Informing healthy building design with biophilic urbanism design principles: a review and synthesis of current knowledge and research

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SUMMARY
Links between human health and wellbeing, and contact with nature are well understood in the fields of health and psychology, and more recently are gaining attention in the built environment industry. In 1984, E.O. Wilson coined the term 'biophilia' to describe the tendency for humans to have an innately emotional response to other living organisms. A growing number of researchers around the world are now exploring the impact of nature in urban environments (i.e. biophilic urbanism) on the human condition, including many indicators of human physical and mental health, recovery and performance. There is also an emergence of research on the potential for biophilic urbanism to address other challenges related to climate change mitigation and adaptation. This paper presents key findings from a review of key literature to date, discussing opportunities for biophilic urbanism to both improve occupant experience and performance, as well as addressing other sustainability objectives including climate change mitigation and adaptation. The paper presents an emerging framework for considering biophilic design opportunities and highlights implications for the built environment industry. This research draws on an Australian project considering biophilic urbanism in the response to climate change, within the Sustainable Built Environment National Research Centre. This includes findings from a literature review, a survey pilot study and two workshops undertaken in Perth and Brisbane with a variety of industry and government stakeholders.

KEYWORDS
Climate change, Ecology, Energy performance, Healthy homes and buildings, Human performance, Sick Building Syndrome (SBS), Surveys

1 INTRODUCTION
Links between human health and wellbeing, and contact with nature are well understood in the fields of health and psychology, and more recently are gaining attention in the built environment industry. In 1984, E.O. Wilson coined the term 'biophilia' to describe the tendency for humans to have an innately emotional response to other living organisms (Wilson, 1984). A growing number of researchers around the world are now exploring the impact of nature in urban environments (i.e. biophilic urbanism) on the human condition, including many indicators of human physical and mental health, recovery and performance. There is also an emergence of research on the potential for nature in cities to address other challenges related to climate change mitigation and adaptation (e.g. Gill et al, 2007).

Globally, urban populations are growing in size and density due to population increase and relocation of rural populations to urban centres. By mid-century it is anticipated that the global urban population will have doubled, with over two thirds of the world's population living in cites and megacities (United Nations, 2009). This urban growth adds pressure to

systems including energy, water, food production and distribution, civil infrastructure provision, and manufacturing. These systems are already being strained as they attempt to reduce their greenhouse gas emissions, while adapting products and services to changing operating conditions due to diminishing resources such as oil and fresh water, changing climatic conditions and an unstable global financial system. The convergence of such urgent and challenging issues provides strong impetus for developing systems based solutions that can reduce the speed and severity of these issues, in addition to addressing the underlying system failures that have caused their emergence.

Research investigating the application of biophilia has furthered the understanding of this 'innate emotional affiliation' of humans with nature, finding that experiences with nature can lead to significant mental and physical benefits. Within this context, Timothy Beatley has explored how urban environments can be designed to foster 'closeness to nature', through both preserving and restoring existing urban nature and finding innovate ways in which to inject nature into the fabric of the built environment (Beatley, 2010). This emerging body of research, termed 'biophilic urbanism', can produce synergistic design solutions to address the multiple challenges facing society and urban settlements, such as mitigating the heat island effect and improving thermal comfort, improving social outcomes and well-being, improving business and productivity outcomes, and improving water cycle management.

With this context in mind, this paper distills the key findings from the body of research investigating biophilia, biophilic urbanism, green infrastructure and the link between nature and human health and wellbeing, to discuss opportunities for biophilic urbanism to be applied in Australian buildings and cities. The intent of the biophilic urbanism research is to both improve occupant experience and performance, as well as addressing other sustainability objectives including climate change mitigation and adaptation. An emerging framework is presented for how biophilic design opportunities can be considered by decision makers in the built environment industry. This research draws on an Australian project considering biophilic urbanism in the response to climate change, within the Sustainable Built Environment National Research Centre (SBEnrc). This includes findings from a literature review, a survey pilot study and two workshops undertaken in Perth and Brisbane with a variety of industry and government stakeholders.

2 METHOD

The research methodology for inquiring into the biophilic urbanism agenda comprises a qualitative, mixed method approach to explore the body of foundation and emergent literature, and address apparent gaps. To date this has included literature review, case study analysis (20 case studies to date), and two stakeholder focus groups in Perth and Brisbane.

Initially the authors undertook to synthesise the biophilic urbanism literature, distilling a number of elements of biophilic design that are informing initiatives to green cities around the world. The desktop review sought to identify the breadth of ways in which nature can be integrated into the fabric of the built environment, seeking specifically elements which concurrently responded to the predicted impacts of climate change and population pressures on Australian settlements, and provided 'biophilic' benefits to residents. Hence, the literature review concentrated in general on external biophilic elements (i.e. outside the building shell), and those that incorporate vegetation and substrate (i.e. for example as distinct from purely aesthetical representations of nature, which may provide biophilic benefits but do not assist in the response to climate change or population pressures). The literature review considered

Australian and international experience, identifying in particular case studies that described and/or quantified the costs and benefits of urban biophilic elements, and those which provided insights into the social, economic and political factors that both enabled and disabled the application of biophilic urbanism. The aim of this literature review was to unpack the concept of biophilic urbanism to provide decision makers with a functional framework that, along with the further development of an economic argument and policy pathway for the Australian context, facilitate the application of biophilic urbanism in Australian cities.

A series of workshops was then undertaken in June (Perth, 14 participants) and September (Brisbane, 11 participants) 2011 to inquire into: 1) the level of understanding of 'biophilic urbanism'; 2) enablers and disablers to biophilic urbanism in Australia; 3) potential pathways to increasing biophilic urbanism in Australian cities; and 4) key components of an effective economic argument for biophilic urbanism. The workshops were held as part of the SBEnrc by a joint research team from Curtin University and Queensland University of Technology. Workshop participants included key industry, government and academic representatives responsible for decisions relating to biophilic urbanism and/or engaged in urban planning, green building, and urban biodiversity.

The workshops used the 'Collective Social Learning' process, created by Emeritus Professor Valerie Brown (Brown & Harris, 2012). This steps participants through a process of first considering their vision for an ideal biophilic city (what should be); followed by an inquiry into the current situation and what is enabling and disabling progression to the ideal biophilic city (what is). Participants are then asked to consider how those enablers and disablers could be addressed (what could be); before making a personal commitment to an action that they will take in the immediate future to help create biophilic urbanism in Australia. Participants also collectively explored key components of an effective economic argument, and how to value externalities and non-quantitative benefits. The workshops involved both brainstorming within small groups, and discussing findings as a whole group. This ensured a diversity of responses was received while enabling key points to emerge from the groups as a collective.

The workshop data was analysed using a subjective, qualitative approach that began during the workshop itself with participants asked to prioritise and group enablers and disablers, and key measures to be taken to respectively enhance enablers and overcome disablers to biophilic urbanism. The research team further distilled key language, themes and ideas from the workshops, based on both notes taken by the research team during the workshops and from the written data provided by workshop participants.

The results of the literature review, combined with the findings of a survey pilot study and two workshops undertaken in Perth and Brisbane, were used to inform an emerging framework for considering biophilic design opportunities. The following stage of this research initiative, funded through the SBEnrc as part of the Greening the Built Environment Research Program is to use expert peer review and further case study exploration to inform the framework and the elements of biophilic urbanism.

3 RESULTS

Summary of literature review

In considering the overlap between the benefits derived from biophilic urbanism, and the threats posed to Australian cities by climate change and population pressure, the review of available literature found significant synergies. Although evidence of a truly 'biophilic city'

was not found, there is a wealth of experience from around the world of the use of biophilic elements to address urban issues including: improving water cycle management and mitigating the effects of increased precipitation (e.g. Holman-Dodds, et al, 2003; Mentens et al, 2006; Loh, 2008); mitigating rising urban temperatures, and the urban heat island effect; mitigating urban energy demand (base and peak) (e.g. Akbari, 2002); mitigating threats to biodiversity (e.g. Benedict & McMahon, 2002); reducing GHG emissions and sequestering carbon (e.g. Nowak, 1993; Jo & McPherson, 1995; Pouyat, et al, 2006); encouraging active transport (e.g. Dixon & Wolf, 2007); and enhancing urban food security (e.g. Deelstra & Girardet, 1999).

These benefits of biophilic elements address many of the key threats to Australian settlements from climate change and population pressures. Additional benefits were found for the impact of biophilic urbanism on urban residents, including for example enhanced recovery from illness (e.g. Ulrich, 1984); reduced neuropsychological, mucous membrane and skin symptoms in office workers (e.g. Fjeld et al 1998); increased productivity and reduced stress (e.g. Lohr et al 1996); and reduced stress and enhanced performance (e.g. Hartig et al, 2003). It is beyond the scope of this paper to provide a detailed summary of these findings here, other than to note that the research covers a breadth of biophilic elements, and evidences an emergent interest in the application of biophilic urbanism (frequently termed green infrastructure, urban nature or discussed by biophilic element, such as those listed below in Table 4). The body of research stems largely from Europe and North America, however limited data was found for the Australian context or climate.

Summary of Workshop findings

A detailed account of the workshop findings is presented in the SBEnrc Project 1.5 *Harnessing the Potential of Biophilic Urbanism in Australian Cities, Stakeholder Engagement Report*. In summary, participants from all three workshops noted the need for local evidence for biophilic urbanism, as the research in this field is currently focused on North America and Europe, where the vegetation, climate and urban development patterns differ from those in Australia. Considering an economic argument for biophilic urbanism, the workshop findings strongly suggest that a successful economic argument will be critical to stimulate an increase in the implementation of biophilic urbanism in Australian cities. Workshop participants identified a clear need for metrics and indicators to measure the costs and benefits of biophilic urbanism. Furthermore, the workshop participants in all three locations identified many innate benefits that are difficult to quantify, but which provide further evidence and a broader picture of the impacts, interactions and benefits of biophilic urbanism.

With regard to challenges and opportunities, the workshop findings revealed that these are frequently paired, such that a disabler (such as policies and planning frameworks) can also be an enabler (or become an enabler), depending on the context and content. The following two tables summarise the wide range of enablers (Table 1) and disablers (Table 2) that workshop participants identified may assist in increasing biophilic urbanism in Australian cities.

Table 1. Factors that enable greening of urban environments

Factor	Description
Policy	Supportive and adaptive policies and building/design standards that encourage and enable beyond compliance performance to drive innovation.
Government	Leadership in various levels of government and planning and a willingness to trial and/or introduce supportive policy measures. Creative leadership responsive to community expectations rather than political cycles and traditional economics.
Social pressures	Existing social capital, including community groups, community gardens and community appreciation of and pressure for biophilic urbanism. Availability of community leaders and change agents to assist in educating their community, establishing norms and supporting political processes. Existing appreciation of the benefits of nature.
Private Sector	The private sector can provide funding, leadership and 'biophilic entrepreneurship' to drive the development of biophilic urbanism demonstration sites and general use within cities. This is further enabled through effective policies and incentives, and new economic models and valuation methods.
Demonstration	A growing number of demonstration sites showcasing the multiple benefits of biophilic urbanism and driving new norms in urban design.
Economics	Interest in new valuation techniques and metrics to enable the inclusion of traditional externalities in financial evaluations of building and urban design with biophilic urbanism, which in turn may enable access to finance for biophilic elements.

Table 2. Factors that disable greening of urban environments

Factor	Description
Lack of proof and quantification	Limited local research, information and economic data on biophilic elements prevents decision makers from making informed and justifiable decisions. Biophilic elements are vulnerable to financial pressures due if the full economic and social value isn't demonstrable.
Existing policy and planning frameworks	A "silo effect" does not allow governments to look holistically at a concept, and exacerbates split incentives. A lack of mandatory requirements makes biophilic urbanism a 'beyond compliance' addition to building and planning. Existing regulations and planning requirements generally don't seem to support the inclusion of biophilic urbanism elements.
Cultural and social inertia	Cultural disconnection from the natural environment leads to ignorance of the benefits of experiences of nature and a lack of support for policies to increase urban nature.
Split incentives	Benefits and costs of biophilic urbanism are unequally borne by various government departments and between stakeholders (i.e. private organisations, government and society) such that the costs may be paid by a department, organisation or individual that doesn't recoup the full benefits.
Traditional economics	Traditional economic models that do not value externalities disempower decision makers from including biophilic elements in urban and building design.

Summary of case study findings

A review of cities around the world that have facilitated an increase in biophilic urbanism highlight the myriad ways that nature can be woven into the fabric of the built environment, as well as pathways to overcome many of the disablers uncovered in the workshop series, and capitalize on the enablers. The following table highlights the emergent classification of elements that was observed through the case study analysis, grouped by three geographic areas.

Table 3. Case studies of greening of urban environments

Initiative & Location	Biophilic Element
America/ Canada/ South America	
Backyard Commons, USA (National)	Green island, Green corridors
Millennium Park, Chicago, USA	Green Roof
Green Alleys Program, Chicago, USA	Green streets
The High Line Park, New York City, USA	Green corridors
Green Streets, Portland, USA	Green streets
Street Edge Alternatives, Seattle, USA	Green streets
Green Roofs Bylaw, Toronto, Canada	Green Roofs
Urban Forest, Toronto, Canada	Green island
Green Links Project, Vancouver, Canada	Green corridors
Reduced Road Infrastructure, Curitiba, Brazil	Green corridors
United Kingdom/ Europe	
Urban Green Space Access, United Kingdom (National)	Green island
Green Roof Legislation, Copenhagen, Denmark	Green Roofs
Vauban Ecological Traffic and Mobility Concept, Freiburg, Germany	Green corridors
BAF System, Berlin, Germany	Green island
Minimum Green Space Requirements, Malmo, Sweden	Green island
Asia-Pacific	
Urban Forest Biodiversity Program, Adelaide, Australia	Green island, Biodiversity
Core Biodiversity Network and city greening projects, Brisbane, Australia	Green island, Green corridors
Collingwood Childrens' Farm, Melbourne Australia	Green island
City in a Garden, Singapore	Green island, roofs, corridors
Day-lighting an Urban River, Seoul, Korea	Waterways

4 DISCUSSION

Emerging Elements of Biophilic Urbanism

A comprehensive review of how cities around the world have integrated nature into the fabric of the built environment has been distilled into an emerging taxonomy of biophilic elements, as presented in Table 4. The taxonomy, which is by no means exhaustive or definitive, can guide decision makers towards a consideration of the diversity of ways, and scales, in which biophilic urbanism can be created and enhanced.

The elements have been categorized by the scale at which they are applied, being either building, neighbourhood or city, building on findings of the literature review that the benefits of biophilic urbanism are maximised when applied in a diversity of forms and scales.

Table 4. Emergent Elements of Biophilic Urbanism

Scale	Element	Incorporated terms and applications
Building	Green indoor environments	Pot plants, Indoor living walls
	Green roofs	Shading roof spaces, vegetated walls
	Green walls	Vertical green space, vegetated walls, shaded walls, shade trees
	Green outdoor environments	Private green space, backyard, lawns, vegetated balconies
Neighbourhood	Green streets	Street trees, shade trees, green verges, green roads, green alleys, green footpaths
	Green Islands	Urban forest, nature reserves, parks, backyard commons, community gardens, zoo, sporting fields
City	Green Corridors	Connecting green space, biodiversity corridors, backyard commons
	Waterways	Day-lighted streams, rivers, coastal areas, wetlands, ponds

5 CONCLUSIONS

The findings presented in this paper provide the basis for a whole system perspective on the application of biophilic urbanism in Australian cities. Biophilic urbanism, as for the broader concept of sustainability, engenders the consideration of new methods of economic valuation, as well as policy development and application and decision-making. As highlighted through the stakeholder workshops, enabling the application of biophilic urbanism requires taking into account benefits which currently are not quantifiable, and involves an ongoing collaboration between a broader group of stakeholders and decision-makers than for many traditional urban planning and design processes, potentially including private entities, various government departments, community groups and educational facilities.

In many of the reviewed case studies, the introduction of biophilic elements has seen the emergence of non-linear outcomes, such as urban renewal and economic stimulation, enhanced community engagement and involvement, increased social, psychological and physical health, reduced overall and peak energy demand, and repaired ecosystems leading to restored ecosystem services (flood mitigation and water cycle management, urban heat island mitigation, air quality improvement, habitat provision, carbon sequestration and food provision). In most cases, the biophilic element was introduced for one specific purpose, with other benefits received as a ‘bonus’.

Further, the literature review and investigation of case studies showed the variety of biophilic elements that can be incorporated into an urban environment, and of greater consequence that these can be retrofitted into the existing urban fabric and do not need to reduce urban densities or compromise the provision of infrastructure or services. Indeed, the innovative inclusion of nature onto roofs and walls, inside buildings and along existing corridors such as roads and rivers can reduce the strain on urban systems, such as energy provision, water cycle management, food production, and transportation.

There are hence a number of implications of the findings to date, including a body of local, state, and federal government precedents to underpin the development of a policy pathway to encourage biophilic urbanism in Australia. The research has identified clear opportunities in both how biophilic urbanism can be applied (i.e. a broad range of biophilic elements) as well as a synergy of benefits emerging from such biophilic elements. Further, the research has highlighted emerging common barriers that can be addressed through strategic policy and incentives, and enhanced collaboration between stakeholders including building designers, urban planners, residents and governments. With these findings in mind, the research team, within the SBEnrc, will consider how to unpack the learnings from these case studies to address the identified enablers and disablers to biophilic urbanism in Australia, including the development of an economic argument for the Australian context and a policy pathway for decision makers to encourage and enable biophilic urbanism.

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