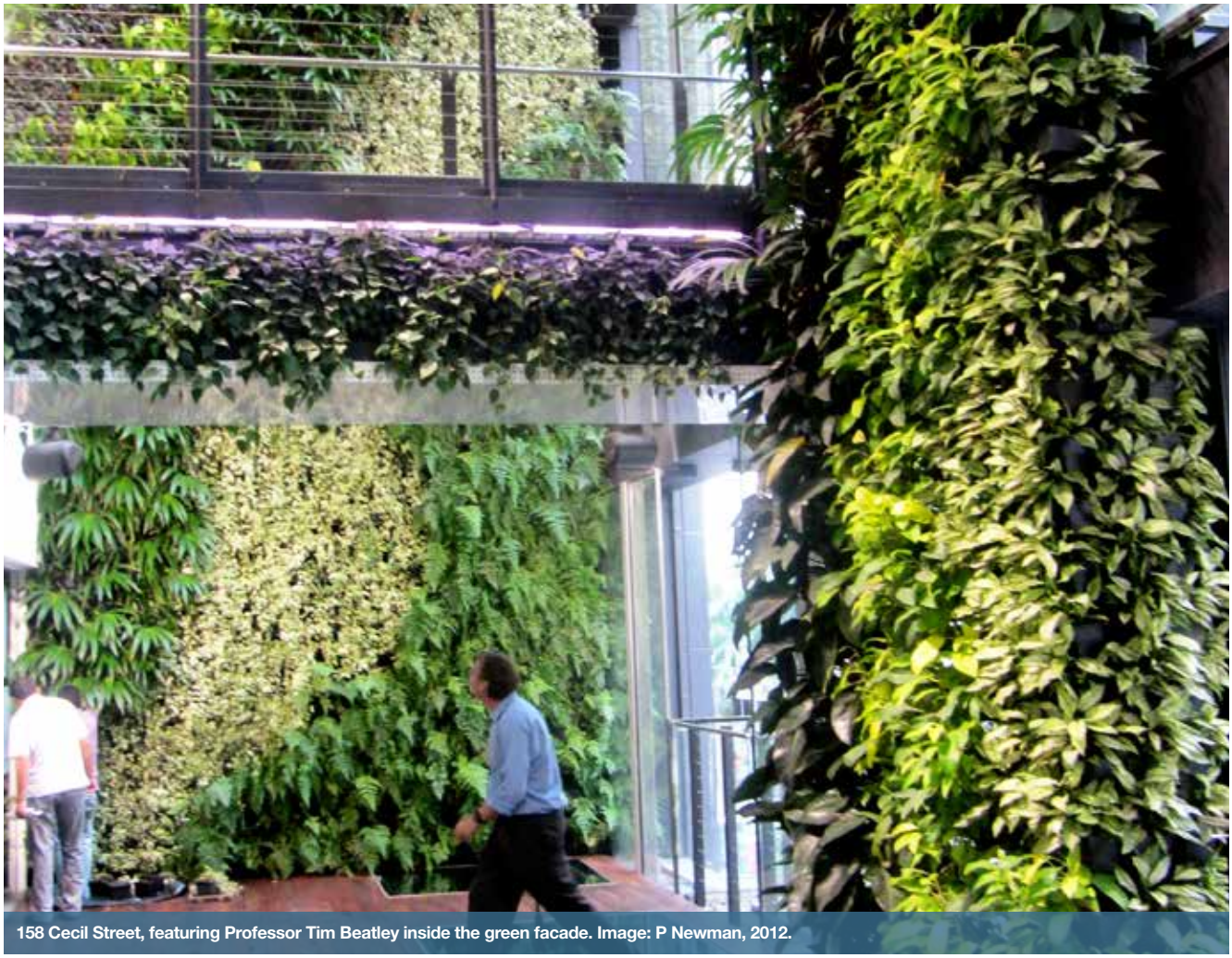
Expectations for urban development are rapidly shifting. Governments and citizens alike are increasingly demanding smart, sustainable, sophisticated urban design solutions to meet the pressing challenges facing cities today. Developments need to be multi-dimensional and provide aesthetic, social, and environmental benefits along with innovative solutions to meet growing demand for infrastructure and services. In such a competitive industry, firms need new approaches to differentiate themselves from their competition, and they need to show that they can deliver multiple outcomes. Biophilic urbanism provides such an approach and the outcomes of this project can benefit industry in the following ways:

- *Building Demand for Biophilic Urbanism*: The project's findings will be widely promoted to inform government and industry about the benefits of biophilic urbanism, increasing the level of discussion about it and supporting the case for biophilic requirements in urban development proposals and tenders.
- *Forecasting Future Requirements*: The findings provide evidence of the current level of government requirement for biophilic urbanism in a number of cities around the world, thus substantiating forecasts of such requirements in Australia and the region in future.
- *Improving Strategic Positioning*: The findings provide clear guidance to industry as to current and future opportunities for harnessing biophilic urbanism to enhance strategic positioning efforts. Biophilic urbanism is rapidly growing as a core urban design paradigm, and companies in the sector will benefit from appropriate consideration of this opportunity.
- *Increasing Capacity Building*: The project's literature review and case studies provide a clear and structured understanding of how key elements of biophilic urbanism can be practically applied, and the benefits likely to accrue from this.
- *Enhancing Project Offerings*: The findings provide designers, consultants and contractors in the built environment sector with a clear overview of how biophilic urbanism is being implemented around the world, which will inform innovative design inclusions in a range of urban development projects.
- *Reporting Industry Perceptions*: The stakeholder engagement report provides industry with an indication of the perceptions of biophilic urbanism held by the industry. The report provides guidance as to the ways biophilic urbanism may be applied in Australia along with consideration of the key enabling and disabling factors.

Benefits to Government of the 'Biophilic Urbanism' Project

The findings provide governments with valuable information about the range of benefits from biophilic urbanism for government programs and the broader community, as follows:

- *Benefits to Government*: These include enhanced stormwater management, reduced urban energy demand, lower urban temperatures, reduced impacts of heat waves, and increased tourism and tax revenue.
- *Benefits to the Community*: Such benefits include enhanced liveability in cities, increased health and well-being, improved productivity, increased real estate values, and reduced crime and violence.
- *Informing Policy Design*: The findings outline what cities around the world are doing to introduce and support biophilic urbanism, and thus highlight the range of successful mechanisms currently in use.
- *Project Precedent*: The findings provide a detailed consideration of five leading 'green' cities to identify evidence of the application of biophilic urbanism. The case studies provide valuable precedents to build support and understanding for greater biophilic urbanism in Australia.



158 Cecil Street, featuring Professor Tim Beatley inside the green facade. Image: P Newman, 2012.

Key Findings

Policy and Program Findings

The project distilled the following key recommendations for policy and program design. Success biophilic urbanism projects need to have:

- *A focus on specific beneficial outcomes*: These can include improved stormwater management, increased urban amenity, the economic revitalization of derelict urban areas, enhanced international competitiveness, a countering of the loss of biodiversity and ecosystem services, and mitigation of the urban heat island effect.
- *A high level champion with a policy or vision*: Successful project typically have champions with high political and public profiles (such as Mayor Daley in Chicago, and President Lee Myung-bak in the Republic of Korea). There is also an overarching governing framework that provides a central focus for issue-specific policies, plans and programs, such as the German and Berlin Nature Conservation Acts. Multi-departmental advisory boards (such as Portland's Bureau of Environmental Services) or institutional positions (for example a Chief Sustainability Officer) also provide opportunity for cross-departmental communication and collaboration.
- *Support through government demonstration and local data capture*: Governments need to initiate or support demonstration projects and pilot programs in order to generate evidence and experience, and to refine techniques and technologies and adapt them to the geographical, climatic, and cultural context of the city. It is vital to start small and develop through effective demonstrations, as many benefits are difficult to quantify. However, the benefits of urban greening need to be measured if possible, and communicated across government, industry and the community.
- *Mandatory measurement requirements, especially for new and renovated properties*: Mandatory performance measurement can drive innovation and improve outcomes, resulting in greater transparency. Measuring and evaluating outcomes can help communicate the benefits of biophilic elements and drive continual improvement in these. Some examples include Portland's stormwater and drainage management policies, and Berlin's Biotope Area Factor.
- *Specific incentives for private property owners*: Several cities that were investigated as part of this project charged property owners separately for stormwater, enabling them to then provide a discount where stormwater was managed onsite, principally through the use of biophilic elements. These schemes raise awareness about the costs of stormwater management, and engage property owners as partners with the city in managing the issue together.

Economic Assessment Findings

The project distilled a number of economic recommendations for urban greening that highlight how this field is still emerging and needs further research if it is to be mainstreamed. Success requires:

- *An understanding of the range of benefits of biophilic urbanism*: The full scope and cost of urbanisation challenges are generally not recognised. They include the urban heat island effect, increased stormwater runoff, a lack of visual amenity and green space, a lack of local food and food security, and a loss of biodiversity. As the costs these challenges impose are often disaggregated into many different municipal, state and federal budgets, governments and citizens are often unaware of their extent, or of the scale of benefits possible through urban greening.
- *A balance of economic, social and environmental argument*s: The experience of Berlin, Singapore, and Chicago has shown that economic arguments alone are not always strong enough drivers for biophilic urbanism. There also need to be arguments that highlight the innovation and world-leading practice involved, that stress the importance of urban beautification and enhanced liveability, and that point out how real but unquantified urban challenges like the urban heat island effect and flooding are alleviated through urban greening. As Portland and Toronto have shown, a partial cost-benefit analysis can be sufficient to justify action, particularly when it is recognised that other benefits will result even though their economic value can't always be calculated.
- *Data on financial costs and benefits of urban greening*: A lack of cost-benefit data about urban greening may prohibit a holistic approach and consistent support. Economic reporting can support benchmarking, demonstrate the effectiveness of biophilic features and foster knowledge sharing between cities worldwide. Data can show how urban greening boosts revenue from property and sales taxes, stimulates real estate development, improves living standards and enhances tourism.
- *Financial incentives*: Meaningful financial incentives can encourage private property owners to integrate nature into their property, especially in the case of more costly biophilic elements such as green roofs and green walls. Economic modelling elsewhere suggests that these biophilic elements provide an array of public benefits that can justify such incentives.
- *Communication of the competitive advantage that urban greening provides*: Visionary and innovative approaches to urban planning have given cities like Berlin and Singapore a competitive advantage in various green technology markets and a leading edge in the global environmental sector workforce. According to the head of Singapore's Lee Kuan Yew Public Policy Centre, Dr Balakrishnan, at the World Cities Summit in 2012, '*cities that provide a green and welcoming environment soothe their citizens and gain a competitive advantage…people want to stay and invest in your economy*'.
- *Creative funding systems that respond to local context*: A creative financial scheme that attracts private or public funding is particularly important to ensure a consistent source of funding for a project such as an urban park.

Summaries of Detailed Case Studies

The imperative to respond to climate change, increasing costs of energy, and steadily growing urban populations all call for innovative approaches from companies and governments. The popularity of biophilic urbanism is rapidly growing in cities around the world as it provides a proven innovative approach to urban development that can deliver a range of benefits. Building an evidence base to support this, however, can be complex, and it requires some level of risk to trial and demonstrate new tools and techniques. The findings of this project will contribute to reducing this risk by providing a foundation of evidence for the application of biophilic urbanism. Table 2 highlights a growing number of cities developing regulations and incentives to support biophilic urbanism and reaping multiple benefits as a result.

Table 2: Examples of requirements and incentives for Biophilic Urbanism in cities

Location	Name of Policy	Key Policy Requirements
Linz, **Austria**	*Linz Green Space Plan*	New buildings with area of over 100m^2 and a slope of up to 20° require a compliant green roof, with a subsidy available.
Port Coquitlam, **Canada**	*Zoning Bylaw, No 2240 and 3569*	All new commercial and industrial buildings of greater than 5,000m^2 require a green roof of at least 75% of the roof area.
Toronto, **Canada**	*Toronto Bylaw No 583, 2009*	All new developments above 2,000m^2 require 20-60% green roof (except residential buildings of less than or equal to the greater of six storeys or 20 metres).
Faenza, **Italy**	*Municipal Structural Plan*	Subsidies are available to encourage developments to maximise ground permeability, save water and include green areas and appropriate landscaping.
Berlin, **Germany**	*Development Code: Biotope Area Factor*	New residential structures require 60% ecologically effective area and new commercial structures 30%. (Only mandatory in areas with legally binding landscape plans.)
Cologne, **Germany**	*Cologne Green Roof Policy (Flood Mitigation)*	A 50% stormwater fee subsidy is offered for compliant green roofs.
North Rhine Westphalia, **Germany**	*Initiative for Ecological and Sustainable Water Management*	A subsidy is available for green roofs with either a minimum depth of 15cm or certification of a runoff coefficient of less than 0.3.
Basel, **Switzerland**	*City of Basel's Building and Construction Law*	All new and renovated flat roofs require a compliant green roof with native vegetation.
Portland, **USA**	*Stormwater Management Manual*	New developments and redevelopments with over 500ft^2 of impervious surface are required to manage stormwater onsite through replicating as much as possible the pre-development hydrological conditions.
	Building Code Floor Area Ratio Bonus	Developers are offered an extra 3ft^2 of building space per foot of green roof without additional permits, along with a grant of $5/ft^2 for stormwater retention.
New York City, **USA**	*New York State Law*	A subsidy is offered for a green roof of more than 50% of available roof space.
Seattle, **USA**	*Seattle Green Factor*	There is a requirement for 30% landscaped area for commercial developments.

The City of Chicago, USA

Overview

Chicago is a leader in green urban design. Over the last 20 years, the city has created numerous plans, ordinances, policies, and programs to encourage the use of various natural elements in urban design, and this has transformed the city from its industrial roots into one of the world's greenest cities. Chicago has actively encouraged the development and application of many types of urban greening, including urban parklands, street trees, green roofs, green alleys, and the iconic '*Millennium Park*'. The transition was driven by former Mayor Richard Daley, who served for 22 years from 1989 to 2011 and initially focused on urban beautification and access to green space.[27] The economic and political benefits soon became evident, and these continue to underpin Chicago's ongoing urban greening initiatives. In Chicago there are now over 600 green roofs covering over 5 million square feet,[28] over 1,300 acres of new open space,[29] over 500,000 trees planted, and a network of over 110 miles of landscaped median strips.[30]

What were the key drivers for biophilic urbanism in Chicago?

There were several major drivers for Chicago's urban greening policies and programs, including:

- *Access to green space*: In 1998, Chicago compared poorly to other US cities in terms of open space provision, with 63 per cent of Chicago residents having only limited access to parks and green space. Chicago sought to improve its international competitiveness by increasing green space access, as, according to Richard Florida,[31] companies and individuals consider a city's quality of life when deciding where to be based.[32]
- *Stormwater management*: Chicago's combined sewer and stormwater mains are over 100 years old and have not been able to keep pace with the increased imperviousness of the city, which leads to overflow with as little as 170cm of rain in 24 hours.[33] The financial and political implications of surface ponding, basement flooding, and the release of sewage into the Chicago River were a strong incentive to increase vegetation and pervious surface cover.[34]
- *Urban heat island effect*: Summer temperatures in Chicago typically exceed 32˚C on around 17 days each year. During a heat wave in 1995, temperatures reached 41˚C and, along with the associated high humidity, led to approximately 600 deaths.[35]
- *Climate change*: Temperatures and heavy rainfall events in Chicago have already significantly increased, and projections suggest that, even under low emissions climate scenarios, future weather events will have even more serious impacts on human health and welfare, the city's infrastructure and economy, energy demand, flood frequency and stormwater management, and biodiversity.[36]

How was support built for biophilic urbanism in Chicago?

Support for urban greening was gained by first demonstrating and providing education about its benefits and performance, and then this was followed by incentives for private landholders, before mandating the use of natural elements where appropriate. This process was particularly important where evidence was not yet available on the benefits. Demonstrating the biophilic elements provided experience and acceptance of benefits, including those that are difficult to describe and quantify, such as impacts on health and well-being. Members of the public initially opposed to urban greening often supported it once they had direct personal experience. By recognising the full suite of benefits provided by urban greening programs, the city has been able to access funding from multiple sources, including several government departments, philanthropists and property developers. The city was also able to leverage future income from property tax and assets, as well as from the willingness of philanthropists and developers to meet the minimal upfront cost of urban greening if the city carried the cost of maintenance, as it did for many developments.

Have there been economic benefits from biophilic urbanism in Chicago?

Urban greening has stimulated significant economic development in Chicago, such as the Millennium Park development which cost approximately US$490 million, but is estimated to have increased nearby property values by a total of US$1.4 billion and tourism revenues by US$2.6 billion.[37]

The following are examples of biophilic urbanism's benefits:

- *Property value*: While under construction a Michigan Avenue commercial building was reportedly sold for $90/ft^2, more than double what the seller purchased it for six years before. Once construction was complete buyers were reported to be '*standing in line for hours to put down deposits, and sales contracts being signed at a faster pace than any other downtown neighbourhood*'.[38] The Heritage tower completely sold out all its apartments, selling at a premium of $592/ft^2.[39]
- *Tourism revenue*: The Millennium Park is one of Chicago's most popular destinations for tourists and residents, attracting around 19 million people since its opening in June 2004[40] and helping to make Chicago

Chicago Hancock Tower green roof. Image: C Seeman, 2009.

America's most popular tourist destination in 2006.[41] Significant tourism revenue is anticipated over the next ten years with hotels expecting to generate as much as $580 million, restaurants $865 million and retailers some $710 million.

- *Tax revenue*: Individual buildings in proximity to the Park are known to produce over $10 million more than pre-Park amounts annually in property taxes. In addition, over $4 million is generated annually in sales tax revenue from the new population of downtown residents.[42]

Have there been social benefits from biophilic urbanism in Chicago?

In a study of crime rates in Chicago neighbourhoods over a two year period, buildings surrounded by greenery reported 52 per cent fewer felonies than those devoid of surrounding greenery, and of this a 7 to 8 per cent reduction was estimated to be directly attributable to the greener surroundings.[43] Research of parks and green spaces in Chicago also found that residents who live in housing developments near green space tend to build stronger social relationships with their neighbours than those who live in similar developments surrounded by concrete.[44]

Taking a whole of government approach

Collaboration is vital for effective urban greening policies and programs, particularly between government departments. In the Chicago, a number of key policies provide strategic direction to development in the city across 12 departments, including the '*Chicago Stormwater Ordinance*', the '*Adding Green to Urban Design Plan*', the '*Chicago CitySpace Plan*', and the '*Chicago Climate Change Action Plan*'. These policies work towards multiple goals, and each highlights how urban greening can be used to achieve various development goals and provide a range of additional co-benefits. The city's Department of the Environment and the Chief Sustainability Officer are able to provide centralised guidance and foster communication between departments. Similarly, key plans and policies have been introduced after extensive community consultation, enabling them to be targeted to community needs and resulting in community groups providing in-kind support for many projects. Aaron Durnbaugh, who worked with the city's Department of Environment for over ten years, summarised this history as a three-pronged approach: the '*tambourine*' (demonstration, quantification and education), the '*carrot*' (incentives) and the '*stick*' (regulation)'.[45]

Underpinning efforts

To overcome cost barriers to the use of biophilic elements, several financial instruments were introduced, many of which were cost-neutral or of minimal cost to the city, for instance, expediting building permit applications through the Green Permit Program, offering grants to support green roof construction through the Green Roof Grants Program, offering a density bonus for downtown developments with green roofs that increased the number of dwellings allowed, and leveraging future revenue from increased property taxes using Tax Increment Financing. In the case of Millennium Park, a skilful combination of public and private funding helped the Park become what it is today. In an interview with the Executive Director of Millennium Park, Ed Ulhir, the research team learned that attracting donations from Chicago philanthropists helped the city secure donations for the park totalling US$220 million. Ulhir added that these donations enabled the city to fund iconic sculptures and infrastructure in the park, on a scale that would have been inappropriate to fund with public money. The donations also provided access to some of the most influential sculptors in the world.[46]

A Historical Timeline of Biophilic Urbanism in Chicago

1989: A tree-planting campaign was launched by then Mayor Daley, resulting in over 500,000 trees being planted by 2008 through public-private partnerships.

1991: The Landscape Ordinance was introduced (and later updated in 1999) to beautify the city, requiring developers to integrate green elements into their projects.[47]

1995: Over 80 miles of median strips on Chicago's main thoroughfares were landscaped, and the 'Greencorps' was launched as a community landscaping and job training program.[48]

1997: Chicago adopted the 'Cityspace Plan' outlining key opportunities for increasing green space throughout the city.[49]

1998: The city introduced the 'Open Space Impact Fee Ordinance' requiring developers of new residential properties to contribute a proportionate share of open space and recreational facilities, or pay the 'Open Space Impact Fee', the funds from which are used for open space acquisition and improvements.[50]

1998: In collaboration with 270 other mayors of metropolitan regions, Chicago initiated 'Clean Air Counts' as a public-private initiative to voluntarily improve air quality.[51]

2001: The Chicago City Hall green roof was officially opened, covering 38,000 square feet and encompassing one square block.[52]

2001: O'Hare Airport developed a design manual to improve the sustainability of the airport, with the air traffic control tower being the first in the USA to have a green roof.

2002: The Chicago Center for Green Technology opened as a free green design educational facility. The building was the first municipal renovation in the world to be a LEED Platinum building.[53]

2003: The Chicago Water Agenda was introduced, and this provided for increased green infrastructure throughout the city to reduce the strain on the combined sewer system.[54]

2003: Chicago signed on to become a charter member of the Chicago Climate Exchange and committed to reduce the city's greenhouse gas emissions by 6 per cent by 2010.

2004: Millennium Park was opened, a 24.5 acre landscaped park built over two underground carparks and commuter rail lines, making it one of the world's biggest green roofs.[55]

2006: Chicago Conservation Corps was launched. This trains members of the community to run local projects introducing nature into the urban environment.[56]

2007: The City of Chicago 'Stormwater Management Ordinance' was passed, requiring developments over a certain size and density to manage the stormwater falling on the site.[57]

2008: The 'Chicago Climate Action Plan' was introduced (with 26 mitigation actions and 9 adaptation actions) to guide the city to reduce greenhouse gases to a level 25% below the 1990 level by 2020. Measures include the addition of natural elements to the city to reduce the urban heat island effect, reduce building energy consumption, manage stormwater and sequester carbon.[58]

2008: The 'Adding Urban Green to Urban Design Plan' was adopted and identifies strategies to marry compact, mixed-use, dense urban design with tools to mitigate the negative environmental impacts of this urban form.[59]

2010: FedEx installed a 174,442 square foot green roof at its O'Hare facility, creating the largest freestanding green roof in the Chicago metro area and the largest at an airport worldwide.[60]

The City of Berlin, Germany

Overview

Berlin has a long history of integrating nature into the built environment, and has some of the most advanced and sophisticated urban greening policies and programs in the world. These are strongly supported by citizens and developers, whose experiences of urban nature have led them to understand the financial, social, environmental, and personal benefits that it brings about. As a result, approximately one third of the Greater Berlin area is natural habitat, and, through mechanisms such as the 'Biotope Area Factor', green space and nature continue to be added to the city.[61] These policies and programs are underpinned by strong federal and city level legislation that protects them from changing political and economic fortunes. Because far-sighted policies to protect and conserve the environment have been mainstreamed in all areas of the city's economic activity, Berlin today enjoys a ring of parks, allotments, forests and agricultural areas in and around city. Its land use consists of 43.6 per cent developed areas, 18 per cent forest, 15.2 per cent traffic areas, 11.9 per cent open space, 6.7 per cent water and 4.9 per cent agriculture.[62]

What were the key drivers for introducing biophilic urbanism in Berlin?

The proliferation of urban greening has clearly been supported by a complex set of political requirements at multiple levels of government. These in turn have come about partly in response to a range of drivers, including:

- *Historical and cultural concern for the environment*: Strong environmental sensitivity amongst the residents of Berlin strengthens the mandate for biophilic urbanism policies and initiatives, and residents continue to be vocal in their support and demands for these.[63]
- *Urban heat island effect*: After the fall of the Berlin Wall, the city developed rapidly, particularly in inner-city areas, resulting in significant soil-sealing, inadequate infiltration of rainwater, a lack of green space, and low humidity.[64] These factors contribute to the urban heat island (UHI) effect, which is most pronounced in inner Berlin and has been measured to produce temperatures 9°C higher than surrounding areas. A recent study predicts up to 7,500 heat deaths in the city by 2100.[65]
- *A focus on quality of life*: Germany has one of the strongest ecological traditions in Europe,[66] and Berlin seeks to promoting a relaxing and pleasant atmosphere. Recreation opportunities are thus regarded as essential to the quality of life in a congested metropolis.[67]
- *Waterway protection*: In total, 6.6 per cent of the Berlin area is water.[68] The city protects these waterways for their aesthetic and environmental value, as well as for drinking water, by classifying 'water protection areas' throughout the city and giving them special protection.[69]

Have there been economic benefits from biophilic urbanism in Berlin?

Ingrid Cloos (Berlin Senate Department for Urban Development and the Environment) reported to the research team that the city had not undertaken economic modelling or assessment of the urban greening projects as they were not in dispute, but rather had focused on understanding, quantifying, and mapping environmental conditions throughout Berlin to inform biophilic urbanism efforts. Cloos considered that there is already an inherent understanding of the benefits of urban greening, as evidenced by the strong bi-partisan political

The Biotope Factor, Stormwater management fee and incentive system, and public education have resulted in widespread use of green roofs, green walls and vegetated private lands such as this property in Spaziergang Rehberge, Berlin (Image: Patrick G, 2011).

support it receives, as well as by citizen advocacy for and developer interest in greening the city.[70] This is not to say that economics is not playing an influential role in biophilic urbanism in Germany. Though the 2008 global financial crisis led to budget cuts and significant staff reductions in the Department of Urban Planning and Environment, thus slowing the progress of some programs, the legally binding environmental requirements in place have continued to deliver valuable outcomes.

However, as with most cities, competition between land uses in Berlin puts constant pressure on green and open space, while financial pressures limit the city's ability to maintain existing green space and develop new areas.

Are there social benefits from biophilic urbanism in Berlin?

The strong ecological tradition in Germany, with mainstream appreciation of the benefits of integrating nature into cities and towns, has been a key driver for Berlin's urban greening. It continues to ensure that the city preserves and even enhances its urban nature in the face of financial pressures and demand for urban development. Hence there is a good understanding of the social benefits of green space and features in the city. According to the Berlin Senate Department for Urban Development and the Environment:

> *The appearance of the city is defined as much by open space as by individual buildings or architectural ensembles. The size of the open spaces and the extent to which they blend harmoniously with the surrounding buildings make a first and lasting impression. They are responsible for the feeling of well-being and ease which the city provokes, and are crucial for the sense of identity the inhabitants have with their city. Open space brings to life the natural and cultural development of Berlin.*[71]

Taking a whole of government approach

Post-reunification, unemployment in Berlin was exceptionally high and an influx of refugees entered the city increasing the population. With the global financial crisis further exacerbating these problems, economic stimulus was required. With national, state, and local funding in place, broad inter-governmental collaboration and strong community engagement, some

43 projects were undertaken, designed to trigger economic development. This established a strongly collaborative government process and the mainstreaming of environmental conservation policies in numerous government departments, creating a holistic approach to nature protection. For instance, collaboration between staff from Berlin's Landscape Planning and Town Planning departments helped to develop new classifications (e.g. for environmental mitigation and replacement measures) in the Landscape Programme. Cross-departmental working also helped to improve mutual understanding of the various laws applicable to green spaces.[72]

Underpinning efforts

Use of flexible regulations rather than financial incentives has proven to be an effective means of increasing green cover in Berlin. For instance the 'Biotope Area Factor', which requires applicable new residential structures to have 60 per cent ecologically effective area and new commercial structures 30 per cent, allows developers to select from various options to achieve this outcome.[73] Further, the comprehensive mapping of the city's greenspace and environmental conditions has supported urban planners to make informed decisions and target efforts and funding towards areas of need in the city, while also demonstrating the impact such efforts have on the city's stormwater, air quality, urban temperatures, and biodiversity.[74] The green roof industry in Germany initially faltered because a rapid boom in green roof construction led to the emergence of new, inexperienced companies making and installing poor quality green roofs and cutting corners on installation to keep costs down. The resulting slump in consumer confidence affected the entire green roof industry, and led to the development of the '*Guidelines for the planning, execution and upkeep of Green Roof sites*' to ensure compliance with appropriate standards.[75]

A Summary of Biophilic Urbanism related policies and programs

Policy or Program	Description of the Policy or Program
The Federal Nature Conservation Act, and Berlin Nature Conservation Act	The German Federal Nature Conservation Act was first established in 1976 to regulate development in order to conserve, preserve and develop nature and landscapes throughout Germany, while balancing these objectives against other demands of the community on nature and landscapes.
The Federal Building Code	The Federal Building Code establishes the legal requirements for building in Germany, and seeks to minimise the impact of development on the environment.
Natura 2000	Natura 2000 is a coherent network of protected areas throughout Europe to ensure that habitat and species protection permanently preserves biodiversity.
Landscape Programme and Land Use Plan (LaPro)	The LaPro specifies strategic background policies related to environmental and landscape issues on a citywide level, and sets a city level basis for evaluating environmental issues required under federal legislation.
General Urban Mitigation Plan	The General Urban Mitigation plan supports the LaPro, and defines the areas throughout the city where there is a particular need for urban greening as potential offset sites.
Biotope Area Factor (BAF)	The Biotope Area Factor policy dictates the percentage of total land that should incorporate vegetation to provide an ecologically-effective surface.
Berlin StEPKlima	Berlin's climate change action plan, the StEPKlima, was passed by the Senate in May 2011 as a binding plan of action for addressing climate change in Berlin.
Environmental Atlas	The Atlas uses GIS to depict information on over 80 topics, with over 500 maps under the broad headings of soil, water, air, climate, land use, traffic, noise and energy.
Berlin Agenda 21	The 'Berlin Agenda' provides an overarching structure for Berlin's social and physical development, and allows for future links and synergies between these development goals.[76]

The City of Toronto, Canada

Overview

Toronto has a population of 2.7 million people, making it the largest city in Canada and the fifth most populous city in North America, while the Greater Toronto Area surrounding Toronto city is home to 5.6 million people. Toronto is also ranked the 10th most economically powerful city in the world by Forbes magazine,[77] with Canada one of the fastest growing of the G8 nations. Toronto is facing numerous environmental challenges commonly associated with urbanised environments, such as poor air quality, increased urban heat island effect, and stormwater management issues.[78] The city has developed several environmental initiatives to address these issues, such as a '*Green Development Standard*', a '*Green Economic Sector Development Strategy*', the '*Climate Change, Clean Air and Sustainable Energy Action Plan*', a '*Climate Change Adaptation Strategy*', and an '*Environmental Plan*'.[79] In May 2009, Toronto became the first city in North America to adopt a by-law that requires and governs the construction of green roofs and applies to all building applications for new residential, commercial, institutional and industrial developments. It mandates green roof coverage of 20 to 60 per cent on all new development above 2,000m^2 of gross floor area.

What were the key drivers for urban greening in Toronto?

There were several key drivers for Toronto's urban greening policies and programs, including:

- *A desire for enhanced urban liveability*: The City of Toronto's formal involvement in green roofs began with the 2001 Environment Plan, which set out a strategy to encourage green roofs and rooftop gardens as part of a broader strategy to produce a cleaner, greener, healthier and more sustainable future for Toronto.

Toronto City Hall green roof. Image: P J Mixer, 2010.

- *The need to manage stormwater and improve water quality*: Green roofs were also included in the Wet Weather Flow Management Master Plan for the City of Toronto completed in 2000, which examined ways to improve the water quality of local rivers and Lake Ontario by strengthening mechanisms to prevent and reduce stormwater runoff.
- *A response to climate change*: More recently, green roofs are being promoted as a greenhouse gas mitigation tool. The Eco-Roof Incentive Program promotes both green roofs and cool roofs. It was adopted by City Council in 2009, and is a key element of the city's Climate Change Action Plan.

How was support built for urban greening in Toronto?

Support for urban greening was gained through a number of mechanisms designed to gain both public and political support. Extensive community consultation and engagement was undertaken to inform the initial 'Green Roof Strategy', which included installing green roofs on city buildings, running a pilot incentive program, developing approval processes for green roofs, and engaging in publicity and education. Public acceptance and participation in green roof programs fostered a sense of community ownership, encouraging people to volunteer time to help construct and maintain some of the roofs. Political support was gained by highlight how green roofs would contribute to solutions to a range of existing political concerns, and how they would align with existing programs and policies. To support the uptake of green roofs a 'Green Roof Demonstration Project' was developed to demonstrate Council's commitment, enhance knowledge, address concerns and visually demonstrate the aesthetic benefits of a green roof.

The City of Toronto also developed a Construction Standard for Green Roofs to guide their design and development.[80]

Are there economic benefits from urban greening in Toronto?

A number of economic benefits have been delivered by biophilic urbanism in Toronto, including:

- *Effects on urban air quality*: A study of 72 monitored plots (of 400m^2 each) in midtown Toronto was undertaken to investigate the localised reductions in atmospheric pollutants, 0_3, $S0_2$, $N0_2$, C0, and PM_{10}. The study estimated that the economic value of the air quality benefits resulting from the installation of green roofs on all suitable roofs across the entire city of Toronto would be US$394.07 per hectare (or US$1,970,000 in total).[81]
- *Effects on energy budgets of individual buildings*: Several studies report that green roofs act as thermal insulators by reducing surface temperature,[82] thus reducing daily demand for air-conditioning by as much as 75 per cent. Research on the effects of the green roofs on Toronto City Hall found that heat flow was reduced by 50 to 90 per cent during the summer, while in winter it was reduced by 10 to 40 per cent.[83] According to a 2007 report by Toronto and Region Conservation, during a typical July day in Toronto an 820ft^2 green roof achieved energy savings of 73, 29 and 18 per cent, for 1, 2 and 3 storey air-conditioned buildings respectively.[84]
- *Roof longevity*: The literature suggests that green roofs last longer than standard roofs, further strengthening the economic case. One study by Acks[85] found that a green roof will have a service life of up to 40 years, some 20 years more than a standard roof.

Toronto City Hall green roof. Image: Wiliepoon, 2010.

Are there social benefits from green roofs in Toronto?

A study by Ryerson University identified a range of direct and indirect economic benefits from green roofs in Toronto.[86] Benefits can accrue to the local municipality, such as through reduced stormwater flows, or to building occupants, such as at the Toronto Metro Central YMCA, where the green roof installed in 2009 has been used for conferences, movie nights, yoga classes, school classes, as well as for running, relaxation, and recuperation. According to Alex Versluis, Vice President, Property Management YMCA of Greater Toronto, there has been significant community engagement in the design, installation, and ongoing maintenance of the roof.[87]

Taking a whole of government approach

A number of Toronto's existing policies, such as the Environmental Plan, foster inter-departmental cooperation that creates consistency in policies and programs across the departments involved. For example the Green Roof bylaw involves departments responsible for parks and wildlife, water, planning, building approvals, economic development and air pollution. The issue of government departments operating in individual 'silos' is often a barrier to biophilic urbanism, due to the fact that the costs, benefits and responsibilities are often spread across departments.[88]

Underpinning efforts

A basic, lower-cost green roof may not offer the full range of benefits that green roofs can provide, and for building owners and tenants considering installing a green roof, the additional costs necessary to achieve a greater level of benefits may be daunting. However, presenting these benefits as a set of stratified thresholds – that is, showing which benefits are likely to result from which aspects of the roofs – allows decision makers to make informed decisions about the levels of investment they can make, and the benefits that will accrue from these different levels. For instance, greater accessibility to the roof and a greater diversity of plant species may make design and construction more expensive, but it will provide additional benefits in terms of the health and wellbeing of building tenants, and environmental benefits from greater biodiversity. In this case, government grants (such as the Toronto Water Incentive Program and the Eco-roof Incentive Program) are effective in underpinning such upgrades.

The City of Portland, USA

Overview

The City of Portland has one of the most comprehensive urban greening programs in the world. Initially, this was largely driven by stormwater management concerns, although, as experience with urban greening tools and technologies has grown, the city has recognised the broader benefits of urban greening that can be used to leverage further support for it. The use of demonstration sites, public education and public policy has underpinned Portland's urban greening activities, and the evaluation, quantification, and communication of the performance of urban greening installations have also been integral to these projects' success. Programs such as the 'Grey to Green Initiative' introduced in 2008 have accelerated urban greening, and by 2011 the benefits have been extensive: an additional 6.5 acres of green roof space with approvals for an additional 8.4 acres, 8,500 trees planted in private yards and 9,000 street trees planted,[89] 546 new green street projects, 261 acres of land purchased for conservation and open space,[90] and the restoration of over 2,800 acres of natural area in the region commenced.[91]

What were the key drivers for urban greening in Portland?

There have been several key drivers for Portland's urban greening policies and programs, including:

- *Stormwater management*: The Federal Clean Water Act requirements and regular sewer overflows constituted a huge financial and political cost for the city. The scale of traditional infrastructure investment necessary to mitigate these problems led the city to trial and evaluate the performance of natural design elements, which were found to be well suited to Portland's rainfall patterns.[92]
- *Cost savings to government*: The city has demonstrated that urban greening projects make good fiscal sense. For example, for a particular design of a large stormwater management system the inclusion of natural elements into the design saved in the order of US$60 million.[93]

Green streets used throughout Portland incorporate vegetated infiltration trenches, which add visual amenity while also capturing, cleaning and infiltrating storm water. Image: Lisa Town, 2009.

- *Cost savings to residents and business*: Since 1977 the city has had a stormwater tax, and as green roofs provide stormwater retention it offers a way to reduce tax paid. Revenue from the tax provides a dedicated funding source for urban greening initiatives related to stormwater management.[94]
- *Opportunities for co-benefits*: The city realised that urban greening for stormwater runoff enabled it to meet other municipal objectives at the same time, such as increasing neighbourhood liveability, expanding green space throughout the city, and protecting groundwater.[95]

How was support built for urban greening in Portland?

Support for urban greening was gained by demonstrating and educating about its performance and benefits, followed by the provision of financial incentives and tax relief. Demonstration and pilot projects allowed Portland to build an experience and evidence base for urban greening, incrementally gaining support and understanding and allowing designs to be modified and improved before these were used throughout the city.[96] A range of projects were trialled and evaluated, enabling cost and performance comparisons with conventional approaches.[97] Projects were monitored and measured to provide rigour in quantifying performance and economic benefits.[98] According to staff involved the projects didn't always have full community support initially, but as the community gained first-hand experience of greening projects and saw evidence of cost savings support grew.[99] The city provides education and assistance in the design, installation, and maintenance of green roofs, including a do-it-yourself guide it has developed for homeowners.[100] The city also conducts tours of green roofs and actively promotes demonstration projects around the city to raise awareness of and familiarity with the technology.[101]

Have there been economic benefits from urban greening in Portland?

Portland's urban greening has demonstrated substantial economic benefits. For example, the use of natural elements for stormwater management reduced overall costs significantly by lessening the need for conventional infrastructure, while delivering a range of co-benefits such as improved air quality, groundwater recharge, and social benefits. This was a turning point as, by demonstrating urban greening's fiscal benefits, the city no longer needed other justifications for its use as this 'alternative' practice.[102] For example, a $15,000 investment in urban greening on one street reduced basement flooding and the total flow to local sewers by 85 per cent.[103] Overall, an US$8 million dollar investment in green infrastructure in Portland is estimated to have saved the city over US$250 million in hard infrastructure costs.[104]

Are there social benefits from urban greening in Portland?

The City of Portland has investigated and developed metrics for the potential social benefits of urban greening, focusing on health and community livability.[105] In the area of health these metrics consider air quality improvements (relating to particulate matter and respiratory illnesses) along with other impacts on physical and mental health. Community liveability metrics consider improvements in amenity and aesthetics (including how these are reflected in increased property values), community cohesion (such as social capital and crime), access to nature (including the number of people affected by urban greening elements), and environmental equity (such as the share of urban greening elements in minority or low income neighbourhoods).

Taking a whole of government approach

Strong political leadership in Portland has allowed the city to pursue urban greening while other cities in the USA are constrained by inexperience and systemic barriers.[106] Staff involved reflected to the research team that the politicians were '*generally open-minded thinkers who were willing to look creatively at options, and seek to develop the capacity to design and develop innovative solutions*'.[107] The city is now moving towards an increasingly integrated approach that ensures that developments are optimised for stormwater management, air quality improvement, and habitat provision. For example the 2005 'Portland Watershed Management Plan'[108] calls for the city's bureaus to work together to find creative and collaborative ways of improving the health of the city's watersheds. It explicitly acknowledges the city's commitment to creating an '*urban environment where nature and city coexist and support each other*', and recognises the interconnectedness of watersheds, transportation systems, neighbourhoods and the economy in developing whole-of-system stormwater management solutions.

Underpinning efforts

The City of Portland has a number of procurement requirements related to government owned buildings and government run programs. For instance, the 'Green Building Policy' requires all city-owned buildings to install a green roof, and provides incentives for private building owners to do so. The city's 'Stormwater Management Manual' requires that new developments and redevelopments with over 500ft^2 of impervious surface manage stormwater onsite through replicating as much as possible the pre-development hydrological conditions.[109] The Green Streets Policy stipulates that green street facilities be incorporated into all City of Portland funded development, redevelopment or enhancement projects, while the '1% for Green' fund requires qualifying city-funded development, redevelopment or enhancement projects to invest 1 per cent of the project's construction costs in green measures. Finally, the Green Street Resolution requires that either green street facilities be incorporated into public and private developments, or an off-site stormwater management fee be paid.[110]

Infiltration gardens reduce storm water runoff throughout Portland, reducing the need for more costly grey infrastructure. Image: Steve Vance, 2010.

The City of Singapore, Singapore

Overview

The greening of the city-state of Singapore began with the 'Garden City' campaign under the auspices of then Prime Minister Lee Kuan Yew in the 1960s, well before the international focus on the benefits of biophilic urbanism. Lee recognised that urban parks and greenery contribute to the quality of life in the city and can be a decisive factor in a city's global competitiveness, reflecting in 1996, '*In wooing investors, even the trees matter*'.[111] Today, Singapore is arguably the world's best example of a 'biophilic city'. Natural elements are an intentional, mainstream and integrated component of urban design, and are well supported by policies, programs and the community. Singapore has set a new vision of becoming a 'City in a Garden', where natural elements are integrated into the built environment to create '*a city that is nestled in an environment of trees, flowers, parks and rich bio-diversity*'.[112] This new vision integrates the 2007 Streetscape Greenery Master Plan, which aims to create a '*seamless green mantle*' throughout the island, and the Park Connector Network – a recently developed network of almost 200 kilometres of linear parks throughout Singapore that connects major green areas and destinations to allow people, flora and fauna to move between these areas.[113]

What were the key drivers for biophilic urbanism in Singapore? There have been several key drivers for Singapore's biophilic urbanism policies and programs, including:

- *International competitiveness*: The primary interest in urban greening in the 1970s was to ensure that the city remained internationally competitive for foreign investment. Singapore has no natural resources and is economically reliant on being an attractive place for top talent to live and work, and for companies to base their operations.[114]
- *Economic stimulation*: The 'Gardens by the Bay' development opened in June 2012, and spearheads the city's ambition to transition from a stopover to a destination. Nature is used in innovative ways to encourage visitors to engage with the plants and animals, and to see the relationship between human beings, the built environment and nature in a new light. It is anticipated that the park will increase property values in surrounding areas by around 15 to 20 per cent.[115]
- *Stormwater management*: Singapore redesigned its stormwater management infrastructure, through the 'Active, Beautiful, Clean' (ABC) master plan. Concrete canals are being replaced with natural elements, thus enhancing biodiversity and aesthetics while concurrently meeting stormwater management goals.

How was support built for urban greening in Singapore?

Singapore has faced the challenge of finding a balance between development, density, and preservation of urban nature. The population nearly doubled from 2.7 million to over 5 million in the 25 years between 1986 and 2010, and yet the city has simultaneously managed to increase green cover from 36 to 47 per cent.[116] This is impressive by international standards, and is due in part to the wide level of support for biophilic urbanism investments. With strong leadership from Singapore's Prime Ministers, the vision and understanding of urban nature's importance in the city's economic development has been clearly communicated and widely understood. Singapore

has additionally invested in research, development and demonstration of urban greening, such as the green wall and roof test sites in 'Horticulture Park'. Financial incentives are used to reduce cost barriers to industry, such as through the 'Skyrise Greenery' scheme, which funds up to half the costs of installation of green roofs and vertical greenery in skyscrapers throughout the city.[117]

Have there been economic benefits from biophilic urbanism in Singapore?

The economic benefits of biophilic urbanism are integral to Singapore's 'City in a Garden' agenda, with recognition across Singapore's policies and plans that urban greening makes the city internationally competitive for investment, enhances property values and the urban aesthetic, improves health and well-being (such as through better healing rates), reduces stress, increases walking and cycling rates,[118] and provides ecosystem services (including improved air and water quality).[119]

Are there social benefits from biophilic urbanism in Singapore?

The benefits of urban nature on people can be seen in Singapore's hospitals. The Alexandra Hospital was renovated to include a medicinal garden, fragrance garden and water features,[120] and its success led to the biophilic design of the new Khoo Teck Puat (KTP) Hospital, which integrates food producing roof gardens, green walls, green balconies and a public garden, using the concept that 'nature would nurture'.[121] The innovative design of this hospital is driven by the challenge of integrating nature within the constraints of minimal space, as the relatively small block (3.4 hectares) had to house the 110,000m^2 building. Research is ongoing to verify anecdotal evidence that healing rates are faster in KTP than in other non-biophilic hospitals.[122]

Taking a whole of government approach

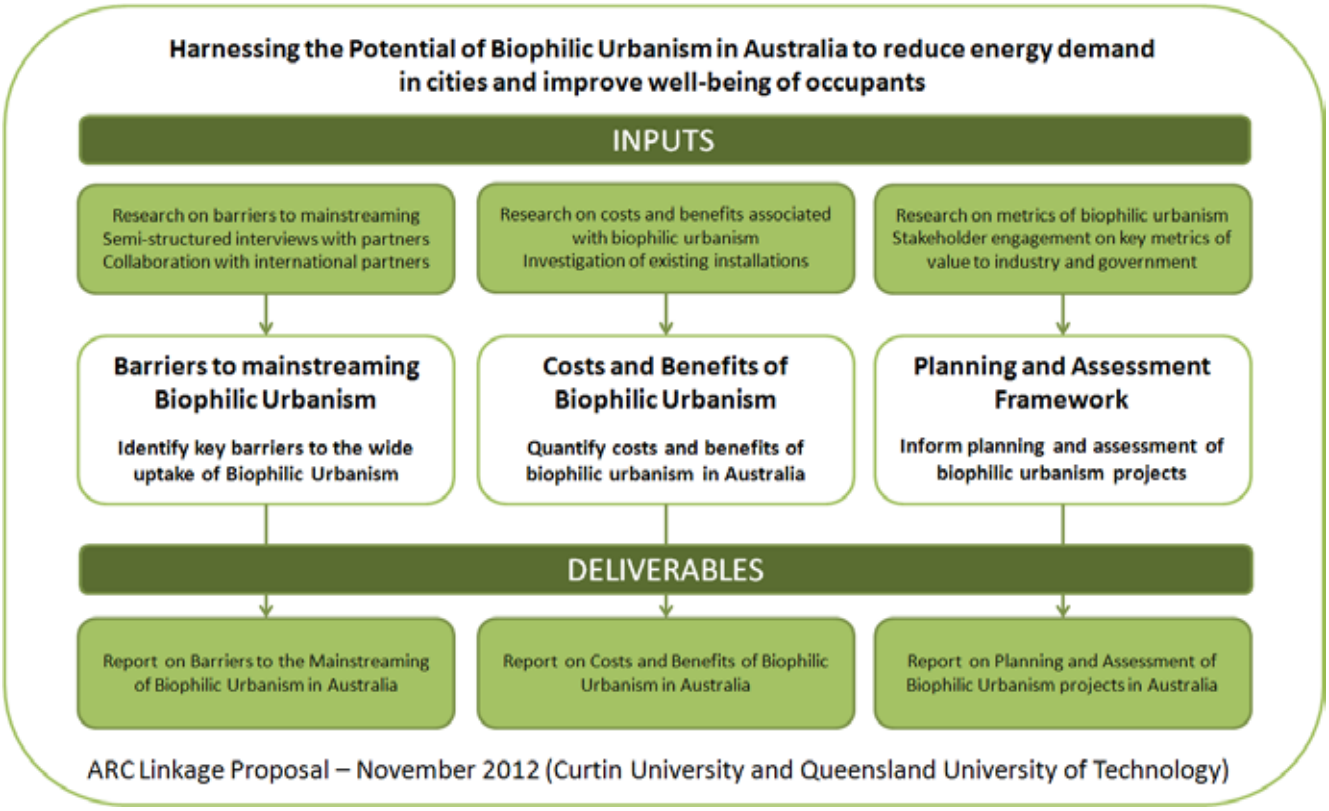
The Singapore National Parks Board was integrated into the Ministry of National Development in 1963, and the Ministry now supports innovation for the biophilic city in Singapore.[123] In 1968, the government set its urban greening agenda during the second reading of the Environmental Public Health Bill, stating '*the improvement in the quality of our urban environment and the transformation of Singapore into a garden city – a clean and green city – is the declared objective of the Government*'.[124] From these initial efforts, the 1992 Singapore Green Plan was introduced as the country's first formal plan to balance environmental and developmental needs. This was periodically reviewed and revised, with the most recent version released in 2002 and updated in 2006.[125] The Green Plan is the government's blueprint for realising Singapore's vision of a green, environmentally sustainable city. Key components of the Plan are to replace any natural areas disturbed by development, to educate locals and visitors on local nature, and to create new parks and park connectors. There are multiple drivers for the Green Plan, including biodiversity improvements, reductions in the urban heat island effect, improved urban liveability, mitigation of stormwater surges in the city, and reduced building energy demand.[126] To facilitate measurement of progress towards urban biodiversity by any city, the 'Singapore Index on Cities' Biodiversity' was endorsed on 29 October 2010. This scientifically credible and robust evaluation tool enables cities to measure and benchmark their biodiversity conservation efforts.[127]

Conclusion

The rise of biophilic urbanism is a phenomenon that builds on earlier traditions of environmental planning and landscape architecture and has taken a more deliberate and detailed approach to bringing nature into the very fabric of cities. The examples provided here show that there are multiple benefits, but unfortunately not enough cities are implementing biophilic urbanism policies and reaping these benefits. The mainstreaming of biophilic urbanism and the development of key metrics to measure its outcomes does, therefore, need to be clearly on the agenda for all competitive cities of the future.

Future Work

Biophilic urbanism is emerging as an important urban design principle within urban planning and design, yet it is still an ad hoc addition to most planning processes. It is capable of considering the multi-dimensional and interdependent complexities of many aspects of urban systems and infrastructure. It is also recognised as being able to enhance 'urban liveability', providing benefits to residents by creating living conditions that are conducive to health and wellbeing, reducing stress, increasing cognitive abilities and attention. However, research from the first stage of the project (2010-2012) identified a number of significant barriers to implementation, spanning technical issues to behavioural constraints. Hence, the lack of current integration is seen as a significant opportunity for Australian cities and planning, if the challenges to mainstreaming its application can be overcome. A proposed ARC Linkage proposal will investigate key barriers to mainstreaming this innovation in city building. Collaboration with industry partners will enable innovative field research and establish precedents for biophilic urban design principles to be incorporated into our mainstream urban planning.



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Sustainable
Built Environment
National Research Centre

The Sustainable Built Environment National Research Centre (SBEnrc) is the successor to Australia's CRC for Construction Innovation. Established on 1 January 2010, the SBEnrc is a key research broker between industry, government and research organisations for the built environment industry.

The SBEnrc is continuing to build an enduring value-adding national research and development centre in sustainable infrastructure and building with significant support from public and private partners around Australia and internationally.

Benefits from SBEnrc activities are realised through national, industry and firm-level competitive advantages; market premiums through engagement in the collaborative research and development process; and early adoption of Centre outputs. The Centre integrates research across the environmental, social and economic sustainability areas in programs respectively titled Greening the Built Environment; Developing Innovation and Safety Cultures; and Driving Productivity through Procurement.

Among the SBEnrc's objectives is to collaborate across organisational, state and national boundaries to develop a strong and enduring network of built environment research stakeholders and to build value-adding collaborative industry research teams.

SBEnrc Core Partners:

GOVERNMENT OF WESTERN AUSTRALIA

Queensland Government

PARSONS BRINCKERHOFF

John Holland

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