AN APPLICATION OF BIOPHILIC CITY DESIGN PRINCIPLES TO THE
JANE-FINCH NEIGHBOURHOOD OF TORONTO

by
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ABSTRACT

AN APPLICATION OF BIOPHILIC CITY DESIGN PRINCIPLES TO THE JANE-FINCH NEIGHBOURHOOD OF TORONTO

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A biophilic city is designed and planned to increase residents’ contact with nature. Biophilic cities promote environmental sustainability and people’s health and wellbeing, especially where population density is high. The Jane-Finch neighbourhood of Toronto has high population density and low green space coverage, providing an opportunity to apply biophilic city principles to address the public concerns of limited nature contact opportunities. This thesis will explore how biophilic city principles apply to Jane-Finch, identifying opportunities and challenges to application. Design proposals are created for two land use typologies in Jane-Finch neighbourhood by applying biophilic design principles and discussing when they are most opportune or most challenged. The results show the most challenging site typology is the residential street and the most challenging principle is prospect. The research contributes to understanding the biophilic city concept and its application; the findings provide suggestions on how to transform Toronto into a more biophilic city.

Keywords: Landscape Architecture, Biophilic Urbanism, Urban Nature, Design Principle, Urban Ecology, Streetscape
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CHAPTER 1 INTRODUCTION

1.1 Background

According to the latest data from the United Nations (2017), 55 percent of people globally live in urban areas, and the figure will increase to 68% by 2050. Cities are becoming the main habitats for people. Urban development of industries, transportation, and buildings replace the natural spaces and diminish natural functions, leading to environmental problems commonly associated with the process of urbanization (for example, loss of ecosystems and urban heat island (Ziari et al., 2016). Urban ecology emphasizes the importance of urban planning and landscape architecture in maintaining an ecologically diverse city.

The concept of urban ecology was used in 1920 by sociologists (Park et al., 1925), and in the 1970-80s it became highly regarded and emerged as a scientific discipline. Forman (2014 p.3) states “urban ecology studies the interaction of organisms, built structures, and the physical environment, where people are concentrated.” Urban ecology as a discipline provides or suggests solutions to urban problems. McPhearson et al. (2016) state that urban ecology advances cities’ sustainability and resilience. It increases cities’ capacity to absorb stress from shocks to the economy, environment, and human well-being, to continue to develop without loss of “essential structure, function, identity, and feedback” (p.198).

Urban nature refers to the presence of natural areas in urban contexts that includes green corridors, urban parks, and street trees, and is a significant component of urban ecology. Previous studies summarize urban nature benefits that include local climate
cooling, stormwater management, and improved drinking water quality (Elmqvist et al. 2013). Other researchers emphasize that urban nature results in substantial physical and mental health benefits to people’s living and working environments (Beatley & Newman, 2013).

Biophilic city theory acknowledges the need for daily contact with urban nature for citizens to have healthy, meaningful and productive lives (Beatley and Newman, 2013). Because of the demand for buildings and infrastructure in cities, urban nature assets like parks, green corridors, and urban forests are limited and need effort to further enhance them for humans and other species. This necessity requires biophilic design features at different scales across a city, from streets and community gardens to natural corridors and large, regional parks. Biophilic city theory has been successfully applied in cities like Singapore - a dense city with 700 square kilometres and 5.4 million people, but also a “city in a garden” with 47% green spaces by area (Biophilic Cities, 2018).

1.2 Research Goals and Objectives

The City of Toronto is of comparable area to Singapore (630 square kilometres), with about half of the population (2.8 million people) and only 13% of the City’s area is public green space (World Cities Culture Forum, 2018). Inspired by the case study of Singapore, the research is to explore how principles of a biophilic city can be applied to a neighbourhood in Toronto.

The research goal is to identify a set of principles that can be assessed through an application in the Jane-Finch neighbourhood as a community within a biophilic city. This
will lead to an understanding of the benefits and limitations of the transformation of Jane-Finch into a biophilic city neighbourhood. To achieve the goal, this research report has the following objectives:

1. Conduct a literature review on biophilic cities to identify the features of a biophilic city;
2. Explore the biophilic design principles and biophilic features for landscape design;
3. Test the effectiveness of the design principles by applying them to different land use typologies;
4. Critically reflect on the application of biophilic city principles to the selected area.

1.3 Thesis Outline

The thesis is organized into five chapters; the flowchart shows the components of the research project. The research starts with a literature review to provide a basis for understanding urban ecology, and biophilia, and to extract the features of biophilic cities. Then biophilic design principles and associated features are summarized for design application. Site selection criteria are established and a neighbourhood in Toronto is chosen, landscape typologies are identified, and example sites within the types are selected to apply the biophilic design principles. Inventory and analysis of the sites based on the features of biophilic cities is used to identify current conditions. Analysis is followed by proposed biophilic public-space designs in an iterative process to adjust the designs to achieve a maximum number of biophilic principles and features in the design. Finally, the biophilic designs are analyzed to summarize how each
principle was achieved, or why a principle was not achieved. The last chapter discusses opportunities and challenges in the application of biophilic landscape design principles for a dense urban neighbourhood. Figure 1-1 provides a graphic description of the research project components.

Figure 1-1 Graphic Description of Research Project Components
CHAPTER 2 LITERATURE REVIEW

2.0 Introduction

In recent decades, because of increasing populations in cities and climate change, urban nature is increasingly recognized for its important role in maintaining the livability and sustainability of urban areas. Urban nature refers to various built environments like urban greening and green infrastructure (Reeve et al., 2015). Urban nature is considered to provide positive effects to solve current challenges faced with urban intensity, such as stormwater runoff and urban heat island effect (Forman, 2014). Besides, more researchers proved that urban nature brought substantial physical and mental health benefits to people in living and work environments (Beatley & Newman, 2013).

Due to acknowledged benefits of urban nature, more cities, urban planners, architects and landscape architects are interested in biophilic design approaches to design cities that provide residents with more chances to connect to nature and get people outside. There are various existing natural assets in urban areas like parks, rivers, and trees. Biophilic design approaches introduce nature into every element of built environments such as the roads, walls, buildings, and concrete watercourses (Beatley 2010).
2.1 The Origins of Biophilic Cities

2.1.1 The Definition of Biophilia

The biophilic city concept, based on the physiological principle of biophilia, was widely known by Harvard myrmecologist and conservationist E.O. Wilson. According to Wilson (1993), biophilia is the “innately emotional affiliation of human beings to other living organisms. Innate means hereditary and hence part of ultimate human nature”. Simply, human beings have an instinct to connect with nature that is a result of thousands of years of our evolution. Through more than 99 percent of our species’ history, humans lived intimately with nature and depended on nature to hunt and gather food (Kellert, 2005). It is a behavioural response to be neurologically and physiologically positive when people see the landscapes which potentially provide food and shelter for human beings (Reeve et al., 2015).

The biophilia concept gained attention after Kellert and Wilson published their book *The Biophilia Hypothesis* in 1993. Though some researchers (e.g., Kahn, 1997) claimed the concept is a hypothesis, growing evidence supports it. Researchers in architecture showed the presence of interior greenery, natural light and fresh air provide a positive correlation with the productivity and happiness of workers (Leather et al., 1998). Herschong et al. (2002) suggested the presence of green elements like natural light in school can improve students’ performance and test results. In addition, some researchers (Ulrich, 1984 and DeVries et al., 2013) showed the positive effect of views of nature in healing patients in hospital and healing facilities. Researchers from multiple fields such as architecture, education and childhood development support the hypothesis of biophilia and make more people realize the importance of nature.
However, our modern life is different from our ancestor’s lives, because people no longer live as close to nature as our ancestor; we mostly live in a constructed environment (Kellert, 2016). Nowadays, over 50 percent of people globally live in urban areas which have high population density, and they spend 90 percent of time indoors (Kellert, 2016); this weakens human connections to nature and transforms natural habitats. In other words, modern natural habitats for human beings have become built environments. Faced with the reality and proved benefits of contact with nature, landscape architects and urban planners are obliged to create more green spaces in urban areas to enhance people’s experience with nature.

2.1.2 Biophilic Design

To address the present issues and help people get satisfactory experiences of nature in cities, the biophilic design draws on landscape design and urban planning fields (Kellert, 2016). The purpose of biophilic design, is according to the principle of biophilia, to create good habitat for people as “biological organisms” in constructed urban settings (Kellert, 2016). In this way, the biophilic environment improves people’s physical and mental health, dwelling, and work experience in cities. According to Kellert’s theory (2005), there are three ways to achieve biophilic designs in urban settings, including to enhance the direct and indirect contacts to nature and improve the experience of spaces and places.
2.1.2.1 Direct Contact with Nature

Direct contact with nature is the result of the immediate experience of nature in interior settings like buildings and exterior settings like landscapes (Kellert, 2005). Contact with natural light and ventilation are the most fundamental connections with nature that can influence people’s physical and mental well-being (Kellert, 2005). The presence of environmental elements like vegetation, soil, water, natural terrain and animals in landscapes can also enhance the direct contact with nature. The contact includes visual and non-visual connection. Views of natural systems such as rivers, woodlands and mountains in an urban environment can reduce the anxiety and threats from high and dense buildings. The natural elements normally have physical and psychological impacts on people, but the effect depends on the design (Kellert, 2005). For example, design with biodiversity and multiple habitats can stimulate people’s multiple senses that can improve the quality of direct contact with nature.

The presence of water in buildings and landscape can enhance direct contact with nature. Positive psychological effects are always associated with the view, sound and smell of water (Kellert, 2005). The positive psychological effects can be stronger when the water is moving or providing habitats for vegetation and wildlife. The building façades and rooftops can be opportunities to reinforce direct contact with nature. Green walls and green roofs on buildings can provide habitats for plants and animals that enhance human relaxation, health and productivity. The green wall and green roofs can reduce the environmental impacts of buildings development. Native plants, edible vegetation and animals increase ecological values of landscapes and enhance direct contact with nature (Kellert, 2005).
2.1.2.2 Indirect Contact with Nature

Indirect contact with nature is a result of controlled and manipulated natural elements that requires human management and intervention in buildings and landscapes (Kellert, 2005). In landscapes, examples include the formally designed fountains, natural elements (e.g., vegetation, light and water), natural materials (e.g., natural stones, wood, wool and leather), and natural process (e.g., weathering and climate). Different from artificial materials, human beings have a deep affinity for natural materials because they have evocative power and can be associated with dynamic and natural forms. For example, there are no two stones or wood grain that are exactly the same.

2.1.2.3 Experience of Spaces and Places

Finally, to improve the experience of spaces and places in cities can also enhance people’s connection to nature; that can be achieved by six paired elements that reflect human beings’ evolution and human affinity for nature. (Hildebrand, 1999). They are refuge and prospect, enticement and peril, order and complexity.

Prospect reflects human beings’ evolution history; we prefer observing objects from long distances because when we were primitive we could locate food and shelter this way. In modern life, people prefer elevated outlook views and without occluding objects. This creates feelings of brightness and openness that enhance the experience of the spaces. Refuge is contrasted with prospect; it reflects people’s desire for protection and shelters (Hildebrand, 1999, p.22). In landscapes, a comfortable seating position, a fireplace and canopy coverage can achieve refuge feeling.
Enticement reflects human’s nature to explore and discover. In landscape design, it can be achieved by obscured views to attract people to explore (Kellert, 2005). Landscape design also enhances the experience by providing various natural details. Peril is like the enticement; it reflects the people’s desire for challenge and mystery (Kellert, 2005). It can be achieved by exciting heights and overhanging structures in landscapes.

Complexity reflects the human nature of desires for natural environments that have a variety and are full of details. Kaplan and Kaplan (1998) suggested that complexity normally provide opportunities to imagine and discover. Order reflects people’s desire for patterns and organization (Kellert, 2005). According to Hildebrand (1999), the two concepts are necessary allies. If the experience of complexity is without order, the environment can be overwhelming. If the experience of order without complexity, the landscape can have boring repetition. This is consistent with Kaplan & Kaplan’s preference matrix.

From the approaches listed above, biophilic design is not only focused on improving the number of green spaces in urban areas. Its important objective is to encourage people directly and actively to engage and enjoy the nature around them; this can be achieved by multiple-scale biophilic design elements in cities (Beatley, 2014).

2.1.3 Biophilic Urbanism

Biophilic urbanism refers to "the use of natural elements as purposeful design features in urban landscapes" (el-Baghdadi & Desha, 2017). Its goal is to change the modern urban disconnect from nature; to integrate natural experience within everyday urban life; to address ecological and social problems of urbanization (Kellert, 2016). Biophilic
urbanism recognizes that human beings are part of ecosystems and tries to design cities to make every resident have a satisfactory experience at individual levels (el-Baghdadi & Desha, 2017). Thus, a particular biological requirement of species or ecosystem is not the focus of biophilic urbanism, such as a red-tailed hawk or wetland (Kellert, 2016). They can be taken into consideration when it can improve human beings’ relationships with these species and ecosystem.

2.2 The Characteristics of Biophilic Cities

Timothy Beatley (2010) described biophilic cities in his book *Biophilic Cities: Integrating Nature into Urban Design and Planning* as “a city that puts nature first in its design, planning and management: it recognizes the essential need for daily human contact with nature as well as the many environmental and economic values provided by nature and natural system” (Beatley, 2010, p.45). Nowadays, to meet the needs of cities, dominance was given to cities’ infrastructure such as industries and transportation, which reduces the possibilities of green spaces in cities. The biophilic city theory changes the situation, to put urban nature at the dominant position in city development to create a biodiverse and full-of-nature place. Biophilic cities recognize the need for sustainability, including ecological sustainability that includes biodiversity, but it emphasizes the presence and design of actual green features and focuses on improving people’s intimate connection with nature as a species (Beatley, 2010).

Beatley (2010) states that the key of a biophilic city is a biodiverse city that is full of nature and with different natural habitats for trees, plants and wildlife across different
scales. This can be large ecosystems such as riparian systems or small green public spaces like a pocket garden. In addition, biophilic cities not only focus the existing green spaces we have in urban areas but also creates more opportunities to form nature into design and construction of new projects in cities to enhance residents’ intimate connection with nature (Beatley, 2010).

Beatley (2010) states that the core value of biophilic cities is the love and care of nature and green elements in cities. Correspondingly, the green elements not only show psychological power on recreation, healing and education, but also they serve some important infrastructure functions, such as stormwater management, relieving urban heat island effects, and air pollution reduction (Beatley, 2010).

According to Beatley (2010), the characteristics of biophilic cities include:

Full of accessible and abundant nature. This requires all residents to have equal access to various and abundant urban nature in their daily life. It also requires the urban nature to be present at every scale in cities like parks, streets and rooftops to increase people’s contact with nature.

Rich textured and multisensory environment. This requires the urban nature in a biophilic city to provide multiple sensory experiences. This characteristic aligns with the Kellert’s theory about the biophilic design. The landscapes in biophilic cities should be with various views, smells and sounds.

Inspired and mimic nature. It requires the biophilic design should follow the natural forms and avoid rigid and artificial design.
2.2.1 Biophilic Conditions and Infrastructure

Beatley (2010) notes biophilic cities should provide all their residents equal chances to access and enjoy nature. To make urban nature, including: “parks and greenspaces, rivers and mountains, trees and forests, green rooftops” (Beatley, 2010, p.50), accessible to all citizens is the most convenient way for them to enjoy nature. Thus Beatley (2010) summarizes qualities found in biophilic cities and lists some key indicators to identify the level of a biophilic city. Example indicators are: “percentage of the population within 100 metres of a park or greenspace, and percentage forest cover in the city” (Beatley, 2010, p.47) These indicators show to what extent residents in cities can access and enjoy nature.

2.2.2 Biophilic Features across Scales

Building scale elements include green rooftops (referring to green spaces on the top of mid-high rise buildings), green walls (referring to horizontal vegetation on the facades of buildings), green courtyards (referring to small green space surrounded by buildings) (Beatley, 2010). As a high proportion of urban areas are composed of buildings, these elements can efficiently improve the chance for people to connect with nature. They can decrease dramatically building energy demands, urban heat island effect and increase usable spaces and urban biodiversity (Reeve et al., 2015). However, buildings are the easiest overlooked parts to contribute to biophilic cities. They are within the property boundary lines, and the uses of the features are likely limited to the property owners.

Street-scale elements include green streets (referring to streets with biodiversity that can manage stormwater), and low impact development (referring to a design approach
to manage stormwater runoff, a high degree of water permeability pathways) (Beatley, 2010). Streets are important linkages within cities; biophilic design elements on the streets can improve the ecological connection. Successful biophilic design streets can work as green corridors to connect urban nature patches and support the movement of wildlife within them. Street-scale biophilic elements can also improve urban amenity and walkability of urban areas (Reeve et al., 2015). However, as they are public-owned functional spaces, when taking consideration of biophilic design, the basic function of streets such as transportation and underground service should not be compromised. City scale elements include city parks, linear green spaces (e.g., green corridors and ravine systems), urban agriculture (e.g., urban farms and edible gardens), and river systems (Beatley, 2010). Unlike the building scale elements, these spaces are generally accessed by the public and residents. They encourage public active physical activities; provide spaces for outdoor recreation; and improve residents’ health and wellbeing. In addition, the features improve urban ecology and urban biodiversity.

2.3 Benefits and of Biophilic Urbanism

2.3.1 Resilience through Biophilic Urbanism

Beatley and Newman (2013) state that urbanism will enhance urban resilience through providing protection and enhancement of the natural system in and around the city. For example, green infrastructure such as rivers, floodplains, and wetlands play essential roles to absorb flood waters from storms and respond to extreme climatic change in early spring. The green infrastructure reduces the vulnerability to floods and enhances water supply and water system resilience (Beatley & Newman, 2013). Biophilic cities
with extensive tree canopy coverage are more able to moderate air pollution, reduce urban flooding and runoff and decrease urban heat island effect. Natural vegetation in cities and neighbourhoods also can protect buildings and properties from disasters such as wind, rain, and flooding, that carries considerable economic and social value (Beatley & Newman, 2013). Cities with extensive green space networks and parks are resilient to long-term global climate change, and they improve urban micro-climate conditions. Biophilic features along streets and around neighbourhoods increase people’s contact with nature and encourage residents to walk more to have healthier lifestyles. Healthier individuals and communities are foundations of urban resilience (Wolf, 2008).

2.3.2 Health and Wellbeing Benefits of Biophilic Urbanism

Biophilic cities provide positive benefits for health and wellbeing at both family and individual levels. Research shows that the presence of nature in urban areas is beneficial to reduce stress, depression, and anxiety. The views of vegetation and nature and walking within nature can lower stress and anger (Leather et al., 1998). Also, biophilic urbanism can create more healthful environments and lead to healthier lifestyles in many ways (Beatley & Newman, 2013). For example, an extensive network of trails and large blocks of parks near communities contribute to more physical activities (Beatley & Newman, 2013). Participation in activities that engage nature possesses emotional and physiological benefits for people (Beatley, 2010). Food production in urban areas can provide an opportunity to connect with nature and produce a great deal of healthy food (Beatley & Newman, 2013).
2.3.3 Biophilic Cities Can Help Build Social Capital and Trust

Biophilic cities can also “help to bring people together in pursuit and enjoyment of common interests and concerns and can expand and strengthen social networks and capital” (Beatley & Newman, 2013, p.3338). Biophilic cities provide opportunities to engage citizens in outdoor activities that build direct relationships between citizens and nature, like hiking, camping, and bird watching and some social activities. Klaus et al. (2009) state that children can benefit from outdoor activities to build friendships and improve intelligence. Even for adults, parks and green spaces are essential places to socialize and meet new people. "It can be a platform for breaking up social segregation, and therefore, public places are indispensable for meeting and establishing contacts" (Klaus et al., 2009, p.16). The social interactions build a degree of social trust and strengthen adaptive capacity. This is helpful to develop and maintain the connection and attachment between cities and their citizens. In the long term, social interactions ultimately influence positively on the economic growth of cities (Beatley & Newman, 2013)

2.4 Obstacles to Biophilic Urbanism

2.4.1 Economical and Land Use Obstacles

The main challenges for biophilic urbanism are land use constraints in urban areas and financial limits. The constraints require the biophilic features to enhance multi-functional benefits and ensure the maximum value is achieved from the spaces (Reeve et al., 2015). The “prevailing short-term centred political and economic decision-making
mechanisms” (Beatley & Newman, 2013, p.3342) also influence the process of biophilic urbanism. Some biophilic design features can be expensive projects, such as green roof and green walls, with the high cost frequently impeding implementation of such projects.

### 2.4.2 Social and Cultural Obstacles

Though biophilic urbanism was shown to have multiple benefits for residents’ health and wellbeing, the greener and more natural biophilic design features still are challenged by the traditional cultural and aesthetic bias (Beatley & Newman, 2013). Comparing native and ecological vegetation, many residents still prefer seeing well-maintained lawns that are seen as “green deserts” in the view of biodiverse green infrastructure (Ignatieva & Ahrné, 2013). Biophilic cities also bring an increasing number of wild animals near neighbourhoods; that many residents resist seeing around their homes (Beatley & Newman, 2013). In addition, there is some resistance from residents themselves: a great proportion of urban residents overlook the value of connection to nature and relied on indoor and car-dependent lives (Beatley & Newman, 2013).
CHAPTER 3 METHODS

The goal of the study is to explore if it is feasible to make Toronto into a biophilic city and to explore the application of biophilic design principles in Toronto to learn when the principles are the most opportune or challenged. This chapter describes the methods used to find a site in Toronto and the application of biophilic design principles to the site through landscape design. The chapter concludes by showing how the application of the principles is characterized as challenged or opportune.

3.1 Identification of biophilic design principles

A literature review summarizes the biophilic landscape design principles from previous studies. According to Beatley (2010), to have a biophilic city the primary thing to do is to increase the direct and indirect contact of people with nature. According to Heerwagen and Hase (2001), design should improve people’s experience of space in ways that also contribute to the biophilic design. A report (Terrapin Bright Green 2014) published a review of fourteen patterns of biophilic design that outline the tools and design considerations when using each biophilic design pattern. The fourteen patterns include these major patterns and sub-patterns:

"**Nature in the Space Patterns:** Visual Connection with Nature; Non-Visual Connection with Nature; Non-Rhythmic Sensory Stimuli; Thermal & Airflow Variability, Presence of Water, Dynamic & Diffuse Light, Connection with Natural Systems

**Natural Analogues Patterns:** Biomorphic Forms & Patterns; Material Connection with Nature; Complexity & Order

**Nature of the Space Patterns:** Prospect; Refuge; Mystery; Risk/Peril." (Terrapin Bright Green, 2014, 23)
There are some connections among the ideas of these authors. An example is that some design principles improve direct contact with nature, such as visual connection, presence of water. Other principles improve indirect contact with nature, such as natural forms and patterns, and material connection with nature. Finally, design principles like complexity, prospect, refuge, and enticement can enhance the human experience of spaces and places.

However, the patterns and design considerations in this report (Terrapin Bright Green 2014) are from the perspective of architectural design, which might not be fully transferable to this study’s landscape design. Below, combining the research of Beatley (2010) on Biophilic cities, Heerwagen and Hase (2001) on the experience of places and Terrapin Bright Green (2014) on biophilic design patterns, commonly-identified design considerations suitable to landscape design are listed for the use of this study. The identification of each design principle will connect the theory with the application in Toronto. They also will act as design strategies and assess them for design application and assessment.

3.1.1 Visual Connection with Nature

The principle refers to how a biophilically-designed place should provide views of natural elements, or natural processes that are not invented by people. The natural elements include vegetation, wildlife, and natural soil and terrain. Moreover, natural processes include the natural seasonal changes like blooming in spring and colour changes in fall. Also, weather changes are also part of the natural process, like rain and
snow. The views should inspire people’s feelings; the vegetation coverage should be adequate to be sensed. Usually, in open spaces, the vegetation coverage should be over 50%, and the form of vegetation should not be visibly structured and trimmed. Plants need to appear natural in forms and arrangement to avoid interpretations of artificial placement. This principle can be used to present a natural feeling on constructed areas such as streets where vegetation can screen the view of buildings or urban elements. For example, to present a natural view of building façade a green wall can be designed on the building. Usually, the design principle presented occurs in concert with other principles, such as biodiversity and natural forms, to achieve multiple objectives. When trying to build a visual connection, the location of the viewer is also a significant design consideration. Good visual connections with nature should provide view opportunities from a seated area and standing position. When space is limited, biodiversity can better enhance the visual connection rather than increase the size of green spaces. To apply this principle, the design should emphasize a natural environment, avoid views of constructed structures, and attempt to increase vegetation coverage to over 50% in open spaces.

3.1.2 Non-visual Connection with Nature

The principle refers to how biophilic design builds a positive connection between people and nature in multiple senses, like auditory, gustatory, olfactory, and haptic. It means that in biophilic cities, natural elements and natural processes should be perceived with multiple senses, so that nature is heard, tasted, smelled, and touched. In terms of auditory, the sound of cities should be minimized and avoided. Biophilic design tries to
insulate unpleasant sounds from city traffic and other people. A noise buffer along the main streets with a high volume of traffic can mitigate traffic sounds. In parks, the active recreation area and the passive recreation area should be separated to encourage biophilic sounds. The principle attempts to provide some opportunities for city residents to hear nature, like flowing water, singing birds, and flying bees. These elements can improve the auditory connection with nature.

In terms of gustatory, it can be achieved by building some edible gardens, herb gardens, or urban food production on the neighbourhood and planting some fruit trees along streets and in parks. In this way, the biophilic principle can engage people in the landscape. On the other hand, edible vegetation provides habitats for wildlife and attracts them. As a result, it can also enhance the biodiversity of the site. For olfactory senses, the principle can be achieved by planting fragrant flowers and trees and encouraging smells of fresh soils and rainfall.

Nature and natural systems can also be perceived by feelings, such as the breeze and the sun on the skin. Thus, design projects should consider microclimate patterns, such as providing open lawn for sunbathing and avoiding blocking spaces to allow airflow freely on the site.

3.1.3 Presence of Water

This principle refers to the presentation of water in biophilic design projects that improve the experience with the place by sounds and views of the water. Water is an essential natural element. The presence of water in the landscape is various. Natural forms of
water are the most general forms in the environment, like rivers, streams, lakes, and natural ponds. Usually, people have hydrophilia because water can make human beings feel calm and peaceful. When a site already has natural water resources, biophilic design can use the resources as opportunities to create some seating positions around water or to build a trail along the water to enhance visual connection. However, in the urban environment, most sites do not have natural water. The presence of water can be achieved by building fountains and ponds, including stormwater detention. The sound and movement of water can provide multiple sensory experiences. Ponds can provide habitat for some aquatic plants to improve biodiversity. When the size of the site is limited and cannot support a permanent water feature, some seasonal and temporary water features are also good choices. For example, designing open swales along the trails and rain gardens along pathways will provide opportunities to view water during and immediately after rainfalls. This design approach also contributes to the collection of rainwater and the reduction of runoff.

### 3.1.4 Connection with Natural System

The connection with natural system principle refers to how biophilic design projects should serve some ecological functions in the landscape. The biophilic design of spaces needs to be a part of natural ecosystem functions and enhance the connection between the space and natural processes. It can be achieved by highlighting the seasonal and temporal changes that improve the ecological function of the site. For example, designed flowering plantings on site can provide nectar for bees in support of pollination. In linear landscape elements, improving the connectivity to support the flow
of wildlife can increase the ecological function of the landscape. Connection with the natural system can also be achieved by providing various habitats to support biodiversity. Sometimes, this principle pairs with the presence of water principle, building open swales and rain gardens that make the space involved in rainwater capture more ecologically-viable through connected native vegetation. Presenting seasonal patterns is also a way to connect with the natural system by planting various plant species that show different colours and vegetative stages along with seasonal changes. Moreover, native plants in design can improve the ecological value and enhance the connection with nature.

3.1.5 Natural Forms and Patterns

The principle for natural forms and patterns refers to how the design and arrangement of a biophilic project should follow organic lines and patterns and avoid the use of geometric lines and shapes. A biophilic design should present a natural and unstructured environment that seems less contrived by humans. For example, the arrangement of vegetation should be random or follow freely-flowing lines. For the trail and other landscape elements, a biophilic design would use curvilinear shapes or natural forms instead of geometric shapes. The natural forms are not limited to the flat surfaces or unbuilt-form; they can also be used vertically and for structures. For example, in larger areas, designs should avoid flat surfaces and can change elevations of some parts to present natural terrain. The presence of natural terrain can also enhance the prospect of the site – the ability to get an overview provided by elevation.
Plants of different heights and colours can create natural forms and patterns from an elevated viewpoint to help reinforce natural forms and patterns.

### 3.1.6 Material Connection with Nature

This principle refers to how biophilic design attempts to use natural materials that help people link to the natural environment. Instead of concrete and asphalt, pathways can use various materials to present a natural feeling, like gravel, river stones or natural stones. Some permeable pavements for water permeability can also provide for connections with nature. Moreover, river stones and natural stones can also be used in a biophilic design project as part of raingardens. Natural materials such as wood and other plant materials can be used for some furnishings, such as pergolas, arbours, benches, and picnic tables. The colours of materials should be in a natural colour palette instead of a vibrant but unnatural colour scheme.

### 3.1.7 Complexity

The complexity principle refers to how a biophilic design should present information-rich landscapes that are like natural environments. However, spaces cannot be too complex because they begin to feel crowded and overwhelming. This principle pairs with other principles such as the enticement and visual connection with nature. According to Papadimitriou (2010), landscape complexity includes three types: structural complexity, functional complexity and qualitative complexity. Structural complexity can improve by creating a biodiversity environment through, for example, layered vegetation. The plants
need to be different in colours, forms, and flowering times. This ensures visual complexity in different seasons and weather. Functional complexity can be improved by increasing recreational functions and ecological functions, for example, increasing recreational facilities to provide more-diverse recreational opportunities. The qualitative function can improve by increasing vegetation coverage (area) and habitat types (diversity).

3.1.8 Prospect

This principle refers to creating unobstructed views in biophilic design. Prospect can provide the space with a sense of safe and open views that are typically associated with natural ecosystems like prairies or savannas. Open spaces without objects that block sights can create prospect, like open lawns, baseball diamonds, and some other sports fields. A narrow but long opening can create prospects, like narrow pathways without occluding objects. Usually there is a focal point at the end of the view. The distant prospect can be achieved with views of over 30 metres that can provide a good sense of openness (Herzog & Bryce, 2007). The minimum distance that creates a sense of prospect is 6 metres (Herzog & Bryce, 2007). Elevation change can also support a sense of prospect by having a high viewpoint for overlooking the landscape. If space is too open, it makes people feel unsafe and they can feel like they are being observed by others.
3.1.9 Refuge

Refuge refers to providing a safe condition in which people can feel protected. Standard protections are from behind and above. It requires that the designed space provides some observation areas in which individuals can watch others' activities without being seen. In open spaces and parks, the biophilic design should provide some seating areas with vegetation arranged to protect from behind and above.

3.1.10 Enticement

The final principle of enticement refers to how obscured views promise there is more information behind the scene and attract visitors to explore more, equivalent to the concept of mystery (Kaplan and Kaplan, 1998). Enticement usually appears at the entrance of parks and open spaces. It can be achieved by curvy edges and screening to partially block views. However, some interesting focal points and elements like statues or gardens need to be presented to attract visitors to travel deeper into the three-dimensional space. Wayfinding can also entice people to explore an area. Changing views along seasons can also make the space more interesting and attract more people.
<table>
<thead>
<tr>
<th>BIOPHILIC DESIGN PRINCIPLES</th>
<th>DESCRIPTION</th>
<th>FEATURES</th>
</tr>
</thead>
</table>
| 1. Visual Connection with Nature | Provide views of natural elements, or natural processes |  • Vegetation  
  • Wildlife  
  • Soil and terrain  
  • Seasonal Change  
  • Vegetation coverage over 50%  
  • Natural form vegetation  
  • Green wall  
  • Biodiversity |
| 2. Non-visual Connection with Nature | Build a positive connection between people with nature in multiple senses, like auditory, gustatory, olfactory, and haptic |  • Noise buffer  
  • Separate active and passive recreational area  
  • Flow water  
  • Singing birds  
  • Flying bees  
  • Edible garden  
  • Fragrant flowers  
  • Airflow freely  
  • Open lawn |
| 3. Presence of Water | Present water that improves the experience with the place by sounds, views of the water |  • Connection with natural forms of water like lakes and rivers  
  • Fountains  
  • Pond  
  • Swale  
  • Raingarden |
| 4. Connection with Natural System | Serve some ecological functions in the ecosystem |  • Flower plants  
  • Improve connectivity  
  • Rainwater capture  
  • Different seasonal patterns  
  • Native plants |
| 5. Natural Forms and Patterns | Design and arrangement of a biophilic project should follow organic lines and patterns and avoid the use of straight lines and diagonal lines | • The natural form of vegetation arrangement  
• Natural terrain  
• Free flowing trails  
• Vegetation in different heights |
|---|---|---|
| 6. Material Connection with Nature | Try to use natural material that can make users link to the natural environment | • Gravels  
• River stones  
• Natural stones  
• Wood and bamboo structure  
• Natural colour palette |
| 7. Complexity | The design should work with some degrees of complexity to present information-rich feelings that are like natural environments | • Biodiversity  
• Plants in different colours, textures and flower time  
• Recreational functions  
• Multiple ecology function  
• Multiple habitats  
• Vegetation coverage over 50% |
| 8. Prospect | Creating unobstructed views in the biophilic design | • Open lawn  
• Baseball diamond  
• Sporting field  
• Narrow pathway without disturbance  
• Elevation change |
| 9. Refuge | A safe condition in which people can feel protected | • Canopy tree  
• Sitting area with protection  
• Shrub screen  
• Adequate light |
| 10. Enticement | Obscured views to promise there are more information behind the scene and attract visitors to explore more | • Curvy edges  
• Green screens  
• Wayfinding  
• Changing view along seasons |
3.2 Site Selection Criteria

3.2.1 Accessible to abundant nature

This research project focuses on the relationship between urban areas and the ecological environment. The selected study site should have the typical characteristics of urban places and be potentially accessible to nearby nature.

The ravine system in Toronto is a precious natural resource that shapes the city’s landscape. It has high ecological values, but also provides recreational opportunities for citizens. The central principle of a biophilic city is to enhance humans’ contact with nature, and the natural ravines can provide places for people to get away from the built environment and connect with nature. The ravines act as an ecological corridor to link the ecological systems and different parts of the city. Beatley (2010) summarized the critical design elements of biophilic urban design; ecological corridors are indispensable elements for a biophilic city at both community and city scales.

Thus, taking advantage of the natural system on site selection and enhancing the connection between the site and the natural system will benefit the application of biophilic city principles. In addition, the corridors not only connect the site at the community scale but also connect the natural system at regional and city scales. Moreover, the ravine system is typical of the natural ecosystem of Toronto, so selecting a site along the ravine system will provide for generalizability within the city.
3.2.2 High Population Density

In the Background section, the future urban population growth has been discussed. Toronto, according to the data from the World Population review, is the fourth largest city in North America with a population of 2.8 million in 2016. The human population is expected to increase over the next three decades (Toronto Population).

However, according to research by the Fraser Institute (2018), compared with other major cities, Toronto’s human population density is low with 4,457 people per square kilometre. Table 3-2 shows the population density of Toronto compared with a number of other major cities. It has the sixth highest population density of cities in North America.

Table 3-2 Population Density of Major Cities                Data from: Fraser Institute, 2018

<table>
<thead>
<tr>
<th>City</th>
<th>Population Density</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hong Kong</td>
<td>25,719</td>
</tr>
<tr>
<td>Tokyo</td>
<td>14,796</td>
</tr>
<tr>
<td>Singapore</td>
<td>11,245</td>
</tr>
<tr>
<td>London</td>
<td>11,054</td>
</tr>
<tr>
<td>New York</td>
<td>10,935</td>
</tr>
<tr>
<td>San Francisco</td>
<td>7,171</td>
</tr>
<tr>
<td>Vancouver</td>
<td>5,493</td>
</tr>
<tr>
<td>Montreal</td>
<td>4,916</td>
</tr>
<tr>
<td>Chicago</td>
<td>4,594</td>
</tr>
<tr>
<td>Toronto</td>
<td>4,497</td>
</tr>
<tr>
<td>Seattle</td>
<td>3,244</td>
</tr>
<tr>
<td>Manila</td>
<td>2,468</td>
</tr>
<tr>
<td>Calgary</td>
<td>2,112</td>
</tr>
</tbody>
</table>

From the perspective of the biophilic city, higher population density makes it more possible to walk and live outside every day. Higher density contributes to the walkability of the community and encourages citizens to walk more. Through natural and ecological
street designs, the daily walks of more citizens might increase their contact with nature. A high-density area chosen as a research site will make the research more meaningful and applicable to future city conditions.

### 3.2.3 Multiple Land Use Typologies

According to Beatley (2010), to achieve a biophilic city, natural and biophilic elements should be applied at every spatial scale and within every land use typology, such as street systems, parks, and neighbourhoods. The biophilic features across different scales and land uses can reinforce the biophilic behaviour of the local citizens.

The diversity of land uses can increase interactions among different areas of the city neighbourhoods and provide various services rather than singular functions. Moreover, multiple land use typologies can provide comprehensive opportunities for biophilic design principles. This project will compare the applications of biophilic principles on different land uses and scales. It will also analyze the challenges and opportunities that different land use typologies face during the design process.
3.2.4 Selected Site

The Jane-Finch neighbourhood was selected as the study site, which meets the listed site selection criteria. First, it is along the green corridor on the east side which provides opportunities for the community to experience natural vegetation. In addition, a power line corridor goes across the area, which offers potentials to enhance greenspace connectivity. Second, the area has a high population density compared with the other suburban areas of Toronto. This area is mainly composed of mid-to-high rise
apartments. Finally, there are multiple land use typologies on the site, such as residential, commercial, and green corridors, which provide opportunities to explore the application of design principles.

3.3 Site Overview

The selected site is located on the northwest edge of Toronto which is centred at the Jane and Finch intersection. The site boundaries are Highway 400 to the west, Sheppard Avenue to the south and the Steeles Avenue to the north. On the eastern side, there is a green corridor going across the site (See Figure 3-1).

The current Jane-Finch community was developed in the 1970s. The government intended to build an instant community to meet the requirements of the fast-growing populations in suburban areas and provide housing to low-income families in the community (Jane-Finch.com, 2016). The percentage of private dwellings within the apartment towers (refers to apartment buildings of five stories or more) is higher than the average percentage of Toronto (City of Toronto, 2018b). In some areas, building towers with long lengths were placed along the main road creating superblocks of high population density (see Figure 3-2). For the single-family houses, the majority of them are detached, or semi-detached houses with front yards predominated by concrete or asphalt driveways. The area was planned to provide accommodation to a high population with low incomes; few thoughts were given to landscape design and infrastructure (Jane-Finch.com, 2016).
3.4 Site Land Use Typologies

From the land use map (see Figure 3-2) of Toronto’s Official Plan; there are multiple land use typologies on the site. Because of the research scope, the thesis will only focus on public spaces that include the streets along the single-family neighbourhood, main streets, parks, and green spaces. The site inventory is based on different land use typologies, and typical features will be described and summarized for each typology.

![Land Use Designations](map.png)

Figure 3-2 Land Use Map of Jane-Finch Neighbourhood (not to scale), (Source: Toronto Official Plan, 2015)
3.4.1. Single Family Residential Neighbourhoods

The single-family residential neighbourhoods comprise most of the site area. There are three types of single-family houses including detached houses, semi-detached houses, and townhouses. Among them, semi-detached houses predominate followed by the detached houses. Townhouses only take small portions of the total area of single-family dwellings.

Generally, the street setback for single-family houses is small. As a result, the front yard is small with limited area for planting. Especially for the semi-detached houses, the two-lane driveway takes a significant amount of space, and only a small portion between two semi-detached houses is green (See Figure 3-3). From the street the visual connection with nature is weak, and buildings occupy most of the view. There are sidewalks along both sides of the single-family residential streets that take spaces for green areas. The driveway entrances fragment the public boulevards along the street.

Figure 3-3 Semi-Detached House Plan and Perspective in the Jane-Finch Neighbourhood of Toronto, Canada
The plant species diversity on the public boulevards is limited. Typically, there are only trees and mown turf on the planting zone along the street, and no shrubs or perennials in the street right-of-way. The single-family residential neighbourhood is highly homogenous with similar and rigid streetscapes for both detached and semi-detached houses.

Because the residential areas lack planting and adequate setbacks, the house owners have limited privacy. They can easily be seen by pedestrians and neighbours. Similarly, pedestrians on the streets also lack a sense of privacy because they are open to the view from inside house.

3.4.2 Apartment neighbourhoods

Apartments are mainly located along both sides of Jane Street including mid-rise and high-rise apartments. The mid-rise apartment here refers to buildings that are five stories and below. High-rise apartments here refer to residential buildings more than five stories. Generally, the number of high-rise apartments is much more than mid-rise apartments. Notably, most of the high-rise apartments are more than ten stories; the tallest apartment in the neighbourhood is 33 stories.

For most of the apartments, there are some green spaces around the building. However, the design of landscape is rigid and lacks species richness and textured richness. Forms of planting beds and sidewalks are in straight lines. On Jane Street, the public planting zones have a similar problem to the single-family neighbourhoods with limited species diversity. Some planting zones are only covered by mown turf. There are no buffers zone between the apartments and the street. The residents in the
neighbourhood suffer from noise pollution that originates from traffic. Fragmentation of public planting zones on main street is less distinct than that on the single-family neighbourhoods because the entrances to the apartments’ parking lots on the main street are much less closely-spaced than the entrances to the driveways in single-family neighbourhoods, providing more space for connected plantings.

3.4.3 Parks and Open Space Area

In this neighbourhood, there are 17 parks. However, nine of them primarily serve as sports fields. Sports programs include soccer, basketball, and tennis. Because sports fields need to follow certain programmatic standards, this limits the park's design and area of plantings. The nine sports parks are near the single-family neighbourhoods, and with sizes from 0.5 ha to 2 ha. Mertes and Hall (1995, p. 94) stated that the service radius of a mini-park which is generally between 0.4 ha to 2 ha is less than 400 m. Thus, the parks primarily serve residents around them. The parks are isolated from each other and to address a specific recreational need for the neighbourhood. They provide active recreational opportunities for nearby residents, but the recreational programs are limited. Limited by size, each park commonly provides one to two sporting programs. (See Figure 3-4). Apart from the sporting facilities, there are little other infrastructure and a limited amount of non-mown vegetation.

Because of the low canopy coverage, most sports parks have limited ecological value. The parks cannot provide habitats for various wildlife to make the spaces biologically diverse and more full-textured. The locations of the parks are isolated and surrounded
by dwellings. Moreover, the parks’ designs do not follow natural forms. The shapes of sports fields are rectangular or fan-shaped as required and made of concrete, turf, stone dust, or other industrial material. Even though the parks provide outdoor spaces for residents, the connection with nature is weak.

Figure 3-4 Hullmar Park, a sports park in the Jane-Finch neighbourhood.
Similar to the parks, the open space under the power line towers also has limited ecological value. The green space is mostly covered by turf and lacks biodiversity (See Figure 3-5). The recreational trail going through the open space does not follow free-flowing lines. The open space under the power line intersects with the green corridor going through the neighbourhoods from the north to the south. The location of the open space could be an advantage to increase the ecological connectivity of the area by increasing ecological value through biophilic design.

Figure 3-5 Green Space Under Powerlines in The Jane-Finch Neighbourhood.
3.5 Data Collection and Analysis

To examine how the design principles fit the neighbourhood, a typical site will be selected to represent each of a few land use typologies. For the single family residential neighbourhoods, because the semi-detached housing type is the most-extensive housing typology, a street in the front of semi-detached houses will be selected to propose a design solution. Similarly, along Jane Street most of apartments are high-rise, so a part of Jane-Street in front of high-rise apartments will be selected to apply biophilic principles. For single family residential and apartment neighbourhoods, the design will be presented in a plan and section to show the changes from the existing condition. A park with sports facilities and surrounded by houses will also be chosen to apply the biophilic design principles. For parks and open spaces, it will be presented in a plan drawing.

The design will start from the problems identifiable from the site inventories (sections 3.4.1 to 3.4.3). Then to solve the problem, the principles summarized in sections 3.1.1 through 3.1.10 and Table 3-1 are used to guide the application of as many biophilic features listed under each design principle as the site can reasonably accommodate without compromising the program apparent in the site and typology observations and photographs. Finally, the designer will continue iteratively adjusting the design to make sure all possible biophilic features are included in the design.

After the initial design, an assessment (count) of how many features included in the design and how well it fits the site will be performed. The assessment will be based on the number of biophilic features under each principle, and if the presence of the biophilic feature appears to negatively impact the normal functions of the site or landscape type.
Finally, an overall rating will be given and presented in a table on how well each principle fits the sites by types. The rating is provided at three levels, “good” means the principle can apply to the site and increase the chances with nature without impacting the normal function; “medium” means the principle can apply to the site without impacting the normal function but also with limited benefits on improving nature contact, and “poor” means it is difficult to apply the principle to the site or doing so significantly impacts the site’s functions.
4.0 Introduction

This chapter describes the application of the biophilic design principles to three landscape types in the Jane-Finch neighbourhood of Toronto. Three sites were chosen: two streetscape typologies (residential and main) and one park/open space. Each type is described and broadly analyzed, then the biophilic design is proposed and illustrated, and then evaluated for the achievement of principles and ease of fit.

4.1 Residential Street Design Typology

A design solution was developed for a residential street to apply the biophilic principles to change existing problems of improving opportunities for contact with nature.
As this street is crowded with elements to ensure the normal functions of streets and meet the requirement of traffic flow, a restrained intervention was made for the residential street. The structures of residential streets did not change in the design solution. The width of the car lanes, sidewalks, and planting bed remain the same dimensions to support vehicular circulation. The design focuses on the planting area along the residential street and in the public right-of-way. Though it is a narrow area (approximately 3 metres wide), there are still some opportunities to contact with nature.

The biophilic design maintains existing street trees in the right-of-way area but changes the elevation slightly, so in the centre of planting beds, there is a rain garden to capture
rainwater and visibly present water. Various native shrubs and perennials with different colours and textures are planted in the planting bed to provide diverse ecological value.

The following sections assess the application of the biophilic principles to this landscape type.
4.1.1 Visual Connection with Nature

As the design does not change the current street structure, the size of green space of along residential street does not change as well. This means that the planting area does not achieve a critical threshold value which is vegetation proportions over 50%, but as in Figure 4-4, vegetation proportions can increase in the visual plane, achieving higher values than planform proportions. However, the construction of rain garden provides habitat for native vegetation and enhances the biodiversity of the area and might attract...
some wildlife like birds and insects. The planting design varies texture and form. These plants can present different colours and form along with the change of seasons.

### 4.1.2 Non-visual Connection

The design changes the elevation of the planting bed, so when there is rain, the river stone can gather water and temporarily detain runoff. The various edible plants can attract birds and insects that enhance natural sounds. The fragrant flowers provide the space with pleasant smell during the blooming period. Some plants are edible and provide food sources for wildlife and people. There are no barriers on streets and sidewalks so air flows freely with sound and sensation. People can feel the breeze when the weather condition allows. The canopy trees can provide summer shade on public sidewalks and streets.

### 4.1.3 Presence of Water

The residential area is without natural water pooling. The rain garden can temporarily gather and detain water during wet weather, but the presence of water is limited by weather. Due to the size of rain gardens, the amount of water on site is limited. Finally, combining vegetation with the rain gardens means that the visibility of water can be obscured by plantings, making this principle possible to achieve, but for short durations and limited conspicuousness.

### 4.1.4 Connection with Natural System

The planting beds serve some ecological functions for the streetscape. The flowering plants provide nectar and pollen for bees and butterflies, and the edible plants provide food sources for wildlife like birds and small mammals. However, even though there are
planting beds proposed on both side of the residential streets by the biophilic principles, they are fragmented by the entrance to the driveway of each house. The average dimension of planting beds is 3.5 by 7.5 metres, so the ecological connectivity at ground-level is limited in the area. However, the rain garden can capture rainwater and reduce run-off. The diversity of native and horticultural plants enhance the human connection with the natural system.

4.1.5 Natural Forms and Patterns

The residential street design maintains the current structure and dimension, so sidewalks still follow the current straight-line layout. However, the arrangement of vegetation follows organic forms both in vertical and horizontal and the shapes of rain gardens are curvilinear. The biophilic design applies and increases natural forms and patterns at human scales. However, at the street scale, the form remains geometric for vehicular circulation.

4.1.6 Material Connection with Nature

This typology offered limited opportunities to increase natural materials because structural amenities are limited. River stones were used in the rain garden. The current sidewalk is made of concrete, however, and the street surface is asphalt. With no other elements for natural materials such as wood and stone, the material connection with nature is limited.
4.1.7 Complexity

For structural complexity, the planting beds increase urban biodiversity with plants of different colours, texture, and forms. The planting bed increases the richness of information is structurally-layered with herb, shrub, and canopy layers. For functional complexity, the streetscape plantings provide some ecological functions such as nesting, nectar, cavities, and vertical structure, but human recreational functions are limited. The biophilic streetscape design can encourage some additional passive recreational opportunities like walking and running, but surface changes from turf to diverse plantings reduces walkable surfaces. The overall vegetation planform coverage is under 50%, but types of plants are various and in view plane increase from planform. In general, the qualitative complexity of the site is limited because only a limited portion of right-of-way is covered with vegetation.

4.1.8 Prospect

Along residential streets there are no open spaces and fields-of-view are limited by buildings. Elevation changes along the street are not visually-significant and do not provide an elevated overlook position. The straight sidewalk, where surrounded by the planting bed and private yard, can be seen as a narrow opening that allows vista, even as it is disturbed by entrances to driveways. Therefore, the prospect principle and its features were difficult to achieve for this landscape.

4.1.9 Refuge

Overall, the residential streetscape is designed for safe use. There are some canopy trees providing protection from above. Shrubs in the planting bed can block unwanted
views. Street lamps provide illumination. The terrain changes and diverse plantings that result from biophilic principles attempt to maintain openness and safe use, without creating obstacles to natural surveillance: shrubs and sub-canopy plants that might block views are limited (see Figure 4-4).

4.1.10 Enticement

The planting beds can be described as interesting features along the street that can attract pedestrians to take a closer look. The curvy edges of the rain garden and openness in the centre can give obscured, mysterious views to attract residents to explore more. The geometric layout of the street and sidewalks do not increase enticement, but the incremental rain gardens in the right-of-way provide for serial exploration and enticement.

4.1.11 Residential Streetscape Typology Assessment

In general, there were opportunities for most of the biophilic principles, yet some limits were also clear when spatial dimensions, planform layouts, or programmed functions restricted additional biophilic interventions. Table 4-1 summarizes under each biophilic design principle what features are presented in the proposed design for this typology. An overall assessment for how well each principle fit the area is also given based on the review of application.
Table 4-1 Summarize the assessment of residential street design based on biophilic design principles

<table>
<thead>
<tr>
<th>BIOPHILIC DESIGN PRINCIPLES</th>
<th>FEATURES</th>
<th>PRINCIPLE ACHIEVED?</th>
<th>EASE OF FIT?</th>
</tr>
</thead>
</table>
| 1. VISUAL CONNECTION WITH NATURE | - Vegetation  
- Wildlife  
- Soil and terrain  
- Seasonal Change  
- Natural form vegetation  
- Biodiversity | ✓ | Good |
| 2. NON-VISUAL CONNECTION WITH NATURE | - Flow water  
- Singing birds  
- Flying bees  
- Edible garden  
- Fragrant flowers  
- Airflow freely | ✓ | Good |
| 3. PRESENCE OF WATER | - Rain garden | ✓ | Medium |
| 4. CONNECTION WITH NATURAL SYSTEM | - Flower plants  
- Rainwater capture  
- Different seasonal patterns  
- Native plants | ✓ | Good |
| 5. NATURAL FORMS AND PATTERNS | - The natural form of vegetation arrangement  
- Natural terrain  
- Vegetation in different heights | ✓ | Medium |
| 6. MATERIAL CONNECTION WITH NATURE | - River stones | ✓ | Poor |
| 7. COMPLEXITY | - Biodiversity  
- Plants in different colours, textures and flower time | ✓ | Medium |
| 8. PROSPECT | - Narrow pathway | ✓ | Poor |
| 9. REFUGE | - Canopy tree  
- Shrub screen  
- Adequate light | ✓ | Medium |
| 10. ENTICEMENT | - Curvy edges  
- Green screens  
- Changing view along seasons | ✓ | Medium |
4.2 Main Street Typology

As Jane Street goes through the neighbourhood, there are mid-rise and high-rise apartments along both sides of the street. A segment of Jane Street was selected to apply the biophilic design principles (See Figure 4-5).

As with the residential street typology, to support the normal traffic volume and flow the structure of four lanes does not change. The bus stop shelter on the side of Jane Street also remains. There is a paved boulevard area between opposing lanes that was considered opportune to increase vegetation coverage by transforming it from asphalt into an area for planting. The design also considered that the current straight sidewalks were opportune for natural forms and increases in vegetation coverage for the neighbourhood.

Figure 4-5 Existing Main Street Conditions on Jane Street (Source: Google Maps)
Figure 4-6 Proposed Main Street Plan on Jane Street

- Bus Station
- Sitting Area
- River Garden
- Fountain
- Street Tree
4.2.1 Visual Connection with Nature

The biophilic design keeps the original width of the right-of-way planting bed – currently in mown turf – along Jane Street, but it changes the structure of sidewalks and increases the number and diversity of plant species, in place of mown turf. The new design includes multiple plant layers that build a space with biodiversity and enhance the visual connection with nature. However, the vegetation coverage of the whole plantable right-of-way is still below 50%. The layouts of sidewalks and planting beds are designed to follow natural forms and organic arrangements of vegetation. There is a slight elevation change in the planting bed to show the natural terrain. The biodiversity of the streetscape has increased to attract more wildlife like birds and insects. The
vegetation on the site is more diverse, and present different colours and forms along with seasonal change.

4.2.2 Non-visual Connection with Nature

The main street has daily heavy traffic which is a source of noise. To attenuate the noise and provide a more-peaceful environment where pedestrians walk and sit, on the side closest to the street some shrubs are planted to buffer the sense of traffic sounds. Sounds from wildlife such as birds and insects can also increase the auditory sense of the streetscape. The design adds fountains to widened areas of the sidewalk to enrich the auditory presentation. Olfactory connection with nature can be achieved by the scent of flowering plants in the streetside plantings. Similar to residential streets, the dimensional limits result in only a few edible plants designed for the streetscape.

4.2.3 Presence of Water

Along the street, there is no presence of natural water forms. To provide water in the place as a way to meet the biophilic principles, small fountains are designed where the sidewalks are wider to act as a focal point to attract people’s attention. There are designed rain gardens in the planting beds to capture and detain water temporarily during wet weather.

4.2.4 Connection with Natural System

The flowering plants on the site can provide nectar and pollination opportunities and show different forms along with the seasons. Most plants on the site will be native plants
that increase the ecological value of the site. Different from the residential street, the entrances along the main street are fewer and farther apart than on the residential streets. This makes the planting areas less-fragmented as in residential areas and improves the connectivity. The rain gardens capture and detain rainwater and reduce run-off while providing an opportunity for people to connect with the natural system.

4.2.5 Natural Forms and Patterns

The layout of the sidewalk and planting beds are natural, following free-flowing lines. The design elements on the site also are curvilinear, such as the fountains and seating areas. Horizontally, elevation changes use natural landforms to visually present natural-looking terrain. The heights of plants also have natural variability. At both human- and street-scales, the design achieves the natural forms and patterns principles.

4.2.6 Material Connection with Nature

Multiple natural materials are used in the design. The seats along the sidewalk are made from wood. The sidewalks are constructed by permeable pavement. The design applies natural stones and river stone in the river garden. The colour of materials also follows the natural palette. The use of natural wood and stone materials associates the design with nature.

4.2.7 Complexity

To achieve structural complexity, the various plants are in different forms, colours, textures, and layers to support a more biologically-diverse landscape. In addition to the transportation function, the streetscape also provides seating areas and fountains to enrich the recreational functions for pedestrians. However, recreational functions are
still limited to passive recreation due to the streetscape vehicular and pedestrian circulation requirements. Though the vegetation coverage is below 50%, it also provides ecological functions such as rainfall interception, habitat for urban wildlife, and carbon capture and storage, all within a restricted size limit.

4.2.8 Prospect

Similar to residential streets, the prospect principle is hard to achieve along main streets. There is no open view present on the site such as an open lawn or sports field vista. Different from the residential streets, however, the sidewalk has only a few interruptions that allow for longer views. There are designed elevation changes within the plantings, but these are not intended for human circulation. The prospect principle is achieved in the biophilic site design, but the principle fits poorly for the site.

4.2.9 Refuge

The refuge principle is achievable for the streetscape by providing canopy trees along both sides of the sidewalks. Behind the seating areas, there is a shrub screen to provide pedestrians seated there with a feeling of safety. Shrub screens on the street side of the pedestrian walkway can block views from the traffic.

4.2.10 Enticement

The biophilic principles result in a design that is rich with information and can provide interesting experiences for visitors. The shapes of sidewalks are curving which obscures the view and attracts people to walk them. Moreover, the view changes along with season that can encourage pedestrians to explore more of the streetscape.
4.2.11 Main Streetscape Typology Assessment

The main street landscape type offered additional spatial dimension that affected the application of biophilic principles. Compared to the residential street type, the main street allowed more application of principles. Table 4-2 summarizes under each biophilic design principle what features are presented in the proposed design and how well they fit.
Table 4-2 Summary and assessment of main street design based on biophilic design principles

<table>
<thead>
<tr>
<th>BIOPHILIC DESIGN PRINCIPLES</th>
<th>FEATURES</th>
<th>PRINCIPLE ACHIEVED?</th>
<th>EASE OF FIT?</th>
</tr>
</thead>
</table>
| 1. Visual Connection with Nature | • Vegetation  
• Wildlife  
• Soil and terrain  
• Seasonal Change  
• Natural form vegetation  
• Biodiversity | ✔️ | Good |
| 2. Non-visual Connection with Nature | • Noise buffer  
• Flow water  
• Singing birds  
• Flying bees  
• Fragrant flowers  
• Air flows freely | ✔️ | Good |
| 3. Presence of Water | • Fountains  
• Rain gardens | ✔️ | Medium |
| 4. Connection with Natural System | • Flowering plants  
• Improve connectivity  
• Rainwater capture  
• Different seasonal patterns  
• Native plants | ✔️ | Good |
| 5. Natural Forms and Patterns | • Natural form of vegetation arrangement  
• Natural terrain  
• Free flow trails  
• Vegetation in different heights | ✔️ | Good |
| 6. Material Connection with Nature | • Gravels  
• River stones  
• Natural stones  
• Wood and bamboo structure  
• Natural colour palette | ✔️ | Good |
| 7. Complexity | • Biodiversity  
• Plants in different colours, textures and flower time  
• Recreational functions  
• Multiple ecology function  
• Multiple habitats | ✔️ | Medium |
| 8. Prospect | • Narrow pathway without disturbance  
• Elevation change | ✔️ | Poor |
| 9. Refuge | • Canopy tree  
• Sitting area with protection  
• Shrub screen | ✔️ | Good |
| 10. Enticement | • Curvy edges  
• Green screens  
• Wayfinding  
• Changing view along seasons | ✔️ | Good |
4.3 Parks and Open Spaces

Parks and open spaces in the Jane-Finch neighbourhood are faced with similar problems to other landscape types: they lack plants species diversity and have geometric, unnatural design forms. To increase the biophilic features and increase the opportunities to connect with nature, a neighbourhood park was selected to apply the biophilic design principles.

The park is surrounded by single-family and detached residential dwellings and serves as a sports park with two outdoor basketball courts, three tennis courts and two bocce courts. The biophilic re-design kept the sports facilities to continue to provide active recreational opportunities for residents. The proposed park will add passive recreational opportunities and increase plants to enrich the park.

Figure 4-8 Existing Neighbourhood Park in the Jane-Finch Neighbourhood, Toronto, Canada (Source: Google Maps)
Figure 4-9 Proposed Parks and Open Spaces in Jane-Finch Neighbourhood, Toronto, Canada.
4.3.1 Visual Connection with Nature

The proposed biophilic design provides rich information and strong visual connections with nature. The vegetation coverage of the park is over 50% and in multiple plant structural layers including canopy trees, understory layer, shrub layer, and herb layer. The varied vegetation creates additional biodiversity. There is an elevation change in the open lawn area that mimics natural landforms. There are multiple habitat types in the park, including a pollination station, edible gardens, tree canopies, and a pond that can support wildlife. The trees around the boundaries of the park both limit the views from residential houses and enhance visual connections with nature.

4.3.2 Non-visual Connection with Nature

The trees around the park boundaries not only limit the residential views but also attenuate noises from outside the park and create a more-peaceful environment. The active recreation areas such as basketball and tennis courts are separated from each other by vegetation screens. There is a pond in the park where visitors can see water and aquatic plants. The wildlife in the park - birds and insects, especially - can also enhance the auditory experience. There is an edible garden of vegetables and herbs adjacent to the picnic area; it enables the landscape to be tasted. The design provides for some fruit trees in the park, enhancing the gustatory connection with nature. There are multiple fragrant flowers in the pollination station that not only attract bees, butterflies, and birds, but also provide the park with pleasant smells. The open lawn can provide a place for sunbathing in warm weather.
4.3.3 Presence of Water

There is a pond by the trail, that provides habitat for aquatic plants and increases the biodiversity of the park. The pond enhances the multiple sensory experiences of the park through the sounds of water flowing from the fountain. Along the trail, there is a bioswale that collects rainwater and temporarily detains water in the park.

4.3.4 Connection with Natural System

The park has high ecological potential to connect with the surrounding natural systems. There is a large pollination station planting with flower plants. The pond and the swales along the trail can contribute to capturing and restoring rainwater. Plants in the park are mostly native plants to increase the ecological value. Because of the diversity of plants, vegetation has different seasonal patterns that also connect with nature. The design can enhance the ecological connectivity in the park by supporting species dispersal. However, parks like this one are surrounded by single-family houses which limit structural connectivity, meaning they can still need additional connectors like biophilic streets to enhance the connectivity of the whole neighbourhood.

4.3.5 Natural Forms and Patterns

The biophilic design follows natural forms and patterns in horizontal and vertical planes. The layout of the trail is curvilinear to mimic natural forms such as streams. The shapes of landscape elements in the park - including the edible garden, open lawns, and pollination station – are curvy and organic. Moreover, the arrangement of vegetation follows these natural and organic forms. The elevation changes on the open lawn also mimic natural forms to appear like remnant terrain.
4.3.6 Material Connection with Nature

Multiple natural materials are used in the biophilic design. The covered seating structures like the pergola and the pavilion are made from wood. The trails are made of gravel and river stones which, compared to the present concrete and asphalt pathway, are natural and provide for better water permeability.

4.3.7 Complexity

The biophilic-designed park has a high degree of complexity. For functional complexity, multiple recreation opportunities are provided, including passive and active recreation such as walking or free-play, and basketball and tennis, respectively. The open lawn and picnic area enrich the recreational opportunities in the park. The biophilic design has multiple ecological functions by providing multiple habitats and enhancing connectivity in the park. In terms of structural complexity, the vegetation coverage is over 50% and different vegetation combinations create varied habitats and improved biodiversity. Vegetation is designed with four vertical layers to enhance structural complexity in support of habitat. The plants also offer different seasonal views.

4.3.8 Prospect

The prospect principle is achieved well in the park, whereas it was limited in the street typologies. There are sports fields and open lawns in the park that provide open views. The elevation changes on the open lawn create a high point in the site that allows an outlook-like overview of the park. Along the trails, there are shrub screens that open vistas and enhance the sense of prospect across the park.
4.3.9 Refuge

The refuge principle fits well for the site by providing canopy trees along the trails that make the pedestrian feel protected from above. The are multiple sitting areas in the park, such as the pergola near the fountain, the pavilion on the open lawn, and the picnic table under trees. They are all protected by trees or built structures and have views to watch others in the park. The protected sitting area can make visitors feel safe. Shrub screens are also placed along with the trail near the seated areas to block views from others.

4.3.10 Enticement

The entrance of the park is curvilinear and partially blocked by vegetation, which attracts visitors to enter the park to explore. Though it is a long trail, the curvy edge can obscure some views that can evoke a sense of mystery, encouraging people to find what is behind the view. The park is dynamic with seasonal changes. These changes can keep the attention of the residents who come often to increase their contact with nature.

4.3.11 Park and Open Space Typology Assessment

The area and shape of the selected park and open space type example provided additional opportunities to apply biophilic principles. In Table 4-3, the principles are summarized and under each biophilic design principle the features are presented in the proposed design. The overall rating for how well each principle fits the area is also given in the table.
Table 4-3 Summary and assessment of main community park based on biophilic design principles

<table>
<thead>
<tr>
<th>BIOPHILIC DESIGN PRINCIPLES</th>
<th>FEATURES</th>
<th>PRINCIPLE ACHIEVED?</th>
<th>EASE OF FIT?</th>
</tr>
</thead>
</table>
| 1. Visual Connection with Nature | • Vegetation  
• Wildlife  
• Soil and terrain  
• Seasonal Change  
• Natural form vegetation  
• Biodiversity | ✓ | Good |
| 2. Non-visual Connection with Nature | • Noise buffer  
• Separate active and passive recreational area  
• Flow water  
• Singing birds  
• Flying bees  
• Edible garden  
• Fragrant flowers  
• Airflow freely  
• Open lawn | ✓ | Good |
| 3. Presence of Water | • Fountains  
• Swale  
• Pond | ✓ | Good |
| 4. Connection with Natural System | • Flower plants  
• Improve connectivity  
• Rainwater capture  
• Different seasonal patterns  
• Native plants | ✓ | Good |
| 5. Natural Forms and Patterns | • Natural form of vegetation arrangement  
• Natural terrain  
• Free flow trails  
• Vegetation in different heights | ✓ | Good |
| 6. Material Connection with Nature | • Gravels  
• River stones  
• Natural stones  
• Wood and bamboo structure | ✓ | Good |
| 7. Complexity | • Biodiversity  
• Plants in different colours, textures and flower time  
• Recreational functions  
• Multiple ecology function  
• Multiple habitats | ✓ | Good |
| 8. Prospect | • Narrow pathway without disturbance  
• Elevation change | ✓ | Good |
| 9. Refuge | • Canopy tree  
• Sitting area with protection  
• Shrub screen  
• Adequate light | ✓ | Good |
| 10. Enticement | • Curvy edges  
• Green screens  
• Wayfinding  
• Changing view along seasons | ✓ | Good |
4.4 Summary of Results

The biophilic design principles were applied to three landscape sites in two different typologies in the Jane-Finch neighbourhood of Toronto. Each application of the principles has been critically reviewed and summarized for how applicable the principle was and how easy the features associated with the principle were achieved. Across these selected sites, many principles were consistently achievable, but others had some common challenges in application. The next chapter will discuss these results in greater detail and identify principles and features that are opportune or challenged in applications in dense urban settings.
CHAPTER 5 DISCUSSION AND CONCLUSION

This chapter will discuss the application of biophilic design principles and features to three landscapes in Jane-Finch neighbourhood, with a focus on how opportune or challenged the principles were. The discussion is formatted on the principles, for applicability to other landscape locations. The chapter will finally discuss the outcomes and obstacles of the transformation of Jane-Finch neighbourhood into a biophilic neighbourhood.

5.1 Opportunities and Challenges of Biophilic Design Principles

In general, the results show that many of the biophilic design principles are achieved in the design solutions for the three landscapes. The application of each principle, however, shows various degrees of difficulty in different typologies. In general, the application of biophilic design principles in parks and open spaces was the least constrained among the three landscape typologies.

Detailed opportunities and challenges faced with the application of each biophilic principle are discussed below.

5.1.1 The Visual Connection with Nature

This principle is well-achieved in the three landscape applications through the multiple layered vegetation in natural forms and increases in biodiversity. In all three of these design solutions, there are opportunities to enhance views of natural elements such as
vegetation and natural terrain, and natural processes like seasonal changes. The relatively simple conditions of the existing landscape provide many opportunities to increase nature connections. The principle is opportune to apply in the dense urban area by increasing the layers and varieties of vegetation to visually connect people with nature. For example, on the residential streets, the vegetation area in the public right-of-way is limited in width to the public-right-of-way. Instead of expanding the planting beds that may influence the normal functions of streets and diminish safe vehicular circulation, the principle can be achieved by increasing the richness of vegetation and replacing mown turf with more diverse plants. This method is effective at providing biophilic features in dense urban areas that have limited green spaces.

A feature of the visual connection with nature principle is that the vegetation coverage should be over 50% of the spatial area. The feature is only achievable in the parks and open spaces typology where the built structure is limited. It is impossible to achieve 50% vegetation coverage in streetscapes because of the requirements for vehicular and pedestrian circulation. However, it might be possible to achieve 50% of a view as vegetated, instead of measuring only the area on a plan. While this principle states a 50% area coverage, the experience of nature by people suggests that a view-plane assessment could be a better measure of the feature. Climate conditions may influence the application of this principle. A warmer and humid climate like Singapore can create more opportunities for vegetation to enhance the visual connection to nature like on the façade of buildings. The climate of Toronto makes it more difficult to maintain green walls, which limits the visual connection to nature in urban environment.
5.1.2 Non-visual Connection with Nature

This principle is well achieved in three landscapes by creating a buffer against urban noises, planting fragrant flowers and edible plants to attract insects and birds, and presenting water to make the landscape heard, smelled, and tasted.

The fragrance of flowers is only present during the blooming period, though, limiting this connection in a temperate location. The varieties of flowering plants and their flowering time can influence the olfactory sensation of the landscape. Normally, the larger vegetation areas can provide a better non-visual connection with nature because they have more spaces to accommodate various flower vegetations that bloom at different times, but other senses can be achieved with thoughtful planting design.

5.1.3 Presence of Water

The three design solutions try to present water in sites by creating rain gardens, ponds, and fountains. The principle is opportune for water features in parks and the widened sidewalks along Jane Street which can improve the experience of the space with sounds and views of the water.

Due to the freezing temperatures of Toronto in winter, fountains need special maintenance and can not present water in winter, yet the principle is not specific about the presentation of ice as natural water. The principle is also challenged in the application to residential streetscapes because rain gardens in vegetated areas along residential streets can only visibly present water temporarily or water might be obscured by plants.
5.1.4 Connection with Natural Systems

This principle is achieved in these three landscapes by capturing and restoring rainwater, increasing the richness of native plants, and increasing landscape connectivity. The principle is opportune because the landscapes have capacity to increase their ecological values through plant diversity, and because there are locations where it can be connected with the natural ecosystem functions. The application of the principle to open spaces under powerlines intersects with ecological corridors that go through the neighbourhood from north to south, enhancing the connectivity of the neighbourhood to the City’s natural features. However, the connectivity within the residential streets typology is limited because the entrances to driveways fragment the right-of-way vegetation.

5.1.5 Natural Forms and Patterns

This principle is applicable to parks and open spaces by creating curvilinear trails, curvy and organic layouts of vegetation, and natural terrain. To apply the principle, the design mimics natural forms and reinforces the natural appearance to visually associate the landscapes with nature.

The principle is challenged in the application to streetscapes because the geometric structure of streets for vehicular circulation cannot be changed without compromising functions. The principle can be applied at human scales like the arrangement of vegetation along the streets that have insignificant impacts for vehicular circulation.
5.1.6. Material Connection with Nature

This principle is achieved in these three typologies by using natural materials for built structures and landscape fixtures. An example of how this is achieved is placing river stones in rain gardens, and natural stones in planting beds. The principle is opportune in application to the park where wooden amenities such as benches and a pergola are provided for residents. Replacing the concrete or asphalt pathways with ecological pavements like grass permeable pavers can also connect the pathways with the natural system. Because the grass pavers can provide structural sustainability for circulation and also allow the grass to grow, compared with concrete and asphalt pathways that can capture rainwater and reduce runoff.

In the residential streetscape typology, there are limited opportunities to increase natural materials, because structures are nearly non-existent and most surfaces have to be concrete or asphalt to support circulation.

5.1.7 Complexity

The complexity principle is achieved in these typologies by increasing biodiversity, recreational opportunities, and a variety of habitats. The principle is most opportune in application to parks and open spaces, as these have more space than other landscape types to create structural, functional, and qualitative complexity.

The application of the principle is challenged in streetscapes. The streetscapes cannot support multiple recreational and ecological functions to achieve functional complexity because space cannot be too complex to feel crowded and overwhelming, and to
support the vehicular movement. The qualitative complexity requires enough space for vegetation coverage and habitat types. Compared with parks and open spaces, it is difficult to apply the principle in streetscapes because of space limitations.

5.1.8 Prospect

The prospect principle is achievable in the parks and open spaces by creating open views of lawns and sports fields and an elevated outlook view. The prospect principle is opportune to apply in open spaces to mimic the natural ecosystem such savannas that can provide a sense of safety and seeing without being seen.

Consistent with the results, the principle is challenging to apply along streets. Streetscapes are linear spaces with safe, levelled topography, limiting opportunities for open views. A feature for achieving prospect is a narrow opening to frame a vista. To present the feature in streetscapes, this requires shrub screens with heights over 1.5 metres that can block views towards sidewalks on both sides of sidewalks and occlude objects on walkways and intersecting streets. The principle and feature do not easily apply to streetscapes because the enclosed sidewalks might cause some security issues, where seeing is a key attribute of pedestrian and vehicular safety. The application of prospect principle can be easier for streets in a hilly city where natural elevation changes on streets provide opportunities for elevated outlook views.
5.1.9 Refuge

The refuge principle is achieved in parks and open spaces through the planting of canopy trees, shrub screens, and providing protection for sitting area. The principle enhances people’s experiences of places by providing a safe feeling to make people willing to linger in these places. The refuge principle is opportune to apply in parks and open spaces to increase the time they spend in the spaces and increase people’s contact with nature.

Streetscapes are functional spaces that are mainly for vehicular and pedestrian circulations, where sitting areas are only occasionally provided around bus shelters for transit riders. This limits opportunities for the refuge principle in streetscapes where being seen is another key attribute of pedestrian and vehicular safety.

5.1.10 Enticement

According to the results, the enticement principle is achieved in main streets and parks and open spaces. The enticement principle attracts people’s attention and encourages them to have more outdoor activities to increase their contact with nature.

Enticement principle is challenged on residential streets because the straight street layout makes it difficult to have obscured, mysterious views and attract people to spend more time in the streetscape.
5.2 The Outcomes and Obstacles of Application Biophilic Design Principles into the Jane-Finch Neighbourhood

The application of biophilic design principles integrates nature into human scales that increase people’s daily contact with nature. Streetscapes are the most-used outdoor spaces in people’s daily routines. Creating biophilic features in streetscapes can enhance people’s contact with nature and increase the walkability of the neighbourhood.

The biophilic streetscapes also enhance the ecological and circulation connectivity of the neighbourhood. The parks in the neighbourhood are separated and surrounded by residential dwellings. Biophilic street designs can connect the parks and allow ecological flows that are beneficial to increase the ecological value of the whole site. And the biophilic design of the open spaces under powerlines can reinforce the ecological and circulation connectivity to the current green corridors which can provide abundant natural resources to the neighbourhood.

In the dense urban area, the green spaces are limited. Biophilic design can improve people’s experience of the space to increase their contact with nature. In the Jane-Finch neighbourhood, the parks and open spaces are about fourteen percent of the whole neighbourhood area; and alone, they cannot provide enough green infrastructure. By applying biophilic design principles, without expanding the areas of parks and open spaces, people can connect with nature in additional, multiple ways.

However, the application of biophilic design to the neighbourhood is likely to require more maintenance efforts compared with the existing conditions. For example, the
various plantings in flower beds along the streetscapes need more maintenance compared with mown turf. The fountain on the main streetscapes needs special care. Increased maintenance would increase the financial costs to the neighbourhood and the City of Toronto.

5.3 Limitations and Future Studies

From previous literature, the research identified the ten biophilic design principles and listed the possible biophilic features under each design principle for landscape design. Most of the biophilic principles were commonly used first in architectural design. Additional research needs to be done in the future to explore if there are other biophilic design principles and biophilic features that can enhance the experiences with places through landscape design. The benefits of biophilic design suggest that such enhancements are worth pursuing.

The applicability of principles and features was examined from the perspective of the designer, which can introduce subjectivity that might not be consistent across observers. A replicable assessment method could be explored in future study. The design solutions are presented in plans and elevations and there are no perspectives to illustrate these spaces. Three-dimensional drawings can show the specific experiences of places and spaces at human scale such as prospect and refuge. If the designs are represented in three dimensions and assessed that way, findings of the research might be more robust.
The application of biophilic principles in this research project is limited to only public spaces. According to Beatley’s theory (2011), biophilic design needs to be applied at every scale to build a biophilic city. Future research should explore how biophilic design principles fit in multiple land use typologies, including privately-owned green spaces and commercial sites, and in the design of architecture, landscape, and urban patterns to explore the opportunities and challenges of applying biophilic design principles.

The Jane-Finch neighbourhood has a crime rate problem. Theoretically, biophilic design can reduce crime rates by providing more opportunities to connect with nature, but more research should be done to explore the relationship between biophilic city principles and crime rates. Future studies need to compare the biophilic design principles with the Crime Prevention Through Environmental Design (CPTED) to identify any conflicts. CPTED is a crime prevention approach based on theories that people’s behaviours could be influenced by the environment (Toronto Police Service, 2003) and achieving reduced crime in concert with biophilic outcomes would be ideal.

5.4 Conclusion

The research has explored how biophilic design principles fit an application to Jane-Finch neighbourhood of Toronto. From the literature review, ten biophilic design principles were identified along with additional biophilic features associated with each principle. Based on the biophilic design principles and features, experimental design solutions were provided to three sites in two land use typologies in the Jane-Finch neighbourhood. These sites were two streetscapes - including residential streets and
main streets - and one neighbourhood park. The design solutions were assessed for how many biophilic features were included in the design and how well they fit the sites. According to results, the most challenging application of the biophilic design principles was to residential streets, and the most opportune was the application of biophilic design principles to parks and open spaces. While a few design principles were broadly applicable (for example, visual connect with nature), there were others that were commonly difficult to apply (for example, prospect).

The outcomes of the application of biophilic design principles to the Jane-Finch neighbourhood includes enhancing the ecological and circulation connectivity of the area and increasing people’s contact with nature without expanding the open spaces area. For landscape architects, biophilic design principles can be a way to rediscover nature within dense cities and bring nature to everyday life.
REFERENCE


