

# What Makes A City ‘Biophilic’?

## *Observations and Experiences from the Wellington Nature Map Project*

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**Abstract:** Despite clear benefits of maintaining human relationships with nature, people increasingly live in urban settings and spend high proportions of time indoors. Both of these trends are increasing globally. This means it is vital to ensure that future cities are designed, created and managed to enable meaningful human / nature connections. Cities that are examples of urban environments where human / nature relationships are innately encouraged and are part of residents’ daily experiences have been termed ‘biophilic cities’. Wellington, New Zealand is one of a select few cities internationally that has been identified as a biophilic city. In order to test the validity of that claim, this research set out to use GIS mapping to determine specific areas, sites and buildings that could be identified as being biophilic within Wellington. In order to do this, a unique biophilic cities framework was devised where 30 unique characteristics of biophilic cities were identified and used to map Wellington. Results from this mapping research are examined. Key findings include that when several identified aspects of biophilic design are nearby in urban settings, experiencing these through time while moving through a city enhances the positive effects of these elements.

**Keywords:** Biophilic design; urban design; urban nature; mapping.

## 1. Introduction

An increasing body of international research details the benefits that arise when people have a direct or indirect relationship with the natural world. Evidence is clear that positive physical benefits occur such as reduced blood pressure, reduced stress, and increased immunity (Gullone, 2000). Evidence of psychological benefits includes positively modified behaviour (particularly in terms of social interaction and reduced violence), decreased rates of depression, and increased ability to concentrate (Browning *et al.*, 2014). A review of more than 500 recent academic papers detailing quantifiable evidence of benefits of various aspects of biophilic design found that inclusion of such elements into spatial design could ‘*enhance productivity and performance and have a positive impact on attention restoration and stress reduction; increase positive emotions and reduce negative emotions; [lead to] relaxation of the brain, ocular muscles and lenses; [and lower] diastolic blood pressure and stress hormone (i.e., cortisol) levels in the blood stream.*’ (Ryan *et al.*, 2014). Economically, introducing certain elements of nature into commercial buildings results in increased productivity and employee satisfaction (Browning *et al.*, 2012).

When applied to health care environments time to recover from surgery or illness reduces (Ulrich, 1984). Despite the clear benefits of emphasising and maintaining human relationships with nature, people increasingly live in urban settings and spend high proportions of time indoors. This means it is vital to ensure that future interior environments and indeed whole cities are designed, created and managed to enable meaningful human / nature connections (Turner *et al.*, 2004).

## 2. Urban Biophilic Design

Design that seeks to purposefully create human / nature relationships or leverage these to create increase human wellbeing is termed 'biophilic design' (Kellert *et al.*, 2008). Cities that are examples of urban environments where human / nature relationships clearly exist and are purposefully designed have therefore been termed 'biophilic cities' (Beatley, 2011). These are cities where ecological restoration, architecture, landscape architecture, and urban planning are deliberately used to heighten the physical, psychological, and economic benefits that contact with nature can bring to city inhabitants.

## 3. The Wellington Nature Map Project: Methodology

Wellington, New Zealand is a relatively small and compact city of approximately 200 000 residents. It is a coastal settlement located in the southern-most part of the North Island of New Zealand, and is a city of steep and often deep green, bush clad hills surrounding a large harbour. Mostly because of its setting and access to 'wild' nature, Wellington has been identified as a biophilic city, through the international Biophilic Cities Network (Beatley, 2016). In order to test the validity of the claim that Wellington actually is biophilic, this research set out to use GIS mapping to determine specific areas, sites and buildings that could be identified as either: sites of nature in the city; nature activities on offer; or places where the urban fabric reflects some sort of special relationship to the land and sea. The resulting interactive publicly accessible map, termed 'The Wellington Nature Map' (Pedersen Zari *et al.*, 2017) was published online in early 2017, and is a joint project between the Wellington City Council, Victoria University of Wellington's School of Architecture, and the Wellington Living Architecture group, with assistance from Victoria University's School of Geography, Environment and Earth Sciences. Aside from providing a quantifiable evidential basis to the claim that Wellington is in fact 'biophilic', the aim of the Wellington Nature in the City project was to produce replicable methodologies and categorisations for mapping of other cities in terms of urban nature relationships. This is in order to produce measurable comparisons of the types, locations, and ranges of spatial design elements related to biophilic design, so that strategic decision making regarding urban planning for increased wellbeing could be enhanced in the future.

### 3.1. Elements of Biophilic Cities Framework

Various researchers have sought to define sets of biophilic design elements in architectural and interior architecture contexts (Kellert, 2005; Kellert *et al.*, 2008; Ryan *et al.*, 2014) and in urban settings (Beatley, 2011). In order to devise a suitable framework to enable physical mapping of actual biophilic sites or elements of a city, a unique biophilic cities framework had to be formulated. The resulting Elements of Biophilic Cities Framework identifies and categorises 30 unique characteristics of biophilic cities (tables 1-3). These categories are primarily combinations of aspects of cities deemed important in terms of creating relationships between people and nature as defined by Beatley (2011, 2016), that are supplemented by understandings of more abstracted notions of nature-related design that are applied at the building or interior architecture scale. These categories are discussed further in the following sections.

3.1.1 Nature in the city - biophilic conditions and infrastructure

The Nature in the City category addresses the physical and ephemeral presence of nature in urban environments. This includes plant life, water, and animals, as well as sounds, scents, light, wind, and other natural elements. Incorporating nature, both designed and wild into cities has numerous benefits including climate change mitigation and adaptation (Gill *et al.*, 2007), increased urban biodiversity (Rastandeh *et al.*, 2017), more effective storm water systems (Donovan, 2017), cleaner and cooler air, and cleaner water (Samson *et al.*, 2017). There are also measurable and proven benefits to human wellbeing. People who have access to nature tend to be less stressed, healthier, more creative, less violent, more productive and even more sociable (Gullone, 2000; Browning *et al.*, 2014). Table 1 elaborates on the different elements included in the Nature in the City category.



3.1.2 Nature activities – learning about and interacting with nature in the city

A biophilic city has activities for residents and tourists alike that enable connection with and enjoyment of nature, that encourage learning about the specific nature of that place, that keep ecosystems healthy or regenerate them, and enable participation in activity outdoors (Beatley, 2011). This shows how important or celebrated nature is to a city and its residents. By enabling residents to have equal opportunities to access nature, wild places, and other biophilic places in an urban setting, increased physical and psychological wellbeing can occur along with a greater understanding of ecological values and the value of nature based on local conditions (Mitchell *et al.*, 2016). Table 2 details elements in the Nature Activities category.

3.1.3 Nature of spaces and places - designed biophilic buildings and spaces

The Nature of Space and Places category relates to how certain kinds of spaces or spatial relationships in buildings, between buildings, or in urban spaces relate to configurations in nature that can cause people to have positive reactions (Kellert *et al.*, 2008). This includes our innate need and desire to be able to see beyond our immediate surroundings, or to be able to get an overview of a space from up high; our interest in the thrilling or slightly dangerous; and our curiosity to explore spaces that may be partially hidden (Ryan *et al.*, 2014). This category also includes buildings that enable us to connect to the surrounding climate, geography, and ecology through techniques such as: passive ventilation; access to natural daylight, views, and fresh air; and bioclimatic design (where buildings are designed to work with the site and climate they are located in). Table 3 depicts elements in the Nature of Spaces and Places category.

Table 1: Elements of nature in the city - biophilic conditions and infrastructure.

Icon	Element name
	<p><b>1 Parks</b></p> <p>Parks and urban green spaces are perhaps the most recognisable and accessible way to enable public access to nature in urban settings.</p>
	<p><b>2 Green belts / connected ecosystems / wild and semi wild native nature spaces</b></p> <p>Preserving and regenerating native bush areas within a city enables residents to be familiar with and to value indigenous ecosystems. Access to wild nature allows a different kind of experience to visiting only designed and managed park areas.</p>



### 3 Habitat provision

Having the opportunity to interact with animals including insects, birds, and fish is essential for a biophilic city. Interacting with animals has proven benefits for children, the elderly, and those with mental health issues (Barker, 1999). By including certain plants, water sources, or feeding stations in urban areas to attract living creatures to them, the biodiversity of a city may be increased. This may make a city more resilient to certain climate change impacts (Brink *et al.*, 2016).



### 4 Rivers / streams / wetlands / marine reserves

Being able to see, hear, and feel water can be of great benefit to people psychologically (Gullone, 2000). By understanding how water ways and oceans interact with weather, climate, pollutants and each other, people may understand better the importance and value of water.



### 5 Water features

Water allows people to access different emotional metaphors, from 'still waters running deep', to 'water under the bridge', to the swift flows of change. Water enlivens a space and allows people to connect with an essential element of life (Browning *et al.*, 2014).



### 6 Street trees and canopies

Introducing trees into urban streetscapes has benefits such as providing shade, filtering air, providing habitat to birds and insects, locking up carbon, reducing storm water flows, and possibly providing food (Donovan, 2017). It also allows for interaction with living nature as people walk below trees or near plantings, or experience these as views from surrounding windows.



### 7 Green roofs / walls / rooftop gardens

Living green walls (vertical gardens on the sides of buildings and other structures) have benefits that include: bringing more nature and biodiversity into built-up areas, filtering air and soaking up rain water, and deterring graffiti (Francis and Lorimer, 2011). Green roofs can lower temperatures inside buildings meaning less energy is used in cooling and can protect roofing materials for longer.



### 8 Community gardens / edible landscaping

Engaging in food growing, foraging, or harvesting in urban settings has significant benefits in terms of sustainability and human health, and may enable deeper relationships to form between people and nature (Viljoen and Howe, 2012).



### 9 Nonvisual nature

Sounds, smells, tastes, and things people can feel or touch engage the senses beyond just sight. This different sensory information, particularly that from 'nature', is processed in a different way by the human brain. This can in turn increase cognitive performance, aid in relaxation and lowering of blood pressure, and have other positive effects (Browning *et al.*, 2014).



### 10 Sensory stimuli

When people experience surprising movements, or sounds that are not predictable timing wise, this can be positive physically as well as psychologically. Examples include leaves falling off trees, objects moved in a breeze, birds flying past etc. These random movements can temporarily delight and distract, usually on a subconscious level, and can increase the ability to concentrate for longer periods. Such movement can also facilitate relaxation of the eye (Browning *et al.*, 2014).

Table 2: Elements of nature activities – learning about and interacting with nature in the city.

Icon	Element name
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	<p><b>1 Nature clubs and groups</b> Support for groups that focus socialisation, learning, or exercise around outdoor activities enable people to get outside and enjoy and learn about the natural aspects of the city. Such groups may range from tramping and jogging clubs, to gardening and outdoor meditation groups.</p>
	<p><b>2 Outdoor activity centres / sports fields / places to swim</b> Facilities for outdoor activities, including sports, swimming and 'messy play', enable people to get outside and enjoy the climate and ecology of the city.</p>
	<p><b>3 Camping grounds</b> Opportunities to sleep outside and experience camping enable people to connect to nature in a different way than typical dwelling situations.</p>
	<p><b>4 Pedestrian zones / bike paths / tramping walkways</b> A city with dedicated spaces for people to walk or bike rather than use cars, both in high density parts of the city and in more 'wild' areas, not only enables this kind of activity to happen, but it sends a signal to people to engage more with the outdoors.</p>
	<p><b>5 Gathering spaces in nature / playgrounds</b> Places in the city where people can gather outdoors for private or public events, and where there are dedicated facilities such as toilets, bbqs, or playgrounds, normalise being outside and experiencing different climatic conditions while learning more about the ecology of the region.</p>
	<p><b>6 Cafes / restaurants with outdoor spaces</b> Cafes and restaurants that offer outdoor spaces allow people to be outside on fine days and to enjoy the climate while experiencing the urban environment in a different way.</p>
	<p><b>7 Natural history museums / botanical gardens / environmental education initiatives</b> Museum and education facilities dedicated to preserving and learning about a city's natural heritage, ecological history and present condition, and indigenous flora and fauna are part of ensuring citizens understand and value their ecological setting.</p>
	<p><b>8 Natural history markers / celebrations</b> By calling attention to, marking, and explaining sites of important natural history events or locations, people have a richer appreciation and understanding of the dynamic nature of ecosystems and past events that have shaped the present.</p>
	<p><b>9 Ecosystem restoration / conservation projects</b> One of the markers of a biophilic city is how many of its citizens are actively engaged in ecological restoration or conservation projects (Beatley, 2011). These may be paid activities or voluntary.</p>
	<p><b>10 Local / international sustainability organisations</b> Regional and national organisations that focus on various sustainability issues having a noticeable presence in a city helps to reinforce the value of conserving, regenerating and valuing the natural heritage and climate of the city, and wider environment.</p>

Table 3: Elements of nature of spaces and places - designed biophilic buildings and spaces..

Icon	Element name
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### 1 Bioclimatic buildings

Bioclimatic buildings are ones that work with climate. They have a designed connection with nature (sun, wind, rain, ecology, and seasons) to create comfortable interior conditions while being energy and materials effective (Yeang *et al.*, 1994). Bioclimatic design can help people to understand and connect to the seasons and climate around them in a positive way.



### 2 Biomorphic buildings / spaces

Biomorphic buildings are ones that have organic or natural looking forms, patterns or textures or that make use of spatial hierarchies similar to those encountered in nature such as fractal patterns (Joye, 2007). Biomorphic forms allow users to make connections to nature through abstracted representations of shapes or textures that are associated with nature. Biomorphic forms and patterns can in some cases create a more visually preferred environment that enhances cognitive performance while reducing stress (Taylor, 2006). Biomorphic design can be a decorative component such as a façade treatment, or can be part of the actual structure of a space.



### 3 Dynamic natural light

The human eye is attuned to and works better in light that changes in intensity over time. Although people in developed countries typically spend upwards of 80% of our time indoors, human eyes evolved in conditions where they had to adjust constantly to clouds moving over the sun, or to moving in and out of shaded areas. Slight changes in lighting levels actually enable people to better concentrate and stay more alert (Browning *et al.*, 2014). Human eyes are also better adjusted to the colour spectrum of natural light rather than artificial light, and natural light regulates important hormonal functions. It helps to regulate circadian cycles which relate to sleep, mood, depression, heart rate and body temperature regulation. This is why allowing natural light, through windows or skylights is important particularly in working and learning environments. It also allows people to be in contact with the time of day or year and to experience the drama of changing weather patterns in comfort.



### 4 Thermal and airflow variability

An environment devoid of sensory stimulation and variability can lead to boredom and passivity. Variations in air flow and slight temperature and humidity changes indoors have been linked to increases in worker or learner comfort, short term memory, concentration, well-being and productivity, and even the desire to dwell for longer in a space over time (Browning *et al.*, 2014). This is why being able to open and close buildings to the exterior is important.



### 5 Material and colour connections with nature

Spaces or buildings that demonstrate a material connection with nature are ones made from materials or elements that reflect the local ecology or geology. This helps to create a distinct and authentic sense of place. Although research is limited, spaces with high ratios of natural materials (like timber or stone) can calm people, lower blood pressure, and increase pulse (Browning *et al.*, 2014). Use of the colour green, or use of a series of gradients of similar colours as opposed to use of contrasting block colours may have similar results (Gushiken, 2012).



### 6 Celebration of nature / climate / bioregion

Spaces can generate awareness of seasonal and temporal changes as characteristics of healthy ecosystems. By highlighting ecological features along with their history, people can appreciate and therefore value their surroundings more. Ways that nature / climate / bioregion can be celebrated include through art works, murals, street furniture, eco-revelatory design (where ecological processes are made visible to people), biomimicry (where the processes or functions of nature or living creatures are mimicked in design) (Pedersen Zari, 2010), and marking of spaces that are sacred to various groups of people due to cultural beliefs about nature.



### 7 Prospect / view

These kinds of spaces enable a view over a distance for surveillance and if designed well feel open and without restriction, while portraying a sense of safety and control. Potential benefits of such spaces include reductions in stress, irritation, and perceived vulnerability, as well as improved comfort (Browning *et al.*, 2014). Even having a distant or middle-distance view from a working or learning environment can serve to rest eyes, reduce fatigue and improve concentration.



### 8 Refuge / sanctuary

Refuge and sanctuary spaces are ones where people can withdrawal from weather conditions, busy streetscapes, or other people. Such spaces can provide a sense of retreat and withdrawal enabling protection, contemplation, and rest. Refuges are important for stress reduction, and can result in lowered blood pressure and heart rate, and reduced irritation, fatigue and feelings of vulnerability. Potential benefits include improved concentration and attention. A well-designed refuge space enables people to feel protected behind and overhead while still being able to see out beyond the refuge (Browning *et al.*, 2014).



### 9 Mystery, surprise, and curiosity

It is possible to set up a sense of mystery and surprise in spaces. This can be done by offering the promise of more information through partially obscured views or other spatial techniques that intrigue people and draw them deeper into the spaces. Using mystery in biophilic design is based on the idea that people have two basic needs in environments: to understand and to explore. A sense of mystery, surprise or anticipation can create a strong pleasure response within the brain because people like to guess and anticipate what might be coming (Browning *et al.*, 2014).



### 10 Risk and peril

This relates to when people can perceive an identifiable threat which is coupled with a safeguard to minimise actual danger. People might like the thrill of a scary movie or a roller coaster ride for example because they know that ultimately it is safe. Being able to control risk can lead to positive experiences that result in strong pleasure responses. Such experiences are important in developing risk assessment during childhood. For adults when short doses of dopamine occur this can stimulate motivation, memory, and problem solving (Browning *et al.*, 2014).

## 3.2. Geographic information system (GIS) mapping and Story Maps

After the biophilic categories were determined, the team worked with a specially designed GIS mapping application to locate with global positioning system (GPS) coordinates the approximately 170 locations to be shown in the map. Locations were documented through photography and video, and a brief written explanation for each location was prepared in terms of description, history, and relevance to human / nature relationships. The intention was not to map every possible biophilic element of the city, but to focus on elements that were primarily in the inner-city area, were easily accessible, were well known or iconic to Wellington, and that demonstrated a good range of examples of each category.

Once the data had been collected, it was entered into an Esri ArcGIS 'Story Map' software system (<http://storymaps.arcgis.com>). Story Maps combine maps and other GIS information with narrative text, images, and multimedia content in order to explain, enhance, and navigate maps. This platform was the one of choice by the Wellington City Council, who ultimately host the Wellington Nature Map. Combining narrative techniques with geo-spatial mapping is increasingly part of people's navigation experience of modern life, and reflects several global converging trends, such as increased citizen geo-awareness, and fast evolving geotechnologies and sharing systems. These trends are likely to continue to rapidly change how people understand and experience the world around them, particularly as portable digital technologies also evolve (Kerski, 2015).



The Wellington Nature Map Story Map is organised into three sections following the Elements of Biophilic Cities Framework (tables 1-3) with a combined section that overlays all of the mapped elements onto a single map. This demonstrates where biophilic areas of intensity exist in Wellington, and enables planning of routes to experience Wellington as a biophilic city (Figure 1). Each mapped icon relates to a site reflecting a specific category of biophilic urban experience. When an icon is selected a pop-up text and image box appears that provides further details for each site.



Figure 2 Screen shot of the Wellington Nature Map

#### 4. Results and Discussion

Mapping specific biophilic features of Wellington has enabled a tangible and quantifiable way to demonstrate that Wellington is likely to be a city that has enhanced human wellbeing attributes because of opportunities afforded for human / nature relationships and connections to occur. This is in part because of the geography and surrounding ecosystems of the city itself. Because Wellington is a complex folded landscape that surrounds a harbour and is in turn surrounded by bush or green spaces to a large extent, many residents have views of nature from homes and workplaces. These unplanned biophilic aspects of Wellington relate largely to the Nature in the City category of biophilic elements (green icons - table 1), and in particular: green belts / connected ecosystems / wild and semi wild native nature spaces; habitat provision; rivers / streams / wetland / marine reserves; and nonvisual nature. These green icons on the Wellington Nature Map, were the most abundant of the three categories and illustrate that tangible literal inclusion of nature into the city is an important part of Wellington being deemed 'biophilic'.

It should be noted however that many aspects of the Nature in the City elements, and all of the other two categories of biophilic city elements (tables 2 and 3) are aspects of Wellington that are deliberately planned, encouraged, and patronised by the residents and managers of the city. Aspects of the city like the abundance of outdoor activities available to residents, the large number of volunteer driven regeneration projects, and the active celebration of natural history sites (and many of the other yellow icons element in the Nature Activities category) demonstrate that Wellington being biophilic is not just an accident of geography but is also in part due to the actions of the residents and the support for such activities, groups, sites etc.st. A key finding of the research remains however that an abundance of nearby wild nature is vital to the creation of a biophilic city because of its relationship to the evolution of outdoor or nature based activities residents can participate in.



The least abundant category of mapped elements related to the Nature of the Spaces and Places category (the blue icons). These relate to deliberate acts of designing spaces and buildings that reflect or create nature / human relationships. Typically, these are buildings or designed urban outdoor places. It is of note that many (but certainly not all) of the sites and places that were mapped as belonging to the Nature of Spaces and places category are among some of Wellington's newer buildings and spaces. Perhaps this reflects a changing attitude toward nature in the city, to architectural and urban design, or to a Wellington identity or sense of place that relates to human / nature connection in the city.

Spatially there are clear areas of biophilic intensity in the city. These relate to some of the large wildlife reserves and botanical gardens to the west of the city (Zealandia, Otari-Wilton's Bush, and the Botanic Gardens), but more densely urban biophilic zones also exist. Interestingly, these tend to centre on already often visited culturally significant parts of the city. One central city biophilic zone centres on the Civic Square area of the city, which is often thought of as the heart of Wellington City. This zone is a combination of dense street plantings, urban parks, art works, and markers of natural history. Another biophilic zone centres on lower Lambton Quay and the parliament buildings, through various art works, buildings and urban parks. A third zone which connects the first two zones stretches along most of the waterfront area from the local ferry terminals to Oriental Parade and is a collection of urban outdoor features such as bridges, sites of outdoor activities, and several of the city's natural history museums. A final key finding therefore was that the spatial design and materiality of buildings as well as public works of art in cities impact on biophilic experiences, and that when several identified elements of biophilic design are nearby in an urban setting, experiencing these through time while moving through a city enhances the positive effects of biophilia.

## 6. Conclusions

In conclusion, the Wellington Nature Map is a first step in investigating the presence and effects of biophilic design in Wellington. Future research will include observation and survey of how people use the Wellington Nature Map and examination of how its use has (or has not) altered perceptions of the city or of human / nature relationships. The methodology and framework for investigation presented are transferable to other cities. Mapping other cities in a similar way that are part of the Biophilic Cities Network, and using control cities with are not, will enable geospatial comparisons to be made between cities of different sizes, in different climates, and with different demographics, ecological features, and cultural systems. This will contribute to quantifiable evidenced based research investigating biophilic cities and their benefits or impacts on human well-being and relationship to the ecological wellbeing of urban areas. It will enable differences between the preferences or needs of different groups to be deduced and can then contribute to rethinking urban and architectural planning priorities and strategies. This is important for safeguarding both the physical and psychological wellbeing of individuals and communities in the coming decades as humanity increasingly becomes urbanised and removed from outdoor environments, and as digital technologies become ubiquitous.

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